MODERATOR LANCASTER. Thank you Our program this morning, as you have all noted from your bulletin, is broken into three categories. First, A Study of Plant Growth Substances in Easy and Difficult-to-root Cuttings; second, a panel discussion on the quick-dip method of using growth substances, and finally a discussion of the Budding of Dogwood in the Field.

We will hear from our speakers and then immediately following each speaker or panel we will have a short question and answer period.

As I walked into the hotel yesterday evening, one of the first gentlemen I bumped into was my good friend Hugh Steavenson. In the conversation we eventually talked about the wintering of container stock. He said, "We have the answer down in St Louis." I knew they were much, much colder than we are I became very much interested. He went on and explained that "What we are doing, we are selling all of our plants." I thought I would pass that along to you gentlemen.

Without any more ado, may I present Dr Charles E. Hess, Department of Horticulture, Purdue University, who will report to us on "A Study of Plant Growth Substances in Easy and Difficult-to-root Cuttings." Dr. Charles E. Hess! (Applause)

DR CHARLES E HESS: Thank you very much, Art

It is interesting that in the history given by President Nordine that the Propagators Society sort of died out at the time it did. A couple of years later, in 1935, the first identification of the natural hormones in plants was realized. This marked the beginning of the use of hormones to stimulate root initiation, and there have been thousands and thousands of papers dealing with the use of hormones to stimulate root formation. This morning I would like to spend some time on these, and then discuss some new aspects that we are getting into, finding that plant hormones themselves are not the entire answer.

A STUDY OF PLANT GROWTH SUBSTANCES IN EASY AND DIFFICULT-TO-ROOT CUTTINGS

CHARLES E. HESS
Purdue University
Lafayette, Indiana

Since 1935, the use of plant hormones to induce roots on cuttings has received a tremendous amount of attention. However, 1935 did not mark the beginning of the use of plant hormones, since Dutch propagators used a form of root inducing hormone over 100 years ago.

The Dutch propagators split the base of a difficult-to-root cutting and inserted a wheat grain. The "prepared cutting" was stuck into a medium, and rooted faster and in higher percentages. Today, we know that the reason for this response was that as a wheat grain germinates it releases auxins or plant hormones. As the auxins were released by the germinating grain they were absorbed by the cutting and rooting was stimulated.

Auxin is another term for the natural hormone produced in plants. This natural hormone produced in the young leaves and in the buds of the plant, moves down the cutting to the base. If the cutting was left on the parent plant, the auxins would just keep moving down the stem. However, as soon as we take the cutting, the normal pathway of the auxins is blocked and so they start accumulating at the base of the cutting. After the auxins reach an active concentration, roots will be initiated. Also, as you remember from some of the work I presented at a previous meeting (December, 1954) we know that sugars and other food materials also move down the stem and accumulate at the base of the cutting.

Now you may ask, if a plant is going to manufacture its own auxins or hormones, why go to the trouble of applying more? Well, one practical reason is that even though a cutting is easy to root, we can still get an increased rooting response by adding a synthetic auxin. In other words, in many cases the rooting response that occurs normally is not as great or as fast as the propagator would like. We want to speed up the reaction and get more roots on the cutting so we will be sure that we will have a uniform stand and one which will quickly reestablish its root system when potted up.

An example of this can be seen with cuttings of *Hedera helix,* the English ivy. The juvenile form, which is used as a ground cover, roots very easily. With no treatment at all, we get an average of four roots per cutting. However, if we treat them with napthaleneacetic acid, a root promoting substance, we increase the number of roots to 20 per cutting.

A second reason why we treat cuttings with synthetic materials is that besides being able to manufacture hormones, plants have the ability to destroy them This is a safety mechanism plants have, so that if some of the buds or leaves start to produce an excessive amount of hormone, the plant can maintain a proper hormone balance by destroying the excess. In contrast, synthetic compounds are different from the ones that are made within the plant, and the plant does not have the ability to destroy them. As a result the synthetics can get into the plant and do their work without being destroyed Therefore, we have a greater response from using synthetic root promoters in comparison to the use of a natural hormone

Auxins, however, are only part of the problem. I think you all realize that the harder a cutting is to root the less it responds to the application of a root promoter The cuttings with which we really have trouble are the ones which give the least response when we apply our root promoters. An example of this can be seen with cuttings of the mature, flowering form of *Hedera helix.* 'About the best rooting we can obtain with this mature wood is 7 to 16 per cent with an average of 1 or 2 roots on those that do root Treating the mature cuttings with 50 ppm napthaleneacetic acid did not increase the per cent rooting and the number of roots was increased only from 2 to 4 roots per rooted cutting.

