In northern Manitoba some 60 years ago when Manitoba was a very different type of province and region from what it is today, The Skinner family settled on a wheat farm. During subsequent years, Dr. F. L. Skinner, who will talk to us this morning, became very much interested in ornamental horticulture.

Dr. Skinner's growing conditions are much more rigorous than those experienced by the most of us and, from small beginnings, he has launched into a comprehensive type of privately supported plant breeding program which includes lilies, lilacs, many herbaceous species and even such shade trees as lindens and poplars.

Dr. Skinner has been the recipient of an honorary doctor's degree from the University of Manitoba. He is a member of the Order of the British Empire, which is awarded to outstanding persons living within the British Commonwealth by order of the ruling king or queen.

Dr. Skinner's life and work in Northern Manitoba is a monument to the extent to which persons working with plants can encounter difficulties and overcome them. He is, in my personal estimation, one of the greatest horticulturists of our time.

It is with both pride and pleasure that I now present Dr. F. L. Skinner of Dropmore, Manitoba, Canada.

Dr. Skinner presented his paper entitled "Developing New Plants for the Modern Garden." (Applause)

DEVELOPING NEW PLANTS FOR THE MODERN GARDEN

DR. F. L. SKINNER
Skinner's Nursery
Dropmore, Manitoba, Canada

I spent the first thirteen years of my life in Aberdeenshire, Scotland, and it was there that I learned to know and love the old roses, the mock-orange, the lilacs, the rhododendrons and a host of other shrubs, trees and flowers.

In 1895 when our family arrived in Manitoba there was very little ornamental gardening being done on the Canadian prairies and even in the City of Winnipeg it was several years after our arrival that the first lilac bush opened its flowers there.

There were many lovely flowers growing wild on the prairie in those days but I still missed the favourites of my childhood and it was the desire to grow them that started me on my career as a horticultural plant breeder. As soon as I was in a position to do so I imported a collection of about one hundred and forty roses including all the old varieties that were available at that time. Unfortunately none of them proved quite hardy though I was able, by giving them some protection, to keep the hardiest varieties alive for a few years. I thought that grafting these on native root stocks might give them a little extra hardiness, but in this I was dissappointed. Then I decided to try and combine the hardiness of the wild roses with the beauty of the garden varieties by raising hybrids between them using the wild roses as seed parent. I was successful in raising quite a few hybrids but owing to the fact that one of the parents was a pure species many of that parents' poor qualities were usually dominant and only in rare cases did I secure the results I had hoped for. Thinking that the crossing of two hardy species and using the hybrid as hardy parent might bring better results I raised a number of hybrids between *Rosa rugosa* and our three native species and some of my better roses have now got both *R. rugosa* and one of the native roses in their pedigree.

Some of my earlier rose hybrids, though they could not bear comparison with the garden roses, had some value as hardy flowering shrubs and when I secured such fine leaved species as *Rosa koreana, R. primula,* and *R. laxa,* I set to work to try and raise hybrids that would have nice flowers and at the same time have clean, neat and attractive foliage that would work in well with landscape work. I already had some success in mating *Rosa blanda* with double flowered forms of *Rosa spinossima* and by using these same forms on the three species mentioned, I have now secured a number of varieties ranging from three to six feet in height that have the desired attractive foliage as well as semi-double or double flowers of good form.

Now let us go back to the early days of the century. The only horticultural literature available to me at that time was the Evperimental Farm Reports; a study of these showed that many of the woody plants that had proved hardy on the Canadian prairies were natives of northern and northeastern Asia so I collected all the literature I could buy relating to the climate and flora of that region. Atkinson's "Upper and Lower Amoor" and Younghusband's "Long White Mountain" were most helpful and both gave a great deal of information about the climate and flora of northern Korea, Manchuria and eastern Siberia. Throughout this region the prevailing winter winds are from the north-west giving it extremely cold winters, however the flora is more closely related to that of western Europe and eastern North America than is that of north central Asia. When I visited the Arnold Arboretum in October, 1918, I was delighted to receive from Professor Sargent a few very small plants of *Syringa dilotata* and *S. velutina* grown from seed collected by Wilson on the Diamond mountains in 1917. I had previously received quite a collection of named lilacs from England but many of them suffered at times from the severity of our winters. The winter of 1920-21 was very hard on lilacs at Dropmore and manv of the varieties killed back quite badly while both *S. dilotata* and *S. velutina* came through without injury and flowered freely. Pollen of *S. dilotata* was used on the few varieties of *S. vulgaris* that flowered and some interesting hybrids were raised. I did not expect that these would have more than local interest but a few were named. Some of these were sent to the Morton Arboretum and were so well received that I decided to do some more breeding work with this type of lilac. Though the European varieties of lilac are very beautiful, they have several faults when grown in the Great Plains area of America. Many suckered so badly that they do not flower well unless given a great deal of attention and in some districts they suffer a lot from winter injury and late spring frosts. In Iowa, Mr. Leslie Sjulin, of Inter-State Nurseries, tells me that the lilacs grow so tall that one needs a ladder to enjoy the beauty and fragrance of some varieties. *Syringa dilotata* does not seem to sucker and my first hybrids of it, now over thirty years old, still show no sign of suckering. It also seems to have a tendency to produce a high percentage of dwarfs among its progeny. One of these is only three feet high at twenty years of age and has flowered freely for the past sixteen years. Even the taller growing forms have a tendency to flower quite close to the ground. The dwarf forms should be especially suitable for planting near the modern ranch type of dwelling.

The slides to be shown later will show the flowering habit and the pastel shades of mauve pink and blue that are to be found in the newer hybrids of *Syringa dilotata*. Incidentaly,. we propagate our lilacs by grafting on *S. villosa* stocks which seem to be congenial to most varieties. We have tried grafting and budding on both *S. japonica* and *Fraxinus viridis* with little success. *Syringa vulgaris* varieties are difficult to root from green wood cuttings under our conditions; *S. dilitata* hybrids are a little more promising, however we have found a great deal of variation in the response of different varieties to this type of propagation.

I became acquainted with the late Dr. W. T. Macoun many years ago in one of our talks about prairie horticulture he said that there was a great need on the prairies for colourful vines that would take the place of the rambler roses and large flowered *Clematis* that were grown in the east. Later I will show you slides of some of the results of my endeavours to supply this need. In *Lonicera* we have a climbing native species (*L. dioica*) but its flowering period is short and it is not as colourful as *L. hirsuta* which I collected in northern Minnesota. I made several attempts to cross both these species with pollen of *Lonicera sempervirens* and at last was successful in raising four seedlings of *L. hirsuta;* three of these were apparently identical with *L. hirsuta* but the fourth resembled *L. sempervirens* in both leaf and flower and being sterile it continues to flower from June until killed by severe frost. We have found soft wood cuttings or layering the best methods of propagation.

To bring the large flowered clematis into the ranks of climbing plants that are hardy in the Great Plains area presents quite a few problems. I have secured hybrids between *Clematis integrifolia* and some of the large flowered forms that are intermediate in size and form between the parents and very floriferous, but their propagation in quantity is quite a problem. Some of them can be multiplied, in a limited way, from soft wood cuttings, but others are best propagated by division of the roots which is, at best, a slow process. An attempt to secure larger flowered forms by crossing the Dropmore hybrids with *C. Durandi* failed to produce anything better than we already had.

Clematis macropetala and its near relative, *C. sibirica,* are quite promising as parents of a race of hardy woody climbers with large flowers; a slide will be shown of a small plant of a hybrid between these two species, some of the flowers measured over five inches across. The colour of these hybrids range from pale blue to pale rose pink with a tendency to throw an occasional reddish or white flower. These hybrids are quite fertile and about five hundred seedlings were raised last year. Both parents and the hybrids can be raised from soft wood cuttings.

You may find it hard to believe but *Spiraea Van Houttei* requires protection if it is to flower freely on our western prairies, but only once in over twenty years has it flowered freely at Dropmore without protection. The introduction of the *S. tricocarpa* and *S. trilobata* gave me an opportunity to raise hybrids that have about the same ornamental value as *S. Van Houttei* and these hybrids are truly hardy. *S. media* and *S. betulifolia* have also been used at Dropmore in the production of new hardy shrubs.

Crataegus, Malus and *Prunus* are other families of woody plants that have been used at Dropmore in the production of new hardy ornamental plants. Slides will be shown of *Malus* and *Prunus* hybrids later.

In perennial plants I have done a great deal of breeding with lilies and chrysanthemums and lesser amounts with anemone, aster, dianthus, iris, peonies, primulas and tulips and pictures of the results of some of this work will be shown.

My first work with lilies was done about thirty-five years ago with *Lilium concolor*, some bulbs of which had been imported from England a few years earlier. This form was self sterile and not fully hardy and the increase one year was very often killed the following winter. Then I secured a few seeds from Mr. Henry Correvon of *L. concolor pulchellum* that had been collected for him in Manchuria. When the first seedling of *L. concolor pulchellum* flowered the typical form was crossed with it giving rise to the *Dropmore concolor* which won an *A.M.* from the Royal Horticultural Society when shown in 1926 by Mr. Amos Perry.

The introduction of *Lilium Willmottae* led to a great deal of breeding work both by Miss Preston of Ottawa and myself. The selection of slides to be shown will give some idea of the wide range of colour and form that has been secured by mating this fine lily with some members of the *L. umbellatum* group.

The introduction of the regal lily gave a great impetus to the cultivation of the lily, but it was not wholly suited to our conditions. The severe winter of 1941-42 removed the last regal lily from my garden. *Lilium Henryi*, and a form of *L. centifolium*, grown from seed sent me by the late Mr. Wm. Saunders of London, Ontario (son of Dr. Saunders who founded the Dominion Experimental Farm System) both proved hardy and by using pollen I had secured at The American Lily Society's Shows I have been able to build up a race of hardy trumpet lilies that vary from pure white to pale pink and deep rich yellow. The martagon lily and its hybrids has also proved useful to work with and I now have martagon hybrids that range from white to almost black and with a constitution that has enabled some of them to become naturalized in the Aspen woods near my home.

The work of the United States Department of Agriculture at Beltsville, with the use of hormones and disinfectants in the propagation of lilies from scales, has removed many of the hazards of lily propagation and enabled the breeder to multiply indefinitely the best results of his work.

Twenty years ago chrysanthemums that would flower out-of-doors in western Canada were unknown. About that time some of the Azaleamums and Clara Curtis had been tried but only with a very moderate degree of success. I had grown several species including the rather weedy looking *C. Zawadskyi*—an Austrian species that had the virtue of being hardy and flowering with us in late August. While on a visit to Hartford, Connecticut, I had the good fortune to meet the late Alex Cumming and I learned from him how to get chrysanthemums to set seed. *C. Zawadskyi* now proved invaluable for it was able to transmit to its hybrids the necessary qualities of early flowering and hardiness and until recently all my chysanthemum breeding was based on *C. Zawadskyi* and its hybrids. *Chrysanthemum arcticum,* as cultivated in this country, has been too late in flowering to be of any use to us and none of its hybrids that I have been able to secure have ever flowered out of doors at Dropmore. In 1947 I visited the Aberdeen, Scotland, University Botanic Garden and there I saw a variety of *Chrysanthemum arcticum* in bloom in July. I was eventually able to establish this form and it is now being used in breeding work by both Dr. Viehmeyer of North Platte and myself. At both places rather interesting results are being secured.

The foregoing has been a review of some of the work being done at Dropmore that is of fairly general interest. Quite a lot of breeding and introduction work has also been done, which although of more local interest has provided me with some interesting problems. While in Sweden in 1947 I saw some of the work being done in tree breeding at the Ekebo Station and also some specimens of *Populus tremula erecta.* Dr. Keillander, who was in charge at the time of my visit, informed me that in Denmark, hybrids of *Populus tremula* had been rooted from soft wood cuttings and once on their own roots were easily grown from root cuttings. I have managed to introduce the erect form of *P. tremula* and, while it buds easily on *P. tremuloides,* budded trees on this stock would not be satisfactory for general distribution and I have not yet succeeded in getting it on its own roots.

In my breeding work with willows and poplars, I find it necessary to bring in flowering wood of such things as weeping willows and lombardy poplars from some considerable distance. I find that they do not flower very well after having been enroute for several days. A method of handling such material so that it could be brought into bloom when wanted would help me very much in securing the desired hybrids.

Tilia americana is very susceptible to leaf mite with us but *T. cordata* and *T. mongolica* are immue to this insect. We have raised a number of hybrids between *T. americana* and *T. cordata* that are immue to this insect and much faster growing than either parent. In our conditions these hybrids do not bench graft very well but I find that they do take very well when budded on seedlings of *T. platyphyllos.* In this connection it is interesting to note that while *Syringa villosa* does well as a stock when bench grafted it is almost useless if one buds the *S. vulgaris* hybrids on it.

Prinsepia sinensis is a shrub that very few nurseries seem to be able to propagate with any degree of success. Here we have no trouble with it. The seeds are cleaned and sown in beds as soon as possible after they are ripe. The following August or early September most of them germinate and occasionally they will develop one or two true leaves. At this stage they do not look as if they would stand our winters, but by covering them lightly with dead leaves just before severe weather sets in, a very high percentage will survive and start into growth as soon as the leaves can be removed in spring.

(Editor's Note: Dr. Skinner concluded his talk with a number of kodachrome slides showing hybrids which he has developed at his nursery in Dropmore. This discussion is summarized below.)

One of the hybrids obtained by crossing *Rosa acicularis* and *R. rugosa* has been named 'Will Alderman' after Professor Alderman of Minnesota. It grows into a bush about three feet tall, is absolutely hardy, and blooms all summer.

It would take the full time of a secretary to keep all of my records. Since I have to do all of the work myself, as well as all of the recording, some of the records become lost.

Some of the hybrids of *Rosa spinosissima altaica* have flowers of hybrid tea quality. They only bloom for a month or six weeks. The tallest ones will reach five feet.

We have secured a wide range of color in the *Syringa ablata dilatata* hybrids. I believe the color range almost equals those of the Lemoine hybrids. Many of the forms are singles and many are doubles. One of the better doubles has been named "Swarthmore" after Swarthmore College. It has a very nice bloom and is very fragrant, too. Three of the hybrids survived the winter of 1953 in Peace River when none of the *S. vulgaris* flowered. These *S. oblafa dilatata* hybrids did not suffer.

A wide range of color has also been secured in the hybrids of *S. villosa*. There is considerable more work on this plant at Swarthmore College, Dominion Experimental Farm at Ottawa, and the Morton Arboretum than at Dropmore. It has been necessary for me to secure pollen from the Arnold Arboretum by mail. My hybrid *S. villosa* are compact and very hardy. Hybrids of *S. reflexa* are not hardy.

Clematis sibirica is absolutely hardy in our area and reaches a height of six to eight feet. Hybrids which have been developed at Dropmore have flowers that are much more spread out than the species. One I measured was over five inches across.

You may find it rather hard to believe that Cunningham's White rhododendron is hardy with us. I cover it with planer shavings during the winter. One species of rhododendron which I know is hardy with us is *R. chrysanthemum*. It is hard to secure, however. It grows to only one foot in height and will grow on the tops of the highest mountains of Eastern Asia. It belongs to the same group as *R. caucasicum*. Cunningham's White is a hybrid of this species. One of the difficulties of Cunningham's White obtained from Europe is that it is grafted on tender understock and it usually kills from the roots upwards during a severe winter.

Potentillas are attracting considerably more attention now. *Potentilla dahurica* grows to about three feet with us. I think that considerable breeding can be down with this plant.

Dr. Skinner showed a picture of two groups of Scotch pines. He stated that the tall plants were grown from seed collected in Southern Sweden, while the dwarf forms were from seed collected in Northern Sweden. Both groups were germinated and grown at the nursery in Dropmore and have retained their distinctive growth characteristics.

I have introduced *Rhamnus pallasi* from the Caucasus. It grows to a height of about three feet and has very attractive foliage. The leaves are an inch wide and two inches long, quite glossy, and during the summer appear almost evergreen-like. It has a possibility of being used in place of privet. It is very slow growing, however. From seed, it takes three years to obtain plants six to eight inches in height. It is possible that by crossing this plant with another species we might obtain a faster growing form.

A number of years ago, I obtained a hardy form of Japanese plum, *Prunus salicina koreana,* from a Mr. Wycoff in Manchuria. By crossing this plant with sandcherry, we have obtained a very good plum which is quite hardy with us.

The hybrid honeysuckle, which I have named 'Dropemore Scarlet,' obtained by crossing *Lonicera hirsuta* and *L. sempervirens* is covered with flowers in June. I have picked flowers from this plant in late autumn.

Tulipa kolpakowskyana, which was obtained from Russia, has flowers which are about two inches across. I have crossed this with tulips at Dropmore and have obtained hybrids that range from yellow, through orange, to deep scarlet. These plants are absolutely hardy with us. One or two of these hybrids can be grown from small bulbs produced at the base but, as a rule, this type of tulip is grown only from seed.

The Japanese iris is not hardy at Dropmore. Plants grown from seeds of *Iris Kaempferi* are hardy. Hybrids produced from crosses of these two are hardy, but the flowers do not resemble those of the Japanese Iris. In other crosses I have used *Iris pseudacoris.*

Most of the commercial varieties of chrysanthemums obtained from Europe and Eastern North America are too late at Dropmore. One of our crosses of the native Michaelmas daisy with a commercial variety flowers rather freely and is early enough for us. The flowers are about two inches across.

Part of our breeding program has been with lilies. Forms range from the typical Willmottiae types to upright umbrella forms. One of our lily hybrids, named 'Helen Carrol,' won an award at Boston. It is a *Lilium elegans* hybrd which has no spots on it and is a pure yellow. Another hybrid is partially orange. The flowers measure six to seven inches across.

The *Anemone tomentosa,* which I saw growing at the Stockholm Botanical Garden has a more northerly range than the Japanese anemone. It is quite possible that it could be used to obtain a wider choice of anemones for our northern areas.

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PRESIDENT FILLMORE: It is evident to all of us that you have done a remarkable job, Dr. Skinner, in selecting and breeding plants which can be grown in your northern country. We are, indeed, fortunate to have had the opportunity to have you discuss your work and show pictures of some of your hybrids. It is regretable that some of these excellent colored pictures cannot be reproduced in our Proceedings.

There is sufficient time for a few questions.

LESLIE HANCOCK (Woodland Nurseries, Cooksville, Ontario): Have you brought *Rhododendron laponicum* down from the northern part of Manitoba?

DR. SKINNER: No, I have not.

C. S. INGELS (Home Nursery, Lafayette, Ill.): What are the extremes in temperature in your area?

DR. SKINNER: Sometimes in the summer the temperature goes over 100°F. and in the winter as low as fifty below zero.

DONALD NORDINE (J. V. Bailey Nursery, St. Paul, Minn.): What is the rainfall and how much is snow?

DR. SKINNER: Our average rainfall is only eighteen inches. Some winters we have about a foot of snow, other winters as much as three or four feet. The snow lasts all winter. In my sixty years in the area, I recall only two winters when a February thaw removed the snow cover.

MARTIN VAN HOF (Rhode Island Nurseries, Newport, R.I.): Why did you advise us not to use *Syringa villosa* as an understock?

DR. SKINNER: *S. villosa* is not hardy with us. We have found that it is not satisfactory as a budding understock, but that it can be used as an understock for bench grafting in winter providing the plants are set deep enough to become established on their own roots.

PRESIDENT FILLMORE: There are a number of instances reported in the literature in which a given understock is satisfactory for budding but not for grafting, or *vice versa*. Apparently the methods are not always interchangebale.

I regret the necessity of concluding this discussion, however if we are to maintain our program schedule, we must adjourn. Before we adjourn, however, I want to again express the appreciation of our membership to Dr. Skinner for being with us and telling of his breeding experiences.

The session adjourned at 12:15 o'clock.

THURSDAY AFTERNOON AND EVENING SESSION

December 15, 1955

The second session convened at 2:50 p.m., President Fillmore calling the meeting to order.

PRESIDENT FILLMORE: This afternoon our first discussion will be presented by Mr. Roger C. Coggeshall. Mr. Coggeshall is a graduate of the Stockbridge School of the University of Massachusetts. He was my assistant at the Arnold Arboretum for two years and is most certainly one of the brightest of the younger men in the field of plant propagation, both as a practiced art and as a science.

I now take pleasure in presenting Mr. Coggeshall, Propagator at the Arnold Arboretum, Jamaica Plain, Massachusetts.

Mr. Coggeshall presented his paper entitled "The Propagation of Asiatic Maples." (Applause)

THE PROPAGATION OF ASIATIC MAPLES

ROGER C. COGGESHALL

Arnold Arboretum
Jamaica Plain, Mass.

The Asiatic maples about which I will speak today are not commonly known in the nursery business today, nor at some of the botanical institutions of this country.

The talk has been a result of the two hurricanes which caused such widespread damage over the Eastern part of the country, notably New England several years ago. The utility companies in this area suffered very heavy losses when the large elms and maples growing along our streets were blown down.

As the need for newer and smaller street trees developed to replace the giants that caused so much damage in falling, it was evident that methods of plant propagation should be developed to produce these plants. They should be propagated in ways other than seeds.

We have a fair representation of these smaller trees in Boston, and they have, until the present time, been grown primarily for seed. Seed propagation, as you know, is by far the cheapest and easiest method to propagate plants. However the percentage of seed that germinates varies greatly from year to year. One year we obtain a stand of 70 to 90 per cent and next year seed collected from the same plant will germinate only 10 to 20 percent, if it comes up at all.

This latter statement has certainly been borne out in our work at the Arnold Arboretum, in that seed selected from a specific plant of *Acer triflorum* for example, germinates very irregularly from year to year. One year seed collected from this plant, properly stratified and sown, will give us very good germination. The next year seed collected from the same plant and handled in the same manner will give us no germination.

There is certainly too much variation in the viability of these seeds to make seed propagation of these plants practical on a commercial scale.

The following is the list of plants which I will speak about today: *Acer grinnala, A. griseum, A. triflorum, A. tartaricum, A. buergerinaium, A. cappilipea, A. cissifolium,* and *A. palmatum.*

These plants are all of Asiatic origin and are relatively small in size compared with our native maples. At maturity they will range from twenty to thirty feet in height. Even at full height, they will still be below the utility lines.

There is one maple, however, that I did not mention in the preceding list as I do not think it falls in the same category. It is the blood-leaf form of the Japanese maple, *Acer palmatum atropurpureum.* I will, however, include it just briefly, as the time of year that these cuttings were taken should be of interest to you.

However before we discuss the propagation of these maples from cuttings, I would like to mention the technique employed to pretreat the seed for germination. All of our seed is stratified artificially under refrigeration. It is held at a temperature of approximately 40 degrees Fahrenheit for a period of three months. This three-month period is an estimated time, as we have no definite basis for the length of time other than the fact that this length of time seems sufficient to bring about germination of most maple seed.

There is experimental work now being carried out at the Arnold Arboretum where we have stratified seed from some of these maples for different periods of time: one, two and three months at a temperature of forty-one degrees Fahrenheit. We are trying to see if we can find the optimum length of time required to bring about maximum germination at this temperature.

Our regular seed procedure is as follows: the seed is collected in September and October, brought to the greenhouse, and stored dry in cloth bags until the first or middle part of November. At this time we mix the seed, wings and all, with a combination of sand and peat.

This sand and peat mixture is the rooting medium taken from the cutting benches of the previous summer's work. The medium is moistened and the seeds are thoroughly mixed with it. The mixture of seed and medium is then bagged in polyethylene bags. The ability of the plastic to retain water vapor keeps the mixture from drying out during the three months' period of refrigeration. There is no need of further watering once the bag is sealed. We seal the bags with rubber budding strips and, of course, the bags are labeled. The date the bags are to be removed from the cold temperature treatment is written on the label.

I believe that this type of stratification is much better than the technique we used to employ. Previously the seeds were sown out-of-doors in frames, mulched for winter protection, and nature was allowed to provide the necessary cold. The disadvantage of this procedure, however, is that the seeds are apt to dry out during a dry winter. Also, one of the most important things of the current type of seed stratification is that you can actually control the time at which the seed is sown. Figure back three months prior to when the frost is out of the ground in your particular locality, and stratify the seed under refrigeration during the preceding three months. Once stratified, the seed can be sown directly into prepared beds outside. We time our seed stratification operation so that the stratified seed are ready to be sown in seed flats in the greenhouse during the middle of February. By sowing our seed one month or two prior to the normal coming of spring, we gain that much on the growing season. The resultant seedlings are much larger than if we had sown the seed directly in the ground outdoors.

The maples that I will speak of today have been propagated from cuttings in three ways: hardwood cuttings, softwood cuttings taken from forced plants in a greenhouse, and cuttings taken from soft, succulent growth in the summer. Let us first consider the cuttings taken from hardwood material.

As would be expected, the propagation of Asiatic maples from dormant hardwood cuttings is very difficult and we have had very poor results with many of the species that I will mention. With *Acer palmatum*, however, results were significant enough to be mentioned here today. The cutting material was collected in March and brought into the greenhouse. The cuttings were made from six to eight inches in length and were treated with different hormones. Some of the cuttings were wounded, some were not.

The type of wound used was similar to the one employed with rhododendrons where a piece of bark is removed from the base of the cutting. The cuttings were placed under plastic, as were all of the other cuttings about which I will speak today. We root most of our cutting material in one big frame covered with polyethylene. The frame is eighteen feet across and sixteen feet in length. The plastic is placed eight inches above the surface of the medium.

The cuttings were stuck in a medium of sand and peat—half and half by volume. The cuttings were made on March 16th. Of the eighty cuttings, forty were treated with a one per cent indolebutyric acid talc (our own mixture). They were wounded as described above. Of the forty cuttings, we potted 34 on April 27th, a little over five weeks later. Of the forty cuttings which were treated with the indolebutyric acid but were not wounded only ten per cent rooted. This beneficial effect from wounding has been reported repeatedly not only with rhododendrons and holly but with most plant material which is considered difficult to propagate. The cuttings rooted directly from the wounded area, that is, the initial root system came from this area. In time additional roots appeared from the cutting so that a uniform root system developed.

Cuttings taken in March and placed under the plastic, immediately started to grow and form shoots. These reached a length of two to four inches. This soft, succulent growth remained in a turgid condition due to the polyethylene. The relative humidity is very high under the plastic and the soft shoot growth did not grow hard after growth had stopped.

I should mention one other thing about the plastic. In the wintertime one disadvantage of using the plastic is the growth of mold and fungus. It may become disastrous unless controlled. We control the mold by applying Captan 50-W, two teaspoons per gallon of water every week to ten days. If you let the mold get a start, it is certainly harder to reduce than if you keep it controlled by spraying with the above chemical from the start.

I did not mention that when the cuttings were inserted in the medium they are watered in. Cuttings are never tamped. The cuttings are watered very heavily after they are first stuck and during the winter months it is not necessary to water the medium again for a month to. six weeks. The only two procedures necessary to operate a plastic covered propagating case in winter are a weekly spraying of the cuttings with Captan to control the mold and a monthly watering of the medium.

The second way in which the cuttings were propagated was from plants which were originally to be used as understock. However, the work load at the Arboretum was such that the plants progressed too far to be grafted. These plants developed soft shoots two to three inches in length. Since we could not graft them, we decided to use the new soft shoots for cuttings.

Here again the procedure was exactly the same. The cuttings were treated with hormones, stuck in sand beneath the plastic, sprayed with Captan every week or ten days and .watered every month to six weeks.

Cuttings handled in the manner just described were made from the following: *Acer grinnala, A. palmatum, A. griseum,* and *A. triflorum.* We were not successful with *A. griseum.* Thirty cuttings of *A. grinnala* were treated with Hormodin #3 and stuck on January 12. Twenty-seven of these were rooted by February 2d. Another lot of 43 cuttings were treated and stuck on February 2d. Within three weeks time, 37 of these had rooted. Please bear in mind that these are soft succulent shoots taken from plants three to six years old which had been forced in the greenhouse. (Mr. Coggeshall displayed some of the plants developed from these cuttings.)

Cuttings of *Acer palmatum* were handled in the same way. The stock plants were two to four years old and again the cutting material was softwood. Of the 164 cuttings treated on January 26th with Hormodin #3 and inserted in a medium of sand under a plastic cover, 122 were sufficiently rooted on February 23d to be potted. Thirty-nine of another lot of fifty cuttings were inserted on February 11th and were rooted by March 15th. This last group of cuttings was treated with a one per cent idolebutyric acid talc. There was no sign of an over-dosage of hormone.

Cuttings of *Acer griseum* were taken from new growth of plants which were grafted. The scion wood was taken from a fifty-year old plant. None of the sixty cuttings stuck on March 4th rooted. I have this to say about *Acer griseum,* it is probably the hardest plant to propagate that I have worked with.

The last maple tried with cuttings of forced growth was *Acer triflorum.* We have run two tests during the past two years. One hundred cuttings were taken on February 1, 1955 and treated with one per cent indolebutyric acid (IBA) in talc. However most of the cuttings were killed because of the strong hormone used. There is, therefore, some variation within the maples as to the concentration of hormone that they can stand. Of the fifty cuttings treated with the 1% IBA, 28 were rooted on February 23, but of the fifty untreated cuttings, thiry had rooted. In another case, we treated fifty cuttings with 15 milligrams per gram of 2, 4, 5—trichlorophenoxyproprionic acid. This treatment was very injurious and we only rooted nine of the cuttings. Again the untreated group rooted very well, 36 of the fifty untreated cuttings developed roots. Cuttings of *Acer triflorum* do not grow nearly as rapidly as cuttings of some other Asiatic maples.

The third way in which we propagated these Asiatic maples was with softwood cuttings taken during the normal growing season. Until now I have been talking about cuttings taken from forced growth and rooted under plastic tents during the winter months. All we had to do was to control the growth of mold with a Captan spray every week and water the medium every month to six weeks. However, in the summer-time the plastic traps heat and, if you do not shade, the cuttings will burn up.

Inside our greenhouses, we have wooden lath shades which can be raised or lowered as desired. We roll them down in the middle of April and they stay down until September. When the temperature outside of the greenhouse rises above 90° Fahrenheit, we shade the plastic cases with Saran cloth from noon until 5 p.m. This is the only shade that the cuttings receive other than the lath shade on the greenhouse. The temperacture underneath the plastic will exceed 100 degrees in severe hot weather. The cuttings will stand these high temperatures providing the temperatures and humidity are not changed suddenly by opening the cases. Thus shading is added to the operation of spraying with Captan every week and watering the medium every three to five weeks.

The following are the plants propagated in the manner just described: *Acer buergerianum, A. capillipes, A. cissifolium, A. tartaricum,* and *A. triflorum.* Our trials with *A. triflorum* were unsuccessful and *A buergerianum* was difficult to root. The other three species were successfully rooted.

Acer buergerianum is an excellent example of why some maples should be propagated from cuttings or grafts. We have a single plant in our collection and, to my knowledge, it has never set seed in five years. On August 24, 1954 we made fifty cuttings of *A. buergerianum.* Of the 25 treated with Hormodin No. 3, only four rooted, and only three of the 25 treated with Hormodin No. 2 rooted. The age of the stock plant was a great influence on the rootability of cuttings. I believe that in time and with more experience we will be able to increase this percentage of rooting.

Cuttings of *Acer capillipes* were taken from a forty year old plant on August 17, 1955. Only four of the 25 cuttings treated with Hormodin No. 3 rooted. This rooting response was increased to fourteen if the cuttings were wounded prior to treatment with the Hormodin powder. Five of the twenty-five cuttings treated with 1% IBA rooted, whereas only two cuttings rooted when wounded and treated with the 1% IBA.

Acer cissifolium is probably the easiest maple to propagate that we have tried. We obtained the following rooting for cuttings taken from a 35-year old specimen:

Treatment	Per Cent Rooting
1% IBA	88
1% IBA + Wound	100
Hormodin No. 3	72
Hormodin No. 3 + Wound	92

Wounding not only improves the percentage of rooting but also resulted in better root systems.

Another maple which we were also fairly successful in rooting was *Acer tartaricum.* In this case fifty cuttings were treated with each of two materials. Only 15 cuttings treated with Hormodin No. 3 rooted, while 37 treated with 1% IBA developed roots. Although there is not a great difference in the strengths of these two treatments (.8 and 1%), the slight increase in strength of the treatment made a marked difference in the results obtained.

I mentioned previously that *Acer triflorum* cuttings taken from young plants rooted quite successfully. However, the stock plant used in these tests were thirty years old. We used three diferent hormone preparations but were unsuccessful in obtaining any rooting. This again emphasizes the advantage of taking cuttings from young juvenile growth.

Throughout this talk I have mentioned *Acer griseum*. We tried to root cuttings without success. Previous to this year we have tried to grow it from seed collected in the Orient, at different Botanical Gardens in this country, and at the Arnold Arboretum. We have not had success with seed from any of these sources except for a few seedlings obtained one year from the seed collected at the Arnold Arboretum.

We have tried grafting *A. griseum* on a number of different understocks but compatibility is a problem. On the strength of our work last year, I believe that we have finally found a partial answer in that *A. griseum* can be successfully grafted on *Acer triflorum* understock.

(Mr. Coggeshall illustrated the method of grafting used at the Arnold Arboretum with a number of kodachrome slides. A summary of his discussion is presented here).

I should emphasize that the technique you will see used with *Acer griseum* is the same method which we use on all of our deciduous grafting.

The understock is established in the pot one year prior to grafting. We use the whip and tongue graft on this established understock. Newly potted seedlings cannot be used successfully. The grafts are made when the roots start to grow and the top is still dormant. The top of the understock is removed with pruning shears by a slant cut. In a whip and tongue graft, when the stock and scion are placed together properly, there are four places where the cambiums can match. The ordinary whip graft affords a maximum of only two places for matching. We have found that with the whip and tongue graft there is an increase in the number of successful grafts and that the union is stronger.

The graft is tied with waxed string. We use No. 20 cotton twine that has been dipped in paraffin. The string is not tied; the ends are merely twisted together.

We have had trouble with fungus in the grafting case. The conditions of the grafting case are optimum for growth of fungus. We have also experienced difficulty in transferring the grafts with soft, succulent growth from the grafting case to the open bench. Now, instead of placing the grafts in a sweat box, we cover the graft unions with strips of polyethylene which are cut approximately one inch in width. The polyethylene is .002 inch in thickness. The plastic will break if it is pulled too hard.

The entire area of cut surface is covered with plastic and the completed grafts are placed in an upright position on an open bench. They are left here until time for planting out. New growth of the scion is hardened before being planted outside and we have experienced no loss. Fungus trouble has not been noted.

In a comparison of the polyethylene strip method with the waxing method, we have found no differences whatsoever. It is our experience that less time is required to wrap with polyethylene than to wax the union.

I realize that the work I have discussed involves only small numbers of cuttings or grafts, however we cannot work with the large numbers which you use. I believe that one of the functions of an arboretum, such as the Arnold Arboretum, is to test methods of propagating new plants and to develop techniques for the propagation of difficult species.

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PRESIDENT FILLMORE: This has been an interesting discussion of the work at the Arnold Arboretum on the propagation of Asiatic maples. We thank you, Roger, for the information.

Our schedule will permit a few questions on this paper.

MR. CASE HOOGENDORN (Hoogendoorn Nursery, Newport, R.I.): Does *Acer griseum* turn a brilliant red in the fall?

MR. COGGESHALL: As far as I know it does not turn as red as some of the other Asiatic maples. The outstanding characteristic of this plant is the bark.

MR. CARL KERN (Wyoming Nursery, Cincinnati, O.): What is the fall color of *Acer manchurian?*

MR. COGGESHALL: That is one of the best for fall color. We have two very old plants in our collection. So far, we have been able to root only one cutting from this plant.

MR. LOUIS VANDERBROOK (Vanderbrook's Nurseries, Manchester, Conn.): What was the understock used for grafting *Acer griseum?*

MR. COGGESHALL: We have used *Acer triflorum* successfully. The understock can be obtained from seed or by rooting cuttings.

MR. JOHN VERMEULEN: (Vermeulen's Nurseries, Neshanic Station, N.J.): We have lost grafts of *Acer saccharum monumentale* after they are well started. What do you use for the understock?

MR. COGGESHALL: We bud it on seedlings of *Acer saccharum*. We have also been successful in grafting it on *Acer platanoides*.

MR. VERMEULEN: Are the understock potted a year before grafting or can they be potted immediately before grafting?

MR. COGGESHALL: They are potted a year prior to the time they are grafted.

MR. WILLIAM H. BURTON (Burton's Hill-Top Nurseries, Casstown, O.): Can you give any comparative results between waxing the union and waxing the entire scion?

MR. COGGESHALL: In only two instances have we dipped the entire scion in wax. Both of these were successful.

MR. MARTIN VAN HOF (Rhode Island Nurseries, Newport, R.I.): Were the cuttings taken in February shaded?

MR. COGGESHALL: No sir. We do not use shade from September through the middle of March. Cuttings are placed in the polyethylene cases without any shade.

MR. CONSTANT DE GROOT (Sheridan Nurseries Ltd., Sheridan, Ont.): Have you had experience grafting *Acer palmatum* in August?

MR. COGGESHALL: I have not had such experience. Perhaps someone in the audience can describe his experiences.

MR. CHARLES HESS SR. (Hess Nurseries, Mt. View, N.J.): We find the results very good. Lately, we have also grafted dogwoods and beeches in August with excellent success. The understock, in all instances, was potted the previous spring.

MR. JACKSON: How do you secure the plastic strips?

MR. COGGESHALL: The plastic strip is tied with a half hitch just as a budding strip is tied.

MR. CHARLES E. HESS (Cornell University, Ithaca, N.Y.): Have you used the adhesive plastic material for tying buds and grafts?

MR. COGGESHALL: No I haven't, perhaps someone here can describe their results.

MR. JAMES S. WELLS (Bobbink Nurseries, East Rutherford, N.J.): It is actually a latex material which is used as a finger bandage.. It sticks the moment it touches. We have tried a few Koster Blue Spruce grafts with it. The results were quite satisfactory, however the material was unhandy to use. It is now available in narrow strips, and, if made in the required lengths, would be quite valuable.

MR. PETER E. GIRARD (Girard Brothers, Geneva, Ohio): We have also used this material and found that it works quite well.

MR. JOHN M. BOGDANY (Stephen Hoyt's Sons Co., New Canaan, Conn.): Does it have to be taken off or does it eventually disintegrate?

MR. GIRARD: It has to be taken off. We removed it at the time of transplanting.

DR. STUART H. NELSON (Central Experimental Farms, Ottawa, Ont.): In regard to the quick bandage material, it is adhesive only to itself. Therefore, when it is taken off, it can just be rolled off. It does not stick to the bark nor to the hairs on herbaceous plants.

DR. JOHN P. MAHLSTEDE, (Iowa State College, Ames, Iowa): I think that the greatest disadvantage in the use of polyethylene strips is the time required. It takes more time than other methods. The adhesive material can be put in a Scotch Tape dispenser and easily cut any desired length. Eventually it will disintegrate. If some of you are thinking of using polyethylene strips on junipers, it is essential that the juniper understock be as clean as possible. We have encountered growth of mold under the strips. An effective spray program prior to grafting will eliminate this trouble.

MR. GERALD H. VERKADE (Verkade's Nurseries, New London, Conn.): Is it also necessary to tie the graft before using the adhesive material?

DR. MAHLSTEDE: With the adhesive, all you need is a little piece of the tape.

MR. COGGESHALL: We have found that if the grafts are not tied, the polyethylene strips do not hold the stock and scion tightly enough. This is because of the elasticity of the polyethylene material.

MR. WILLIAM FLEMER III (Princeton Nursery, Princeton, N.J.): We have tried all kinds of grafting wraps and have settled on rubber budding strips as being the cheapest, the quickest to put on, and the easiest to take off.

PRESIDENT FILLMORE: I am very sorry we have to terminate this discussion, however there is a full program scheduled for the remainder of this afternoon and evening. Again I want to thank Roger for his splendid talk. I am certain that many of you have found his work with the Asiatic Maples of considerable interest.

The session recessed for fifteen minutes before commencing the Speaker-Exhibitor Session.

Agriculture at Beltsville, Maryland, which describes a new apparatus for controlling intermittent mist.

(Editor's Note: This apparatus has been described in a recent issue of the American Nurseryman. May, Curtis and Edward Hacskaylo. New Control Unit Developed for Intermittent Misting of Cuttings. American Nurseryman 103 (8) :18. 1956)

MODERATOR MEAHL: Our first speaker this afternoon is Mr. Charles E. Hess, a graduate fellow in ornamental horticulture at Cornell University. Charlie has spoken to this group on several occassions and is well known to most of you. This year he will discuss results of the work on rooting and over-wintering the pink flowering dogwood.

Charles E. Hess presented his paper entitled "Propagating and Over-wintering of *Cornus florida rubra* cuttings." (Applause)

PROPAGATING AND OVER WINTERING *CORNUS FLORIDA RUBRA* CUTTINGS

CHARLES E. HESS
Cornell University, Ithaca, New York

Nurserymen have tried for many years to propagate *Cornus florida rubra* from softwood cuttings, yet none have ever reported success at a commercial level. In a few instances one or two cuttings were rooted and overwintered successfully, but whenever large scale production was attempted, only a few cuttings remained alive the following spring. It became apparent that the difficulty in propagating *Cornus florida rubra* from softwood cuttings is found only partially in the process of rooting, but is mainly a problem of carrying the rooted cuttings through the first winter of dormant period. Many methods have been attempted commercially, such as burying the cuttings of peat moss in a cold frame, or keeping the cuttings inside a greenhouse, but none have resulted in any degree of commercial success.

The problem was divided into two parts. The first was to find the most efficient procedure for rooting the cuttings. The second was to find the reasons why the rooted cuttings do not survive the first dormant period and then develop an economically feasible method of overcoming or preventing the cause.

To find the best method of propagating *Cornus florida rubra*, fifteen hundred softwood cuttings were taken on July 1st from the second flush of growth. These were split up into three groups; open bench, double glass and intermittent mist. In 30 days there was 60% rooting in the open bench, 67% under double glass, and 92% rooting under intermittent mist. The medium in all three treatments was 1 part peat moss to three parts sand. The mist was controlled by a five minute timer, using 1 minute on and 4 minutes off.

Attempts to solve the overwintering problem were from three directions. One was to try and prevent the onset of the dormant period by extending the length of day and keeping the cuttings in active growth during the winter months. Although it was possible with a daylength of 16 hours to extend the growing period four months beyond the normal onset of dormancy, the cuttings eventually became dormant by February 15th. Furthermore, this method could not be considered practical because the savings gained by making a cutting instead of a graft would be lost in the expense of maintaining the cuttings in a greenhouse throughout the winter.

The second attempt to overwinter the cuttings was to try and prevent the loss of roots which occurs during the dormant period. Nutrients which were considered possibly deficient due to the immature condition of the original cutting were applied but no practical results were obtained.

The third approach was to try and break the dormancy of the rooted cuttings by cold treatments. Cuttings were placed in commercial freezers at different temperatures and for different periods of time. It was found that in order for cuttings of *Cornus florida rubra* to completely break dormancy, the cuttings must be exposed to 1000 hours of temperature between 32°F. and 45°F. Below 32° the roots were killed and the stems split. The cuttings would break into growth, wilt and then die. At temperatures above 45°F., the cuttings did not receive sufficiently low temperatures to break dormancy.

The following year this information was applied on a commercial scale. The cuttings were handled the same as the previous year. In the fall they were placed in a cold frame which was heated just enough to maintain the temperature above freezing. Although the temperature would occasionally go up to 50°F. during the day there was plenty of time throughout the winter for the 1000 hour minimum between 32-45°F. to accumulate. The 32-45°F. period does not have to be in one continuous exposure but can be made up of many short exposures below 45°F. In May 96% of the cuttings broke dormancy and continued to make vigorous growth throughout the spring and summer. The second winter the plants survive normal field conditions and breaking dormancy is not a problem.

A program for rooting *Cornus florida rubra* on a commercial basis would be as follows: Take softwood cuttings from the second flush of growth, in the Northeast this period ranges from June 21st to July 15th. Propagate under intermittent mist, using 1 part peat and three parts sand for the medium. Pot in 30 days or whenever rooted sufficiently. This insures a long period for the cuttings to reroot and become well established before the overwintering period. After potting or in the fall place the cuttings in a cold frame in which you can maintain the temperature above freezing but below 45°F.

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MODERATOR MEAHL: Thank you, Charlie, for this interesting discussion. We will have a few minutes for questions and discussion.

MR. CASE HOOGENDOORN (Hoogendoorn's Nursery, Newport, R.I.): If you make the cuttings between June 21 and July 15, then you don't wait until growth stops. Is that correct?

MR. HESS: We purposely take them when they are soft and when there is actually some elongation taking place.

MR. HOOGENDOORN: Will you describe the resistance rod you mentioned in the discussion?

MR. HESS: It is similar to lead covered heating cable and is placed around the sides of the frame. The purpose is to keep the air temperature from going too low.

MR. CARL GRANT WILSON (Cleveland, Ohio): What root-inducing material did you use?

MR. HESS: The first year we did not use any material and obtained about 92% rooting. The second year we used Hormodin No. 1. The percent rooting was about 95, but the cuttings were more heavily rooted.

MR. ROGER COGGESHALL (Arnold Arboretum, Jamaica Plain, Mass.): Was there any relationship between the over-winter survival and the continued or new growth of the cuttings the previous summer under the mist?

MR. HESS: With the dogwood there was no indication of any relationship of this sort. However with Japanese maple there is some indication of this.

MR. COGGESHALL: We have stored cuttings comparable to yours which were rooted in the case. They did not make new growth and were all dead in the spring.

MR. ARTHUR W. PARRY (Parry Nurseries, Signal Mountain, Tenn.): What advantages does this method have over grafting or budding?

MR. HESS: We feel you can propagate by cuttings more quickly and economically than by grafting but not than by budding.

MR. PARRY: Isn't over-wintering quite a problem compared to budding?

MR. HESS: That is why I didn't say budding. In the South a nice plant is grown from budded material. In the Northeast, where I haven't seen budding done successfully, you don't get the growth you do in the South. Certainly the costs are much less than grafting because it is not necessary to maintain a greenhouse, you don't have the cost of grafting, and you don't have to raise the understock.

MR. JAMES S. WELLS (Bobbink Nursery, East Rutherford, N.J.): Did your wound any of the cuttings?

MR. HESS: No, we did not. In many instances there were only four leaves on a cutting and we didn't cut them off. We made a slant cut on the base and stuck them in the medium.

MR. HOOGENDOORN: Where was the basal cut made?

MR. HESS: We tried them both under and above the node. We found in some cases we make a little more rooting above the node. It wasn't worth while to take the trouble to try to select the cut.

MR. WALTER PEFFER (Level Green Nursery, Trafford, Pa.): What soil mixture did you use to pot the rooted cuttings?

MR. HESS: It was a mixture of two parts top soil, one part sand, and two parts peat moss.

MR. ROBERT SIMPSON (Simpson Orchard Co., Vincennes, Ind.): Why isn't budding a success in the north and east?

MR. HESS: I don't know. I haven't done it myself.

MR. WILLIAM FLEMMER III (Princeton Nurseries, Princeton, N.J.): I would say that budding is not a failure in the Northeast. It has been very successful with us.

MR. HARVEY GRAY (Long Island Agric. & Tech. Inst., Farmingdale, N.Y.): It has been our observation that budding turns out to be a failure because of the improper timing of the operation. Now in the case of budding dogwood, there is a rather critical period when the stock is right and when the bud is the right size to do the work. If you are a bit ahead of time you will find that the stock will push the buds out. If you are late, you will find that callusing is poor. It is a matter of careful timing.

MR. GEORGE T. HOYSIC (Hoysic Bros. Nursery, Rochester, N.Y.): We are located in the same area as you. In the first year, our budded plants make up larger than those cuttings. During the second year, they make excellent growth.

MR. HESS: I am not going to argue cuttings against budding. What I am trying to argue is cuttings against grafts. As I said, I am presenting what is more or less the standard procedure of grafting dogwood.

MR. JAMES ILGENFRITZ (Ilgenfritz Nurseries, Monroe, Mich.): I would like Harvey Gray to tell us how he tells when the understock and the scion wood are ready for budding, and I would also like to have him say a few words about irrigating the understocks before and after budding.

MR. GRAY: In answer to that question, it is a matter of chance to a certain degree. I think the details would be similar to apple. If the bud can be readily seen and taken hold of, it is probably the right stage. Get the buds from the flower portion of the bud stick, but not way down at the very bottom because at that point, the buds are in a tight state and with a latent tendency. As you come up the stem, they are of a larger size. In the mid-section of the bud stick are the ones, which, in our experience, have proven to hold on the understock when inserted.

If the understock is cut much before the latter part of August or the early part of September, in which you are going to attempt to insert these buds, you will find the growth of the understock will be quite rapid, and it will push the buds out, and the buds at that date are not too well developed. Or, to put it another way, try to hold off the budding as late as you possibly can. Still you must have the wood so it will slip, and doesn't hold too tightly, or you can't get your cut to open up.

Now, in relation to the irrigation practice, again there is one thing that you have to watch out for, for if you have too much moisture in the soil the chances are you will tend to keep plants actively growing too long, and the action of the cambium will split out the bud and push it out. Sometimes the wood may be perfect, but the understock may be growing so fast it will push the buds out.

If you have any control over the moisture of the soil, through irrigation, that is the thing to watch out for. In other words, don't irrigate in advance of inserting the buds, but do it when the wood is more or less on the firming up side, but the wood will slip.

MODERATOR MEAHL: We will have to close the question period on this topic at this time, but we should give Charlie a good hand here for his presentation. Thank you very much, Charlie.

Our next exhibit about which we will have a discussion is one having to do with the effect of the length of-day on the growth of plants, and this, as I mentioned earlier, is work which has been done by Sidney Waxman, a graduate student at Cornell University. Unfortunately Mr. Waxman was unable to be here, but his work and his paper will be presented by one who is well qualified to do so—Dr. J. P. Nitsch, who is Assistant Professor of Ornamental Horticulture at Cornell. He has been there since September, folowing Bill Snyder's move to Rutgers.

Dr. Nitsch comes to us from France, receiving his undergraduate, as well as some of his graduate work in France. He took graduate work in this country at the California Institute of Technology under Dr. Went, and, after that continued postgraduate studies at Harvard University. He comes to us, then, with a very fine background and he is going to present to us the material of Mr. Waxman on photoperiodism.

DR. J. P. NITSCH: I won't be able to present his work entirely. I am here for the first time, and I am not a nurseryman and most of the things you are talking about are new to me, but very interesting because I am interested in the ultimate mechanism of propagation and plants. I am not going to read the paper, just try to summarize it.

. . . Dr. Nitsch read Mr. Waxman's paper on "The Effect of the Length of Day on the Growth of Woody Plants." (Applause)

THE EFFECT OF THE LENGTH OF DAY ON THE GROWTH OF WOODY PLANTS

SIDNEY WAXMAN

Cornell University, Ithaca, N.Y.

It was as far back as the year 1686 that the length of day was observed to effect the growth of plants.

Between 1890 and 1905 many workers used arc lamps to determine the effect of additional light on the growth and flowering of various greenhouse plants.

Garner and Allard in 1920 carried out a great amount of research proving definitely that long days and short days effected the growth of many herbaceous plants in different ways.

The name they gave to this daylength effect was Photoperiodism.

To site an example of the effect of the "photoperiod" one can use the chrysanthemum. It will keep growing all summer when the days are out. Sometimes the wood may be perfect, but the understock may be growing so fast it will push the buds out.

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To site an example of the effect of the "photoperiod" one can use the chrysanthemum. It will keep growing all summer when the days are long and will flower when the days get shorter as they do in late summer and fall.

Much intensive research has been and is being carried out concerning the flowering of herbaceous plants.

As a result of much research, this principle is now being used on a commercial scale. Eighty percent of the chrysanthemum growers of New York now use this principle in their cut flower and potted plant production.

By artificially giving their plants "short days," that is, by pulling a black cloth over them; or by giving them "long days," that is, by turning on lights at night they are able to manipulate the time of flowering so that they now have chrysanthemums in the market the year round instead of just during the fall months.

Now the question arises—are the woody plants affected by the photoperiod as are the herbaceous plants?

Wareing in England working with 1st year seedlings of Scotch Pine found differences in the amount of growth under various daylengths.

Last June an experiment was set up in the greenhouse to find out just which woody plants would react to the photoperiod.

The plants were set into pots or cans and were separated in different plots that had their own lighting systems. All of the plots were covered with black cloth from 5 o'clock in the evening until 8 o'clock in the morning. In this way, all of the plants in the different plots received the same amount of sunlight and any additional light they received came from 4-60 watt mazda bulbs. (6′ above bench)

There were 7 different daylength treatments ranging from 9 to 24 hours of light per day.

As an example, the 15 hour light treatment received 9 hours of sunlight and then when the black cloth was pulled the mazda bulbs were turned on by time clock for 6 more hours. In this way the plants received a total of 15 hours of light and 9 hours of dark. There was one additional treatment that was given normal day conditions with no additional light nor shade applied.

The intensity of the light given off by the bulbs ranged from 8 to 30 foot candles which is fairly low when compared to the intensity of full sunlight which is about 10,000 foot candles.

In all we used 8 different species of plants. Two of the plants showing good response are the Pink Flowering Dogwood and Weigela.

In the case of the dogwood, treatments were started at the start of the second flush of growth on June 27.

In three weeks, those plants held in the short day plots (the 9 hour day and the 12 hour day) became dormant. They had an average of two leavse per shoot and havent't grown any since then.

Those held under long days (15 and 18 hour day) remained active, and are to this day still actively growing and producing new leaves.

From June to September there were an average of 13 leaves produced on each shoot on the 18 hour day plants as compared to two leaves on the 9 hour day plants and for leaves on the normal day plants.

The average length of the stems on the 18 hour day plants was 9 inches as compared to 1¼ inches on the 9 hour day and 2½ inches on the normal day plants.

The Weigela plants used were cuttings that were rooted the previous year. They were placed in the plots during active growth. As you may have seen on the exhibitors table there was a large difference in the amount of growth between the long day and the short day plants.

One treatment of special interest is the one that receives light for 9 hours during the day, and then, during the middle of the night they are given just one hour of light. The growth in this plot was much more than one might expect with plants receiving a total of 10 hours of light, but the plants were as tall as the long day plants receiving 15 to 18 hours of light.

The use of an one hour light break during the middle of the night has the same effect as giving the plants 9 hours of additional light. This is important to remember when considering its practical use.

The second phase of the experiment was to determine if the day-length affected the rooting of cuttings.

On June 27, cuttings of *Cornus florida* were placed under mist and given treatments of 9, 18 and 24 hours of light and one additional treatment which was given normal days.

The cuttings were removed after one month and it was found that those cuttings under the 18 hours day treatment had twice as many roots as those under 9 hours of light and 1½ times as many as the normal day cuttings.

Also there were 2 more leaves on each cutting in the 18 hour day group, which had been produced during the rooting period.

I would hesitate to say that the 18 hours of light directly caused the greater number of roots.

Probably it was an indirect effect, that is, the 18 hour day caused new leaves to form which in turn caused a more rapid initiation of roots probably due to a greater supply of hormones coming from the actively growing tops.

The practical application of this daylength effect seems very promising.

Perhaps it would be best to say now that not all plants respond to the photoperiod and of those that do, the effect could vary among the different plants. Boxwood, *Viburnum prunifolium*, and flowering cherry showed no response.

Those giving indications of an increase in top growth are *Magnolia soulangeana, Viburnum opulus, V. Carlesii, Juniperus horizontalis,* (under continuous light only), and *Rhododendron catawbiense.*

By giving additional light to cuttings in the propagating bench and then continuing the light treatment following rooting, it is possible to obtain as much as 3 years growth in one season.

This has been done with cuttings of the pink and white flowering dogwoods and it is probably that it may work with other plants sensitive to the length of day. Also there is good indication that additional light over seedlings would give a similar result.

Further experiments will be carried out this spring to determine:

1. Which plants respond to the photoperiod.
2. When to start and when to stop the light treatments.
3. The least amount of light necessary to obtain the most growth.

*   *   *   *   *

MODERATOR MEAHL: We are indebted to Dr. Nitsch for his willingness to discuss the work of Mr. Waxman on the effect of daylength on the growth of woody plants. There will be time for a limited number of questions.

MR. ALBERT LOWENFELS (White Plains, N.Y.): What kinds of light did you try on these plants?

DR. NITSCH: Incandescent light was used. It is more effective than fluorescent light. I am certain that Dr. Borthwick will give more information on this point tomorrow.

MR. HANCOCK: Could not these cuttings be taken earlier in the year to get the benefit of the long day?

MR. CHARLES HESS SR. (Hess' Nursery, Mt. View, N.J.): That is fine, but who, commercially, has the time at that time of the year?

MR. HANCOCK: We try to finish our work by the first of June. Then we immediately make our summer cuttings. Incidentally the lateral cuttings will root just as well as stronger cuttings.

DR. NIETSCH: I would like to add that if you are late in doing your propagation you can always supplement the day by some artificial light.

MR. GRAY: Just a point of clarification. I am wondering about the statement you made that it wasn't the length of day as much as it was *the length of the night, and as you indicated, one hour of light added in* the middle of the night will do the job. Did I understand that correctly?

DR. NITSCH: That is correct, however Dr. Borthwick will talk about it tomorrow in detail. You can reduce the length to perhaps a matter of minutes if you use the right light at the right time.

MODERATOR MEAHL: Since a later session of this meeting is devoted to a detailed discussion of the effects of daylength on plant growth, I suggest that further discussion should await the paper on this subject by Dr. Borthwick. It has been a pleasure to hear of Mr. Waxman's work and we thank you, Dr. Nitsch, for presenting it to us.

The last scheduled speaker at this afternoon portion of the Speaker-Exhibitor Symposium is Mr. Constant De Groot of the Sheridan Nurseries Ltd., Sheridan, Ontario. Mr. De Groot will discuss the results obtained at that nursery with the use of Chloromone on summer and winter cuttings.

Mr. De Groot presented his paper entitled "The Use of Chloromone on Winter and Summer Cuttings." (Applause)

THE USE OF CHLOROMONE ON WINTER AND SUMMER CUTTINGS

CONSTANT DE GROOT
Sheridan Nurseries Ltd.
Sheridan, Ontario

Korean boxwood is a favorite of ours and we have been growing it for over thirty years. I have heard comments that it is difficult to grow, but we have had quite good success growing it over the years.

Korean boxwood from seed is exceedingly variable. Some plants have large leaves; others small leaves. Some plants are green in color; others are colored. Cuttings from some plants root considerably earlier than others. Plants which turn red in winter are much harder to root. These are reasons why it takes two years to get maximum rooting.

The time for making boxwood cuttings it just as important as for other cuttings. After many years of experience, we have found that the best time for taking cuttings is early August. The cuttings have to be firm before they will root. If they are too soft, they will shrivel under the glass. It has been our experience that about seventy per cent of the cuttings will root after one year in the greenhouse. That is not a profitable operation.

Last year we ran a few trials with Korean boxwood and *Taxus,* using Chloromone. With boxwood we used several dilutions of Chloromone as well as the 100% material. The biggest surprise I have ever had with boxwood was the cuttings treated with 100% Chloromone. We found that after 30 days in the bench some of the cuttings were rooted as well as untreated cuttings which had been in the bench for a year. By using Chloromone we also found that we could make the cuttings twice the size. This is very profitable to the nurseryman.

We also ran a few tests on *Taxus* that we usually have trouble rooting. The strength of Chloromone used was 100%. *Taxus media browni* did not root as well with Chloromone treatment as with the usual procedure. *Taxus media hicksi* was included by mistake. We usually get near 100% with Hormodin No. 2 treatment. We also obtained 100% with the Chloromone treatment. *Taxus cuspidata wardi* was not as satisfactory as the other forms. We rooted only 85 of 105 cuttings. We have a yellowleaved form of *Taxus cuspidata,* but we were only able to root only one of the 140 cuttings tested. Why the yellow form did not root, I do not know.

During the winter we also tried 100% Chloromone on *Juniperus tameriscifolia.* The cuttings burned heavily and I think we rooted only about 10 per cent.

Since we had burning on the Juniper cuttings treated with 100% Chloromone during the winter, we tried 33% Chloromone on juniper cuttings during the summer of 1955. Of the twelve varieties tried, we had excellent rooting on about five. They were treated and stuck in cold frames. The frames were covered with glass but were not under our lathe.

Juniperus chinensis stricta was one of the varieties which rooted strongly after only 60 days. The same juniper, stuck the same day but treated with Hormodin No. 2, did not show any sign of rooting in the 60 day period.

Juniperus chinensis obelisk and *J. squamata meyeri* both had about the same response as the stricta juniper. *J. communis hibernica* and *J. c. cracovia* also responded well following treatment with 33% Chloromone.

Of the three varieties of *Thuja occidentalis* tested, *T. o. pyramidalis* was by far the best.

Examples of many of these cuttings can be seen in the exhibit.

* * * *

MODERATOR MEAHL: I am certain that many of our members have been interested in your results obtained with Chloromone. Thank you, Mr. De Groot.

MR. HOOGENDOORN: How was the Chloromone cut?

MR. DE GROOT: With water.

MR. HUGH STEAVENSON (Forrest Keeling Nursery, Elsberry, Mo.): Did you try Pfitzer's juniper with Chloromone?

MR. DE GROOT: Yes, I did, I did not take the cuttings out because they didn't respond as well as the other varieties. They are still in the propagation bed.

MR. GERALD H. VERKADE (Verkade's Nursery, New London, Conn.): What medium do you use to root these cuttings?

MR. DE GROOT: We use a mixture of sand and peat.

MR. VERKADE: What temperatures did you run the greenhouse during the winter?

MR. DE GROOT: The average temperature is about 55°F. I would like to bring it to nearer 65 next year.

MR. CHARLES E. HESS: I think that the reason Mr. De Groot has had very good success with Chloromone and many nurserymen have had trouble with it burning the cuttings, lies in the cooler condtions inside the greenhouse. Plants, such as holly, react tremendously to this material at higher temperatures. If it is used on holly at lower temperatures there isn't this severe reaction.

MR. STEAVENSON: What is Chloromone?

MR. DE GROOT: I don't know.

MR. CHARLES E. HESS: We have been told that it is an extract from the young tips of alfalfa. We have tried to extract it ourselves but have not obtained a solution comparable to the commercial preparation. With Dr. Nitsch's help, we are now trying to determine its contents by bioassay methods.

MR. INGELS (Home Nursery, Lafayette, Ill): Will freezing damage the material?

MR. CHARLES E. HESS: We have accidentally frozen it and have also tried to inactivate it by oxidation. Neither treatment was effective in reducing the strength of the material to any extent. It seems to be a water base, but we are not certain.

DR. L. L. BAUMGARTNER (Baumlandia Hort. Res. Lab., Croton Falls, N.Y.) : There is some question as to just what it is. If it is only an extract of chlorophyll, it would deteriorate very rapidly. It seems to be a copper salt form. This is probably what protects it in storage. Reports which I have heard are quite variable as to the value of the material. We have had some good results which, unfortunately, we have not been able to repeat. I am curious if anyone has been able to repeat with the same variety of plants.

MR. CHARLES HESS SR.: We have with holly. Results are consistently good.

MR. WELLS: I have repeated it twice and the results were nil both times.

MODERATOR MEAHL: We will have to terminate the first session of the Speaker-Exhibitor Symposium. I am certain you all have enjoyed hearing this report of Mr. De Groot's. I will turn the session back to the President.

PRESIDENT FILLMORE: Thank you very much, Professor Meahl, for conducting this excellent session this afternoon.

Before we adjourn, I have a brief statement to make to our guests. The Plant Propagators Society does not solicit members in the usual sense of the word. But we do welcome all persons who are sincerely interested in plant propagation and who are willing to share their knowledge and exchange ideas with others. You have seen an example of exchange of ideas this afternoon and you will see many more instances of this during our meetings. We hope that both the members and guests enjoy these meetings. If any of the guests are interested in membership in the Society, you should contact the Secretary, who has application forms, and talk with the members of the Membership Committee, who are Mr. William Flemer, Mr. Fred Galle, Mr. Roy Nordine, and Mr. Hugh Steavenson.

The Exhibitor-Speaker Symposium will be adjourned until 8:00 this evening.

The session recessed at 5:00 o'clock.

The Speaker-Exhibitor Symposium recessed from 5:00 p.m. to 8:30 p.m.

MODERATOR MEAHL: We will continue this part of the Fifth Annual Meeting with a paper sent by F. L. (Steve) O'Rourke, USDA, Point Four Program. Steve was one of the original members of the Plant Propagators Society, but because of his work for the USDA in foreign countries it has not been possible for him to attend recent meetings in this Society. Mr. O'Rourke will not be present today, but his paper is of such interest that the Program Committee have requested that it be read.

Mr. F. L. O'Rourke's paper, entitled "The Bolivar Pit Method of Rooting Softwood Cuttings" was read by the moderator, Professor Meahl.

THE BOLIVAR PIT METHOD OF ROOTING SOFTWOOD CUTTINGS

F. L. (STEVE) O'ROURKE
USDA Point Four Program

During the past fifteen years a number of methods have been developed to prevent wilting of leaves of softwood cuttings while in the propagation medium. Water sprays, mist nozzles, fans, insulated opaque chambers with lights, humidified air, etc. have all been used more or less successfully for certain plants under specific conditions. Some systems have been comparatively simple and some rather complex, but all have been designed to lessen hand labor and eliminate detailed attention to the cuttings during the rooting period.

A very simple system which was devised in the tropics may prove quite valuable to temperate zone plant propagators for the rooting of cuttings during the summer season. It consists merely of a pit in the ground covered with burlap or cotton cloth which is kept constantly wet by a manually controlled rotary type "lawn sprinkler." The cost of construction and maintenance is slight and the production of rooted cuttings has been highly satisfactory.

The Bolivar pit method was first developed about 1951 by Mr. R. K. Malins-Smith, a citizen of the British West Indies who was trained in cacao propagation in Trinidad and subsequently hired by a syndicate of Ecuadorian cacao growers to propagate cacao clones from cuttings at Hacienda "Bolivar," Province Los Rios, in the cacao belt of Ecuador. Preliminary reports of the Bolivar pit method were published in the Fourth (1952) and the Fifth (1954) proceedings of the Interamerican Cacao Conference. The system takes its name from the Hacienda "Bolivar" where it was developed, but is also a tribute to the memory of the great liberator of South America SIMÓN BOLIVAR, under whose peerless leadership and wise direction nearly the whole of a continent was freed from European domination.

A pit approximately 20 feet wide is excavated to a depth of 20 inches. In poorly drained land it may be necessary to place tile beneath the pit to carry off excess water. Six to ten inches of stone or coarse gravel is placed in the bottom of the pit and lightly covered with sand. Then six to eight inches of a rooting medium, selected according to the locality and the availability of the material. In the tropics sawdust, rice hulls, and coffee parchment are commonly used, but in the temperate zone sand, vermiculite, or peat moss will serve. The prime consideration is that the selected medium be porous and well aerated so that water will pass through quickly and easily.

Wires, preferably copper, are strung horizontally at ground level in order to support strips of cotton cloth or burlap. The burlap or cloth may be used several times if first treated with a one per cent solution of copper naphthenate. Any ordinary rotary type "lawn sprinkler" may then be attached above the center of the pit to a 3/4" pipe brought in either through the ground or from overhead to suit one's convenience. The lawn sprinklers will operate on very low water pressure. They are manually controlled by a valve placed at any convenient location.

At the Tropical Agriculture Experiment Station near Quevedo, Ecuador it was found that a long rectangular pit divided into a number of square compartments was more efficient to construct and operate than several circular ones. The 20 foot wide pit was divided into square compartments by placing boards at 20 foot intervals. A sprinkler controlled by an individual hand valve was mounted above each compartment so that each square could be operated as an independent unit.