Apparently, there is something else involved in root initiation besides auxin and food materials since if only these two factors were involved, we should be able to increase the rooting response of mature cuttings up to that obtained with the juvenile cuttings. I feel we can say it is not food materials which are lacking because you can propagate the cuttings under mist where you have just about ideal conditions as far as food manufacture is concerned, and still the cuttings remain difficult to root In fact, the 16 per cent rooting we did get with mature *Hedera* cuttings was under mist.

What else, then, can be involved in the formation of roots other than auxins and food materials? The first lead to a solution of this problem was in a paper that was presented by Spiegel at the 14th International Horticultural Congress in the Netherlands

Working with easy and difficult-to-root cuttings of grape he found that the difficult-to-root cuttings contained an inhibitor or a substance which would block rooting rather than promote it.

To demonstrate this he took difficult-to-root cuttings and put them in a water bath and soaked them at room temperature for various periods of time ranging from 24 to 96 hours. After the cuttings were soaked, he planted them in the medium and found that they were much easier to root. It seemed that during this period of soaking something which was in the cutting was leached out, and then the cutting became easy to root.

To check this a little further, he took easy-to-root grape cuttings and soaked them in the same water in which the difficult-to-root cuttings had been soaked, and sure enough, the easy-to-root cuttings became difficult-to-root.

We decided to see if other difficult-to-root plants would respond in the same manner. We chose the English ivy as a plant to study, not only because we had a great difference in rooting between juvenile and mature forms, but also because we could get both forms of cuttings on the same plant In this way we were assured that the material was at least genetically similar, which may not be the case when you are using varieties.

The first thing we did was to make cuttings of the mature form and soak them in water They were still difficult to root. The next step was to make extracts of the mature and juvenile tissue to see if the extracts had inhibitors. As it turned out, we found inhibitors in both the mature and the juvenile wood With these results we could not explain the great difference in rooting between the juvenile and the mature form on the basis of inhibitor content.

About this time we began working on a rooting test which made use of etiolated Mung bean cuttings. The beans are germinated in complete darkness in a room which is kept at 78 degrees Fahrenheit and 80 per cent relative humidity. Five days after germination the beans are decapitated, that is we cut off the seed leaves or cotyledons as well as the primary leaves This removes a rich source of root promoting substances Cuttings, seven centimeters long, are made from the portion of the seedling which remains and then are placed in vials, with the extracts we are testing They remain in this vial for four days, and are then transferred into water and allowed to form roots. Root formation takes about five days from the time the cuttings were first made.

The most important thing we found with this test is that these cuttings do not respond to auxin or hormones. The cuttings form a certain number of roots, which is not increased by the addition of auxin. The Mung bean cutting, then, is very similar to the mature ivy cutting, which does not respond to the addition of root-promoting substances. We now have a test with which we can find substances that promote rooting other than auxins.

We first used this test to determine the response of the cuttings to extracts of the juvenile and mature forms of ivy. Both extracts alone did not increase the number of roots produced in the Mung bean cuttings Mixing the mature extract with auxin also, gave little increased rooting However, when we mixed the juvenile extract with auxin, we obtained a very large increase in the rooting response. From this and similar experiments we concluded that in the juvenile cutting, which is easy to root, there are substances which promote rooting only if they are in the presence of the natural plant hormone or a synthetic, like indolebutyric acid. We call the substances we find in the juvenile cuttings, "cofactors." They won't work alone, but when you apply them in combination with auxin, you get an increased rooting response. In contrast, the "cofactors" are lacking in the mature cuttings.

This can also be shown in an experiment in which a scion of juvenile ivy is grafted onto a mature ivy cutting. The mature portion of the cutting-graft combination, treated with an auxin, will now root! From this experiment we assume that the cofactors that are produced in the juvenile scion move through the graft union into the mature cutting. When the cofactors combine with the auxin, roots are initiated.