A board or movable cradle may be suspended over the pit to allow the propagator to set cuttings without stepping in the rooting medium. In the tropics, however, the workmen usually work bare-footed in the medium. As soon as a section of the compartment is set to cuttings the burlap is stretched across and wet immediately.

The aftercare of the Bolivar pit is quite simple. The maintenance operator is merely instructed to keep the burlap wet at all times. Usually turning on the sprinkler for a minute or two once every two or three hours will suffice unless the day is extremely hot and sunny. As long as the burlap cover is wet the cuttings will not wilt or suffer from heat. After the cuttings form roots the frequency of watering and the amount applied are decreased little by little and later the burlap strips are gradually pulled aside to harden the rooted cuttings to light and air. In all probability temperate zone propagators may be able to overwinter rooted cuttings in the Bolivar pits if a light porous mulching material is used over the cuttings and above the earth at the sides of the pit.

The pit method of propagation takes advantage of the insulating power of the earth to maintain a fairly constant temperature. It thus avoids the rapid fluctuations of temperature with attendant changes in relative humidity that cause water loss from leaf tissue in aboveground propagating structures. Proof of the value of the pit over box-type propagation frames beneath lath houses is that at both the Hacienda Bolivar and at the Tropical Agricultural Experiment Station at Quevedo, Ecuador the number of well rooted cacao cuttings were increased by more than 25 per cent by use of the Bolivar pit.

Other advantages on the Bolivar pit are the cheapness on constructions and the use of only a small quantity of inexpensive and easily obtainable material. Neither electricity nor high water pressure are needed although there is no reason that an electronic leaf and solenoid valve apparatus could not be used if the propagator wished to make the unit strictly automatic.

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MODERATOR MEAHL: That is the paper on "The Bolivar Pit Method of Rooting Softwood Cuttings" by Steve O'Rourke. I am not personally familiar with the work that has been done with this pit, but it may be some of you may have comments about the procedure. Perhaps you have tried something of this sort or perhaps you have questions which someone in the room might be able to answer.

MR. ROSCOE A. FILLMORE (Fillmore's Valley Nursery, Centreville, Nova Scotia): It seems to me that this method is similar to the method that Mr. Hancock uses except that Mr. Hancock roots the material in sandy soil. It appears to me there is a considerable amount of labor expended on that pit.

MODERATOR MEAHL: I think that the observation of a similarity is correct. Undoubtedly, Mr. Hancock will comment on that when he speaks to us a little bit later.

MR. EVERETT CONKLIN (Rutgers University, New Brunswick, N.J.): How much space was there between the top of the rooting medium and top of the burlap?

MODERATOR MEAHLE: As given in the paper, it may be made flexible. It struck me if I used the maximum figures given here, there would be no space left. I would say in such a case it would be necessary to dig the hole deeper or use less material to fill it.

Two years ago Mr. Leslie Hancock of the Woodland Nurseries, Cooksville, Ontario described in detail his method of rooting softwood cuttings in salt and protected by moist burlap. It was an interesting and informative discussion. Today Mr. Hancock has some additional comments and ideas to express about his propagation technique.

MR. LESLIE HANCOCK: Mr. Moderator and Fellow Propagators: Before I speak about my subject, I would like to pay tribute to what we heard this morning. After hearing Dr. Skinner, I wondered why we were standing on the platform beside him. After all, creators of new plants like that make the world progress. We propagators merely multiply them. I think any of you who have ambitions to be producers of new things should take courage like I am going to, even in a small way, to do what Dr. Skinner has done. Such an example of perseverance and endurance, and under such difficult conditions, I have seldom heard of.

THE BURLAP CLOUD METHOD OF ROOTING SOFTWOOD CUTTINGS IN SOIL

LESLIE HANCOCK
Woodland Nurseries
Cooksville, Ontario

Since the Burlap-cloud method of rooting summer softwood cuttings in ordinary soil was described here two years ago, and fully reported in the 1953 Proceedings, my remarks this evening will be very brief. Specimen blocks of rooted cuttings from this year's crop are to be seen with the exhibits.

This year we set up an electronic mist control section for comparison with our ordinary burlap covered frames. The only difference from our standard method was that the misting apparatus and full sunshine was substituted for the burlap shade. However, this was not fair to the intermittent mist method. The new bed should have been on higher, more completely drained land, and the recommended wind baffles should have been used. Next year, we will insure perfect drainage and have burlap strips attached to both sides of the frame, which can be fastened up vertically during the hot part of the day.

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Our results were not as good with the mist control system as with the burlap cloud method for the reasons above stated. But we used ordinary soil as the medium for both methods and will continue to do so as I am sure you will agree, when you see the results which I will show. It is difficult to understand why more propagators will not use nursery soil as a rooting medium when it can be so thoroughly demonstrated that the results are superior.

At least, they are superior under our conditions. I am not trying to lead you up a rose path. You have to work under your own conditions. As far as we are concerned, they are superior to sand and in making special prepared beds in the orthodox manner.

I believe in the new electronic mist control system wholeheartedly for the propagation of difficult subjects. The costs are too high for easily rooted items. It appears that lilacs, potentillas. flowering almond, *Cornus florida,* azaleas, and some broad-leafed evergreens will root particularly well under mist, provided the drainage is perfect. Even for the mist system we will continue to use our standard frame, nursery soil and flooding technique before sticking, also plant from either side of the frame and raise the burlap wind walls afterwards. These wind walls can be let down at night at the same time we are throwing the burlap off the "Hancock frames," and then raised again the following morning. In this way, we will not have two competing systems but one system, part of which receives mist. The beds in both cases will be of standard width and handling throughout. The fog line is at perfect elevation when laid on top of the ten inch high frames. However novel or promising the equipment experimented with, we feel that costs per 100 or 1,000 plants produced will be the final arbiter of the method used.

Before I get the questions, I would just like to break down these two bundles of rooted cuttings just to show the results we get.

(Demonstrating)—This is a sod dug out of the bed just before I came away. That is *Potentilla emesi,* one of the horticultural varieties of potentilla, and I will pass that around so you can see for yourself. It is good soil. See what you have got.

Now while you are looking at those, I would like to explain to those who weren't here two years ago what we do. We mark the whole field carefully. First, we make raised beds of sandy soil, just the same as you would if you were setting out thousands of little plants. We set the frames so that this will be the final elevation of the bed. The frames are exactly twelve feet long with a central bar which is a perfect point of balance. It is built of British Columbia red cedar. It can be carried on or off the field, or anywhere in the field. The frames are set down in long lines and the soil is sifted. Now we have a six-foot, ¾-inch sieve that will fit exactly on half of the frame. We start at one end of the field and dig out a half bed to a finger depth above the level you originally added and sift the soil systematically from one end. We leave the soil in two piles in these frames and only spread it as we need it, for the simple reason if we spread we may get a heavy rain.

Each frame has its burlap strip of standard 40-inch burlap attached to it. When we are ready with cuttings, we gather the cuttings in the field. We do not take any leaves off. We put them in pails during the cool part of the day we put them in, and we put just a little water—about an inch. We gather thousands of them without taking the tips off, without taking the leaves off. We spread a pile as we require it and water it thoroughly until it becomes a soup and the water sinks away fairly quickly. As it is sinking away, we put the cuttings in as fast as we can put them in. They are left standing there and that is all the watering they get except rain. They are covered immediately with burlap. Since the frame is twelve feet long, the burlap won't cover it very conveniently, we have ordinary sections made up that we can put on temporarily as we move along.

Many people have criticized our method in that it is expensive keeping the burlap wet. As a matter of fact, two boys put the cuttings on either side of the frame. Every half or three-quarters of an hour if the burlap begins to look dry, they take a hose, which is systematically up, so they can go up two sections and the whole bed of 200,000 cuttings never takes more than 20 minutes to water. Since we usually have three or four waterings daily, (some days none at all, some days six or seven) you can see the total overhead of watering that burlap is very small. It gives the chap a change and he goes back to the sticking cuttings. We gather the cuttings all day long and bring them in at night. If we haven't stuck them, we don't allow water to stay in the pails. You just have to dump the water out and leave the cuttings in a cool place. They are as easily stuck in the morning.

After we have stuck the cuttings they are sprayed. The burlap is kept moist; if it is a cool day and high humidity you can throw the burlap off at 5:30 and leave it off until 9:00 o'clock next morning. So there is almost no overhead at all.

With the Bolivar method, you can't see how the cuttings are getting along. With our system they are uncovered daily and you can go through the frames in the morning and see if there are molds or fungi starting.

One thing I should have said, we do something to the cuttings. We do dip them with Tersane, which is a fungicide. Now I am ashamed to say we don't use hormones because we are so successful growing them this way that we haven't time. When I get to growing rhododendrons, I am going to follow Jim Wells' method to the letter. When we get plenty of stock plants we will get into that. When we get into mist control and with difficult material, I am going to use the hormones. Although you might not hear about this, I am coming right back one of these days with a lot of dope all about the hormones.

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MR. MARTIN VAN HOF (Rhode Island Nursery, Newport, R.I.): You say you screen your sand before you wash them?

MR. HANCOCK: Yes. With our soil, it is better to screen. We throw the lumps aside.

MR. VAN HOF: Do you use a shredder?

MR. HANCOCK: If you had a rather rough soil, I suppose a shredder would be good. All we do is one man throws the soil in and another rakes it in. You would have to wet the frames. You put your shredder there, and if you think that is a better thing for your operation, then it would be better than our screen. I would certainly adopt the shredder if I found it improved the technique.

MR. VAN HOF: I would also like to ask if you ever tried to flush off the top?

MR. HANCOCK: I made a frame once and I was going to have complete humidity in there It was not a polyethylene cover but a treated cover, and I put my plants in for 24 hours. You have to have the air movement for this method. I know you are referring to Mr. Kepton's method, but he keeps a spray going all the time.

MR. HOOGENDOORN. I think there is one thing you forgot to mention. That is, that you have a hard bottom in order to hold the water.

MR. HANCOCK: I don't want to miss a single thing because it is very important We found when we rototill the land and just leveled it and put the cuttings in, every time you felt a cutting dying you could push it two more inches down. We found out by having a uniform base so it was only finger depth of soft soil, we even tramped it, as they cleaned up the shovel they tramped on it, so when the next lot came along this sifted soil contacts the capillary moisture and the cuttings moves to the bottom.

MR. ROSCOE FILLMORE· I am inclined to disagree, Leslie. After all, we learn from experience, I suppose. I listened to Leslie two years ago and talked with him many, many times personally about this and was inclined to accept his theory entirely but this year we made several thousand cuttings of heather. They were made extremely soft and they were not more than an inch and a half long. You couldn't get them in the hard top. They rooted one hundred per cent. The same was true of Zawadskyi, which were taken in the field by shearing the soft tips, put right in the Hancock frame, and they didn't go anywhere near down to solid soil and still they rooted.

MR. HANCOCK. My good friend lives on the Atlantic, and heather cuttings probably would live there on top of the ground.

MR. JOHN VERMEULEN (John Vermeulen and Son Nursery, Neshanic Station, N J.) : Mr. Hancock, would you describe the texture of your soil?

MR. HANCOCK· It is a fine dust. It is part of the old lake bed which used to exist before Niagara went out, and has a clay base several feet down. The sand is not a true sand, it is really a granite dust. You might as well be growing plants in glass beads for all the fertility there is in it. You have to put everything in it. It is extremely fine. It is so fine we don't get sufficient aeration ordinarily. When we sift it, of course the year the cuttings are in there it is never trampled, so it doesn't get real tight and the trenches make it real light.

MR. VERMEULEN: If we tried your method in our soil I wouldn't have any cuttings. If we watered our soil like you do, we would have nothing but water standing, and it would stay there for three or four days, and we would have a solid layer of water It should be brought out that your soil is of fine texture and it draws your water through. It can't be used everywhere else.

MR. HANCOCK: You could use a sand everywhere provided you have some sort of a water table about three feet down. I think you have to have that.

MR VERMEULEN: When we rototill we have a solid layer of hardpan. Then we have this three inches of soil which you make into mud The water stays three or four days.

MR. JACK SIEBENTHALER (The Siebenthaler Co., Dayton, O.): In your other presentation and also in this one I have never heard you say what you did with this particular soil after you were through using it and before you put in another crop of cuttings.

MR. HANCOCK: We just turn it back to ordinary crops. We don't fertilize the piece we are going to use the next year, but the previous year it may be heavily fertilized.

MR. SIEBENTHALER: In relation to your trial of the mist system tonight, I thought you inferred that you stuck the cuttings in the same soil but with a mist system.

MR HANCOCK. I did use the same soil I merely put the beds on a higher elevation.

MR. VINCENT K BAILEY (J V. Bailey Nursery, Co, St Paul. Minn) Did I understand you to say you do not remove any leaves?

MR HANCOCK: None whatever. Furthermore, we make them in June. You can't take long shoots — that won't work You have to make them from laterals Just as soon as the laterals of **S. persica** or **Deutzia lemoine** are about 5 or 6 inches, we strip them off as fast as we can and push them into the slimy soil

MR HESS: All I want to say is that it is too bad that the nurserymen didn't take the privilege of stopping at your place. The nurserymen are lucky, because if he had in this condition on the American side, we would all be out of business.

MODERATOR MEAHL: We thank you very much, Mr. Hancock. If you have further questions to the question box The next speaker is Thomas B Kyle, Bohlender Nurseries, Tipp City, Ohio Mr. Kyle will discuss grafting varieties of **Juniperus virginiana** without potting the understock.

GRAFTING **JUNIPERUS VIRGINIANA** VARIETIES WITHOUT POTTING THE UNDERSTOCK.

Thomas B. Kyle
Bohlender Nurseries
Tipp City, Ohio

It is not my intent to tell you the details of how to graft junipers, but I thought that some of you, especially those who are primarily growers, might be interested in our method of grafting junipers without potting the rootstock.

P: 60
T: GRAFTING JUNIPERUS VIRGINIANA VARIETIES WITHOUT POTTING THE UNDERSTOCK.
A: Thomas B. Kyle
H: It is not my intent to tell you the details of how to graft junipers, but I thought that some of you, especially those who are primarily growers, might be interested in our method of grafting junipers without potting the rootstock.
At one time we grafted on a large commercial scale. We filled several greenhouses with potted grafts for sale to other wholesale growers. Now we just grow a few grafts for our own planting.

When we discontinued grafting, we were limited for case space, so we started grafting bare-root. We planted the bare-root grafts directly in the field rather than in frames, and we found that a lot of the tender roots would die.

It was decided that the simplest procedure would be to wrap the seedlings and that the simplest wrapper would be a paper handtowel. If you were planning to ship these grafts, it would be necessary to use better paper.

The roots are packed in peat, wrapped with paper-towel, and the top tied. We have used a mixture of hall peat and hall soil, however,

PANEL ON PLANTS AND LIGHT

FRIDAY MORNING SESSION

December 16, 1955

The fourth session convened at 10:00 o'clock, President Fillmore presiding.

PRESIDENT FILLMORE: We are resuming the program of the Fifth Anniversary Meeting of the Plant Propagators Society with a presentation based primarily on scientific research It frequently happens in trying to set up a program of this kind that there is a considerable debate as to whom should be choosen to present a particular topic There may be several individuals of equal rank in the particular field under consideration. In such a case the Program Committee has a difficult job in making the choice. There is, however, one field of plant research in which there is no debate, in which there is one preeminent leader The preeminent leader in the field of light and plant growth is Dr. H. A. Borthwick of the United States Department of Agriculture at Beltsville, Maryland.

Dr. Borthwick will discuss light and plant propagation. I am now happy to present Dr. Borthwick.

Dr. Borthwick presented his paper entitled "Light and Some Plant Responses" (Applause)

LIGHT AND SOME PLANT RESPONSES

DR. H. A. BORTHWICK*
United States Department of Agriculture
Beltsville, Maryland

We have long known that plants are influenced by light in many different ways. For example, the seasonal change in daily duration of light controls flowering of many species, some flowering only when days are short and others only when days are long. Daylength also determines the time of year at which many trees and shrubs cease expansion of new leaves and produce resting buds before the onset of winter. Light is required by some seeds for germination, but it prevents the germination of others It regulates elongation of stems of some plants and promotes coloration of the ripening fruits of others. It enters into the regulation of growth and development of plants in countless ways that are familiar to us and probably in many others that have not yet come to our attention.

In the last 4 or 5 years we have learned that a number of these seemingly unrelated responses of plants to light have some points in common. Several of them are, in fact, controlled by the same basic light reaction. This means that detailed studies of one response give us in-

*Dr Borthwick's official title is Plant Physiologist, United States Department of Agriculture, Agricultural Research Service, Horticultural Crops Research Branch, Plant Industry Station, Beltsville, Maryland formation about the light reaction that is common to all. Thus a study of the light control of seed germination may give us information on how to manipulate light to promote or inhibit the growth of a tree or a shrub so that its wood will be in suitable condition for propagation at times of our choice.

The purpose of this discussion, therefore, is to describe several light responses of plants and to explain our present understanding of how light operates to produce them. The principles involved are basic not only to plant propagation but also to many other phases of plant culture.

The daylength responses of plants Let us first consider the effects of the daily duration of light on plant responses that are often attributed to temperature. The cessation of growth of various woody plants that occurs in late summer or early autumn results from the short days of that season, not from the low temperatures In fact, the stoppage of growth and the onset of bud formation frequently occur well in advance of the time when temperatures begin to fall. In addition to regulating growth of woody plants, daylength also controls other vegetative responses such as the formation of bulbs of onion, the runners of strawberry, the tubers of begonia, and the thickened roots of dahlia.

More widely known, however, are the regulatory effects of daylength on flowering. The flowering of chrysanthemum in autumn and that of poinsettia at Christmas are responses to the short fall and winter days. For that reason these plants and others of similar seasonal flowering habit were called short-day plants. Long-day plants, which flower best when the days are long and fail to flower when days are short, are also known. They include radish, spinach, beet, certain clovers and alfalfa and most of our cereals.

In addition to long and short-day plants, there are others that seem uninfluenced by daylength. Tomato is an example. Most of our commercial tomato varieties flower equally well on a wide range of daylengths, but flowering of certain types introduced from South America is somewhat dependent on this environmental factor. Another example is the Red Kidney bean, which initiates flower buds equally well under a wide range of daylengths. The subsequent maturation of flowers and production of pods by Red Kidney bean, however, are limited by daylength if the plants are grown within one range of temperature but not if they are grown within another Plants that do not usually exhibit a response to changes in daylength thus may do so under a certain combination of environmental conditions, and frequently they may have close relatives that are sensitive to daylength over a wide range of environmental conditions. Such observations suggest that the mechanism for daylength response may be rather universally present in all plants but that in some such as Red Kidney bean the mechanism, although present, does not function as a control on flowering except under certain conditions.

Discovery of daylength response. Our knowledge of the daylength response of plants began in 1920, when W. W. Garner and H. A. Allard, two plant scientists in the U.S. Department of Agriculture, reported their discovery of it They named the phenomenon "photoperiodism," a term coined to indicate the controlling action of daily duration of light or dark on flowering of some kinds of plants. In the 35 years since that time the photoperiodic response has been found to occur in a wide range of plants.

Application of controlled daylength to plant production. Artificial light, although very weak in comparison with sunlight, was found to substitute satisfactorily for it to extend the length of day and thus meet the photoperiodic requirements of plants. Plant breeders were quick to use this in a practical way to make plants of early and late varieties bloom simultaneously so that they could be hybridized. Breeders also induced plants to bloom out of season by appropriate use of light and thus hastened breeding projects through production of more than one generation a year.

Use of light on plants by commercial growers thus far has been largely confined to chrysanthemums Regardless of their natural time of bloom, flowers of many varieties of "mums" are now produced throughout the year in greenhouses by use of artificial light during the months when natural days are short and by shading to decrease the daylength when days are long. In the warmer southern parts of the country, where chrysanthemums can grow outside throughout the winter, artificial light is used over many areas of them during late fall and early winter to delay blooming until late winter and spring. As these practices become more widely known and understood they can no doubt be extended with similar success to a number of other crops grown outdoors in the south and can be used elsewhere to improve methods of production of greenhouse crops in addition to chrysanthemum.

It would seem that many phases of plant propagation and nursery practice might be benefited through the judicious use of light Maintenance of plants in condition for the production of cuttings by appropriate light treatments has already been mentioned. The rooting of cuttings of many plants is known to be favorably influenced by light, and the growth of seedlings and rooted cuttings of many woody plants can be continued for long periods or promptly brought to a halt at the will of the grower by his choice of light treatment Some examples include rooted cuttings of *Weigela* and seedlings of catalpa, American elm, some species of maple, certain pines and others. These various responses of woody plants to light need further research, but the possible practical application of facts already established needs the imaginative consideration of those who are actively engaged in the business

Night length, not daylength, the controlling condition Addition of light at the end of a naturally short day prevents the flowering of short-day plants and promotes flowering of long-day ones. This lengthens the day, but it simultaneously shortens the night; so one wonders whether these responses result from the longer days or the shorter nights. The term photoperiodism suggests that the duration of light may be the controlling factor, but this is incorrect. The daily duration of darkness is the condition that regulates flowering. Moreover, this darkness must be continuous to be effective. Twelve-hour dark periods, for example, may promote flowering of soybean plants very effectively, but if the dark period is interrupted near the middle with only a minute or two of light, thus dividing it into two 6-hour dark periods, flowering fails completely. Barley plants, on the other hand, are unable to flower when grown with 12-hour nights, but a brief interruption about the middle of the dark period causes them to flower normally. On long nights the short-day plant flowers and the long-day one fails to flower, but on long dark periods interrupted near the middle, the long-day one flowers and the short-day one fails to flower. A short-day plant thus is one that requires long dark periods for flowering and a long-day plant is one that requires short dark periods or continuous light.

Dark-period interruptions are also effective in maintaining woody plants in a continuing state of growth. Experiments of this type, although not numerous, have established the validity of the procedure. The minimum amount of light required as a dark-period interruption for controlling the growth of trees and shrubs that are known to be responsive to daylength has not been determined. For a few species, such as *Weigela,* catalpa, American elm and some maples, one or two hours was found effective, and it is probable that appreciably shorter periods may be sufficient. Much variability in minimal amounts of light required for control of flowering and certain other responses in different varieties of plants within a species has been found and is to be expected among related varieties within species of woody plants when these are adequately investigated.

Location of the flower-regulating reaction. The part of the plant that is active in regulating flowering is the leaf. Some plants such as soybean and cocklebur flower if a single leaf is subjected to dark periods of the proper duration even though all the other leaves receive dark periods of durations unfavorable to flowering. Soybean requires a succession of two or more long dark periods, but under ideal conditions a cocklebur will flower in response to a single long dark period. Flowers occur on parts of the plant situated some distance from the treated leaf, this would imply that some flower-inducing substance must be made in the soybean or cocklebur leaf during favorable dark periods and that this substance must move from the leaf to the growing points of the plant where it induces flowering. Such substances are thought to be special flower-forming hormones, have not been isolated and identified. Numerous attempts have been made to extract from a plant that is flowering materials that when applied to a non-flowering plant would cause it to flower. Such experiments have in general not succeeded, but the lack of success does not necessarily disprove the possible existence of such compounds in the plant.

Studies involving the grafting of leaves of the Agate soybean on plants of the Biloxi variety give further evidence of the importance of leaves in controlling flowering and show an important difference between early and late varieties of soybean. Both of these soybean varieties are of the short-day type, but the Biloxi variety requires very long dark periods for flowering, while the Agate variety is able to flower on considerably shorter ones. If a single leaf of agate is grafted to a Biloxi plant, the latter no longer requires such long dark periods for flower formation; its dark-period requirements then become the same as those of Agate. At least one cause of differences in earliness of varieties of soybean or varieties of other photoperiodically sensitive plants would thus seem to be differences in flowering-regulating reactions going on in their leaves during darkness. In Agate soybean, products of these reactions reach an effective level in a shorter period of darkness than in

Biloxi. This is one reason that Agate plants can be grown so much farther north, where dark periods during the growing season are too short for flowering of varieties such as Biloxi.

Kind and amount of light needed. The amount of light required to regulate flowering of many plants is very low. For barley, hemp, soybean, poinsettia and certain others, less than 50 foot-candle-minutes of light from an incadescent-filament lamp is sufficient. This can be given in various ways without greatly altering the result. One might use an intensity of 50 foot-candles for 1 minute or 1 foot-candle for 50 minutes with equal effectiveness. If dim light is used throughout the "dark period" the intensity required is about 0 03 foot-candle. Flowering of hemp and soybean occurs if the intensity drops below this value and fails if it exceeds it. Such intensity is roughly equivalent to the light from a 100-watt lamp at a distance of about 40 feet. Some plants, such as chrysanthemum and possibly beet, require somewhat more light than this. The reasons for the difference are not completely understood but are not thought to depend on any different basic principles. As mentioned earlier, comparable information for growth responses of woody plants is very scarce.

Knowledge of the relative effectiveness of different colors of light has given information of both theoretical and practical value about photoperiodism. We know, for example, that red light is the most effective to use in the middle of the dark period to prevent flowering of short-day plants. Similarly, it is the best to use in the middle of the night to promote flowering of long-day plants Blue light is also effective in both cases, but far less so than red. Green light, however, is only slightly effective in preventing flowering of short-day plants and in promoting flowering of long-day ones. Although the end results of a given light treatment are opposite in long and short-day plants, the similar relative effectiveness of the different colors of light in controlling flowering of the two kinds of plants strongly suggests that both kinds are controlled by the same basic photochemical reaction.

Relation of daylength and other light responses of plants. The light reaction causing the daylength response also controls various other responses of plants. Growth of bean leaves and stems, for example, is regulated by light and the relative effectiveness of the different colors follows the same pattern as in photoperiodism. If seedlings of these plants are grown in darkness, their stems become long and their leaves remain small. Very briefly daily periods of light of very low intensity cause their leaves to become appreciably larger and prevent their stems from becoming so long. Red light is more effective in causing these changes than any other kind just as it is in the daylength response.

Another response that is similarly dependent on red light is the germination of light-sensitive seeds such as those of some varieties of lettuce and tobacco. A single exposure of the seeds to a relatively small amount of light is sufficient to induce a high percentage germination. These responses of seeds and seedlings to light seem outwardly to have little in common with photoperiodism, but experimental evidence indicates that all are controlled by the same basic light reaction.

This finding in itself has been very useful because it enables one to study various aspects of this basic regulatory reaction of light in any one of these several phenomena. This has led to a discovery about photoperiodism that probably would not have been made by a direct study of that phenomenon. Investigation of the light reaction that controls seed germination showed that light near the limit of visibility at the red end of the spectrum, for convenience called the "far red," counteracts the action of red light Thus, moist lettuce seeds that are given red light for a few minutes will germinate when placed in the dark, but moist seeds given first red and then far red remain dormant. This reversing action of red and far red, moreover, can be repeated many times, the final germination response always being determined by the kind of light given last in a series of light alternations. As mentioned previously, the promotion of germination of seeds and the inhibition of flowering of short-day plants both require red light. Since far red reversed the action of red for seed germination, one naturally wondered whether it might not likewise reverse the action of red in controlling flowering of short-day plants. If it did, this would be powerful evidence confirming the belief that these two plant responses are controlled by the same light reactions. An experiment was made, therefore, to test for this far-red effect; and reversibility of the light reaction controlling flowering was discovered.

This means that one can destroy the flowering stimulus in a short-day plant by irradiating its leaves in the middle of the night with red light. He can then immediately regenerate the stimulus to flower by irradiating again with far red. These reversals can be made repeatedly just as they can with germination of seeds and as many as four complete reversals of control of flowering in cocklebur have been made successfully.

The same reversible reaction has also been found to control the growth habit of bean plants. One can transform bush beans into climbing ones by treatments with far-red light for as brief a period as 5 minutes once a day only two or three times during the seedling stage. The climbing response thereby induced in the plants can then be completely counteracted by giving them 2 minutes of red light after each treatment with far red Such reversals in bean can be repeated several times without appreciable decrease in responsiveness of the plants. The phenomenon occurs in many bush varieties and even in pole beans. In the latter the climbing habit is exhibited precociously if the young seedlings are appropriately treated with far red.

The same reversible reaction is also present in tomato fruits and is responsible for a difference in color between dark-ripened and light-ripened fruits of certain varieties. This color difference results from the presence of a yellow pigment in the outermost part of the skin of the light-ripened fruit and its complete absence in the skins of dark-ripened ones. If green tomatoes are given only a minute or two of weak red light each day and complete darkness all the rest of the time, the skins become as yellow as they would be if ripened in full sunshine. However, if the tomatoes are given some far-red light after each treatment with red, the action of the red is completely nullified and the skins remain as colorless as they would be if ripened in complete darkness. In tomato the reaction is also repeatedly reversible, thus showing this response to be under control of the same light reaction that regulates seed germination, photoperiodic response and growth of bean seedlings. Although flowering of tomato, as mentioned previously, is not controlled by daylength, the light mechanism for such control is thus shown to be present. This again suggests its rather universal occurrence in plants but again indicates that a plant does not always have to use this mechanism even though it is present.

Significance of photoreversible responses. The various ramifications of this discovery of photoreversibility in control of flowering and other light-regulated responses have not been fully explored, but the discovery opens up new avenues of experimental approach to the study of photoperiodism and control of flowering. Conversely, knowledge about the photoperiodic reaction is now brought to bear on the physiology of seed germination. Identity of the light reactions controlling the various phenomena mentioned strongly suggests the universal occurrence of this control mechanism in plants and reemphasizes the great importance of further basic study of its action.

Research of this nature is not directed primarily toward immediate practical application to specific plant production problems Instead, its purpose is a basic understanding of the biological principles involved. Almost invariably, however, research workers or others make practical use of the results. Knowledge of the great effectiveness of red light in controlling flowering thus underscores the importance of having a lamp that produces light rich in red. Such a lamp is the ordinary incandescent-filament bulb, inexpensive to buy but very effective in regulating flowering and other daylength responses of plants. Ordinary fluorescent lamps are relatively ineffective when used for this purpose on some kinds of plants. Knowledge of reversibility of seed germination by light raises questions about survival of weed seeds in soil and their subsequent germination. What part does light play in the eventual germination of these seeds? The success of pre-emergence herbicides in controlling weeds depends on various factors, one of which is avoidance of cultivation after application of the herbicide. If the surface soil is disturbed, new weed seedlings appear. Does this happen because light-requiring weed seeds brought to the surface by cultivation have their light requirement satisfied and are thus enabled to germinate? Choice of kind and amount of light and time of its application for best control of flowering and finding the principles involved in seed and other light-controlled dormancies are only a few of the problems that are finding solution or new experimental approaches through basic studies of the action of light in photoperiodism and related phenomena.

Although our knowledge of the action of light in regulation of growth and development of plants is still very far from complete, we can begin to recognize at least the outlines of a basic controlling reaction. That it is some kind of master reaction is shown by the diversity of responses that it controls and enough has been learned about the way it operates to serve as a guide to further experimentation The reaction is of widespread, perhaps universal, occurrence in plants including, of course, all those with which plant propagators are concerned. The possibilities for making use of this light-controlled regulatory mechanism are numerous and depend largely for their discovery and development on the ingenuity and imaginativeness of those immediately involved with the problems of the individual plants. These persons will find a sizeable backlog of unexploited scientific information already available. They must also remain constantly alert, however, to the outcome of current basic research any phase of which may yield results of special interest and importance to them.

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PRESIDENT FILLMORE. Dr. Borthwick, we are indebted to you for the excellent discussion which you have given us on the influences of light on plant growth. It has been very inspirational and I am certain that our group have a number of questions for you.

GERALD H. VERKADE (Verkade's Nursery, New London, Conn.): Is there also increased root growth resulting from the light treatments?

DR. BORTHWICK: We have not made careful measurements, so I cannot say.

CHARLES A. BURR (C. R. Burr & Co., Manchester, Conn.): Have you had any experience with light with respect to growth of rose bushes?

DR. BORTHWICK: I have not had experience with rose.

ALBERT LOWENFELS (White Plains, N.Y.): What is the effect of filtering out a certain amount of sunlight by protecting cuttings using mist, polyethylene covers, cheesecloth shade, etc.?

DR. BORTHWICK: You are cutting down the total intensity and you are not interfering with the of light coming through. The chances are that you still have enough light intensity to take care of the desired rooting response.

DR. L BAUMGARTNER (Baumlandia Hort. Res. Lab., Croton Falls, N.Y.): Is it necessary to have additional red light or is it sufficient to weed out the undesired portion of white light?

DR. BORTHWICK: The difficulty with trying to weed out the non-red light from an incandescent lamp or from sunlight is that it is hard to filter the far red from the red. It is better to select a source that has no far red in it and then to remove the red. To do that, one uses a fluorescent source, which has practically no far red in it, and then use a red filter.

DR. BAUMGARTNER: Is it necessary to supplement the red that normally comes from an incandescent light?

DR. BORTHWICK: Yes You understand that Mazda lamp has both far red and red light in it. They are working in opposition to each other and under some circumstances either one might get the upperhand. The red action so far surpasses the far red that Mazda light gives the red effect.

MARTIN VAN HOF (Rhode Island Nursery, Newport, R.I.): Does light play an important part in the germination of evergreen seeds?

DR. BORTHWICK: One of the men at the station has run germination tests on pine seeds. I do not know the species he used, but some were light sensitive. Knowing what we do about the germination of seeds of many kinds of plants, I think that light may be involved.

MR. VAN HOF: Would you advise us to apply light to yew seeds which take two years to germinate?

DR BORTHWICK: Let me say that there are many things which may keep a seed from germinating One might be a requirement for light, another a hard seed coat, a requirement for after-ripening, or incorrect temperature. I may have unduly emphasized the role that light plays in the germination of seed, but even with such things as yews, I would certainly try light.

HARVEY TEMPLETON (Phytotektor, Winchester, Tenn.): Is it true that chlorophyl is destroyed in light and regenerated in darkness?

DR. BORTHWICK: This is getting into a field I know relatively little about. I believe you are correct in assuming it is destroyed in light. It is not my understanding that it is formed in darkness however.

LESLIE HANCOCK (Woodland Nurseries, Cooksville, Ontario): Certain woody plants, which are brought inside in early spring for forcing, do not react to heat alone. Is that because they weren't receiving the right daylength?

DR. BORTHWICK: I haven't had experience with that. I do understand that plants which have not had an adequate amount of cold to release their growth capabilities can have it promoted by continuous light sometimes when long days will not suffice.

MR. HANCOCK: The practical question is this: We used to get woody plants in January and they would not break bud. Certain types responded to forcing but others did not. Do you think that increasing the length of day might help?

DR. BORTHWICK: I can't answer the question except to predict that it would have a good chance of working

DR WILLIAM E. SNYDER (Rutgers University, New Brunswick, N.J.): I would like to comment on this question. While at Cornell University, I worked on the effect of lenght of day on a number of woody ornamentals. It was found that if evergreens had received a cold treatment, they would respond to the length of day. For example, *Taxus* cuttings showed lateral bud growth thirty days after being placed under long-day conditions (16 hours of light daily), however, those maintained continuously under short-day conditions (8 hours of light daily) had not developed any new growth even after eight months.

FRANK TURNER (Springfield, Ohio): Can you give any estimate of the number of woody plants which will respond to this light treatment.

DR. BORTHWICK: Beyond what Dr. Nitsch discussed yesterday and what Dr. Snyder has just told you, I can state that about two-thirds of the native trees which we have tested at Beltsville were highly responsive to light treatments I have the feeling that a large number of plants will be found which are sensitive. I am also fully convinced that every plant has the mechanism in it, but whether or not this mechanism is used or not may be a different matter.

PRESIDENT FILLMORE: I am sorry that we will have to terminate the discussion of this topic. Dr. Borthwick, unfortunately, will have to leave us early this evening. Questions which you may have can be directed directly to him during the remainder of the day.

Again, I want to express our thanks to you, Dr. Borthwick, for being with us and discussing your interesting work on light.

The next discussion this morning will be concerned with the propagation of chrysanthemums by Mr. Vernon Gifford of Yoder Brothers, Barberton, Ohio.

Mr. Gifford is a graduate of Ohio State University. He was a student of Dr. Chadwick's while at Columbus Yoder Brothers is a major producer of rooted chrysanthemum cuttings. In fact their annual production of this crop alone is in the neighborhood of 75 million cuttings It would seem, then, that we have one of the best sources of information about rooting chrysanthemum cuttings.

Mr. Gifford presented his paper entitled "Propagation of Chrysanthemums by Cuttings." (Applause)

PROPAGATION OF CHRYSANTHEMUMS BY CUTTINGS

VERNON E. GIFFORD
Yoder Brothers
Barberton, Ohio

The new developments and progress made in flowering chrysanthemums in the past few years have also influenced the propagation of "mums"

It was not too many years ago that propagating mums was generally conceded to be a Spring and early Summer proposition. Plants to be used for stock were selected during the flowering season and held in a more or less dormant or inactive state during the winter. This was accomplished by replanting the selected stock in benches, flats or perhaps cold frames. Low temperatures and low moisture conditions were maintained for the winter period. Plants were held thusly until Spring when they were given conditions necessary for resuming their normal growth. This procedure is still followed in some greenhouses.

With the advent of year round flowering of mums which is becoming more and more a common practice, it was necessary that rooted cuttings be also made available any time of the year. The diligent work of several large concerns have made this possible so that now rooted chrysanthemum cuttings are available each week of the year

Propagation of mums by cuttings is by no means the only method of propagation. Seeds, grafting, and division are other methods of propagation. However, propagation by cuttings is probably the most important method. The following discussion will deal entirely on propagation by cuttings

In discussing propagation by cuttings a number of important aspects both physiological and environmental come to mind. Many of these

PRESIDENT FILLMORE: I am sorry that we will have to terminate the discussion of this topic. Dr. Borthwick, unfortunately, will have to leave us early this evening. Questions which you may have can be directed directly to him during the remainder of the day.

Again, I want to express our thanks to you, Dr. Borthwick, for being with us and discussing your interesting work on light.

The next discussion this morning will be concerned with the propagation of chrysanthemums by Mr. Vernon Gifford of Yoder Brothers, Barberton, Ohio.

Mr. Gifford is a graduate of Ohio State University. He was a student of Dr. Chadwick's while at Columbus Yoder Brothers is a major producer of rooted chrysanthemum cuttings. In fact their annual production of this crop alone is in the neighborhood of 75 million cuttings It would seem, then, that we have one of the best sources of information about rooting chrysanthemum cuttings.

Mr. Gifford presented his paper entitled "Propagation of Chrysanthemums by Cuttings." (Applause)

PROPAGATION OF CHRYSANTHEMUMS BY CUTTINGS

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The new developments and progress made in flowering chrysanthemums in the past few years have also influenced the propagation of "mums"

It was not too many years ago that propagating mums was generally conceded to be a Spring and early Summer proposition. Plants to be used for stock were selected during the flowering season and held in a more or less dormant or inactive state during the winter. This was accomplished by replanting the selected stock in benches, flats or perhaps cold frames. Low temperatures and low moisture conditions were maintained for the winter period. Plants were held thusly until Spring when they were given conditions necessary for resuming their normal growth. This procedure is still followed in some greenhouses.

With the advent of year round flowering of mums which is becoming more and more a common practice, it was necessary that rooted cuttings be also made available any time of the year. The diligent work of several large concerns have made this possible so that now rooted chrysanthemum cuttings are available each week of the year

Propagation of mums by cuttings is by no means the only method of propagation. Seeds, grafting, and division are other methods of propagation. However, propagation by cuttings is probably the most important method. The following discussion will deal entirely on propagation by cuttings

In discussing propagation by cuttings a number of important aspects both physiological and environmental come to mind. Many of these could be the basis of a discussion covering most any plant material. Their application, however, could be of varying degrees as applied to different plants. Two distinct phases, "Stock Plants" and "Cuttings" should be considered, and under these headings all the factors that effect them as—temperature, moisture, fertility, lighting, disease, selection of cuttings, and medias to mention a few.

STOCK PLANTS

It goes without saying that stock plants are the basic factor permitting propagation. After a new color or type has been produced by hybridizing, or a sport or mutation is discovered, it becomes necessary to build up a supply of plants as a source of cuttings. The above mentioned plants then become one phase of stock for propagating. Considered from another viewpoint, the continued selection from existing named types and colors constitutes the other phase of stock plants.

Perhaps before going further, it would be best to name the qualities to expect and demand of a stock plant. First, if selecting from established varieties, it should be a true representative of the parent plant as to color, type, size, and date of flowering Failure of a cutting to be a true representative will result in customer dissatisfaction.

Secondly, it should be free from disease. This means a program designed to produce disease free cuttings by any acceptable means must be enforced. Graft indexing, rouging, careful selection, and rigid spraying practices are part of this program.

Thirdly, stock plants should be productive. This statement might be questioned for perhaps productiveness might better be based on good cultural practices. However, if productiveness is based on the characteristic of a free breaking plant then it should be considered as a desireable quality.

With the demand for cuttings now on a weekly basis the year round, the stock program must be geared to meet this demand This means extremely careful planning months ahead to have sufficient stock plants in production to meet the demand at any given time To accomplish this, it means that the productivity of varieties must be known for any time of the year. The keeping of accurate records is a means to this end. The planning of any stock program must take into consideration all cultural and environmental factors.

SOIL—The basic soil for stock plants would be the same that would be acceptable for growing a top quality cut flower crop. A soil with plenty of organic matter and well drained would be acceptable Actually each grower should adjust soil mixtures to suit his particular needs. No doubt satisfactory plants can be grown by the gravel culture method although this may have limited use. Also good stock plants can be grown in a sand peat media by giving ample nutrients in a weak solution at frequent intervals.

The spacing of plants for stock purposes could very well be a debatable subject. Any of several different spacings may be used with acceptable success. The closer the spacing, the more cuttings must be used to plant any given area. Spacings of 4″ x 4″, 4″ x 5″, 5″ x 5″ or wider can be used. The production from any one spacing must be known to enable the grower to plan his plantings. The time of year that the crop is being planted and the length of time it would be in production are factors in determining the spacing.

Soil preparation is a very important factor in getting a good start. If ground beds are used, whatever organic matter and superphosphate that is to be added should be applied and this well worked with a roto-tiller or some other type of tiller. Steam sterilization is next. Details of why sterilize are well enough known that they need not be discussed here. Raking and leveling now become the next important steps. The beds should be so raked and firmed that after planting and watering, no low spots or sunken areas will appear. These low areas are sure to cause trouble, too much moisture in some places will mean a lack of aeration, high spots will be too dry, salts can accumulate in low or poorly drained areas and cause trouble, and in general the bed will be uneven in growth which will result in poor production and appearance.

Great care should be used in planting cuttings particularly in so far as depth is concerned. A mum cutting planted too deep has only a slim chance of survival. The roots are so deep that oxygen is excluded and very often the stem will rot off. After planting, the cuttings should be watered in just as soon as possible. Cuttings should never be set in a dry soil. Have the soil moist enough so that it works up well without packing. Some syringing may be necessary for several days particularly in hot, sunny weather. Once they become established so that new root growth is showing, fertilization may begin.

PINCHING—The time of pinching will vary with season of the year. In the winter when plant growth is at its lowest, three weeks or more may be needed before a pinch can be made. During other seasons when growth is more rapid, 10 to 14 days may be all that is needed. Pinching should not necessarily be based on any certain number of days after planting but rather at the time when the plant has made sufficient growth to make a soft pinch This will leave enough soft growth from which new breaks will develop rapidly. If just the tip is rolled out, there should be no danger of getting into hard wood. Pinching too low or too hard can result in retardation of new breaks which in turn will reduce production.

TEMPERATURES—There has been conducted considerable investigational work on temperatures for mums in recent years. This has been done primarily in regard to its effect on flowering Some of it is applicable to stock plants. There has been some speculation on the effect of temperatures on stock plants as to the carry-over effect on flowering. How important a factor this is remains to be seen. The most satisfactory night temperatures, when they can be maintained may be somewhere in the 50°—60° range.

The growth characteristics should be studied as a means of determining most desirable temperatures. Some varieties exhibit a very vegetative or rosetting type of growth in the cooler range of temperatures. Growing varieties that exhibit these characteristics at a higher temperature would conceivably exert an influence toward a more favorable type of growth. Production of cuttings from these varieties will generally be very low.

Now on the other side of the picture are those varieties which have a tendency to be thin and elongate excessively and possess a reduced leaf area when grown under the higher range of temperatures. Again, cuttings produced from these plants are of reduced quality and are not desirable. Corrective measures here would be to grow these varieties at a lower temperature.

The manipulation of temperatures on the downward scale should begin in the late fall or early winter as the days become shorter and light intensity reduced. Lowering the temperature should be a gradual process until the lowest temperatures desired are reached and maintained for the shortest days of spring. As the days lengthen, temperatures should be gradually raised until the point of no control is reached.

WATERING—Watering is a procedure that, it has been said, can make or break a grower. The degree of exactness in applying water can determine to a high degree the final outcome of any crop.

Watering stock plants for production of cuttings perhaps is a little more of a critical procedure than normal watering for most crops. The amount of water and frequency of application will of course depend on several factors. season of the year, age of stock plans, varieties, and type of soil. The role these factors exert on watering is generally well known and need not be discussed here

For stock plants to produce cuttings of consistent quality the year round, the watering must be carefully controlled. Plants not receiving enough water will have a tendency to be on the hard side Cuttings taken from plants on a reduced watering schedule will in themselves have a lower moisture content. These cuttings when struck for rooting will wilt more rapidly or fail to recover fast enough from a wilted condition to root properly. If rooting does occur, after a longer normal time, quality will be much reduced. Fewer roots may be formed and slower initial "take-off" after planting the rooted cuttings will be experienced.

Considering the other extreme in moisture, stock plants grown at too high a soil moisture content do not make good cuttings. Several points can be covered in a discussion of how too much water affects plant growth.

Over watering or an excess of water will have a leaching effect and unless the loss of nutrients are soon replaced, chlorotic plans will soon result. Chlorotic plants do not produce quality cuttings. Too much water can also result in poor aeration or even a complete lack of aeration in the soil. Under these conditions, the root system is soon destroyed due to a lack of oxygen. Again plants with injured or damaged roots are incapable of normal functioning and the production of cuttings is reduced.

Too much water accompanied with quantities of fertilizers may very well produce a type of growth that is much too soft and succulent for the production of desirable cuttings. Maintaining as even a soil moisture content as is possible without extreme fluctuations should very closely approach the requirements for most desirable growth of stock plants in the production of cuttings.

The methods of applying water are many, both by manual or automatic or mechanical methods. It would be difficult here to say which method of application is best. The limitations both favorable and unfavorable should be studied and then use the one which most satisfactorily meets the need for any particular situation.

Good watering practices should be followed at all times. In watering during periods of high light intensities, it may be permissible to water in such a manner that the foliage is moistened. This will have somewhat of a cooling effect on the plants. Also the plants dry off quickly and the dangers of disease are minimized. However, during periods of low light intensities, it may be best to avoid wetting the foliage to help in the reduction of disease.

FERTILIZATION—There is no question that the fertilization of stock plants is of a much more critical nature than is fertilizing of crops for other types of production. The fact that it is necessary to produce cuttings of the same quality each week of the year necessitates the most precise application of nutrients. Soil tests are available to enable the grower to more accurately diagnose nutrient requirements. These tests should be used only as a guide in the final analysis of how much and how often to apply nutrients. Visual observation of plant growth should also go a long way in making the final decision on any application.

If cuttings are to be taken each week or as ready, it would appear logical that the application of nutrients to replace those used by the plant should be made on the same basis. This then would keep a steady supply or reserve available at all times This sort of condition can be achieved by the use of weak liquid feeds at regular intervals. This could mean a watering between each feeding or feeding each time water is applied. The strength of the solution and frequency of application should be determined by each grower. The areas to be planted for stock should have included in the preparation the application of organic matter, superphosphate and lime or gypsum. If correct applications of these are made, then future applications would need only to contain nitrogen and/or potash in varying amounts.

The application of large amounts of nutrients at infrequent intervals could result in spurts of plant activity or growth. This type of "off and on" growth does not produce consistent quality cuttings.

After a plant has been pinched or a cutting removed, the subsequent break or breaks from the portion of the plant remaining should duplicate as nearly as possible the first removed If the soil nutrients are too low at this time, the breaks could be slow in starting and of a reduced or constricted stem diameter. This in turn means that cuttings will have to remain on the plant a longer time than actually would be needed in order to reach optimum stem diameter and leaf development. Any length of time over the very minimum necessary to produce a desirable cutting results in wasted growth and loss of production.

LIGHTING—The chrysanthemum has long been spoken of as a short-day plant, that is, one that blooms in the period of the year when days are short or when short days are provided by shading with black cloth. It has now been established that since flowering can be delayed and or provented by giving additional light in the middle of the night that mums might more correctly be called a long-night plant.

Be that as it may, it is due to this fact that additional light will prevent bud initiation which makes possible the production of vegetative shoots during the normal short days of the year.

The date when the stimulus for flower bud formation first occurs in this latitude is somewhere between the middle of August and the first of September. Knowing this, and desiring to prohibit flower bud formation on stock plants, it becomes necessary to apply additional light at this time. This could be set up for a period of two additional hours of light during August, April and May. Then as the nights become longer, it is necessary to increase the lighting schedule to three hours in September, October and March. four hours in November and February, and 4½ to 5 hours during December and January. If lighted at the right time, 4 hours additional light may be sufficient for December and January.

It has been found that lighting is not always 100% effective in preventing budding particularly on some varieties. The so-called garden varieties or very early blooming varieties many times will set bud and even flower in spite of additional light. Also at times if stock plants are permitted to become too tall, some of the lower side shoots will be shaded by higher parts of the plants. These shoots will then set buds. Another phenomena that has been noted in the fall and early winter is that when tops or first pinches are rooted and planted for stock, that they may set bud or the bud develops to a visible stage soon after planting.

CUTTINGS

To talk intelligently about a topic, one must first clearly define it. Since this portion of the paper concerns "cuttings," a definition is in order at this time. Just what a cutting is has been described or defined in many text books. However, the following definition, although not taken directly from a text, should be sufficient. A cutting is any portion of a plant which when severed from a plant and given certain favorable cotnditions is capable of regeneration. Now that a definition has been stated, the next thing to consider is what constitutes a good cutting or, just what are the characteristics of a good cutting.

First, assuming that it is a true selection from the parent plant, as mentioned earlier, the cutting must be one that will root with the minimum of applied effort. It must be the proper length when taken, it must have sufficient stem diameter, adequate leaf area, be free of any insect, disease or mechanical injury, and should contain an adequate amount of carbohydrates.

There is a general tendency for cuttings to elongate to a certain degree after being placed in the propagating bench. Some varieties do this to a greater degree than others. Also at certain times of the year the tendency to elongate varies. Some cuttings elongate seemingly at the expense of rooting. Length uniformity is becoming an important factor in customer satisfaction. Therefore if the demand is for any given length rooted cutting, it must be known how much it will elongate in the bench Knowing this, the proper length for taking the cutting can then be determined This is not quite the entire story. For as mentioned above, the rate of elongation varies at different times of the year which means that the length will have to be modified to meet these changing conditions Also, if using the first pinch for a cutting, its' length will have to be reduced, as a tip cutting most generally elongates more rapidly than subsequent cuttings. Generally speaking, the length range for most mum cuttings, according to present day thinking is around 2½" to 3".

Stem diameter is another important factor in selection of cuttings. In selecting, it must be known what is an acceptable stem diameter for each variety. Knowing the natural growth tendencies of each variety will aid considerably in selecting the cutting of proper diameter. Some varieties have a natural growth habit that is somewhat on the thin or spindly side. Cuttings from stock plants of these varieties will be somewhat the same way. On the other hand, varieties with a normal growth habit that is stocky and husky may produce thin cuttings if improperly grown. The fertilization program will affect the cuttings either way—under-fertilized plants will have a reduced stem diameter, and it is also possible to over-fertilize and have cuttings with a larger stem diameter than is actually needed. Temperatures also play an important part in determining stem diameter. Any variation one way or another will effect the rooting This effect could be in time to root, number of roots initiated or length and strength of the roots. If cuttings are to be produced and rooted consistently the year round, uniformity throughout the cutting is necessary.

Many times cuttings will be of sufficient length to be taken but will lack sufficient leaf area or development to insure proper rooting. Perhaps the term immaturity would fit in here. Cuttings taken in this stage could be so soft that excessive wilting or drying out would occur if cuttings were not stuck immediately. Wilted or dried out cuttings respond slowly, if at all, to additions of moisture and will be very difficult to root. To correct this, cuttings must be left on the stock plants a little longer to gain more maturity. In doing this extra length or height is added to the stock plants which is essentially wasted growth. Pruning a stock plant after taking cuttings to reduce the height is a practice that may be resorted to in an effort to correct the height problem This cannot always be considered a desirable practice for the pruning may go down into wood that is too hard. Breaks from this portion of plant are slow and few in number. The ideal situation to arrive at is to force plant growth so that it meets all requirements to produce desirable or quality cuttings as soon as they are of the proper length and still have enough stem left on the plant for breaks for future cuttings

There should be no question that cuttings should be free of any insect, disease or mechanical injury, any one of which lowers the quality or reduces a cutting to one of little value.

The proper carbohydrate-nitrogen relationship is a physiological condition bearing on proper cultural and environmental conditions. Too little nitrogen compared to carbohydrates may cause the plant to be too much on the hard side, making rooting difficult. On the other hand, too much nitrogen may result in a weak and soft type of growth to the point where rooting would be unsatisfactory. To make sure that stock plants are well supplied with carbohydrates, give them the best of cultural practices and provide for all sunlight possible.

The actual taking process should involve no more than being able to snap off cutting with the fingers with a nice clean break. Cuttings that fail to snap off at the proper length are not ready to take and in turn will not root satisfactorily or make good rooted cuttings. Cuttings taken from stock plants that are somewhat on the dry side will have a reduced internal moisture content and will be difficult to root. Any mal-practice in growing that results in cuttings not snapping off easily will result in cuttings of reduced quality.

Is there a best time to take cuttings in so far as time of day is concerned? No doubt there could be arguments for and against taking either in the morning or afternoon. Temperature, wilting, and food storage would all have to be considered in arguing for one time or the other. Results observed so far in taking cuttings in the morning or afternoon show no positive indication one way or another. However more comprehensive and exhaustive tests might throw more light on the subject.

MEDIA—Of all the various medias used at one time or another for propagation, sand or sand and peat appear to have stood the test of time and are still the most widely used. A few years ago vermiculite appeared for a while that it might be a big asset in propagating While many still use it today, it has enough faults that it is not as popular as before.

There is, however, a new product today that shows promise of becoming a very satisfactory media for propagation. This material is called "perlite." It is a white granular material of several different sizes or grades It is being used in the East and Denver areas for carnation propagation, and to some extent for chrysanthemum propagation. It has been used alone and in combination with peat. For mums, a mixture of peat and perlite seems to work best. Used alone, it requires the equivalent of a mist system to keep the cuttings turgid and moist. Being of a granular structure and very light, water drains through it very readily. Cuttings stuck in it dry out very rapidly unless an almost constant supply of moisture is applied. As soon as cuttings show roots, watering can be reduced for the granule seem to retain a supply of water which is available to the root hairs. Considerable amounts of perlite are retained by the roots when pulled for shipping. Preliminary tests indicate that cuttings rooted in perlite are of just a little different quality, not quite so soft, and ship better than cuttings rooted in sand and peat.

Mixtures of peat and perlite appear to be more satisfactory for mums than perlite used alone. The peat provides for more moisture retention in the media in the beginning and cuttings do not dry off quite as rapidly. One thing that is important is the mixture; it must be uniform The peat must be completely broken up and thoroughly mixed with the perlite. Perlite is extremely dusty and some kind of respirator is necessary when handling it. Also it seems that some sort of a large mixer would be necessary for mixing the peat and perlite For whatever media is used, if a mixture, it must be uniform and should be sterilized. To date, steam sterilization is probably the most widely used. The mixture most suited for one propagation may not meet the requirements of another propagator Using 1/3 peat and 2/3 sand as a starting mixture, it can then be modified one way or another to meet the propagators needs.

STICKING—Before sticking the media must be thoroughly moistened. Sticking into a dry or non-uniformly moist media can mean trouble from the start. If the base of the cuttings is inserted into a dry media, moisture will be lost immediately from the cuttings into the media. This will result in more time and energy being spent trying to get the cutting turgid, all of which will mean longer time in the propagating bench.

The old process of sticking cuttings by firming the media, cutting through it with a sharp edged tool, sticking the cuttings and then tamping the media firmly about them has been replaced by another method. Now markers or dibble boards are used with the pegs set for whatever spacing is desired. The marker is plunged into the surface and then withdrawn leaving a series of holes in which to place the cuttings.

It may be necessary at certain times of the year to remove some of the lower foliage of certain varieties before sticking. This is necessary to reduce spread of any disease that might get started in the propagating bench. Actually in so far as rooting is concerned, the more foliage that can be left on the cutting, the better up to a certain point. That would be when it interfers with sticking or would be conducive to spread of disease.

The use of some root promoting substance in propagating is almost a universal practice. Several different materials are available and may be used either in powder or liquid form. Their value has been proven and more uniform results are obtained when they are used.

WATERING—After the cuttings are placed in the holes, they should be watered in by any convenient method It should be kept in mind that the watering-in process should be thorough enough so that the media is well settled around the cuttings. Failure to water them in thoroughly may result in the base of the cuttings drying out and rooting will be retarded or completely inhibited. After the cuttings are well watered-in, subsequent applications of moisture need only to be some means of dampening or misting to keep the humidity up and the cuttings turgid.

Some means of protecting the cuttings from the sun is necessary after sticking. This means covering the cuttings or shading the glass or both. Newspaper and cheese cloth have been used as coverings. Shading compound or camouflage cloth may be used to cover the glass. All of these methods work to a degree but in so doing are excluding the maximum light available to the cuttings in full sun. The mist keeps a constant or near constant film of moisture on the cuttings. This prevents any burning or sun scalding and at the same time keeps them turgid so that the full photosynthetic capacity can be realized.

The results published to date on mist propagation of mums indicate that there are some drawbacks to this procedure Mum cuttings under mist have a tendency to stretch or elongate to the point that fertilization in the propagating bench is necessary to prevent chlorosis. If the cuttings are to be used by the propagator, this practice may be entirely satisfactory. If the cuttings are to be shipped, this practice might not be advisable as the fertilized cuttings would elongate excessively during shipment.

HUMIDITY—Without sufficient or proper humidity in the propagating area, the rooting of cuttings could be quite a problem. High humidity will of course mean less watering and to a degree lower temperatures. High humidity will keep the cuttings in a turgid condition and will hasten rooting. When the cuttings are turgid, the internal plant processes are able to function more efficiently and in turn hasten rooting.

There are several different methods of maintaining humidity and this may be accomplished by applying the moisture to the cuttings themselves, or by applying moisture to the walks or atmosphere. Skinner lines, Binks system, air conditioning, mist systems are all means of applying moisture to increase the humidity.

DISEASE—It must be kept in mind that in providing ideal conditions for rooting cuttings, ideal conditions are also provided for disease. In combating this nuisance, prevention is probably the best path to follow. Cleanliness in the propagating area is of prime importance. This means that everything must be kept clean from the ground up. A rigid program of disease control in the stock area must be practiced to avoid bringing any into the propagating area To insure against the start or spread of disease, the cuttings may be sprayed after they are partially or fully rooted with any good fungicide Spraying too soon or before rooting has progressed to a certain point will slow down the rooting. There may be times when disease hits the cuttings before they are sufficiently rooted for spraying. It is still possible to spray them provided they are dampened before the spray becomes entirely dry This may not give complete control of the disease but it will slow it down. Hand cleaning or rouging is necessary at times.

TEMPERATURE—In propagating all year, the temperatures employed will cover a wide range During the summer when there is little chance of control, the temperatures may run rather high in the high 80's or 90's. During other seasons of the year when it is possible to control temperatures, a lower range is probably more satisfactory In attempting to maintain any kind of a schedule, the temperatures must be controlled within a range for any given period Thus during periods of the year when there may be frequent rises in temperatures above the average, additional heat would have to be available to bring up temperatures at these times to meet this peak. This would tend to keep scheduling as stable as possible.

For winter time propagation much lower temperatures can be maintained. This in order due to short days and reduced amount of sunlight. The important temperature phase in winter propagation is bottom heat. Here bottom heat can be more or less adjusted to meet the propagators needs. Low temperatures, below 60°F in the media, means that the cuttings will be in the bench a longer time before rooting. Any rise in temperature up to somewhere around 70°F. will mean less time in the bench due to more rapid rooting. If a figure could be stated that would most closely come to being the most satisfactory temperature, it would probably be around 65°F. media temperature with approximately a 10°F. lower air temperature.

One thing that must be said about bottom heat is that it must be uniform. Merely having heat pipes under the bench is not sufficient unless the sides are enclosed so that the heat is uniformly dispersed under the media. Where the sides are not enclosed, the media will be the warmest just over the heat lines and rooting will be more rapid here than elsewhere in the bench.

This discussion on "chrysanthemum propagation" should by no means be considered as a closed subject. Only the more important points have been covered and some of these only briefly. In making any concluding statements, it should be kept in mind that the above discussion has been prepared mostly on the basis of experience and review of literature and not on the basis of any planned experimental investigation.

(Mr. Gifford concluded his discussion by showing a series of kodachrome pictures illustrating the procedure of rooting chrysanthemum cuttings at Yoder Brothers.)

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PRESIDENT FILLMORE: We thank you, Mr. Gifford, for this excellent discussion based on the extensive chrysanthemum cutting operation at Yoder Brothers. The late start this morning necessitates our concluding this session at this time. Mr. Gifford will be present at the Plant Propagation Question Box Session tonight and questions relating to his talk can be taken up at that time.

The session recessed at 12:30 o'clock.

THE PROPAGATION OF *MALUS* SPECIES

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Fruit trees, and apples in particular, are usually composed of two genetically distinct parts the root-system developed from the rootstock, and the stem or branch system, grafted upon the rootstock, both functioning together as a single living organic unit On the other hand most other economic plants are produced either from cuttings or from seeds, and consequently their root and shoot systems are of the same genetic origin and constitution Apple rootstocks may be raised either from seeds, in which case the stocks are of miscellaneous genetic origin, or they may be raised by a vegetative method such as stooling in which case the stocks are uniform in their genetic composition. In practice there is a range of the vegetatively raised rootstocks each with its own special characteristics.

The choice of a rootstock is governed by the aims of the tree propagator. In the early development of the apple industry in Continental Europe. The British Isles and in North America, fruit growers sought trees of vigor and longevity. Until recently seedlings have been regarded as the most suitable understocks for such requirements, but certain of the vegetatively propagated rootstocks are now shown to possess vigor. For our present purpose it is sufficient to realize that the seedling rootstocks are generally regarded as "vigorous" but that they are of non-uniform genetic origin; while on the other hand certain vegetatively raiesd rootstocks are also vigorous, but of uniform genetic origin. Some vegetatively raised rootstocks produce trees of medium vigor and still others are associated with extreme dwarfing and precocity. In practice, therefore, the propagator may choose a vegetative rootstock that will give him a tree with the desired degree of vigor and precocity.

It will be realized at once that the apple tree presents a number of complex problems. What, in fact, is the nature of the so-called rootstock influence? Does it depend upon the ability of a root-system to absorb substances from the soil or upon the ability of the stem to transmit these substances or upon some combination of both? The literature on the subject has now assumed considerable proportions; in fact, it is so large that a general review is out of the question. From the data on rootstock and scion relationships presently available, it seems that no one plant part dominates the entire tree. The rootstock may influence the scion at one time, the intermediate stempiece at another, and the top scion at still another, all indications of the complexity of rootstock and scion relationships Actually, it could hardly be otherwise since both scion and rootstock are so very dependent upon each other for the means of subsistence. There is evidence to suggest that in some cases it may be the "nature of the union" as when EM IX gives it characteristic dwarfing and precocious effect. Fundamentally, however, the nature of the union depends not only upon the co-ordination of the many stem tissue functions but also upon the sheer mechanical problem of obtaining xylem and phloem continuity in tissues which may or may not have the same cell size, shape and structure. Furthermore, the normal periodicity in tissue development and the whole problem of translocation are involved. It is apparent that a great deal of research in the field of applied plant physiology is necessary before the fundamental aspects of the rootstock and scion effects are clearly understood.

Seedling Rootstocks: As stated earlier propagators have generally used seedlings as understocks for apples. The main objections to the seedling rootstocks in widespread use are their vigor and mixed genetic origin, for most apple trees on seedling roots are lrage and somewhat variable in tree performance. Nevertheless, seedling rootstocks have certain desirable features. They are relatively cheap, they are less likely to become virus infected, and they have a wider range of compatibility. Even that fault of too great vigor can be partly overcome if the propagator uses seedling rootstocks that are known to produce smaller trees. For example, at Ottawa, McIntosh trees propagated on *Malus baccata robusta* and Antonovka seedlings are about the same size after 18 years as those propagated on EM I and EM II. In other words, *M. baccata* and Antonovka seedling rootstocks produce hardy semi-standard trees. These are selected parental combinations which greatly improve the uniformity and general performance of the seedling understocks. Further, at one of our Experimental Farms a seed block planting of Antonovka and Beautiful Arcade, another hardy variety, has proved very successful. In the Great Plains region some nurserymen prefer Columbia seedlings. Here again the source of seed could be improved by a seed block of Columbia and Bedford, another hardy crab. Seed selection for rootstock production is probably more expensive than extracting seed from cider presses. However, at Ottawa the procedure has been very effectively handled by grinding the apples in an ordinary turnip pulper and extracting the seed from the pulp in a long sluice containing a number of baffles. By this technique very little seed is lost providing the water flow is not too great. With gentle agitation the pulp and abortive seeds are carried over the baffles and the good seed settles in the sluice. Where seedling rootstocks are preferred more attention should be given to the seed source.

It would not be right to discuss apple seedlings without mentioning Apomixis. Apomixis is the production of seed without fertilization. It is a definite hindrance to the plant breeder but may prove to be useful to the propagator. Since apomictic seedlings are usually genetically identical with the mother plant they are essentially a clone. Apomictic seedlings of *Malus sikkimensis, toringoides, M. Sargenti, M. platycarpa, M. Sieboldii* and *M hupehensis* are presently being tested as dwarfing rootstocks. Sax at the Arnold Arboretum, Harvard University, Brase at the N.Y. State Agricultural Experimental Station, Geneva, N.Y., and Clarke at the Pennsylvania State University are conducting these tests. Brase (1) has found that *M. sikkimensis* seedlings are dwarfing and precocious. and that they are quite promising as understocks. With *M. toringoides* seedlings he has found that ten commercial varieties tested are not only fully compatible but also that they fruit at an early age. Clarke (2) in his investigations of apomictic seedlings observed that those of *M. Sargenti, M. Siebaldii* and *M. pehensis* were incompatible with the red and sports of Stayman Winesap, Rome Beauty and York Imperial.

The workers at the Long Ashton Research Station in England are also interested in apomixis. Since apomictic seedlings arise from somatic tissue, the spread of virus from the parent tree could be a problem. Nevertheless only extensive investigations can determine the full rootstock value of apomictic apple seedlings.

Vegetative Rootstocks: Although most of the apple trees on the North American Continent are on seedling rootstocks, interest brought about mainly through orchardists' demands for smaller than standard trees as one means of reducing a sharply rising cost of management.

One of the main factors in favor of clonal rootstocks is that they produce a known degree of vigor and precocity in the scion variety. For example, the most widely known vegetative rootstocks are the East Malling series where individual rootstocks are classified from dwarf to very vigorous Examples of some of the better known understocks of this collection are EM IX, very dwarf, EM VII semi-dwarf, EM I and EM II moderately vigorous and EM XII and XVI very vigorous.

When I was in Germany recently, I found that the EM XI is being used extensively. This is another example of the vigorous understock. The reason it is used in Germany is that it is the hardiest of the EM series. It is the only EM rootstock that is satisfactory in particular parts of Germany, particularly southern Germany.

Although clonal rootstock can produce orchard trees of the desired size and productivity, a number of factors must be considered in such rootstock production. Possibly the most important factor is the cost of propagation. Stooling, the recommended propagation method for these clonal stocks, as it is practiced in England, is a time-consuming, laborious task. At Ottawa, certain mechanical short cuts have been incorporated and these can be most easily presented by giving a resume of our annual procedure.

Stooling: To establish a stool bed, young rooted shoots of the rootstock desired are planted in rows seven feet apart and two feet apart in the rows. Well rooted shoots which are on the large size for budding are preferred. After spring planting the young trees are pruned. About one-third of their growth is removed and the trees are allowed to grow for one season. Early the following spring the plants are cut back to approximately two inches above ground level. From below these cut surfaces adventitious buds initiate numerous shoots and thus a crown is established. The soil should be a good loam preferably on the light side but with an ample amount of organic matter, thus assuring a friable soil fairly retentive of moisture. If the area can be served by irrigation so much the better. When the youngest shoots are approximately six inches high the plants receive their first mounding of approximately four inches. The soil should be slightly moist at mounding, and the tender young tips of the shoots should not be covered, a precaution that prevents loss from decay. Additional moundings are made as growth progresses until there is a nine to twelve inch mound above the crown. Mounding can be accomplished with the aid of a hiller which consists of a pair of twenty-four-inch discs mounted on a sturdy plank and attached to the hydraulic lift at the rear of a tractor. The mechanical method of mounding must be supplemented by some hand labor. The mounds are left undisturbed through the late summer and fall to allow rooting. The following spring the earth is removed down to the level of the original crown. A digging fork is the best implement for with a fork there is less chance of cutting or breaking off the young tender roots. All the shoots should be removed from the crown, when taking the rooted shoots from the crown a sharp pair of hand pruners should be used. The shoots should be detached as close to the original crown as possible leaving a stub of one-quarter to one-half inch. After the shoots have been removed the crowns are left uncovered while new adventitious shoots are formed from the stubs. Twelve to sixteen well rooted shoots to the crown are considered the maximum production under ideal conditions.

Adaptability. Unfortunately for us on the North American Continent the Malling rootstocks are of European origin. These rootstocks have been known for centuries in Europe under various names. Through the years they have become mixed and it was only through the efforts of Hatton at the East Malling Research Station, England, who rogued and typed these rootstocks that we have the present series. The fact that these rootstocks originated in a climate where moderate winters and relatively cool summer soil temperatures prevail, creates a problem here in North America. For many of our apple growing regions the Malling stocks are not hardy. In these areas complete killing may not occur but the performance and longevity of apple trees on these rootstocks are severely reduced because of the accumulated injury to the root system. At Ottawa, EM IX and EM I rootstocks have been more susceptible to winter injury than the other rootstocks of this series tested Furthermore, the performance of the East Malling clones, has been unsatisfactory in southerly apple growing regions where high soil temperatures exist. Recently through controlled experimentation Nelson and Tukey (7) at Michigan State University have shown that media temperatures affect the performance of these stocks and that they prefer a cool media temperature during the growing season In an endeavour to overcome these problems a rootstock selection program has been carried out for a number of years at Ottawa.

Seed of hardy apple species is brought in to Ottawa through the courtesy of the international seed exchange. The plants grown from these seeds are subjected to a stooling test. Preliminary selection is on rooting ability, and subsequent selections are on hardiness, vigor, and compatibility. It is hoped that this work will provide a series of hardy rootstocks that range in vigor from dwarf to vigorous. *Malus robusta* No. 5 is a rootstock resulting from this project. It is a rootstock which roots readily by the stooling method, is moderately vigorous and is compatible with most varieties Approximately 100 other selections of Malus species are being tested.

Incompatibility: Some serious cases of incompatibility have occurred with clonal stocks. Such have resulted in the complete failure of the stock-scion combination. This is much less likely to occur with the heterogenous seedling stocks. Nevertheless, if the rootstock-scion combination is extremely important the "Nicolin" system of shield budding can overcome such incompatibility. By the "Nicolin" method a small sliver of wood of a compatible variety is placed between the two incompatible varieties. Short intermediate stempieces can also be employed to overcome this trouble.

Viruses have become a very serious problem in clonal rootstocks, and the propagation method itself is conducive to a rapid spread of the disease. In Europe, all the East Malling clonal apple rootstocks have been found to carry virus of one form or another. This situation is very disturbing since the varieties budded on these rootstocks become virus infected also and unless heat therapy proves effective in inactivating the viruses, the use of these clonal stocks may have to be curtailed.

Double-Working: So far, the varieties used as vegetative rootstocks are those that root readily when subjected to stooling. As mentioned, the well-known clonal rootstocks produce certain definite effects. Therefore, different intermediates can produce a great range of these "rootstock effects," and since reciprocal graft unions do not behave in the same way, the range can be increased enormously. Now the EM IX rootstock is dwarfing and precocious, but it is not hardy. In a climate unsuitable for EM IX, the orchardist could use an intermediate stempiece that would give him the desired size, precocity and hardiness.

We are trying, for example, the variety Robin crab, which is used extensively on the Great Plains This variety when inserted between a vigorous scion variety will give a tree of small size and will overcome the hardiness problem present when short intermediates of EM rootstocks are used.

Where hardiness is important in the trunk and crotches of the tree even longer intermediate stempieces are used. The possibility of building a tree with a hardy framework to solve the problem of winter hardiness in the colder regions has received considerable attention at Ottawa. Some sixty stem builders have been and are in the process of being evaluated These stem builders must be hardy; they must be compatible with the rootstock and the scion variety, they must be mechanically strong, and finally, they must produce the desired vigor and shape of tree. Propagators have preferred Hibernal because it is easy to topwork and is compatible with most varieties, but Hibernal has not proved mechanically strong when the trees come into bearing. The stem builder constitutes the main framework of the tree, that is, the trunk and some four to six scaffold limbs worked over to the scion variety approximately twelve inches from the trunk. Budding is the most economical method of working over the scaffold limbs. Top-working at distances greater than twelve inches may cause considerable later twisting and breaking of the limbs. On the other hand, if the buds or grafts are inserted too close to the trunk, continued trunk growth soon envelops the unions and the purpose of topworking or hardy tree building is defeated.

*Cuttings*s The demand for apple trees fluctuates and for this reason stool beds are too constant and since cuttings can be varied to meet the requirements this method of propagation is eagerly sought. Although some successes have been attained experimentally much is still to be learned before fruit trees can be propagated commercially by hardwood and softwood stem cuttings.

The problems of propagating apple rootstock varieties by hardwood stem cuttings have long been understood and have engaged the attention of many investigators at the East Malling Research Station, England, notably Garner and Hatcher (4). The early research was concerned primarily with the cutting in its nursery environment. Later the effects of growth regulating chemicals were investigated intensively. Now the interactions of these factors coupled with those present in the transitional development of the plant are being studied

Growth Stages of Fruit Trees: The fact that plant life and fruit trees in particular undergo, like animals, metamorphosis in their development is not generally appreciated. Unlike an animal, where metamorphosis affects the whole body, fruit trees retain the different phases throughout their life. These phases are of a physiological nature and although the fundamental causes are not fully understood, their external features are quite definite and are generally referred to as the juvenile. transitional, mature and senile phases. These stages of development are of profound importance to those engaged in fruit tree research, particularly the plant propagator and fruit breeder. As early as 1900, Goebel (6) observed the ready-rooting of very young seedlings and established the term juvenility to describe the physiological condition Fritzsche (3), Gardner (5), Olden (8) and Passecker (9) present results illustrating lack of rooting from the mature forms and good rooting from the juvenile forms. Wherever I went in Germany this fall, I found that the fruit breeders and propagators were very much concerned about growth stages in fruit trees. I feel that we in this country have overlooked this matter and should give it more attention

The hardy rootstock, *M. robusta 5*, was developed at Ottawa from one finally-selected seedling raised from seed obtained in 1927 from Russia through the courtesy of the Arnold Arboretum. A stoolbed was established, and it was noted that the young shoots were, and are, rough, thorny and twiggy, all characteristics of what is termed "juvenile" growth. As the *M. robusta 5* trees developed, later shoot-growth lacked the spring and twiggy character. Moreover, when buds were taken from this later shoot-growth and budded in the nursery the resulting trees produced smooth, spineless growth in contrast to the cut-back *M. robusta 5* developing from adventitious buds. These latter produced thorny growth.

Since working with smoother and spinless growth is easier and more pleasant, it was decided to establish a second stoolbed of the smooth type. The buddings for this second stoolbed were layered in 1948. The *M. robusta 5* trees from which the buds were obtained had been planted in 1938, approximately 10 years after germination of the seed. Therefore, bud source for the second stool bed was about 18 years from seed germination.

The second stool bed is providing material of varying thorniness, but the tendency is to smoothness and the absence of spines. However, rooting in the second stool bed is much less prolific and when used as a stem builder further growth appears to be slower and more open than when the thorny type is used, differences both physiological and morphological. The less prolific rooting in and slower growth of the second stool bed may nullify the easier working with such material. Additional morphological differences are the fewer but larger leaves on shoots in the second stool bed and the statistically significant difference in areas of bark between cross-sections of lateral roots of the same age from the two lines. On the other hand, cytological examinations show no differences in chromosome number ($2n = 34$), shape or size. Further, investigations underway on this rootstock include experiments designed to show whether the second stool bed is a "transitional" or "mature" growth stage of *M. robusta 5* and, if so, the effect on earliness of fruiting.

In other propagation studies with *M. robusta 5* it has been observed that the source of propagation material is of prime importance. The number of leaf-bud and soft tip cuttings forming roots was far greater when they were taken from the original stool bed than when gathered from 18-year-old stock trees or from 2-year-old nursery trees that had been budded from these stock trees. Apparently the severe annual pruning of the stool bed retards physiological development of the plants, thus retaining certain characteristics for rooting associated with juvenility.

In rootstocks studies of the past thirty years at Ottawa, attempts have been made to propagate vegetatively such hardy cultivated varieties as Anis, Antonovka, Charlamoff, Hibernal, and Virginia Crab. One-year whips of these varieties that had been propagated on a hardy rootstock were layered. None rooted well and all were considered of no value as vegetative rootstocks. Seedlings of a number of these hardy cultivated varieties were cut back hard and stooled. Several rooted quite well and are now being subjected to stooling, incompatibility and hardiness trials. This again illustrates that young apple seedlings of an apple variety in the juvenile phase root much more readily than do shoots from the mature phase of the same variety. We feel that the time has come when we should retain all our new introductions in the juvenile phase so that they may be propagated vegetatively. I was surprised to find that some of the German plant breeders maintained juvenile clones of all of their new selections. These are being propagated by hardwood cuttings, thereby reducing the cost of production.

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MODERATOR BLAIR: I am now going to call on Dr. S. H. Nelson to give you the results of his work this past season in propagating apple from leaf-bud cuttings.

Dr. Nelson is a plant propagator employed by the Canadian Department of Agriculture. I don't know of any other similar position in the entire Dominion Service. He was appointed a few years ago to work exclusively on the problems pertaining to the propagation of fruit and ornamental materials. We consider this matter of propagation to be of equal importance to other phases of our horticultural work. Dr. Nelson took his undergraduate work at Ontario Agricultural College and, as a graduate student at Michigan State University, worked with Dr. H. B. Tukey. Therefore he has quite an appreciation of propagation work and experiments which are in progress in the United States. Dr. Nelson!

DR. NELSON: I think it is needless for me to say that I am very happy to be here today. It is a pleasure and an honor to have the opportunity to describe to you my recent work with leaf-bud cuttings.

Dr. Nelson presented his paper, entitled: "Malus Understock from Leaf-bud Cuttings." (Applause).

MALUS UNDERSTOCK FROM LEAF-BUD CUTTINGS

DR. S. H. NELSON
Horticultural Division
Centeral Experimental Farms
Ottawa, Ontario

As Mr. Blair has pointed out in his survey, there are two or three broad types of rootstocks that can be used as understocks for apples. With due respect to seedlings and apomictics, we will leave these and concern ourselves only with clonal rootstocks, for the purpose of this paper.

Let us reiterate a little further. It has been brought out that stool bed maintenance is costly and laborious, and even with mechanical aids the production of clonal rootstocks is expensive. Furthermore, with stool beds a rather fixed amount is produced each year and the flexibility required to fit the unstable requirement for apple trees is lacking. Some more flexible method is desired, and cuttings naturally appear to fit this problem.

At Ottawa, random attempts have been made over the years to root harwood cuttings, but with little success. Climatic factors certainly play an important role since we cannot line out cuttings in the field, as is being done in Europe. Another factor, however, may have been the mature physiological condition of the wood, referred to by Mr. Blair.

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Root cuttings have proven to be a successful way of propagating rootstocks, but here, again, cost and availability rather rule out this method unless it is of particular importance experimentally.

Now we come to softwood cuttings. As reported in a recent issue of the American Nurseryman, both soft tip and leaf-bud cuttings rooted in a preliminary survey. Leaf-bud cuttings were particularly promising in this survey under continuous mist and a glazed propagation box. The cuttings were taken similar to the buds used in bud grafting but the leaf was not detached. The cuttings were subjected to meticulous care, such as shading and syringing, in the glazed propagation box. Briefly, it was shown that the apple rootstock Malus #5 could be multiplied successfully by leaf-bud cuttings, and that soft tip cuttings also showed promise under mist.

Having proved that such cuttings would root fairly readily, a sizable experiment was planned this year under conditions more feasible commercially. Six propagation frames were established. These included:

(1) Intermittent mist out-of-doors, using the day-night clock and minute timer. A spray was applied intermittenely through Florida 550A nozzles from 6 a.m. to 8 p.m. daily. At first the spray interval was twelve seconds in sixty, and later reduced to four seconds in sixty. A windbreak of burlap was placed around the frame.

(2) Intermittent mist in greenhouse. Same as previous description. except it was placed on the side bench of a greenhouse.

(3) Continuous mist out-of-doors. Same set-up as intermittent, except spray continuous from 6 a.m. to 8 p.m. daily.

(4) Plastic tent out-of-doors. A wood frame was built over the propagation frame and covered with a double layer of cheesecloth. Over this a roll of polyethylene 132 inches wide was spread, cut to length and stapled in place, leaving the sides so they could be rolled up.

(5) Plastic tent in the greenhouse. Here, again, the set-up was very similar, except the entire frame was hinged on one side and could be lifted.

(6) Glazed propagation box. Here the glass was sloped enough on both sides to allow condensation run-off. The light for reach compartment was hinged to the central ridge.

Four media were included in each propagation frame, namely, sand, sand plus peat, sphagnum moss, and vermiculite.

Over all, five types of cuttings were used—the standard soft tip cutting, and four types of leaf-bud cuttings. Since cutting the shallow shields was time consuming, it would be more expedient to cut the current growth about three-quarters of an inch above and below the bud without scoring, and this formed one of the treatments. For the second type, similar buds were made and scored on the side distal from the bud. For the first two types, the buds had not expanded or were not showing auxillary growth. With M. robusta #5, however, there is a great tendency toward spurring, and therefore the other two treatments consisted of leaf-bud cuttings with active buds that were unscored and others that were scored. For the purpose of this paper, they will hereafter be referred to as active leaf-bud cuttings, although they could well, and possibly more correctly, be called "mallet cuttings."

Cuttings were taken from mature 18-year old stock trees and the juvenile form in the stool beds. It was planned to take cuttings at three intervals during the summer, but due to heavy demands for space by ornamental material only two dates were possible.

Hormone treatments of Hormodin #1, Hormodin #2, Hormodin #3 and Chloromone were employed.

In all, 6,150 *Malus robusta* #5 cuttings were taken. Each treatment consisted of five replications of ten cuttings each. Where only two comparisons were made, the data was subjected to the Student-Fisher "t" test for significance. Where more than two comparisons were available, the data was subjected to analysis of variance and the least significant differences calculated.

Now to consider the results. First of all, the glazed propagation box out-of-doors, the plastic tent out-of-doors, and the plastic tent in the greenhouse were complete failures. With the glazed propagation box, this is rather contradictory to the preliminary findings. This past summer, however, was unusually hot and this unnatural weather was of prolonged duration. Shading was increased, but even two layers of cheesecloth and a layer of burlap failed to stop the scorching of the cuttings. This summer has clearly shown that the glazed propagation box, as well as the plastic tent, cannot be recommended universally, although they prove successful in some seasons. For the comparison of techniques, only three treatments were left, namely, continuous mist out-of-doors and intermittent mist out-of-doors and in the greenhouse. With soft tip cuttings it was found that continuous mist was the best technique, but not very superior to the intermittent mist out-of-doors. Both, however, were superior to the intermittent mist in the greenhouse to a high degree of significance, as shown in Table 1.

Table 1—Results of soft tip cuttings of Malus robusta #5

Treatment	Average per cent rooting Check	Chloromone
Continuous mist out-of-doors	96	94
Intermittent mist out-of-doors	88	92
Intermittent mist in greenhouse	34	42
L. S. D. 5% level	3.8	2.3
L. S. D. 1% level	5.5	3.4

The leaf-bud cuttings, the intermittent moist out-of-doors and continuous mist out-of-doors treatments gave results that were very similar and were superior to the intermittent mist in the greenhouse. The results, however, were insignificant, except with the active non-scored type with no hormone. No explanation for this exception is apparent.

When the media were considered, there were no significant differences between treatments. There were, however, definite preferences as far as the operator was concerned. Vermiculite was found to be rather messy under the misting systems, and tended to settle. With sphagnum moss, severe settling occurred, and although rooting was extensive, considerable breakage occurred in extracting the roots from the medium.

Possibly both of the faults could be overcome, to a degree, by finely shredding the sphagnum. From the propagator's view, sharp sand, or sand plus peat, was the easiest to work with and very satisfactory.

Table 2—Media comparison for rooting Malus robusta #5

Media	Average per cent rooting Tip	Leaf-bud active, scored
Sand	88	78
Sand plus peat	96	74
Sphagnum moss	100	72
Vermiculite	92	56

Only two of nine comparisons between chloromone treated and check cuttings proved to be significant in favor of the addition of this hormone. Hormodin powders were also used along with cloromone in four comparisons. As shown in Table 3, Hormodin #2 and Hormodin #3 gave the greatest rooting in the early maturity and were highly significant over the check. It was noted with Hormodin #3 that there was some toxicity, but with chloromone there was killing of the tissue wherever the liquid touched. This killing was in the immediate region, and rooting occurred above the injured area, but the percentage rooting, although greater than the check, was significantly reduced below the other hormone treatments. With the late maturity the same general pattern existed with the tip cuttings. However, with the leaf-bud cuttings this pattern did not exist and maybe caused by the relatively low percentage rooting and high degree of abscission at this maturity.

Table 3—Summary of hormone treatments

	Type of cutting and average per cent rooting			
	Early maturity		Late maturity	
Treatment	Leaf-bud not active, scored	Tip	Leaf-bud not active, scored	Tip
Check	26	34	8	38
Hormodin #1	68	84	16	68
Hormodin #2	80	88	16	60
Hormodin #3	78	76	34	68
Chloromone	66	42	50	28
L. S. D. 5%	4.9	2.7	3.2	4.6
L. S. D 1%	6.8	3.7	4.5	6.3

It is also apparent, in the last table presented, that maturity played an important part in the rooting ability of the leaf-bud cuttings. Cuttings taken in the last week of June were very much superior to those taken near the middle of August. With tip cuttings this difference is not apparent with the check treatment, but the addition of hormone was less effective on the later date.

Physiological age of the parent material was also of the utmost importance with *Malus robusta #5*. When tip cuttings were taken from adult trees, only the odd success was encountered, and abscission of the leaves was common. With leaf-bud cuttings no rooting occurred, and the leaves abscissed almost 100 per cent. On the other hand, with the cuttings taken from the stool beds, where the severe annual pruning retains the juvenile character, rooting occurred as previously described in the various treatments.

The last, and possibly the most important comparison is the actual type of cutting used. Soft tip cuttings were the most successful, followed closely by the leaf-bud cuttings. The majority of the statistical comparisons were not significant when scoring was considered, but, like results with most plant material, there were exceptions without a conceivable expanation. Furthermore, when considering the comparison of active to non-active buds, there is no consistent pattern and no correlations with treatments. It is apparent, however, on the basis of this work, that active buds do not cause the cutting to root more readily, as might be suspected. Actually, in many cases, the reverse is true.

Only one clonal rootstock has been discussed. Another one, 0-524, was tried, but poor rooting and a high percentage of abscission was the result. These results are similar to those obtained from the adult form of *M. robusta* #5, and suspicion is now focused on the fact that we may not have the juvenile stage in this rootstock. This is substantiated by its performance in a stool bed, since it is not nearly as prolific as the juvenile *M. robusta* #5.

In summary, the following points should be reiterated:

1. Mist systems offer a greater insurance against loss than plastic tents and other propagation boxes. Further, these mist systems are better located out-of-doors.
2. Under mist, the four media tested showed no significant differences, and the choice can be left fairly well to the propagator's preference.
3. Hormones are beneficial, but toxicity will occur if they are used in too strong a concentration. Hormodin #2, or its equivalent, is about the maximum.
4. Date of taking cuttings is important, and although further work is needed, the last week in June gives satisfactory results. As yet, the limits of this period have not been defined.
5. Tip cuttings are the most successful form, but leaf-bud cuttings propagate readily also. Since scoring is apparently not necessary, these cuttings can be made readily, and use made of a lot of parent material that is normally wasted.
6. The physiological age of the parent plant is of utmost importance. Very poor success was encountered with adult material. To date, we have been taking our juvenile M. robusta #5 cuttings from the stool beds, where the crowns are pruned to ground level annually. Whether we can allow this stock to form a hedge row, subject it to severe annual pruning, and still retain juvenility is not known.

* * * * *

DR. NELSON: I forsee several questions which I will answer now. The first is, I cannot answer whether the EM rootstocks will come from leaf-bud cuttings or not. Work along this line has been done in England

and they have reported that most of the stocks are in the adult stage. Frankly, the only two that rooted from leaf-bud cuttings or soft-wood cuttings were EM V and EM VIII. Neither of these is as important as EM IX, EM VII, EM XVI, or EM XII.

The second question which could be answered now is the length of time that it takes these leaf-bud cuttings to make buddable trees. From the preliminary work at Ottawa, it was shown that by planting the rooted cuttings in beds in the fall and letting them grow the following summer, they would be ready for budding in about a year and a half.

MODERATOR BLAIR: Thank you, Mr. Nelson. We will now have questions on these two talks, before proceeding to the remainder of the panel.

MR. HOOGENDOORN (Hoogendoorn's Nursery, Newport, R.I.); Dr. Nelson, how do you get these active leaf-buds? Do you pinch the top of the shoots?

DR. NELSON: The formation of laterals of *M. robusta* No. 5 is a natural process. One of the characteristics of the juvenile form is that it does branch prolifically so that the single shoot coming up at a very young age sends out laterals.

MR. HOOGENDOORN: Have you experimented with varieties such as Hopa?

DR. NELSON: That is rather hard to answer. I have taken a few cuttings. I certainly would not want to be quoted on anything I say because the number has been so small. One of the ornamental crabs, Bakatong, which is the one we are recommending at Ottawa, did root about 50 percent, but only from soft tip cuttings. I have no information on any of the other species.

DR. NITSCH (Cornell University, Ithaca, New York): Do you have any explanation for the better rooting obtained out-of-doors compared to rooting in the greenhouse?

DR. NELSON: I think we should ask Jim Wells that. He was the first to recommend taking the glass out of the greenhouse and installing a mist system. There, I had glass. Whether it was the light factor or not, I do not know, but there was a side bench in the greenhouse and also of light energy was reflected from this sloped glass that never got to the cuttings. This may be one consideration.

DR. MAHLSTEDE (Iowa State College, Ames, Iowa): There is some data to be presented at the session on mist propagation which may be interesting in this respect.

MR. CHARLES HESS, SR. (Hess Nursery, Mt. View, N.J.): Is any work being done on dwarf understock for ornamental flowering crabs?

MR. BLAIR: The answer to that is very simple. Very little, if any, experimental work has been done. This does not mean that ornamental crabs have not been grown on the EM rootstocks at Ottawa for we have propagated several varieties on a range of EM rootstocks. They have behaved similar to commercial apple varieties.

MR. HESS: Which would you recommend as a dwarf rootstock for flowering crabs?

MR. BLAIR: If you want a tree of small stature, you must use EM IX. There is compatibility with most varieties, however Bechtel's crab is an exception and is not compatible on EM IX.

MR. MICHAEL P. SEBIAN (Sebian Nurseries, Painesville, O.): Dr. Nelson, you mentioned injury to tissues by the use of Chloromone. Was the Chloromone used full strength or was it diluted?

DR. NELSON: All of the work was done with full strength, however care was taken to dip only the cut surface of the cutting in the hormone material.

MR. LESLIE HANCOCK (Woodlawn Nursery, Cooksville, Ont.): I would like to report to Charles Hess Sr. that we have found seedlings of *Malus sargenti* to be suitable understock for Bechtel's crab and Olmey rosy bloom, but incompatible for Elcyi and Scheideckeri.

MR. ROSCOE FILLMORE (Fillmore's Valley Nursery, Centreville, Nova Scotia): I would like to suggest to Mr. Hess, that judging from the orchard at Vineland, Ontario, and their use of EM VII for the propagation of commercial apples, that EM VII should give a very nice ornamental crab provided it is well enough anchored, whereas with EM IX you almost have to hang it in the air to keep it standing up on account of the root system.

MR. BLAIR: Actually, this is almost a subject in itself, but I think that probably I should go into it a little more fully than I have.

As I said before, EM IX gives the most dwarfing type of root stock but unfortunately the stock is brittle. Therefore the trees have to be staked. It is quite probable from an ornamental point of view that you wouldn't want to stake the trees and that would rule out the EM IX stock.

The next stock along the line in dwarfing habit, as Mr. Fillmore has pointed out, is EM VII. EM VII, unfortunately, has not been tested in North America too long. In the original root stock trial plantings in this country, EM VII was not included so the experiences with it extend only over a period of about ten years. However, the indications at the New York Experiment Station at Geneva and at the Vineland Station in Ontario are that it will give a smaller tree than the variety propagated on EM I or II. We thought we had an almost ideal type of stock for the commercial grower, but along came hurricane "Hazel" about a year ago and in some of our plantings where we had EM VII, every tree was uprooted. This made us stop and think whether we should go ahead and plant commercial orchards on that stock. So, although EM VII will give the desired shape tree, it doesn't have the anchorage we would like.

Now in the Okanagan, we were all set to recommend EM VII in our apple orchards out there. We found that as soon as the trees got in full bearing, they fell over and we had to drop it from our recommendations. With all of these stocks it takes quite a long while before we can fully evaluate them. Sometimes you have to wait many years to get a certain set of conditions and that is what you are up against in root stock evaluation trials.

I think the answer is that, at the present time, we don't know what the best dwarf stock would be for ornamental crab.

MR. BRUCE VANDERBROOK (Vanderbrook's Nursery, Manchester, Conn.): I would like for Dr. Nelson to define what he means by "juvenile" stock?

DR. NELSON: It is a physiological stage that the plants go through. I tried to correlate it with humans when talking with someone yesterday. For example, a baby gets a set of baby teeth. When they are lost, they are replaced with permanent teeth and the baby teeth cannot return. Likewise an apple tree goes through stages of growth. It has a juvenile stage just as the baby has. However, in the apple the stage is not lost, but rather becomes buried and is retained throughout the life of the individual tree.

This is true, however, only when starting from the seedling. Buds which are usually used for budding purposes are adult, not juvenile, and consequently the propagating material, which is adult, produces budded trees with the adult habit. The line of demarkation between juvenility and adulthood is not too well defined, but most people consider that a tree has reached the adult stage when it starts to flower.

MR. BRUCE VANDERCOOK: How can you recognize juvenility?

MR. BLAIR: There is a marked morphological difference with apple. From the nurseryman's point of view, the main difference between juvenility and adult growth is the type of bark. In juvenile trees, the bark is rough, whereas the bark of a two-year-old tree in the adult form is smooth. The thorny type of growth, characteristic of juvenility, is lost when the plant becomes four or five years old. It gradually looses the spuriness and become smooth. If you propagate from the smooth type, rooting is poor, while cuttings made from the thorny type of growth root quite readily.

MR. CASE HOOGENDOORN: How long can you keep the plants juvenile?

MR. BLAIR: You can keep them in the juvenile stage indefinitely. It is primarily a matter of keeping the plants cut back severely.

MR. JAMES IE. ILGENFRITZ (Ilgenfritz Nurseries, Monroe, Mich.): I would like for Mr. Blair to comment on the Malling Merton stocks and the EM IV stocks, which I understand are in quie frequent use.

MR. BLAIR: EM IV root stock is less vigorous than both EM I and EM II but more vigorous than EM IX and even EM VII. In other words, it gives a tree approaching that of EM I and EM II. The most outstanding characteristic of EM IV is that it is very precocious, that is, it bears very heavily at a young age. It is more precocious than any other of the EM series. Unfortunately, it is a very poor rooter. This rootstock is losing favor fairly rapidly on the Continent where it was used very extensively ten and fifteen years ago. Most of the new commercial plantings in Europe are on EM IX.

The Malling Merton series is a new group of understocks which were developed from crosses made at the East Malling Research Station and at the John Innes Breeding Station. They are crosses between the Malling series and Northern Spy. The objective of this work was to develop a series which were resistant to root aphids. Since they are highly resistant to the insect, this series should be of interest to any nurseryman where root aphids are a problem. The fruiting characteristics are probably not superior to that of the EM series.

The outstanding one is MM 104. It has about the same vigor as EM II but it bears earlier and gives a heavier crop during the first ten years in the orchard. It is not a small dwarf tree. None of the MM series will develop a tree as small as EM IX or EM VII. In Germany, it was found that these stocks are extremely tender. In preliminary trials at Ottawa, the MM rootstocks have shown considerable winter injury.

MR. HESS: Have the Paradise and Doucin apples, which were formerly used in Europe, been discarded?

MR. BLAIR: They have not been discarded. EM II is Doucin "English Paradise" and is one of the most widely used in England. EM I is Broad-leaf "English Paradise." These European rootstocks have been classified at the East Malling Station and are now known as the EM series.

PRESIDENT FILLMORE: This afternoon we have with us, Mr. R. C. Simpson of the Simpson Orchard Company, Vincennes, Indiana. Mr Simpson has had a long experience in the propagation and production of ornamental crabs. He was educated at Purdue University, but this afternoon he is going to give a practical talk on the propagation of apples by budding and grafting.

Mr. Simpson presented his talk, entitled "The Propagation of *Malus* by Budding and Grafting." (Applause)

THE PROPAGATION OF MALUS BY BUDDING AND GRAFTING

ROBERT C. SIMPSON
Simpson Orchard Company
Vincennes, Indiana

Propagation of horticultural plants by budding and grafting is one of the oldest horticultural practices. In ancient Greece the technique was well known and stock and scion effects noted. Today the actual mechanics are commonly known and relatively simple. Results, however, may depend upon a long series of factors.

First I will briefly outline our operation, then mention some of the problems we have encountered. Finally I will go over some of the points we think we have learned. And may I add, I do not presume to speak as an authority, only as one intensely interested in the subject. There are many present who have had more years of experience. If I draw conclusions they know to be in error, I and the rest present will welcome correction.

Our understocks are ordered on a five year basis to obtain a price discount, with minor seasonal adjustments made usually by July. The understocks arrive in January or early February. These are unpacked, series and Northern Spy. The objective of this work was to develop a series which were resistant to root aphids. Since they are highly resistant to the insect, this series should be of interest to any nurseryman where root aphids are a problem. The fruiting characteristics are probably not superior to that of the EM series.

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Our understocks are ordered on a five year basis to obtain a price discount, with minor seasonal adjustments made usually by July. The understocks arrive in January or early February. These are unpacked, the roots pruned to 3 or 4 inches, any low branches or double stems removed and, if possible, buds near the crown rubbed off. Most apple buds lie too close to be removed. Plum and mahcleb often have prominent buds which if not rubbed off, will later cause branching in the area to be budded. The seedlings for budding are then repacked and stored till planting time. Seedlings for root grafts may be branch rooted or straight rooted. The latter are not root pruned of course. For apple and crab the whip or tongue graft gives a firm union. We match root and scion as closely as possible for diameter, bind the union with grafting tape and dip the scion in a special dip wax we make up. The grafts are then stored until planting time.

Our grafts are planted 6″ by 6″ in raised beds in a lath house. We have secured much greater growth and losses have been far less than with field planted grafts. The more vigorous varieties usually make four to six foot whips the first season, twice the growth of plants grown in full sun. After one season the grafts are sold or lined out in the field similarly to the understocks for budding.

Seedlings for summer budding are set in the field as early in the spring as possible. We use a two row trencher to permit two row cultivation. Cultivation time is reduced and only alternate middles are compacted by the tractor wheels. The seedlings are set by hand, the soil pressed with the feet and then firmed hard by a heavy packer that has been in use well over 50 years. If properly packed they cannot be pulled up without stripping the roots from the seedling.

It is important that the seedlings be kept growing vigorously. Cultivation after every rain is the rule, with hand hoeing as needed. The trees are sprayed three or four times at two to three week intervals beginning about June 1; after that, only as often as necessary to control caterpillars and green aphids. Ferbam is used until danger of scab is past. DDT, BHC and a spreader are used throughout the season for wooly aphids, green aphids and caterpillars.

Budding is done in late August or early September, late enough that few if any buds will start growth before winter. The trees are cut back to the bud in early March. Where the bud stand has been poor, the trees are inspected and those with live buds marked for cutting. The others are not cut back but rebudded as soon as the bark will peel, dormant buds from stored scions being used. In about two weeks these seedling tops are cut back severely. As soon as the buds have united or show signs of growth, the remainder of the seedling top is removed.

Careful cultivation and hoeing is necessary as young crab shoots are very easily broken loose at the union. Most varieties must be staked to prevent possible heavy losses from wind and beating rain. This is done as the new growth reaches a height of eight to ten inches. A few varieties as Hopa and Eley are not as easily broken off and need not be staked. Neither do the native types as Bechtel's and Charlotte. These are flexible and bend with the wind where most other crab varieties quickly stiffen and are easily broken from the seedling stub. Scheidecker is one of the worst for this. A few varieties must be staked as high as four feet to maintain an upright head and straight stem.

Many crab varieties continue to grow until after several hard freezes so our crabs are the last stock to be dug. An ancient digger, once pulled by some ten or fifteen teams is now pulled by tractor and 200 foot cables. One and sometimes two men with spades assist when trees are pulled. This is more costly but saves broken roots and branches. The trees are tied in bundles as large as can be handled conveniently and hauled to storage for grading during the winter.

To facilitate field handling and prevent mixtures at digging time, all trees are carefully checked for variety and paint coded with distinct colors of enamel. Thus each tree carries its own label and makes handling easier and more accurate. Even if there should have rapid and accurate separation possible at digging time. This coding is extremely important and is never delegated to any of the help.

The graded trees are held in refrigerated storage until the end of the shipping season. Usually those unsold are re-planted 3 feet apart in 4 foot rows for growing on to larger sizes.

PROBLEMS

Before discussing some of the things we have learned about propagation of crabs, I would like to go over some of the problems in budding or grafting the crabs.

For grafting, the wood of some varieties is very slender. Others produce many spurs and only short terminal shoots. Thus ample scion wood of desirable size may be a problem.

For budding; the crabs pose a number of problems. With many varieties the wood is hard, the bark very thin or the scions very slender. Some crabs have a hard hump beneath the bud making it difficult to make a proper cut. Others have a depression beneath the bud so it is difficult to get enough tissue beneath the bud without cutting too much wood above and below the bud. Buds and leaf petioles vary greatly in size, making some very tedious to handle.

Some varieties for us have given consistently poor stands, or a good stand one year and a very poor one the next. Katherine has always been difficult and Dorothea variable from year to year. What we have obtained as Jay Darling has given such extremely poor stands each of four years that we dropped it. We have not been able to determine why apparently excellent scions of Katherine and Dorothea have been so unpredictable.

If budded early in the season some crab varieties start growth, before winter usually in a horizontal direction. This may produce crooked shanks the next year.

The manner of growth of some varieties makes selection of good buds a problem. Some of the native types like Prince Georges produce many short spurs and terminals of only a few buds which do not mature until very late. Katherine continues to grow until late in the season with long shoots and soft immature wood. Some kinds produce slender, willowy growths as Parkman. Branches of Tanner are little larger than a straw with very close-set buds.

Something resembling blight may kill the new growth when 12 to 18 inches in height. We have had this with Katherine, astrosanguinea and a few others. Pathologists at Purdue found no fire blight infection and suggested delayed winter injury.

Some crabs grow slowly and tend to force numerous suckers from deep roots as well as just below the bud. Sargent is one of the worst. With grafts the root is relatively weaker and there is less suckering.

Some varieties tend to produce only a whip the first year and few branches later. They do not respond well to tipping. This is true of Van Eseltine, baccata Jacki and spectabilis Riversi.

The wood of many crabs is very brittle. Special care is necessary at all times after the wood has hardened or trees will be marred by loss of branches which tend to tear out part of the main stem. Dorothea, Scheidecker and floribunda are among these.

Most budded crabs must be staked from the time they are 12 to 14 inches high. The stem stiffens rapidly close behind the growing tip long before a union is established at the base. Strong winds, driving rain, or brushing by cultivator or hoe handle will cause the shoot to break away. This has been one of our most serious causes of losses, even with staked trees. We do not stake Hopa, Eley and the native types as they unite firmly and the new growth is more flexible. Scheidecker may go down nearly 100% if not staked.

Wooly aphids and accompanying hairy root condition are a problem. Unless woolly aphids are controlled losses from culling may run to 75%. BHC is the most effective spray but it must be applied thoroughly with some running down around the base of the trees. Since adopting this schedule we rarely find serious root injury.

Apple seedlings are very susceptible to attack by blue mold, especially if held in a poorly ventilated common storage or cellar. This will continue to develop after the understocks are planted, finally rotting most of the deeper roots. Puratized is a safe and effective eradicant.

WHAT WE THINK WE HAVE LEARNED

Some basic points need merely be mentioned. Use of healthy vigorous scion wood, healthy disease free understocks, and true to name sources need no discussion.

There are four common propagation methods for the crabs: root grafting, top working, spring budding with dormant buds and summer budding.

Scions for grafting are best selected early in the winter before warm spells have started any development. These keep best if coated with a flexible dip wax, and must be kept dormant. The dip wax formula we like best is that of Ohio State University (Bulletin 510) of rosin, linseed oil and paraffin. Properly applied this is very adhesive, comparatively flexible and yet not sticky. It will not flake off unless applied to cool or to damp scions. Once dormant scions so treated were left in a storage cellar all one summer and still showed green bark the following spring, a full year after collection.

For topworking established trees we use dipped scions. The cleft or cut surface is sealed with hand wax. For coating large stubs we have found asphalt emulsion roofing paint much the best. It is non-toxic and adheres to the moist, freshly cut wood. When smaller limbs are whip grafted, a much smoother union is obtained if budding rubbers are used to bind the stock and scion lips before the hand wax is applied. Trowbridge prepared wax is very adhesive, is transparent, and the clearly visible rubber band can later be cut through the wax.

For whole root or crown grafting, branch rooted seedlings are preferred. These will produce more uniform and vigorous trees with better branched roots. Straight rooted seedlings are an advantage where understocks are limited or expensive or where trees are desired on their own root and shorter scion will give more growth the first year. A scion with roots will result in greater variation in initial tree size. These trees also will have deeper roots with less side branching. A long scion and short piece root is used where trees are desired on their own roots. A longer root and shorter scion will give more growth the first year. A scion with two or three buds above the graft union is adequate. An overall length for the completed graft should be around eight inches. The stem diameter varies greatly at and just above the seedling crown permitting variation of cut for more accurate matching of stock and scion. This in turn gives a cleaner union.

For grafting, No. 1 seedlings 3/16 to 1/4 inch in caliper are about right for crab and apple grafts. For field budding the 1/4 inch up size will develop into larger trees. The size of seedling at budding time has a direct relation to the size tree it will produce.

Dormant budding is done as early in the spring as the bark will peel. We prefer to use the waxed scions as the stiff coating prevents damage to the bud as it is inserted. Drying out is also reduced to a minimum. The seedling tops are cut back one half within about ten days, and removed entirely as soon as the inserted bud begins to break or has had time to unite with the stock. Some varieties will not start until the top is completely removed while others will. The dormant bud shield is cut with a little more wood than for summer budding and inserted in the same T-shaped cut.

Summer budding is the simplest, most rapid method of propagating the crabs and produces the largest trees most quickly. With good soil, a favorable season and a reasonably vigorous variety it is possible to produce many well branched one year trees in the 5 to 6 foot size. This is because the one year top has a three year root system. Usually a root graft requires three years to reach the same size, perhaps longer.

For field budding we prefer apple to Hopa seedlings. For us the Hopa seedlings have been much more variable in every respect. Seedlings with purple wood are too easily confused with purple wooded varieties. Good apple seedlings are much more uniform and the shoots from below the bud not easily confused with the variety. Where extreme hardiness is a factor, Hopa seedlings may be superior.

Selection of bud wood is important. All important of course is use of stock true to name. Wood from one year trees in the nursery row has given good results in some cases but wood from older trees is desirable and ripens earlier. Whether the scion buds are fruiting or vegetative seems unimportant.

Best buds come from the middle two thirds of current seasons wood. Buds from near the base are usually smaller, less easily inserted and often start out at a wider angle. If shoot growth has terminated and begun to harden, good results may be obtained from buds as near the tip as a good cut can be made. With thicker barked crabs having buds more like the commercial apple, good results can be secured by shucking the buds. With thin barked varieties of the floribunda type it is better to cut a shield to include some wood. Our problem varieties have been those with small or sunken buds, thin bark and hard wood. Among these are floribunda, atrosanguinea, hupehensis, Parkman, Scheideckeri and Katherine. In most cases varieties with softer wood, larger buds, thicker leaf petioles, and thick bark have given the best stands. In this class are such varieties as Almey, Eley, Hopa, Crimson Brilliant, spectabilis and the native forms. Varieties such as Zumi, calocarpa and Sargenti must be cut with a very short nosed or small shield because of the hard bump beneath the bud.

The proper side of the seedling to bud is debateable. For mechanical reasons the bud should be inserted on the side toward prevailing winds as the developing shoot is more likely to be loosened by wind or rain. Buds receiving very hot sunshine after insertion or during the winter may be injured where buds to the north are protected from extremes of temperature and sudden changes. If buds are placed in line with the row the new shoots are more easily lost during hoeing, those toward the middle by cultivation. The west or north-west side would seem best with rows running roughly east and west.

Staking is a necessity with most crab varieties. We once lost 90 per cent of our Scheideckeri and micromalus from a driving rain while adjoining rows of Hopa, Eley and Arnold suffered only occasional losses. Staking must be done by the time the shoots are high enough to be tied, or about 12 inches. Number eight wire stakes 30 inches long are adequate. We have found the round "Plant Ties" better than "Twist-Ems." The ends of these are so wrapped around the stake that they can be pulled loose and raised as the shoot grows. A permanent twist is made when the tie nears the top of the stake or at about 18 inches.

Some varieties require use of five foot stakes in order to secure a reasonably upright stem. Among these are Bob White, Katherine, floribunda, Parkman and hupehensis. Otherwise they lean badly from the 18 inch tie.

Why some varieties are so difficult we have not been able to determine. Katherine has always been difficult, whether buds, root grafts or topworked. This year we had a very poor stand and re-budded. These later buds were still alive in early November but no union had taken place. Dorothea and Scheideckeri in one field were 60 per cent alive while in another field nearly all buds had taken. Weather and soil undoubtedly play a part as does the type of scion and the skill of the budder. Variety, however, is an even greater factor.

In concluding, the actual mechanics of budding and grafting the crabs is simple and results with many varieties no problem. Unfortunately two of the fine new varieties, Dorothea and Katherine are among the difficult ones. The crabs are peculiar in the great variation in characteristics of the scion wood. Budding or grafting becomes an entirely different problem as one changes from variety to variety.

I have not mentioned propagation by stem or root cuttings. I feel sure some of the crabs can be propagated in this manner. Eleyi for instance will root above the bud union if planted deep and probably if mounded heavily. Hopa similarly planted has never produced scion root for us. Once on its own roots, root cuttings should be possible.

Again I would like to mention the great advantage of using a paint code where large numbers of trees in many varieties must be handled. We dig, bunch and store some forty varieties of crabs. Labels are seldom used until final grading when variety and size are indicated.

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PRESIDENT FILLMORE: Thank you, Mr. Simpson. It takes years of experience and observation to be able to talk like that. Are there any questions for Mr. Simpson?

MR. GERALD H. VERKADE (Verkade's Nursery, New London, Conn.): Did I understand you to say that you dip the budding scions in wax?

MR. SIMPSON: We use wax for dormant buds only. We do not use it for summer budding.

MR. VERKADE: I know you graft cherries. What do you tie cherries with?

MR. SIMPSON: We just use regular banding rubbers on everything for summer budding. We try to wrap them instead of tying. If you don't pull too hard, you can practically seal them. By properly putting the rubbers on, you can practically make an airtight seal.

MR. VERKADE: When do you bud the cherries?

MR. SIMPSON: In August.

MR. CARL E. KERN (Wyoming Nurseries, Cincinnati, Ohio): Do you use apple understock for grafting Bechtel's crab?

MR. SIMPSON: Yes, we do.

MR. KERN: Most nurseries will bud or graft Bechtel's crab on a common apple seedling. This is a mistake because the two are incompatible. From experience, I know that when the Bechtel's crab gets older, it forms a bowl, and at the end of ten or fifteen years the plant will blow over.

MR. SIMPSON: We have had one in the yard for twenty years. The top wants to sucker. We have to keep cutting the suckers off at the ground. The reason we don't grow it is because it is susceptible to disease.

MR. CONSTANT DE GROOT (Sheridan Nurseries, Sheridan, Ont.): Bechtel's crab or *M. ioensis,* is related to Dorothea, that is why he hasn't obtained results.

MR. SIMPSON: I believe that according to Wyman's "Crabapples in America," it is *M. floribunda.* It is not *M. ioensis.*

MR. LOUIS VANDERBROOK (Vanderbrook's Nursery, Manchester, Conn.): How do you prevent rabbit damage on the crabs?

MR. SIMPSON: If the rabbits chew them it is usually above the bud. We use a full strength lime sulphur paint on the stems. We haven't had trouble.

MR. WILLIAM FLEMER III (Princeton Nurseries, Princeton, N.J.): We had the same trouble with Katherine until we started budding it and Dorothea on *M. baccata*. They take very well and grow vigorously. The same with *M. ionensis* 23. When you bud on *M. ionensis* and *M. corneria* seedlings, which are American types, they grow at least a third larger in a given length of time.

MR. SIMPSON: I have not tried that, however I will.

MR. ROSCOE FILLMORE: We have a lot of complaint from our customers that it takes too many years to bring plants into bloom when they are on Dorothea. What is the reason?

MR. SIMPSON: I would guess that it has to do with vigor and growth. I am merely going by observations in this case. With Dorothea, if you have a strong stock, we can count on one-year trees blooming well. Dorothea, Katherine, and probably Scheidecker, are outstanding. You can count on almost 100 percent blooming. Van Ess is another one that blooms very freely as a one-year whip.

MR. ROGER COGGESHALL (Arnold Arboretum, Jamaica Plains, Mass.): At the arboretum, we use *M. baccata* understock for budding Dorothea and the take is almost perfect. Also the plants set flower buds the second year from budding.

PRESIDENT FILLMORE: I should like to take this opportunity to thank the Moderator, Mr. Blair, and the other speakers, Dr. Nelson and Mr. Simpson, for the excellent roundtable discussion of Malus propagation. The meeting is adjourned until 8:00 P.M. this evening.

PLANT PROPAGATION QUESTION BOX

FRIDAY EVENING SESSION

December 16, 1955

The Plant Propagation Question Box Session of the Fifth Annual Meeting convened at 8:00 P.M. Mr. Louis C. Vanderbrook, Vanderbrook Nurseries, Manchester, Conn., was the moderator for the evening.

The transcript of this successful session of the annual Meeting is not included in the Proceedings.

organisms can be splashed on the foliage, but rather takes cuttings from the tops of the plants. We adopt methods of sterilization from beginning to end. The cutting, the rooting medium, the containers, and the container-medium are sterilized. Growers who suffer severe losses soon learn the value of sterilizing everything.

Another aspect of growing in the West, which I believe is highly important, is that of mechanization. The introduction of the "Plantainer" type of container has made it possible to handle the material in such a way that rapid planting can be carried out. We do have an excellent example in certain nurseries in Century, California, where a machine has been developed which has allowed eight men to plant 120,000 one-gallon containers in two weeks.

Now, getting into what I feel is the substance of what I want to offer for your consideration, I would like to say that much of the folklore of plant growing is being replaced by new information and the ability to control plant growth more completely.

Mr. Matkin presented his paper, entitled: "Prepared Soils for Container Growing." (Applause)

PREPARED SOILS FOR CONTAINER GROWING

O. A. Matkin

Soil & Plant Laboratory

Orange, California

The nursery business has been highly traditional and resistant to change until the past few years. With the introduction of large scale container production and modern sales techniques by a few, the industry has been forced to reconsider the efficiency of its methods and procedures.

To those steeped in tradition the changes occurring must seem radical and, perhaps, discouraging. The "Art" of growing is fast giving way to the "science" of growing. Plants are being made to perform to the utmost of their abilities. The procedures employed by the most successful are those of the factory assembly line.

It is recognized that all plants have similar basic requirements, that they can and do lend themselves to mass production techniques. It is the purpose of this discussion to take up those basic requirements and explain their use in container culture.

Factors influencing plant response may be placed in two general categories—(1) Those *required* for normal response, and, (2) those *retarding* normal response.

In this discussion we are primarily interested in the root zone requirements which are:

1. Available moisture.
2. Adequate aeration.
3. Sufficient mineral nutrient.

In outdoor growing the above ground requirements are not too easily controlled. They may be summarized as consisting of:

1. Light of favorable intensity and duration.
2. Favorable temperatures:
3. Sufficient carbon dioxide for photosynthesis.

Factors retarding normal development might be listed in general as:

1. Competition from weeds or other plants.
2. Damage by parasites and insects.
3. Physiological damage from toxic materials in soil or atmosphere or from applied materials such as insecticides, fungicides and weedicides.
4. Mechanical damage.
5. Unfavorable hereditary characteristics.
6. Unfavorable status of *any of the basic requirements* listed above.

It is often difficult to clearly separate these influencing factors in appraising actual situations. Much of this difficulty stems from a tendency to use some vague or meaningless term to cover a whole range of symptoms. How often have you heard the phrase, "too much water!," as a diagnosis of plant failure? We are all aware that plants can be grown in a water solution, which is certainly the maximum in supply of water. If we try to use reason in breaking down the true meaning of the term, "too much water," we must assume it doesn't mean exactly what it says. It may mean (1) moisture application was at a high enough rate that the soil, presumably of poor structure, contained an inadequate supply of oxygen for normal root function, or (2) disease of some type was present in the soil or plant and a high moisture level allowed this disease to develop at a rate which overcame plant development, or (3) excessive use of moisture caused leaching to the extent that severe mineral nutrient deficiencies occurred, or some combination of any or all three of the foregoing resulted in plant failure. On the other hand, it is possible that none of these was causal. Perhaps the plant was injured mechanically by animal or insect or physiologically by spray material or air pollutant such that conducting tissue could no longer supply the leaves with water. The result would be an accumulation of moisture in the container simply because it was not removed by the plant.

One of the common causes of plant failure in container or field is disease. Many growers feel they are experts when they have learned to "live with disease" so that the plant remains alive. The *real* expert is the man who realizes the true nature of the problem and takes steps to eliminate it rather than live with it. As the retailer and consumer become more educated to the potential of container grown plants, it is going to be more and more difficult to sell them rhizoctonia, pythium and phytophthora root rots, fusarium and verticilium wilts as an acceptable part of plant material.

Very often the problems encountered in plant failure are complex. For instance, plants may be lost because a light infection of rhizoctonia root rot is emphasized by slightly high salinity in the growing medium. Either retardant by itself may not have been lethal, but the two in combination frequently are. A similar illustration might be drawn for water mold root rots and soil structure. Poor areation of the root zone will greatly enhance the activity of the organisms and materially reduce the activity of the plants, resulting in plant failure.

The experienced grower recognizes that it is frequently impossible to "cure" plant ills. Control lies in the realm of "prevention."

With the above in mind, we might first consider the selection of a satisfactory growing site and, second, a specific procedure of container growing as practiced by a number of nurseries on the west coast.

Since artificial irrigation is almost certain to be necessary in container growing, good water quality is a first prerequisite in determining the suitability of a growing site. Light and temperature requirements must be satisfied for the crops to be grown. Trees, hills. or buildings may interfere with light relations and correction is not always practical. Small variations in elevation can make the difference between frost damage and none. The nature of the terrain is certainly important if mechanization is to be used and if flooding is to be avoided. In certain areas of California we have become conscious of the importance of air pollution and its effect upon plant response. This is not an unknown problem in other highly populated areas and should, therefore, not be disregarded.

Once the above conditions have been found satisfactory, the next step is that of selecting a growing medium. Then follows the program of preparing the medium, planting into it, and caring for the plant growing in it.

A discussion of criteria for the growing medium is, perhaps, best carried out by use of a specific illustration. The soil mixes known as the "U.C. system of soil mixes." It is a development from work carried out in the Department of Plant Pathology, University of California at Los Angeles.

By way of background, it might be pointed out that the ultimate sources of disease organisms are (A) soil or (B) plants and plant materials. The former is taken care of by soil treatment, the latter by clean stock and sanitation. In the effort to aid growers in California to control disease in the production of ornamental plants, it was found that soil treatment for this control was often ineffectual because of soil-mix problems. Salinity, poor drainage, poor aeration, toxic reactions to soil treatment, and poor nutritional balance frequently overshadowed the attempts to control disease. What started out as a simple effort to establish some standard mix which would not be subject to these problems became a major project. A comprehensive treatise on the subject is in the hands of the University editors and should be available as a manual in the near future. It is titled, "Diseases in Relation to Prepared Soils for Container Grown Plants," and will be available from Agricultural Publications, University of California, Berkeley 4, Calif.

The following is one of any number of possible combinations of mixes and is selected as a good formulation for general purposes.

- ½ yard fine sand
- ½ yard peat moss, sphagnum type
- 10 lb. dolomite lime
- 5 lb. gypsum
- 3 lb. organic nitrogen (hoof & horn, blood meal, urea-formaldehyde resin)

1 lb. potassium nitrate
1 lb. treble superphosphate

This formulation gives consideration to nine important criteria. They can now be taken up specifically.

1. The ingredients are available in most areas. Peat moss is a common standard used throughout the world. Fine sands are found as windblown deposits, river and beach wash, and as by-products of the sand and gravel industry. The particle size limitations are quite definite as this component is of extreme importance in determining the physical characteristics of the medium. The material used should contain at least 85% of the particle sizes in the range of 0.5 to 0.05 millimeters in diameter. This includes medium sand, fine sand, and very fine sand according to U.S. Department of Agricultural standards. It coincides with sieve sizes of 30 to 270 mesh.

2. The raw material ingredients, fine sand and peat moss, are reliable as to uniformity of physical and chemical properties. Peat moss is accepted as being acid in reaction, low in salinity and low in nutritional properties. Fine sands are generally low in salinity and nutritional properties and are usually near neutral in reaction. A fine sand deposit will normally be found quite uniform in its chemical properties, though one source may vary some from another. The peat moss is quite uniform physically and the particle size specifications on the fine sand insure its physical uniformity.

3. The practice of disease, weed, and insect control will require *stability* of the medium *to steam* or *chemicals*. Both the fine sand and the peat moss satisfy this requirement. The chemical additions to them also satisfy these requirements with the possible exception of the organic nitrogen source, urea-formaldehyde. It has been shown to release a little urea nitrogen upon being steamed, but in many cases this is unimportant.

4. The physical components should be capable of being *easily blended* with one another. Fine sand and peat moss are easily mixed together. The same cannot be said of clays or cloddy materials. They may require expensive grinding apparatus to prepare them for mixing and this process of grinding may destroy physical structure desired.

5. *Good areation* of the physical mix must be assured if the best root development is to be attained. Clays and some organic materials "may" provide good aeration, particularly at first, but it is not assured. The fine sand-peat moss combinations do assure excellent aeration from the first. No amount of fertilizer will overcome poor soil structure.

6. *Nutritional characteristics* of each component and the final mix should be *known*. Components of high fertility are not necessary to a successful mix. Sometimes this characteristic can be undesirable as such materials are apt to be non-uniform. In this illustration both components are known to be of low fertility. Therefore it is a simple matter to add the desired fertilizer elements in the quantity required to raise the fertility to any appropriate level.

7. Moisture retention and the availability of the moisture retained in the medium should be reasonably high. The cost and labor of irrigation can become unreasonable when the soil dries out too rapidly. The

peat moss in this combination is a major factor in retention of moisture. Fine sand, as opposed to coarse sand, is also remarkably efficient in retaining moisture in a container. What is even more important is the fact that most of the moisture retained by these components is available to plant use. Clay mixes do not offer the same high degree of availability of moisture retained.

8. An important feature when handling and shipping container grown plants is that of weight. A low bulk density is generally desirable. There are practical limitations, however, as too light a mix may result in containers being easily blown over in the field during windy periods. Where important, the ratio of fine sand to peat may be altered to suit a particular circumstance. The maximum wet bulk density of the fine sand is approximately 115 lb/cu.ft., while that of peat moss is about 40 lb/cu.ft.

9. A final deciding factor in any soil mix preparation is that of cost. The cost of peat moss in a given area is usually fairly constant. The cost of the fine sand will be primarily dependent upon hauling charges. It is not highly valued as are many of the "top soils." It is unimportant whether the fine sand comes from the surface or from far below the surface. At the present time three to four dollars per yard for the final mix is often considered reasonable. A number of growers on the West Coast have managed to use substitute organic materials which satisfy all the foregoing criteria and have brought the cost down to a figure between one and two dollars per yard. Among the materials used are rice hulls and redwood sawdust.

The foregoing discussion of the nine criteria deal to a large extent with the physical attributes of the illustrated soil mix. Some discussion of the fertility additions is necessary.

Potassium nitrate is added to supply available nitrogen plus potash. If the immediately available nitrogen is not desired, sulfate or muriate of potash may be added. In this illustration nitrogen is also supplied as organic for purposes of extending the period of supply of the element. Where soils are to be stacked for a period of time before use, the organic nitrogen should be omitted as it will begin to release available nitrogen from the time it is mixed with the soil components. Storage might result in toxic build-up of available nitrogen.

Phosphate may be added as single superphosphate, using three times as much in order to match the supplying power of the treble superphosphate.

The dolomite lime is added to supply calcium and magnesium and to counteract the rather strong acidity of the peat moss. Gypsum is sometimes added to boost the calcium level a little higher without changing the reaction.

Variation from the assumed norm in basic physical components will call for variation in fertilizer additions. In some cases a grower may wish to alter the nutritional characteristics quite drastically. In a system of soil mixes such as this it is simple to make the desired alterations.

No single mix, such as that used in illustration, is or ever will be, a soil mix to end all soil mixes. It is for that reason that it is designated as a system. It should be fairly obvious, too, that this system offers an excellent tool for research to produce information in standard and specific detail. Such findings could be applied directly to practical growing since duplication of soil mix properties is entirely feasable.

The final consideration is that of fertilizing the growing plants. Experience to date indicates that nitrogen is the element most rapidly lost. Potassium is next and phosphate is least rapidly reduced. Fertilizer formulae which seem best suited to the system generally follow a nitrogen, phosphate, potash ratio of about 3—1—2. Both liquid and dry materials are currently being used. A detailed discussion of this phase seems unwarranted here as the variations due to conditions of growing and materials in use are too numerous. Frequent, light feeding is desirable.

This is not the only system of soil mix preparation and handling which can be used to produce quality plants and such is not meant to be inferred. However, it is one of the few systems which offers simplicity and reliability. It is the result of careful consideration of basic scientific principles coupled with practical trial in the field. The take home lesson is not the example formulation, but, rather, the principles upon which it is based. Finally, it offers features which lend it to use in assembly line type production.

* * * * *

MODERATOR MATKIN: Our roundtable this morning is to encompass, in addition to this discussion about West Coast production, other parts of the country. You will find that much of the fundamental information that we enjoy in learning how to grow comes from our universities. The universities are doing basic things that we, as growers, are unable to do.

We have with us a gentleman from Ohio State University, Mr. Phillip Barker, who will discuss the research that they are doing on container production at that institution.

Mr. Barker presented his paper entitled "The Production of Nursery Stock in Containers." (Applause)

THE PRODUCTION OF NURSERY STOCK IN CONTAINERS

PHILIP A. BARKER
Department of Horticulture, Ohio State University
Columbus, Ohio

The production of nursery stock in metal containers was begun at Ohio State University in 1953. The project was expanded in 1954 to include a total of 1500 plans of 17 different species and varieties. During the winter of 1954-55 protection tests were conducted with these plants and those that survived, with 3000 additional plants, were included in the 1955 study. Since its beginning the project has been primarily one of determining the adaptability of various ornamental plants to production in containers under Ohio climatic conditions. It is proposed that these plants will be used further in a marketing study to determine customer acceptance of container nursery stock.

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CONTAINERS USED

The nursery stock was canned in either green painted "Plantainers" or "Nursericans" or asphalt coated salvaged frozen food cans. These containers have a total volume respectively of .76, 1.43, and 3.80 gallons. The Nursericans has been the least satisfactory since it rusted out near the soil line, frequently before the end of the first growing season. Also no advantage has been seen for the removable bottom of the Nursercian, so styled for easy removal of the plant and soil ball. Rusting eliminates the advantage of this feature soon after the plants are placed in the containers. The Plantainer, with its corrugated sides, has been very durable even through the second growing season. With the sides tapered inward towards the bottom, the plant and soil ball can be readily knocked out of either the Plantainer or the Nursercian.

The frozen food cans or "egg cans," collected localy, punched with 4 to 6 side drainage holes, were dipped in RC-1 asphalt, a commercial nomenclature for rapid cure asphalt cutback. This asphalt dried sufficiently to permit canning within one week after the cans had been dipped. So treated, these containers have resisted rusting and have been in service for three years and still show no detrimental effects. Because of the straight sides, it is necessary to cut the sides of this container to free the soil ball when planting..

SOIL MIXTURE AND CANNING PROCEDURES

The plants have generally been canned in a "standard" soil mixture which is based on the results of a series of tests. This consists of equal parts by volume of silt loam soil, bank sand, and German peat moss. It is conceivable that the soil mixture might be varied to some extent depending upon the plant type, soil weight limit, or soil drainage. Tests were made in 1954 in which pea gravel was placed ½ inch deep in the bottom of the container over which was placed the plant and the standard soil mixture or a "special" soil mixture consisting of equal parts by volume of hadite, silt loam soil, bank sand, and German peat. This special soil mixture was also used without the pea gravel. With none of these soil variations was there any indication of significantly improved soil drainage or plant development compared with the standard soil mixture. In 1955 all the plants were canned with the standard soil mixture. In all cases the soil was steam sterilized after which it, together with the sand, and the water saturated peat was passed through a Royer shredder. This provided fast and effecient mixing.

Canning was done manually from a bench. At the time of canning, slight to severe root pruning was done depending upon the compactness and size of the root system. With 7 to 8 foot 1 year-old whips of Moraine Locust, it was necessary to prune off as much as two-thirds of the root system in order to get them in the 3.80 gallon food containers. Top pruning ranged from none on the Moraine Locust to cutting back one-year old plants of *Forsythia intermedia spectabilis* to an average height of 6.3 inches.

GROWING AREAS

Before setting the container nursery stock in the growing areas, the ground base was treated with a soil sterilant for the prevention of weeds. Vapam 4-S, a soil sterilant solution of sodium N-methyl dithiocarbamate, applied to the soil surface at 1 quart per 100 sq. ft. and watered in thoroughly has provided good weed control for at least one growing season.

Following application of the Vapam 4-S, the area was divided into 4 plots, (1) a soil check plot, (2) soil covered with 8 inches of wood shavings, (3) soil covered with 3 inches of sand, and (4) soil covered with 1½ inches of pea size crushed limestone. An equal number of each plant type was placed in each plot, arranged in beds 10 feet wide but split by an 18 inch work isle through the center. Walks, 42 inches wide, were provided between the plant beds.

The spacing of the plants in the growing beds is a controversial subject. Plants in the tests at Ohio State University were spaced initially so that optimum sunlight and air circulation might be equally available to every plant throughout the growing season. In this manner all the soil balls, regardless of the location of the plants in the bed or the surface type plots on which they were located, tended to dry out fairly evenly. But shifting and relocation of some of the plant types was necessary as the season advanced due to the ultimate growth of some of the plant types.

Where located on either the sand or wood shavings surface type plots, the plants developed heavy root systems outside the drainage holes. These roots were a hinderance when relocating the plants and certainly are unsightly when selling the plant. Growth measurements indicated no better plant development on these two surface type plots as elsewhere. Consequently the disadvantages of roots growing out the drainage holes seem to far surpass any possible advantage.

Drainage of excess water away from the plants was poorest in the soil surface area. Another disadvantage of setting the plants directly onto soil seems to be that of soil clods collecting on the bottom of the containers, and also the clogging of the drainage holes. The former condition results in uneven setting of the container, either when displaying the plant in the sales area, transporting it, or when shifting to another location. From these tests it appeared that, from the standpoint of best growing conditions, including drainage and general area neatness, crushed limestone was the best.

WATERING AND FERTILIZING

All the plants were hand watered with the use of a watering hose equipped with a wand type aerator so that splashing could be reduced, except for one small growing area which was generally watered with a revolving sprinkler. Plant development appeared to be slightly poorer in the area that had been watered with the sprinkler. Also it was particularly difficult to determine just when enough water had been applied. With hand watering, the exact amount of water could be applied daily by filling the container to the top. This would generally be enough water to provide for some leaching action to carry away the excess salts that accumulated from the frequent fertilizer applications.

The hand watering system, with a Hozon attached, was also useful for fertilizing the plants. Through the Hozon was siphoned a soluble fertilizer concentrate which, when mixed with the water in the hose, could be applied to the plants at any predetermined rate. During the 1955 growing season, four applications of 20-20-20 soluble fertilizer were made followed by a fifth application contained only nitrogen and potassium. The sixth and final application contained only soluble nitrogen. Fertilizer was applied at 3 to 4 week intervals. This fertilizer program differed somewhat from that used in 1954 when soluble forms of nitrogen was applied every two weeks, potassium every two or three weeks and phosphorus three to five times during the growing season. Soil tests were made previous to each application to assess the nutrient requirements.

PRUNING AND GROWTH MEASUREMENTS

During 1954 all the plants were pruned by frequently pinching out the shoot tips with the result that very compact plans were obtained. In 1955 a series of moderate pinchings were made on the more vigorously growing plant types and one or two prunings on the trees and larger shrubs primarily for the purpose of shaping.

In the table below is listed some of the plant types grown and the growth measurements for each. It is of interest to note that the sweetgums, canned in the spring of 1954, grew less that year than in 1953 and in 1955 they grew nearly as much as during the previous three years combined.

PLANT TYPE	GROWTH IN HEIGHT (INCHES) Up to and including 1954	During 1955	Percentage gain in 1955	Percentage of total growth in: '52	'53	'54	'55
Liquidambar styraciflue	33.0	28.5	86.2	13.2	23.6	16.2	47.0
Forsythia intermedia spectabilis	6.3*	15.6	245 4				
Ilex crenata rotundifolia	9.1	7.7	85.5				
Red Leaf Peach	54.6*	24.7	45.3				
Malus purpurea, Eley	41.7	37.3	90.1				
Gleditsia triacanthos inermis, Moraine	99.1	4.7	5.7				

* Plant tops were pruned back when planted to the heighth indicated.

** Growth of these trees was greatest in branch spread.

WINTER PROTECTION TESTS

One of the important factors in the production of nursery stock in containers in Ohio is the determination of the winter hardiness of such plants. The data recorded on the 1954-55 winter protection tests indicate that some plant types might survive the winters with little or no protection. These were: *Juniperus chinensis Armstrong; Juniperus chinensis Hetz; Kerria japonica; Ligustrum obtusifolium Vicary; Lonicera japonica chinensis; and Taxus cuspidata.* The other less hardy plant types, which would seem to need some type of protection, depending to some extent upon what was desired of the plant the following spring, include: *Abelia grandiflora; Berberis thunbergi atropurpurea; Cornus florida; Deutzia gracilis; Forsythia intermedia spectabilis; Liquidambar styraciflue; Mahonia aquifolium; Pyracantha coccinea lalandi; Syringa vulgaris;* and *Thuja orientalis aurea nana.* Only where Pyracantha was mulched up to the top of the container did it flower and fruit heavily this past spring and fall. On the other hand, flowering was heavy on Deutzia only where the tops were protected by wall of baled straw.

Similar protection tests have been set up for the winter of 1955-56. Here the plants have been set tightly together into five 4-foot wide beds as was done the previous winter. One of these beds has been left unprotected for the check, while the others have been protected with one of the following: mulch around and up to the top of the container, baled straw wall around all sides, lath snow fence around all sides, and roofing paper spread over lath snow fence around all sides.

With these three years of growing ornamental trees and shrubs experimentally in containers, there seems little doubt but that this is an entirely feasible method of producing nursery stock in Ohio.

* * * * *

MODERATOR MATKIN: Thank you, Mr. Barker. It occurs to me that possibly the reason you think these Plaintainers are too small is because you have five-gallon-sized plants in them. Perhaps in the West we move them earlier than you do. We will postpone questions and discussion of the various papers until the end of the session.

Next on the program is a discussion of a typical operation in that great State of Texas. We have with us from Verhalen Nursery Company of Scottsville, Texas, Mr. John Roller.

Mr. Roller presented his paper entitled "Container-Grown Trees in Texas." (Applause)

CONTAINER-GROWN TREES IN TEXAS

John B. Roller
Verhalen Nursery Company
Scottsville, Texas

Container-grown trees in Texas are a fairly important subject. In the beginning, may I be permitted just a little missionary work. Container-grown plants and container-grown trees, just like the State of Texas, are with us whether you like it or not. At least, I am firmly convinced they are both here to stay.

There has been a great increase in population and a very great building boom in the Southwest as in all other parts of the country. As a result, there is an excellent market for plants and trees of all types. In some of our cities you can see from one place one or even two thousand homes that are under construction or have just been completed.

As each home is completed, the home owner wants to plant the garden and it makes no difference if he gets there in June, July, or August. With container-grown material he can immediately plant trees and shrubs and they live.

At Verhalen's Nursery, our program for this year called for about 20,000 shade trees in containers. They are not the best types of trees, but consist primarily of chinese elm, sycamore, poplar, Arizona ash and quite spring and fall. On the other hand, flowering was heavy on Deutzia only where the tops were protected by wall of baled straw.

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As each home is completed, the home owner wants to plant the garden and it makes no difference if he gets there in June, July, or August. With container-grown material he can immediately plant trees and shrubs and they live.

At Verhalen's Nursery, our program for this year called for about 20,000 shade trees in containers. They are not the best types of trees, but consist primarily of chinese elm, sycamore, poplar, Arizona ash and quite a few ornamental trees. *Magnolia grandiflora* and mimosa are grown in quite large numbers but as those trees will not grow in the northern section of the country my remarks will deal mostly with two varieties of shade trees that will succeed in northern areas. These are *Liquidambar,* the sweet gum, and *Nyssa sylvatica,* the black gum.

We sow the seed in the spring and germination occurs immediately. We pot the seedlings using a mixture of half peat moss and half soil. The young trees can stay in the pot for one growing season or can be transferred to a one-gallon container after they have become established in the pot. It usually takes about six to eight weeks for the seedlings to become established in the pot.

Usually they are grown in the gallon size container the remainder of that season and should reach a height of 36 to 40 inches. There is a good market for trees of that size. I have heard nurserymen say that they would not plant trees that size, but we have found that there are a great number of people who enjoy planting small plants and trees. They like to see these plants grow. We sell a large number of three-foot trees in one gallon containers, but we also transfer a definite quantity into the five-gallon containers.

At the end of one growing season in the five-gallon container, the sweet gum tree will measure five to six feet in height. It can be grown another season in this large container, if desired. It is easily shipped, is fairly light in weight, and the transplanting losses are practically nothing.

We usually get our seed of the black gum in the early winter. They can be planted immediately and germination occurs in the spring. They are planted in a mixture of Michigan peat and sphagnum. It is not unusual for them to grow as much as twelve inches in a matter of three or four weeks.

The black gum is transferred to the gallon size container at the end of the first growing season. In one year, from seed, they reach a height of about 36 inches and are beginning to branch nicely. Later in the second season, they are transplanted to five-gallon containers and will have reached a height of seven feet at the end of the second season.

In regard to the soil mixture, the one thing in our mind which is paramount for container growing is adequate drainage. Our soil mixing is usually done mechanically in the field. We grow a cover crop for a period of about two years and then the soil is mounded with a road grader. To this we add equal amounts of peat, sawdust, and manure. The mixture is brought to our canning area in dump trucks and there it is run through a shredder where any further additions are made. Additions which may be added include additional moss, fertilizer, or lime.

It takes only a very small labor force to grow a large number of plants in containers. In fact, the labor force of possibly 18 or 20 persons can handle approximately a million plants.

Our method of watering is with overhead sprinklers. This is not a perfect system because there are wet and dry spots. We have not been able to eliminate either of these with the overhead sprinkler system. A dry spot can be readily watered by hand with a hose, but the wet spots remain a problem. For this reason, we add as much humus to our mixture as possible to improve drainage and aeration. Water is applied at a rate of about fifteen inches per month during the growing season. Of course, it is heavier in the summer than in the spring and fall.

We fertilize at two week intervals. We alternate a dry fertilization with a liquid fertilization. The dry fertilizer is applied by hand, just by placing it on top of the soil mixture. Liquid fertilization is done through a power sprayer. It is too expensive to put on through the overhead irrigation system. I believe that about one-third of the fertilizer is lost if applied through the irrigation system.

The dry fertilizer consists only of nitrate of soda or ammonium sulphate. The liquid applications are commercial products, such as Rapid-gro, Instant Grow, etc., which ever is more readily available. We depend upon the liquid fertilizer to supply the trace elements. Since our soil is high in potash, we do not need potash in the fertilizer treatment.

Briefly, that covers our method of growing trees and plants in containers. There is, however, one thing that does not necessarily enter into the growing of container plants but really is one of the big factors. This is the harvest. It is a very easy thing to go out and lift a container plant and put it on a truck on very short notice. Handling container-grown plants is not dependent upon the weather. To us, this is a very important point in favor of container-grown trees and plants. Another important consideration which favors container-grown trees is that trees, even to ten or twelve feet in height, can be planted in July and August without wilting or leaf drop.

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MODERATOR MATKIN: Thank you, John. I am certain that you have given some valid arguments for the use of container-growing in the nursery business.

Next on the program is a discussion on container-grown conifers in Illinois, by Mr. Jack Hill, D. Hill Nursery Company, Dundee, Ill. Mr. Hill is one of your well-known members.

Mr. Hill presented his paper, entitled "Container-Grown Conifers in Illinois." (Applause)

CONTAINER-GROWN CONIFERS IN ILLINOIS

JACK HILL
D. Hill Nursery Co.
Dundee, Illinois

It is a little difficult for me to sort out the actual differences between container-grown plants in Illinois and container-grown plants in Arizona, California, Texas, or New England.

I believe the thought with which I would like to begin its the analogy of what the container actually is. I have commented to many of you here in this group that there is evidently great preoccupation with the technique of growing plants in a container. Actually, it is the same plant, whether grown in a container or in the field. And the same factors—

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water, sunlight, minerals, etc.—control the growth of both. The container should properly be thought of as a package. The principal feature is that it is a package enabling easy distribution.

Another significant point with regard to container-growing, which should be noted early, is the necessity of recognizing the value of uniformity. Our preoccupation with dollars has led us toward a method of keeping track of the costs and the one thing which this cost system indicates is that the ultimate profit in any growing operation depends upon the percentage of harvest at the time of cropping. With the container-grown plants, for the very first time, we have control over many factors which, in the field, are infinitely variable. As long as we have the control, I think we should exercise it to the greatest degree possible. However there is no magic about quality in plants. You cannot take a plant of poor quality, place it in a container, and expect to have something of first quality.

The propagation of plants for containers differs slightly from the production of plants intended for field culture in that a greater emphasis is placed on uniformity. It is necessary to grade cuttings far more carefully than we had been accustomed to doing before we started this type of growing.

Our method at Dundee has followed several diverse lines of reasoning, always headed toward producing the best plant that we can for the least money. We have concluded now that we wish to go directly from the rooting bench to the container. This concept of handling the plant as few times as possible recognizes that the plant invariably sets up its own balance. A plant which is growing probably does not make one extra bit of root more than it needs nor does it make one extra leaf than it can use. It is a delicately poised, exquisitely balanced mechanism. If we accept that concept of a plant, we must recognize that we will achieve the best results by handling it just as few times as possible.

That hypothesis, coupled with economics, has led us to the belief that we will achieve our end best by going directly from the cutting bench to the container. Therefore it is necessary to produce cuttings as large as can be economically handled. For example, we know that *Taxus* cuttings of various sizes can be rooted. In fact, there is belief in some quarters that the larger the cutting the better the rooting. There is a limit, of course, to the size that can be handled conveniently in the greenhouse. We wish to direct the operation toward sticking the largest cutting that can be conveniently handled and putting that cutting directly into the container. The important factor in sticking that cutting is timing—to produce good secondary roots by the time we wish to can it.

We are doing our canning on a powered conveyer. It is not a machine, it is simply a conveyor which permits an adjustment of an accurate rate of flow of material toward and away from the focal point of work. If you were working with a gravity conveyor it would be quite difficult to arrange the flow of the plants to and from the actual canning operation.

The economics of going from the bench to the container involves me in a discussion with the preceeding speaker. It is the difference between going from the cutting bench to the container and from the cutting bench to a two and a quarter inch pot. Obviously, the pots can be spaced much closer together. Consequently the requisite culture can be applied to that confined area with less expense than to the same number of plants in one-gallon containers. A square foot is required for each four containers, whereas about twelve pots can be placed in this area. Therefore, there is an economic difference.

We have chosen to emphasize the importance to the plant of the lack of handling. We know that even in transplanting from a pot to the container that there is a certain amount of shock to the plant. We are willing to incur the extra cost of maintenance in order to eliminate the additional shock obtained by the transplanting from the pots. It is really a problem of economics and recognized plant welfare.

One point that I think needs examining is the matter of trans-canning, that is, shifting the plants to larger containers. It is our present belief that it is not practical to shift from the one-gallon to the two-gallon container. There is not a sufficient increase in volume of new soil in the two-gallon container to justify the cost of the two-gallon container and the labor of making the move. However, we do consider it is entirely practical to move plants from the one-gallon to the five-gallon container. It may easily be that as our technique improves, we will start the fast-growing plants directly in two-gallon containers. This, again, in deference to the feeling of not wishing to move the plant and not wishing to handle it any more than is absolutely necessary.

The problem of selection of the growing medium or mixture has already been very thoroughly covered. I am in complete accord with the principle of the mixture described by Mr. Matkin. The principle that lies behind it is inviolate. Adequate mixing, however, was perhaps not stressed quite enough in the earlier discussion.

We encountered a problem when we added our mixture of fine sand and peat moss. We found the ordinary tumbling barrel type of mixer was far from adequate in getting the thoroughness of mixture which we regarded as necessary. In order to come up with a rule of thumb criterion for determining when a mixture was sufficiently mixed, we simply saturated the material with water. If the peat moss floats to the top, the material is not sufficiently mixed, however, if the peat moss stays in contact with the sand, then there is adquately mixing.

Aeration and drainage have already been given considerable attention. I will simply suggest that there are no two factors which we consider of more importance in the selection of the medium than drainage and aeration. I must confess that I do not know just where one begins and the other ends. There is such overlapping of the factors of drainage and aeration that we have come to use the terms synonymously at Dundee.

Late this Fall, after three years of experimenting with the various soil mixtures and having behind us only one year of experience with the sand-peat mixture, we are converted to the sand-peat. Perhaps I should explain why we have decided on the sand-peat mixture.

The medium which we chose in the Fall of 1952 proved to be entirely inadequate. *Taxus,* in particular, never did become established in it. After we recognized the problem of drainage-aeration, we modified the John Innes mixture and adapted it to the non-porous container. We found at the end of a year's growing that there were many more lateral breaks from the main roots. These branch roots, upon reaching the edge of the container, produced a good root system. A number of plants, even the ones which we considered rather intolerant to low level of aeration such as *Taxus,* rooted very heavily along the outside of the container. We were producing what amounted to a hollow cylinder of roots. The roots were not thoroughly using the total soil volume. Now, after one year of experience with the sand-peat mixture, we have found that the roots grow throughout the container. There is no tendency to develop the hollow cylinder of roots which was evident with the other mixtures.

I believe that irrigation is carried out on a different basis at Dundee than elsewhere. Recognizing the necessity for keeping all factors uniform which affects plant growth, we looked into numerous watering systems. We considered the possibility of the fixed rotating head or simple spray the amount of water applied from the source outward to the edge of the head and quickly learned that there was a distressing disparity between coverage. Generally most of the water fell about the middle. The inside and outside received considerably less water. We finally chose what was regarded by many, including myself, as a sand box toy. It is the self-propelled Rain King Sprinkler. The radius of the spray is adjustable. It is designed for the home owner and is available at most garden stores. The machine pulls itself along on a very thin stainless steel tape. The mechanism has proven entirely reliable.

When to irrigate is a question that is quite frequently raised. We examined many methods. We have tried moisture blocks, copper electrodes, and potentiometers. We have investigated the determination of the water content in relation to field capacity. This latter method is very accurate but quite laborious. Finally we have come to a method at Dundee which depends upon putting a finger in the can up to the first knuckle and seeing how it feels. We do think simple observation of the rate of water usage is probably the most reliable. The best and most scientific plan in the world is quite limited if you cannot apply it to your operation conveniently.

The feeding program which we have followed is quite simple in its concept. We were accustomed to seeing damage to plants grown under field conditions whenever they were subjected to a sharp, violent change of soil chemistry. The classic method of the nurseryman is to watch his block of trees and apply fertilizer the moment he sees signs of distress.

The analogy I have often used is the matter of deciding how to feed a starving man who has been picked up on the Sahara Desert. That man needs food. If you give him a steak dinner, as badly as he needs the food, he cannot use it. It would quite likely kill him. You could, however, provide him a cup of soup every hour for three or four days and restore his whole system to a level where he could use the steak dinner.

It is easier for our purpose to keep the plants on a cup of soup, so our entire principle is to feed very little but often. We tie the frequency of feeding with the necessity of watering. By that, I mean when the plant is actively growing it obviously needs more food. It uses more water and it needs more food. Conversely, when we run through a period of low temperature during mid-summer, with more cloudy days than bright ones, the plant is not as active, and therefore it requires less water and food.

The last thing I want to cover is the matter of winter protection. Our findings parallel exactly those discovered in experiments elsewhere. We believe at Dundee that our plants are not damaged by the absolutes in temperature. I feel that most of the conifers which we are growing are tolerant to temperatures which they are likely to receive in Dundee. But the damage that does occur, whether it is great or little, is almost invariably associated with rapid and violent fluctuations of temperature. The fact that you have detached the soil parcel from the ground, where it would be affected by the leavening influence of the earth's crust, subjects it to frequent changes in temperature. In Dundee, those changes, rapid as they may be on a clear night in June, are all within the growing range of the plants. In contrast, the changes that take place in the winter are beyond the range of growth, and the plant roots can actually be injured.

I think it was pointed out quite rightly that the degree of winter protection which is necessary is determined, first on an economic basis, and second by exactly what performance you want of the plant the next year.

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MODERATOR MATKIN: Thank you, Jack. It is obvious that you have an interesting ability to make observations and to express them in words that are understandable.

Last, but not least, certainly, is a report of a container growing operation in the East. This is at Corliss Brothers Nursery, Gloucester, Massachusetts. Mr. Clifford Corliss will describe the methods used by that nursery.

Mr. Clifford Corliss presented his paper entitled "Container-Grown Shrubs In Massachusetts." (Applause)

CONTAINER-GROWN SHRUBS IN MASSACHUSETTS

CLIFFORD CORLISS
Corliss Brothers Nursery
Gloucester, Mass.

Being at the end of the program and following these able speakers on container-grown material, I think the task would be a lot easier for me to tell you what we don't know about growing container stock than what we do know. However, as you well recognize, California is one situation, Texas another, the Midwest another, and we, in Massachusetts, have another.

I am going to tell you what we have done. We were one of the very first people to grow small shrubs, especially roses, in Cloverset pots years and years ago. We never got very far with shrub material because if the pots were carried over for a year, or occassionally for two years, that was an expensive operation. But we did very well with roses.

Our experience with metal containers is this. I, for one, could not see using a container that had to be cut and until the advent of the Plantainer and the Nursery Can, we did not enter the container business. We used some Plantainers, and after some experimental work, shifted to the

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Nursery Cans. The Plantainer is a good container, there is no question about it, but after we grew plants in them for a year, especially fast-growing plants, we had a job to get the plants out of that container. In most cases we have not encountered this difficulty with the Nursery Can because the bottom pushes out. It has been said that the bottoms rust out. Some of them do, but if you get a three-inch pipe stand with a solid block on top, you can push the can on tight. We have had little or no trouble from rusting. Therefore, I favor that type of container. We are using both the one and two-gallon sizes.

Now, as far as soil mixture is concerned, our situation is different from other parts of the country. I do agree there should be a uniform soil mixture if it can be worked out, and, apparently most growers are doing this. We are not at the present time. Our soil mixture consists of one yard of washed pea-size gravel, two yards of good loam, usually on the clay side, and two yards of peat. We mix these together and add gypsum or lime depending on the plant to be grown. Usually we add 50 pounds of rock phosphate, 100 pounds of magnesium lime, and 20 pounds of superphosphate. The material is sterilized and put through a Kemp shredder. It is not screened. Then we add 10 pounds of 7-7-7. If we are potting rhododendrons or other plants that require acid soil, we use an acid 7-7-7.

Our canning operation is all by hand. We are only a small operation compared with those in Texas and California and we have not invested in machinery to do the canning.

Before I discuss the various plants we grow, I want to tell you why we use pea-size gravel in the mixture. It has been suggested at different times that we might get away without using this, but with the heavy clay soil, which we have in our area, we do not get the aeration that is necessary. As each one of the preceeding speakers has said, aeration and drainage are important.

We are doing something else which most of you would consider to be an extra expense. We are using three-quarters of an inch of crushed stone in these containers. Maybe this is an added expense, but until we know better, we will continue to do it.

With this type of mixture, we canned some 10,000 plants in the late spring or early summer of 1954. At that time we tried numerous plants of various kinds, including some of the plants that we thought would present problems. We used two-year bed grown *Rhododendron catawbiense, R. carolineanum, Pieris floribunda, Taxus cuspidata, T. cuspidata capitata, Cotoneaster divaricata, C. horizontalis, Buxus welleri, Pyracantha coccinea Lelandi, Euonymus fortunei radicans, Buddleia, Caryopteris Blue Mist, Ampelopsis heterophylla, Lonicera Heckrottii, Polygonum Auberti, Wisteria sinensis,* and many more.

Those plants went through the winter of 1954-55 and the loss was negligible—we may have lost two or three here or there. This is very important to us because we had heard of many nurserymen who have had lots of winter loss. There were only three of the 800 *Pyracantha* which did not survive. That kind of loss can happen in the field. We usually keep pyracantha in a protected frame for two years before we put them in the field. I think that speaks fairly well for the mixture used, the aeration and drainage, and the over-wintering.

In 1955, in addition to the material already mentioned, we planted Azlea, Forsythia, hollies of various types (I. *convexa bullata,* and I. *opaca* including many named varieties), junipers, *Taxus, Pieris japonica, Leucothoe Catesbaei, Pyracantha crennulata kansuensis, Rosa Hugonis,* English Ivy, hybrid rhododendrons, and *Clethra alnifolia rosea.* We had some trouble with *Hypericum.*

Now, as to fertilization, what we have done is this: as you will recall, all the new plants in a container have the 7-7-7. We leave them about four or five weeks, depending on when growth starts. After they have started growth in the containers, we will give them another application of fertilizer, the equivalent of about one tablespoon of 7-7-7 to each container. Then we feed them about every three weeks with a water soluable fertilizer. A 20-20-20 has given us very good results. We have also used a 30-15-30. This seemed to be equally as good as the 20-20-20.

As far as the watering was concerned, we felt that watering by hand was an expensive proceedure. With our system, we can water all thirty beds at one time if we wish, but usually only ten beds are watered at one time.

Our beds are eight feet wide, sixty feet long, and there is a three-foot aisle between each bed. A valve controls the water to each bed. There is a special coupling on the three inch main which permits the use of a flexible hose to connect with the aluminum pipe. We are using aluminum pipe with copper risers. Some of the copper risers are a foot, some which is made by Skinner and called the "Superior." This nozzle can be twenty inches, and others thirty-six inches high. We use a flat nozzle adjusted to cover a diameter of 4, 6, 8, or 10 feet. By using the ten foot diameter spread, we do not have small dry triangular areas. There is some overlap, but not much. We use the old method of sticking a finger in the soil to determine when to water. We feel that any grower who owns a nursery should know whether a plant needs water or not.

We still have a lot to learn about the container business, but, I think we have made a good start.

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MODERATOR MATKIN: Thank you, Mr. Corliss for completing the morning discussion on container-grown nursery stock. Questions and discussions about this topic have purposely been delayed until the end of the panel. I think the discussion period can best be handled by your president.

PRESIDENT FILLMORE: Please state to which of the several speakers your question is directed.

MR. CHARLES E. HESS (Cornell Univ., Ithaca, N.Y.): This question is for Mr. Barker. In the tests made with the containers on gravel and soil, which condition do you feel gave the best results?

MR. BARKER: On the plant growth there was not too much difference. From the standpoint of over-all area neatness, I would say that the gravel was best.

MR. JAMES S. WELLS (Bobbink Nurseries, East Rutherford, N.J.): What fertilizer does Mr. Matkin recommend for dry feeding and how often should it be used?

MR. MATKIN: As Jack Hill pointed out, fertilizing is largely related to frequency of irrigation. For dry fertilizing, we have normally endeavored to use something that would have a prolonged effect. Sometimes the size of the plant has to be used as an index in determining how much to apply. A mixture consisting of such things as the urea formaldehyde resins, the hoof and horn bloodmeal, mixed with superphosphate and sulphate or muriate of potash to give approximately a 3-1-2 ratio used at one to two month intervals during the growing period is not unusual. Quantities equivalent to one to two heaping teaspoons per gallon of container size are used. There is no recipe that is going to fill all circumstances. It has to be adapted to your own particular operation.

MR. MARTIN VAN HOF (Rhode Island Nurseries, Newport, R.I.): I would like to ask Jack Hill how they prune the evergreens?

MR. HILL: Our general practice in trimming follows the basic rule of trimming a little and often. Because we can focus our labor effectively in these container areas, it is possible for us to control the growth of a Pfitzer's juniper to a large extent without ever using a knife. You can do it by pinching. It is a case of pinching every time you see a branchlet getting out of hand.

We stake the upright plants. I am talking particularly of grafted junipers. We stake and keep the leader going upward the first year. The second year it may be necessary to discourage that vertical development in an effort to throw more of the growth into the lower branches to fill out the plant.

On spreading types, on the other hand, we pinch quite hard the first year to make certain that the framework for the subsequent development of the plant is ample and adequate.

MR. WILLIAM H. BURTON (Burton's Hill-top Nursery, Casstown, O.): I direct this inquiry to Mr. Hill. How do you prevent action of the fertilizer on the container?

MR. HILL: We have not had any experience nor do we anticipate any problem. Our program is planned on a two-year basis. By that, I mean that if we recognize the precept that we shall go to market with the maximum size plant in the smallest container, we are going to produce a plant in a gallon container for sale at the end of the two years. The plants scheduled for production in larger containers will probably be shifted from the one gallon container at the end of the first year. Therefore, it is never in any one container longer than two years.

MR. DONALD I. VANDERBROOK (C. W. Stuart Company, Newark, N.Y.): I would like to know if any work has been done with a completely sterile material such as sphagnum moss or vermiculite?

MR. HILL: Yes, we have tried material of that type to a limited degree. It is soilless but it is not sterile. We added, as a bulking agent, approximately 30 per cent sytrafoam to sand. However, there is quite a problem of getting the plant to become established in heavy soils. We have about discontinued experiments with any medium that will not enable an easy and rapid establishment of the roots in ordinary soil.

MODERATOR FILLMORE: Perhaps Mr. Matkin will also comment on this point.

MR. MATKIN: We have constantly heard that sphagnum moss is sterile, that it is disease free. It has been our experience, particularly where sphagnum is used for foliage plants, that it is not sterile. In the West, we have adopted a standard procedure of sterilizing all sphagnum before it is used.

MR. PAUL R. BOSLEY (Bosley Nursery, Mentor, O.): I would like to make a comment rather than to ask a question. After the soil has settled in the containers, we have added ground corn cobs to that space and have found that our watering was reduced 50 percent. In other words, instead of watering every day, we could water every other day. The surface was never really dry. I think mulching has possibilities.

MR. LESLIE HANCOCK (Woodland Nurseries, Cooksville, Ontario): This question is for Mr. Matkin. Is there any objection to the use of cow manure?

MR. MATKIN: Yes there is. The use of materials which are not reliable chemically or physically is objectionable because the entire approach is one of as complete controll as possible. Manures, in general, are notoriously non-uniform. Many of the troubles we originally ran into in developing a standard system of growing developed directly from the use of manures. They are not necessarily either similar chemically from time to time nor are they stable in the soil.

MR. ARTHUR J. LANCASTER JR. (Coleman Nursery, Portsmouth, Va.): Using an overhead watering system, how can a plant with a 36-inch spread be watered satisfactorily?

MR. ROLLER: That is a problem with a number of the plants which are grown in southern areas. About the only thing we do in a case like that is to leave the sprinkler on for about twice the normal time. Some of the water is going to reach the soil in the container.

MR. EVERETT CONKLIN JR. (Rutgers University, New Brunswick, N.J.): What is the over-winter survival of plants which are canned in the fall?

MR. CORLISS: We planted some material in September, 1954 from beds. The containers were mulched with sugar cane. We had 100 per cent overwintering.

MR. ZOPHAR WARNER, (Warner Nurseries, Willoughby, O.): Fall potting should be done early enough to get some new root growth.

MR. BRUCE VANDERBROOK (Vanderbrook Nurseries, Manchester, Conn.): I would like to ask Mr. Matkin if he thinks two to three foot evergreens can be grown successfully in containers?

MR. MATKIN: Yes.

MR. TED FOULKE (Peeper Hollow Farms, Cleveland, O.): Mr. Corliss indicated rather high survival of plants, but I don't think he mentioned whether they were protected or mulched?

MR. CORLISS: We have tried over-wintering small quantities of plants without mulching. Most of the plants have been mulched with about one inch of sugar cane. Even *Pyracantha*, when mulched, came through in a fine condition.

MR. CHARLES E. HESS: I would like to hear Mr. Matkin's comments on the use of mulches to reduce water loss.

MR. MATKIN: This is certainly in accordance with our overall idea of trying to reduce labor. It is also an effective factor in reducing evaporation. If you are going to use clay soils, it has a further advantage in that the water droplets will have less tendency to splatter and puddle the surface of the soil.

MR. JAMES S. WELLS: One of the most important things we have heard this morning is Mr. Matkin's comment on and his pre-occupation with cleanliness. I would like to ask him how much difference he thinks it can make in the efficiency of all the events that produce available plants in container practice, if sterile practices are followed?

MR. MATKIN: This could be a lecture, but time will not permit. Naturally if you are lucky, you will have no disease problems and you will receive no benefit by taking special effort to be clean. However this is seldom the case. Usually the benefits to be obtained by clean procedures result in salable plants, which would not otherwise have survived the growing operation. This may vary from a moderate 20 to as much as 100 per cent. I have seen an entire crop lost, especially of sensitive plants, because of disease conditions resulting from unsterilized procedures.

PRESIDENT FILLMORE: Time dictates that this session on container-growing must be terminated. I am confident that much has been learned from each of the speakers and that many of you will view container-growing in a different manner. Our thanks to every one of the participants on this panel.

The session recessed at 12:30 p.m.

REPORT ON MIST PROPAGATION TRIALS FOR 1955

SATURDAY AFTERNOON SESSION

December 17, 1955

The session convened at 1:30 o'clock, President Fillmore calling the meeting to order.

PRESIDENT FILLMORE: The Field Trials Committee, under the guidance of Dr. John Mahlstede of Iowa State College, has been very busy throughout the past year gathering an analyzing information on mist propagation. Those of you who have attended previous meetings of this Society know the intense interest which has attended discussions on this relatively new method of rooting cuttings. It is therefore with a great deal of pleasure that I turn this afternoon session over to Dr. Mahlstede for his report.

Dr. Mahlstede took the chair.

MODERATOR MAHLSTEDE: Thank you, Mr. Fillmore.

Mr. President, fellow propagators and guests: The first project that was undertaken by your Field Trials Committee this past year was a survey of the membership in regard to the availability and cost of all equipment in use for propagation purposes. An excellent return to this questionnaire was received. The information gathered was then summarized and distributed to the membership in the first NEWSLETTER edited by Dr. Snyder. In addition, this NEWSLETTER carried a description of a "typical" intermittent mist system which could be used for rooting softwood cuttings out-of-doors.

The second NEWSLETTER carried a suggested procedure which could be used to evaluate the results obtained from using an intermittent mist system controlled with the Electronic Leaf. From this survey we hoped to establish such practices as: (1) the importance of timing, (2) importance of hormones and (3) procedures for handling cuttings after rooting. To have some common ground for comparison, a list of 12 shrubs grwn commercially in nearly all sections of the United States was suggested. Cuttings from these shrubs were to be stuck within a specified period based on zoning and the advance of the season from South to North.

In the Fall a final questionnaire was circulated on which members who had used intermittent mist were to list their results. Thirty-five replies to this questionnaire were received as well as many letters. From these returns a combined report was prepared, a copy of which will be distributed at the end of this session. In order to make this summary more accurate we have included a zoning number before each reference, this to reflect to some degree the influence of location and timing on expected results.

The final report also contains a general summary which was reached after careful scrutinization of the returns and of the comments made in conjunction with them. These were as follows:

1. Fifty percent of the nurserymen who are using intermittent mist installations are potting the cuttings immediately after they have rooted and have been hardened-off. Another 25% are leaving the cuttings in the bed overwinter.

2. In general, the plants which have been difficult to root from softwood cuttings by other known techniques are also difficult to root under intermittent mist facilities.

Those giving trouble include: *Chaenomeles japonica, Clethra, Cornus florida rubra, Cotinus coggygria purpurea, Evergreens* (*slow to root, not particularly difficult*), *French Lilacs, Kolkwitzia amabilis, Malus spp., Prunus spp.* (*cistena, glandulosa*) *Rosa spp., Syringa rothamagensis, Viburnum macrocephalum sterile.*

Discussion: A wide variety of explanations can be advanced for the difficulties experienced in rooting these sorts. Some of the difficulty can be attributed to improper timing. Certain cutting types show retarded or inhibited rooting as a result of the application of rooting powders; still other types, when placed in beds having poor drainage throw abundant callus as a result of the high moisture content of the rooting medium.

In general, however, given enough time, most of these difficult to root types will throw roots when propagated under intermittent mist facilities.

3. Types giving trouble because of leaf drop either during rooting, or immediately following, include:

Acer palmatum, Berberis, "Crimson pygmy," *Cotoneaster* (*adpressa, apiculata*), *Elaeagnus rotundifolia,* Franch and Persian Lilacs, *Ilex* (those with pubescent leaf surfaces), *Kerria japonica plenaflora, Magnolia stellata, Philadelphus* (*coronarius aureaus, virginalis*), *Platanus acerifolium, Prunus,* (*cistena, glandulosa, triloba*), *Pyrcantha lalandi, Rhus acromatica, Ribes alpinum, Rosa spp., Spiraea* (*b.A.W., prunifolia*) *and Viburnum lantana.*

Discussion: Probably a case of maturity which is regulated by the physiological condition of the cutting at the time of sticking. If a cutting is taken too early many types are difficult to harden-off, and/or are slow to root; if taken too late they have a tendency to drop their leaves if environmental conditions are favorable.

Types such as *Prunus spp.* will defoliate regularly if the cuttings are allowed to remain under mist for any period beyond that required to root the cutting.

It has been generally noted that there has been less trouble with defoliation during the rooting sequence by nurserymen using the Electronic Leaf than by those using an interval timer.

4. Cutting types which have given trouble after rooting are essentially those which defoliate either during the rooting sequence or immediately after rooting; these include:

Cornus florida rubra, Hydrangia P.G., Ligustrum ibota vicari, Philadelphus (*coronarius* and *c. aureus*), *Prunus* (*cistena, triloba*) *Rhus aromatica, Weigela* (*Vaniceki, wagneri variegata*).

Discussion: There are those types such as *Prunus spp.* and *Hydrangia P.G.* which should be hardened-off as quickly as possible once rooting has taken place. There are other types which have a broad leaf blade, such as *Forsythia* and *Chaenomeles lagenaria* which are particularly subject to leaf burn if not properly shaded during the hardening-off process.

It has been reported that cuttings treated with one of the rooting powders have been generally easier to transplant than those not treated at the time of sticking.

As has been previously pointed out the propagator should attempt, as nearly as possible to keep the cutting growing. Any protracted delay in this growing process, before the end of the season imposes a period of delayed activity, during which the cutting may be lost or severely setback. Since the ability of a cutting to grow is tied up with maturity, timing again is very important.

Since eighty-five percent of the nurserymen using the Electronic Leaf control experienced some trouble as a result of the malfunction of the unit, we have asked Mr. Harvey Templeton, its originator, to describe how it functions, temporary repair methods, and the progress he is making in its improvement.

Mr. Harvey Templeton, Winchester, Tennessee presented his paper entitled: "The Electronic Leaf." (Applause)

THE ELECTRONIC LEAF

HARVEY M. TEMPLETON
Phytotector, Winchester, Tennessee

From the reports that I received this summer, those of you who tried it were pretty disappointed and discouraged with the Electronic Leaf control. I sympathized with you, for I was experiencing the same difficulties myself.

Although we developed the "Leaf" and had an experimental model working in the early Fall of 1953, we didn't have the nerve to depend on it for our 1954 production. So it was in March, of this year before we began to use it on our main production.

We immediately ran into difficulties. At first we had the wires between the "Leaf" and the control box too long, and the control acted in a very erratic manner. A little experimentation proved that the trouble was due to the capacity effect between the two long wires. By using a very short connection, that trouble was permantly cured.

By spring we were using 4 or 5 separate Electronic circuits with 3 or 4 beds on each circuit, attempting to provide a variety of mist conditions, including a hardening-off circuit. We were occasionally running two Electronic Leaves in parallel on the same circuit so that either one saftied the other and either would automatically take over correct control if the other failed.

We finally concluded that we weren't going to succeed until we knew exactly what each Electronic Leaf was actually doing throughout the day and the night.

Confronted with the problem of a 24-hour a day vigilance we built three recording devices, using time switch mechanisms, bailing wire, has taken place. There are other types which have a broad leaf blade, such as *Forsythia* and *Chaenomeles lagenaria* which are particularly subject to leaf burn if not properly shaded during the hardening-off process.

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We finally concluded that we weren't going to succeed until we knew exactly what each Electronic Leaf was actually doing throughout the day and the night.

Confronted with the problem of a 24-hour a day vigilance we built three recording devices, using time switch mechanisms, bailing wire, rubber bands, and pencils. The recorders ran continuously and made a pencil mark on a paper chart each time the mist came on. In addition, we connected a self-starting electric clock to each circuit. Thus we had a permanent record of periods of operation (from the recorders) and a record of total spraying time from the clocks. From those records we began to learn something about the operation of the Electronic Leaf.

We discovered that, if the recorder chart showed long "on" periods, the vacuum tube in the control box was going bad. If the chart showed frequent operation during the night it was an indication that the surface of the "leaf" needed cleaning. These indications are consistent and significant. Before we got far we had to get a sensitive ohmmeter with which we could measure the electrical resistance of a "leaf" as its surface dried off. The significant range of resistance was (with our water) between 2 and 3½ million ohms. We then knew the control box must be sensitive within that range. A simple variable high resistance with a calibrated dial then enabled us to test the performance of the control box whenever the recorder indicted the possibility of the deterioration of the vacuum tube.

We use a sensing element (the "leaf" part) of our own design with two graphite contacts sealed in polystyrene plastic and with vinyl insulated lead wires. This element is very simply cleaned by wetting its upper surface with about 20% hydrochloric acid and gently rubbing with a soft wood stick. You should never touch the surface as it might become greasy. Scraping and sanding should be avoided at the original surface seems to improve with use. The "leaves" seem to be quite durable.

We find that the vacuum tube in the control box doesn't last long—varying between a couple of days and a thousand or so hours. Its life definitely seems to be shorter if the control box is hot. Since our controls, of necessity, are out in the sun by the side of the bed and are enclosed in a partially ventilated waterproof metal can, we find it desirable to shade them to keep the temperature down. This winter the 3 or 4 we are still operating seem to show better tube life, probably due to the lower temperature.

Each one of our Electronic Leaf controls is a special heavy duty model with an additional high capacity relay capable of controlling 20 or more solenoid water valves with each valve supplying 12 nozzles. Any one of the controls can be connected very simply to any one or all of the many beds we are operating at one time.

At first we used 3 or 4 control circuits with the idea of providing different conditions in each group of beds. This was not necessary. Also, the hardening-off circuit didn't work out in practice. If the plant material was easy to harden-off we didn't need the circuit. It was difficult, the hardening-off circuit didn't help. In fact, it was worse than nothing. Even if it operated just barely enough to keep part of the leaves and plants wet all the time, those leaves and plants would not harden. After we discovered this fact, we put into operation for the hardening-off process the old interval timer which was limited to certain hours by a time switch.

We now have in operation a special sensing element (or "leaf") which will keep the leaves *less than wet all the time* to any degree we wish within reason, and which is still perfectly weather conscious. This new "leaf" should solve the hardening problem which, incidentally, is not particularly difficult, except with a few plants of which very soft *Viburnum juddii* is the worst.

Even though 3 or 4 different sets of conditions provided by 3 or 4 different leaf control circuits are not necessary, we still have to use the multiple circuits because our water supply isn't adequate to supply at the same instant all of the 34 or 25 beds (that is about 300 nozzles) we are usually operating in the summer. So we put 6 or 7 beds on one leaf circuit, 6 or 7 on another, etc., so as to split the water load, since it is not likely that all will come on at the same time.

The unit is not as complicated as it may sound. You do have to realize, though, that production with the Electronic Leaf is not as simple as we at first thought it would be. I would not consider trying to operate without some kind of recorder to tell me what was actually happening. If everything is right you know it. If something is wrong you know what it is. You can set up a control circuit and be sure it is going to do just what you want it to do.

Don't be discouraged with the device. It isn't going to be as simple as we thought but it does eventually work fine. It is not going to be as cheap for you as we originally thought. A complete workable system of controls, with recorders and test instruments, will be nearer to $150.00 than to the $30.00 most of you paid.

I deplore the fact that I seem to be in the position of defending the Electronic Leaf. It doesn't need defending. We all just jumped in too quickly and thought it was too simple. I know I wasn't willing to market it myself for fear it might not be perfected enough.

Actually, I suppose, I shouldn't care whether or not you like it or whether or not it works for you. If it does not it just gives my own production a little edge on yours. But, after all, it is my baby and I cannot help but want it to work for you. So, if you have trouble with it, call on me and we will see if we can't correct it.

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MODERATOR MAHLSTEDE: Thank you Harvey for that very fine discussion. I believe that your willingness to provide helpful guidance to others exemplifies the objectives under which this organization was founded.

The second speaker this afternoon, and I might add, a heavy contributor to the mist report is Bob Eshelman, who is going to speak to us on the subject of "Rooting Response under Intermittent Mist."

Mr. Eshelman presented his paper. (Applause)

ROOTING RESPONSE UNDER INTERMITTENT MIST

ROBERT J. ESHLEMAN, JR.
Eshelman's Nursery, Bloomsburg, Pa.

I am in full agreement with Mr. Templeton that the Electronic Leaf does have its place, and a high place at that, in plant propagation. I, along with the other 85 percent had my share of trouble with the "Leaf" unit, but they were such that repair was possible and no impairment in the growth of the cuttings resulted.

I like plant materials at any stage, young or old, and I like to see them thrive. After a customer receives the plant I take pride in its surviving after it is in his yard. For a plant to do that there is nothing more important than having a good root system, a root system which originated after that cutting was placed in a rooting medium.

There were several reasons for my using the intermittent mist setup. Among these were: (1) the fact that I raise a great variety of plants which have different rooting requirements, (2) I prefer a plant on its own roots to one that has been grafted, and (3) the fact that the application of water is done automatically, apparently at the most optimum time to result in a better rooting response.

I had a typical setup for intermittant mist. I surrounded the unit with flue liners which made up the bed. The flues as well as the medium was kept above the surrounding ground level. I used about an inch and one half of humus covered with approximately an inch and a half of coarse sand. These were not mixed, although I believe drainage would not have been impaired if they had been worked together. I used the 550A, Florida nozzle with a nozzle spacing of 57 inches between nozzles in beds which were 57 inches wide. I used plastic sheeting around the beds for windbreak purposes.

When the Electronic Leaf control unit failed on one occasion, I placed shade over the beds in order to hold the cuttings until the difficulty could be remedied. Occasional shading during the very hottest days was necessary to prevent injury to cuttings located along the edges of the bed where mist coverage was not adequate.

It has been my experience that cuttings can be collected over a rather wide period, although I believe that it is desirable to stick them as early as possible so that a good root system will be established by Fall. By early rooting the application of water could be reduced, or practically eliminated by September 1st; thereby affording ample opportunity to harden the cuttings off by Winter.

In handling the rooted cuttings overwinter I am trying two methods, i.e., leaving them in the bed overwinter, and boxing. Those which were allowed to remain in the bed were covered with straw and shaded with lath. Whether they will come through, due to rooting down into the humus layer, will have to be determined next Spring. Those which were boxed were moved on the 28th of August, placed in 100% humus, placed under intermittant mist for a period of one week and then removed to a cold greenhouse to overwinter. No fertilizer was added to the humus since I was afraid of forcing secondary growth.

Anything that is to be transplanted, that is not of sufficient size to fend for itself in a transplant bed is boxed. I do not like to pot plants,.

since I feel that it tends to curl up the roots to too great an extent. I also believe that between the soil and the pot, root growth is definitely restricted. I have found that when the cuttings are placed in boxes containing humus (native Pennsylvania humus which is fine in texture and black) the roots are spread out and ready to grow immediately after they are in the transplant beds. Mr. Jack Hill indicated earlier that he likes to move his plants as rooted cuttings right into containers, without potting. I am certainly in agreement with him for the reason that the roots continue growth without any severe set-back.

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MODERATOR MAHLSTEDE: Thank you, Bob. Since we have agreed to hold all questions pending completion of the program our next contributor whom I have the privelege to introduce is Mr. Charles Hess, Sr.

Mr. Hess discussed the subject on "Rooting Cuttings Under Mist in Containers."

ROOTING CUTTINGS IN CONTAINERS UNDER MIST

MR. CHARLES HESS, SR.
Hess' Nurseries, Mountain View, New Jersey

A few years ago I had the pleasure of listening to Mr. Hancock discuss his burlap-cloud method of propagation. His talk interested me so much that the following summer we went up and looked at his operation. I was still more surprised. Seeing his operation led me to believe that we were working at a disadvantage. Our operations were too expensive and therefore it appeared to me that we should cut some corners. With this in mind, last summer we put up an outdoor mist unit using Harvey Templeton's nozzles and a minute interval timing device.

We did not start to make cuttings until August 13th. They were collected and trimmed in the usual manner and placed singly in plant bands containing a mixture of one-third vermiculite, one-third styrofoam, and one-third peat. We put these bands in a bed which was surrounded with a plastic windshield and covered with cheesecloth. We installed a timing device which operated between 6 A.M. and 8 P.M. at a frequency of one minute on and four minutes off. All cuttings rooted within two weeks with the exception of *Taxus spp., Juniperus hetzi,* and *Ilex opaca.* The *Ilex* rooted in three weeks, the Juniper four, and the Taxus took about six weeks.

In this operation we attempted to get a finished product with the minimum amount of labor. The rooted cutting is ready for shipment, in a light weight medium. We found that by using this method we obtained better results in a shorter period of time than if we had used a greenhouse. It is a very cheap operation enabling us to sell a better product for less money.

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MODERATOR MAHLSTEDE: Last in the sequence of discussions of propagation techniques under mist I have asked Mr. A. R. Buckley, of the Dominion Arboretum, Ottawa, Canada to speak on some of his observations regarding the rooting of cuttings under mist and under polyethylene tents.

Mr. Buckley presented a discussion "Mist and Polyethylene Tents for the Rooting of Softwood Cuttings." (Applause.)

MIST AND POLYETHYLENETTENTS FOR ROOTING SOFTWOOD CUTTINGS

MR. A. R. BUCKLEY

Curator, Dominion Arboretum, Ottawa, Canada

Ladies and Gentlemen: First of all, I would like to take this opportunity to express my pleasure at being here at this meeting.

We at the Arboretum have quite a different problem from most of you, in that we are primarily concerned with rooting cuttings of woody plants in small numbers. After they have been rooted they are either placed on the grounds or occasionally disseminated to interested personnel. We had this past year the intermittent mist unit operated both with the minute timer and Electronic Leaf, as well as polyethylene tents, which were without mist. We had only minor difficulties with the Electronic Leaf control unit itself, although a malfunction of the solenoid valve necessitated replacement.

We started out with the idea of tying to determine what one of the particular methods of propagation was best. Unfortunately we had an excellent summer from the propagating standpoint and consequently it would be really impossible to say that one method was any better than the other, unless we interpret it in other terms.

We had less difficulty this year with plant survival after rooting. Although rooted cuttings transplanted from a mist bed gave us particular trouble last year, the difficulty was minimized this year. We never have had a problem transplanting from polyethylene tents.

The polyethylene tent was constructed of ordinary one-inch lumber in the form of a tent. The wood form was covered with half-inch chicken wire which in turn was covered with 1½ mil. polyethylene and factory cotton. Each frame is an individual unit and therefore portable. These frames were watered regularly three times a week. During the summer just past, the temperatures were extreme. Under these polyethylene tents the maximum temperature of 124° F. was not uncommon. If we haven't discovered anything about propagating we discovered that some plants can withstand extremely high temperatures without burning. There were some types which did burn severely. This was experienced generally when we took very soft cuttings, i.e., *Ulmus carpinifolia* which within two days from the date of placement were completely brown. This was also true of *Taxus* and juniper cuttings as well as *Fagus sylvatica aspenifolia,* the Fern-leafed Beech.

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There definitely is a difference in the type of root system produced by cuttings under mist and under polyethylene tents. Cuttings of *Forsythia ovata* under polyethylene tents, for example, produced a more fibrous root system than those under mist. Cuttings under mist produced a long, unbranched water type root, which later branched. At this later stage a cutting of this type is easier to transplant.

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MODERATOR MAHLSTEDE: For the second part of our discussion this afternoon we turn from rooting techniques to a subject that I think is near and dear to all of us who have used mist, namely methods of carrying cuttings overwinter once they have initiated and developed roots. For all practical purposes there are four ways this can be accomplished, i.e., (1) place them in transplant beds or in the field immediately after rooting, (2) leave the cuttings in the mist bed overwinter, providing a mulch and shade, (3) root them in plastic squares or in plant bands, with subsequent placement in deep frames overwinter, (4) roll wrap the cuttings in polyethylene and store overwinter in a refrigerator.

Therefore without further discussion, I would like to read a paper prepared by Mr. Albert Ferguson, which describes his procedure for handling rooted cuttings from mist bed to field.

Mr. Fergusons' paper entitled "Our Experiences in Transplanting from the Mist Bed" was read by the moderator.

OUR EXPERIENCES IN TRANSPLANTING FROM THE MIST BED

MR. A. B. FERGUSON

Linn County Nurseries, Center Point, Iowa

In our operation we have attempted to develop a system that would take as little labor as possible in hardening-off cuttings propagated under mist and in getting them established in field beds where they can develop. Our efforts up to this point have been experimental, but our results have been so gratifying that we intend expanding the operation next year.

Cuttings of *Lonicera claveyi, Spirea bumalda crispa, Hydrangea p.g.,* and *Ribes sp. Red Lake,* placed under mist on May 18th to May 20th were transplanted on June 20th. Cuttings were made generally from the terminal portion of shoots and ranged between six and ten inches in length. In preparing the bed for transplanting the first operation involved cultivation and leveling. As soon as this has been accomplished the soil was watered thoroughly with an overhead sprinkling system in order to have the soil in a moist workable condition. This was done two or three days before planting.

When we were ready to plant, the first step was to make the furrows for planting. For this purpose we so arranged five shoes on a lightweight

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When we were ready to plant, the first step was to make the furrows for planting. For this purpose we so arranged five shoes on a lightweight garden tractor so that five trenches, 12 inches apart were made in a single operation. In order to prevent the furrow or trench from becoming too dry before it could be planted we only opened-up about 100 feet at a time. While this was being done several men were taking-up cuttings from the mist bed. The cuttings were then planted in the furrows by hand at a spacing of 3 inches apart in the row. The soil was firmed around the cutting at the time it was planted.

After an area had been planted that section was soaked-down with a garden hose, covered with lath shade which in turn was covered with a roll of burlap wide enough to drop almost to the ground on the sides. We found that if we did not water the area immediately after planting with a hose it was quite difficult to get enough water through the lath and burlap if we used a sprinkler.

About a week later we removed the burlap, and fourteen days later we planted another strip moving all the shade over to the adjacent new planting. This second planting consisted of *Cornus mas* var. *elegatissima, Cornus stolonifera Kelsey, Forsythia* "Spring Glory" "Lynwood Gold" and *farrand, Viburnum dentatum, opulus xanthocarpum, lentago, pubescens, rhytidophyllum,* and *trilobum.*

Our plantings this year were made June 28, July 11, July 23, August 6, August 20, and September 12. This coming year we hope that we will be able to make our plantings at 10-day intervals. If the beds are kept watered every two to three days after the shades have been removed, we believe that one week of shade should harden the cuttings off sufficiently so that they will be able to take full sun.

Evergreens were also rooted under our mist facilities. These were planted in a manner similar to that which has been described for the softwood cuttings. Cuttings which had been taken the first 15 days in July were planted out as heavily rooted cuttings about September 15. After planting these cuttings were mulched with straw, but were not shaded.

Next year we plan to space our rows so that they can be tractor cultivated and dug. Five rows, spaced 12 inches apart with a 24 inch space for the tractor wheels between beds will be used. Using this spacing the second and fourth row can be dug and the three remaining rows can be left in place to grow another year. A portion of the softwood cuttings planted early this summer were dug this fall.

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MODERATOR MAHLSTEDE: Still another method of handling rooted cuttings is to leave them in the bed overwinter. To describe this sequence we have asked Mr. Merton Congdon to develop the subject.

Mr. Congdon presented his paper entitled: "Hardening and Overwintering Cuttings in Beds." (Applause.)

HARDENING AND OVERWINTERING CUTTINGS IN BEDS

MR. MERTON CONGDON

Congdon's Wholesale Nursery, North Collins, N.Y.

My operation is comparatively small, being confined to softwood cuttings of the more common shrubs. For example, we have been very successful using mist to root the common varieties of such genera as Spiraea, Weigela, Philadelphus, Hydrangea, Ligustrum, Viburnum and Hypericum.

I spent considerable time two years ago with Mr. Fillmore while he was employed in Shenandoah, Iowa. Basically our mist beds have been patterened after those which he and Mr. Ward described to the membership last year. Since we were very much dissatisfied with the Electronic Leaf because it was altogether too sensitive to wind eddies, we switched to the 24-hour clock, coupled with the one-minute timer. The 24-hour clock was initially set up to operate between 8:00 o'clock in the morning and 8:00 o'clock in the evening. We are on the south shore of Lake Erie where we get considerable dew at night and so perhaps it was not necessary for us to start it off in the morning as some of you who are not in such favorable locations.

At the outset, the minute timer was set to function from ten to fifteen seconds out of each minute, depending on weather conditions. As the rooting process started, we gradually decreased the frequency of misting to a point where it was operating only four seconds out of the minute. As far as hardening-off is concerned, we gradually decreased the misting period through the use of the 24-hour clock. In the first stages the clock was set to function from 8 A.M. to 8 P.M., then from 9 A.M. to 7 P.M., and so forth, back to 2:00 P.M. at which point it was shut-off completely. We had absolutely no trouble in handling the items with this clock system.

Now, as far as overwintering is concerned, we would not dream of putting any labor or expense into disturbing these plants until they were ready for the field. Using the stratified medium, the cuttings root down through the sand, into the peat, and finally into the soil, which in our case is a sandy loam. This soil layer under our bed, of course, is fortified with a commercial fertilizer, at the time of preparation.

After the first light frost in the Fall, we take several precautions to protect the stock in the event of an unseasonal cold snap. A number of bales of straw are hauled to the area and in a matter of minutes, if we think we are going to get a severe drop in temperature which might injure the cuttings in the bed, the entire area can be mulched. This is not done with the intention of leaving the straw on, but is a precautionary measure we use in case we get one of those severe temperature drops.

So far as the permanent cover is concerned, we use two methods which are essentially the same, namely reed mats and lath shade covered with straw. We have a slight preference for the reed mats since it is light in weight and gives slightly better protection. The lath is used at times because it is readily available, being used in our operation throughout the summer for shading.

Now you say that this is very nice, but there may be a rodent problem; you are right, there is. We would be particularly troubled with mice if we did not use poisoned bird seed as a control measure. This seed which contains thalium sulfate can be obtained from any exterminating concern. We take cylindrical cans, such as the type that canned grapefruit juice comes in and place a few tablespoonfuls of the poisoned bird seed in them. These cans are then placed under the straw cover and tilted so that the seed doesn't quite roll out. The action is almost instantaneous.

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MODERATOR MAHLSTEDE: For another method of handling mist propagated cuttings overwinter, I will call on Mr. Ralph Shugert of Forrest Keeling Nurseries, Elsberry, Missouri, who will discuss banding.

Mr. Shubert presented his paper entitled: "Handling of Rooted, Mist Propagated Cuttings in Plantbands." (Applause.)

HANDLING OF ROOTED, MIST PROPAGATED CUTTINGS IN PLANTBANDS

MR. RALPH SHUGERT

Forrest Keeling Nursery, Elsberry, Missouri

Our procedure for handling rooted cuttings from mist is to bring the cuttings to the potting bench and pot directly into cypress plantbands. The cypress bands are set up in flats, and after a flat is filled it goes into a "storage area," for a hardening-off period. In 1953 and 1954 we experienced, in certain varieties, losses immediately after banding-off. This past summer we used a shade house which provided approximately 70% shade. As added insurance, we have two auxiliary mist lines, manually operated, using the Florida "B" type nozzle, with the nozzles spaced on twelve foot centers. The operation of these lines held down top dessication and assisted materially in the development of a secondary root system.

After the cuttings have rooted out in the bands, the flats are then moved to an unsheltered propagation area. At this location each band is removed from the flat and placed in beds—five feet in width—on a sand base. The thin layer of sand encourages roots to stay within the band and not grow down into the underlying soil strata. We have found that two or three inches of sand aids materially in lifting the bands when it is time to line the plants out in the field.

The bands then remain in this area until fall transplanting time, or may even remain over the winter,—with a sufficient straw mulch, until spring. At transplanting time they can go in the ground with or without the bands affixed to the soil ball. At the Forrest Keeling Nursery we remove the cypress bands before planting.

I have neglected to mention our potting soil, but as most of you know, we use the John Innes formula with a #1 base. We shall continue the use of John Innes compost next year, with certain modifications.

Our bands are cypress, and I don't believe I shall add to that statement, except to make mention of the fact that we anticipate using some if we did not use poisoned bird seed as a control measure. This seed which contains thalium sulfate can be obtained from any exterminating concern. We take cylindrical cans, such as the type that canned grapefruit juice comes in and place a few tablespoonfuls of the poisoned bird seed in them. These cans are then placed under the straw cover and tilted so that the seed doesn't quite roll out. The action is almost instantaneous.

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After the cuttings have rooted out in the bands, the flats are then moved to an unsheltered propagation area. At this location each band is removed from the flat and placed in beds—five feet in width—on a sand base. The thin layer of sand encourages roots to stay within the band and not grow down into the underlying soil strata. We have found that two or three inches of sand aids materially in lifting the bands when it is time to line the plants out in the field.

The bands then remain in this area until fall transplanting time, or may even remain over the winter,—with a sufficient straw mulch, until spring. At transplanting time they can go in the ground with or without the bands affixed to the soil ball. At the Forrest Keeling Nursery we remove the cypress bands before planting.

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That very briefly is our procedure in handling rooted cuttings in bands. In summation, we believe the most critical phase of mist propagation is not the rooting period, but rather the hardening-off process from the time the rooted cutting is removed from the mist house until it is established on the plantband. We feel the extra shade, and careful watering, during this critical time to be extremely important.

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MODERATOR MAHLSTEDE: Last, but by no means last, it gives me a great deal of pleasure to introduce to you a fellow who I am sure you all will be hearing more about in the years ahead. As a graduate student at Michigan State University he has been doing some very interesting work in the field of Plant Propagation. Here to discuss "A New Approach to the Problem of Rooting Cuttings under Mist" is Mr. Dale Sweet. (Applause).

A NEW APPROACH TO THE PROBLEM OF ROOTING CUTTINGS UNDER MIST

MR. DALE SWEET

Michigan State University, East Lansing, Michigan

I would like to discuss a few points about the propagation and survival of difficult-to-root plants. There are certain fruit stocks which we are particularly interested in from the standpoint of being able to root them economically on a commercial basis.

The mound or trench layering method of propagating fruit stocks is laborious, necessitates the use of heavy equipment and takes a lot of crop land out of production. Consequently, for the propagation of such material as the Mahaleb Cherry, which has to be clonally propagated, it would be desirable to have a simple method of rooting cuttings. This project has been under study for the last two or three years at Michigan State.

Our research has made use of a combination of several techniques and practices currently in use. One is the mist technique. Another one is the polyethylene tent method of propagation; and the third is the use, especially in Europe and certain hot, dry areas of the United States, of air washing for cooling greenhouses.

This past summer, after considerable study, not only of the literature, but also of the propagation operations in mist beds in the south, we came to the conclusion that we would have to manufacture an atmosphere, possibly with controlled wind movement in which to root cuttings of these difficult-to-root plant types. With this in mind we constructed an experimental rooting chamber. The first step involved the selection of suitable greenhouse bench, one which was approximately 25 to 30 feet long.

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This bed need not have been in the greenhouse. A frame six inches deep was built for the two mediums, ie. German peat and No. 1 vermiculite. These media were used in parallel fashion with a central partition along which a line of V-shaped mist nozzles were regularly spaced.

Eighteen inches above the bed, supported on uprights and cross wires was a tent of two mil. polyethylene film which extended down the length of the bed. The film did not have to be fastened down. One end of the chamber was allowed to remain open, while at the other end a 10 inch exhaust fan occupied the opening. One percent evaporation is all that is required to lower the temperature in polyethylene tents; this, of course, was done by the use of the fan. This typical air washing technique also made use of an excelsior pad, which caused a certain amount of static resistance. However, with the 10-inch fan, which was slightly oversize for the size tent we were using, there were some five or six changes of air per minute. We estimate that this size fan would work better on a 30 or 40 foot bench than it would on a 20 or 25 foot bench.

I would like to point out some of the temperature relationships in this particular experiment. The temperature record for the greenhouse on July 25 for the entire 24 hour period shows an extreme in the middle of the day and a low at night. The temperature in the vermiculite medium averaged about two degrees warmer than that in the German peat. Both media were approximately 2 to 5 degrees warmer, half the period, or 12 hours of the 24-hour period than the air temperature. Over the entire 24-hour period the temperature fluctuated in the actual area of the leaf only 12 degrees. In July we had extremely high temperatures during which a maximum of 83°F. was recorded in the leaf area of the cuttings under the tent compared to 110°F. recorded on several occasions in the greenhouse proper. There was not only a noticeable difference in temperatures but it was significant to note that by air washing a very uniform temperature was maintained in the atmosphere immediately surrounding the cuttings.

For rooting comparisons we used a variety of cutting material including peach, several clones of Mahaleb cherries and the EM VII apple rootstock. The Mahaleb clone began rooting in about 15 days. Within 25 days we had 98 percent rooted. If these cuttings were allowed to remain under the mist for periods of 35, 45, or 52 days we obtained a graduated decreasing survival. In other words, cuttings allowed to remain under mist for 52 days when transplanted would remain in a state of suspended dormancy during which they showed no signs of activity. This was true of cuttings of other plants such as the peach.

Cuttings of East Malling VII surprised us, since we were accustomed to a 6-8 week period required to root layered shoots. I was quite disturbed at first because after three weeks I had nothing but callus and after four weeks callus plus a few roots. Shortly after I decided that I would take them out and as I began removing them I found that they all had rooted. A few were potted while the remaining were left in the bench. Within six weeks these cuttings had produced large balls of roots fully 3-4 inches in diameter. Half of these cuttings were placed in a cold storage to satisfy the rest period while the remainder were placed in 4-inch pots. At the present time there is about two feet of growth on the Mahaleb cuttings which were transplanted after 25 days in the rooting medium.

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MODERATOR MAHLSTEDE: Thank you Dale for a very interesting discussion. The time has now come for questions.

MR. HUGH STEAVENSEN: I would like Mr. Congdon to describe the stratified rooting medium that he is using.

MR. CONGDON: We prepare our beds in May well before they are able to be used in June or early July. The beds which we have used the previous year are excavated by using a Ford tractor fitted with a rear bucket. The loam which is left is then fortified with a 5-10-10 formula of a commercial fertilizer. It is then leveled off at the desired height. A one-inch peat moss layer is then spread over the soil and rolled down with a heavy lawn roller. In connection with wetting the peat moss we have found that the only practical way to prepare it is to purchase it a year in advance, placing it under the eaves of a building where it remains until use. After the peat has been rolled, about an inch and a half of sharp sand is applied over the top of the bed. The depth of this sand layer varies somewhat with the type of material we intend placing in the bed, since we want to have the cutting completely pierce the sand medium and contact the peat.

MR. STEAVENSEN: I presume you use German peat?

MR. CONGDON: That is correct.

MR. WELLS: Not a question but a comment on the preparation of peat. We prepare it using either a spreader or a gasoline powered hammermill. We fix a hose on the entrance to the machine, turn it on, shovel peat into the mill and it comes out moist and shredded. Four men, for example, shredded 50 bales of the Jumbo size bale in three hours.

MR. TONY SHAMMARELLO: I would like to ask Mr. Sweet if he could tell us a little more about the leaching of nutrients from cuttings under mist?

MR. SWEET: We have had several reports, not just our own, but from Europe as well, that there is considerable loss of nutrients from plant during a heavy rainfall, as well as from cuttings propagated under mist. From our experiments with radioactive isotopes considerable quantities of phosphorus, nitrogen and very large quantities of potassium, in some cases as high as 75 percent in four hours time are evidently leached from the leaves.

Another aspect of this problem was uncovered recently when we took sections of leaves from cuttings which had been under mist for 15 days and compared them microscopically to sections of leaves from cuttings which had not been under mist. The leaves from the fruitstock cuttings which had not been propagated under mist were full of nutrients; the palisade layer in particular. The stem, on the other hand was highly meristematic and apparently did not contain an overabundnce of nutrients. When we looked at sections of leaves from cuttings which had been under the mist for 15 days the palisade layer, as well as the other tissues of the leaf were completely devoid of food. The cells in the leaf, however, as indicated by the condition of the nuclei were very meristematic. Sections of the stems of these mist propagated cuttings appeared to be completely full of nutrients.

From a comparative test with strawberries we concluded that there was a rather large transfer of nutrients from the blade, down the petiole and finally into the stem. This could be interpreted to mean that possibly the stem of a cutting propagated under mist is serving to store the food materials early, thereby aiding the rooting of the cutting. I might point out in conclusion that this is just an idea which we will have to substantiate.

DR. NITSCH: I would like to ask another question of Mr. Sweet. Would you comment on this dormancy induced by mist?

MR. SWEET: I cannot say that it is a case of true dormancy. It apparently is a physiological condition mediated by the number of days that the cutting is allowed to remain under mist. Another point that I would like to mention in passing is the formation of a considerable number of flower buds on cuttings held under mist for a long time. This possibly could be tied up with the accumulation of foods and nutrients in the stem of the mist propagated cutting.

MR. HANCOCK: I am amazed at the results obtained by Mr. Sweet in his wind tunnel. Last year Mr. Bailey reported on a humidification system which makes use of compressed air and a jet of water. Would Mr. Bailey like to comment on his observations?

MR. VINCENT BAILEY: Our humidification system is the common Binks system and is used in conjunction with our summer propagation schedule in the greenhouse. We have noticed that temperatures are somewhat lower in houses equipped with this system.

MODERATOR MAHLSTEDE: Are there any other questions about mist equipment or the technique of mist propagation?

MR. WALTER CHESPAK, JR. (New Brunswick, N.J.): Has any work been done on the grafting or budding of plants under mist?

MR. CHARLES E. HESS, JR.: In 1953 when we were working with a misting cycle of one minute on, nine off, we made a number of grafts and compared mist with the double sash and open bench systems. We found that we obtained less callus formation on the grafts which had been placed under mist. When the graft was removed the slightest pressure on the scion would dislodge it. We think possibly that we might have had difficulty because of the large volume of mist which was being applied. In the process we were slowing down callus formation which resulted in a very poor union. I think with grafting we have to reach the point where we are humidifying instead of misting.

MODERATOR MAHLSTEDE: If there are no more questions, I wish to express my gratitude to all those who have participated in this afternoon's program. Mr. Fillmore, will you please take over.

President Fillmore resumed the chair.

PRESIDENT FILLMORE: There will be a business meeting immediately following this brief recess. Only those who are members are entitled to vote and to participate in the discussion.

Brief recess.

FIFTH ANNUAL BANQUET

Following the banquet, President Richard H. Fillmore called the meeting to order and introduced the speaker of the evening, Dr. William E. Snyder, Department of Horticulture, Rutgers University, New Brunswick, New Jersey.

Dr. Snyder presented an illustrated talk entitled "Some Horticultural Impressions of Europe."

At the conclusion of this discussion, the Fifth Annual Meeting of the Plant Propagators Society adjourned *sine die* at 10:00 p.m.