We have also worked with the red and white flowering forms of *Hibiscus Rosa sinensis*. The white form is fairly hard to root while the red flowering form is fairly easy to root. There is also a white variety which is intermediate in its ability to root.

We have made extracts of the tissues from the *Hibiscus* to see if we would isolate the rooting cofactors Incidentally, in the easy-to-root red variety, we had 100 per cent rooting, and averaged 15 roots per cutting. In the intermediate-to-root variety we had approximately 80 per cent rooting with an average number of five roots per cutting, and with the difficult-to-root we had approximately five per cent rooting with an average of three roots per rooted cutting From the extracts we found that the easy-to-root cutting had four cofactors or four substances which promote rooting in combination with auxin, the intermediate had three, and the difficult-to-root had one. Perhaps, with an "impossible-to-root" variety we would not find any cofactors Apparently, we can correlate the number of cofactors that are present with the ability of a cutting to root. That is, if the cutting is very easy to root it will have at least four cofactors present, if it is difficult-to-root it may have only one

We are now trying to purify these cofactors so that we can identify them. If this could be done, we could then extract them from the easy-to-root forms and apply them to the difficult-to-root cuttings and obtain good rooting. So far we have been able to do this through a graft union, but have not been able to do this with total extracts. What we would like to do now is find the chemical nature of these substances and apply them to the difficult-to-root types. It may be necessary to have a synthetic form of these cofactors so the plant cannot inactivate them, as it does its natural auxins.

It is going to be a long drawn-out effort, but we eventually hope to be able to make a difficult-to-root cutting, easy to root by feeding it with the cofactors that are missing. We hope that it will be possible to supply these substances in a concentrated dip or talc at the same time we apply the root promoters which are presently being used.

To summarize, then, although auxin or hormones play a very important role in rooting, they are not the complete answer. The more difficult a cutting is to root, the less it responds to auxin alone. In some difficult-to-root cuttings such as the grape, there apparently are inhibitors which can be leached out, making rooting easy. In other cuttings which are difficult-to-root, the difficulty seems to be due to the lack of certain substances or cofactors. The cofactors are present in the easy-to-root forms, but are absent in the difficult-to-root forms. We hope to identify these substances and be able to apply them to the difficult-to-root forms in order to render them easy to root. Thank you.

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MR. RICHARD FILLMORE (Durham, N.C.): I would like to ask whether or not those grape cuttings were dormant, leafless cuttings or whether they were actively growing, leafy ones.

DR. HESS: These were dormant cuttings at the time they were tested. This brings up a point. As a plant becomes dormant the inhibitors that are present increase. This is a safety mechanism on the part of the plant in that these inhibitors keep it from growing during occasional warm periods. You might expect, on the basis of Spiegel's experiment, that you would find inhibitors present, since they were dormant.

Another example are hardwood cuttings which might be hard to root, and show very little response to root promoters. However, you might take softwood cuttings of the same plant when it is in full leaf, and it becomes rather easy to root, in addition to showing a great response to the application of auxins. Our interpretation of this is that in the hardwood cutting the cofactor level is quite low and in the leafy softwood cutting it is fairly high. The reason we can say this is that we know the cofactors are produced in the leaves of the cutting, so if the leaves are absent you would expect the cutting to be low in the cofactors and, therefore, low in their response to an application of auxin.

MR. GERALD VERKADE (New London, Conn.): Charlie, would you say that the same thing is happening when you graft Blue spruce on Norway?

DR. HESS: Exactly. When you graft Blue spruce onto the Norway you may get up to about 25 per cent of these grafts to strike roots from the scion when they are in the grafting case. If you take just cuttings of Blue spruce and stick them under the same conditions, you may get one per cent, which is doing pretty good. Evergreens also have juvenile and mature stages of growth. When they are in the seedling stage they are usually in the juvenile condition; with continued growth they become mature. This is another reason why you can take cuttings from a small seedling of an evergreen and get it to root fairly easily. When it becomes old, it becomes more difficult to root. The Blue spruce is a clone of a mature spruce. I feel what is happening in the case of the Blue spruce is that there is a transmission of the cofactors from the juvenile Norway spruce seedling into the mature Blue spruce scion, and that is why you get more rooting when you have this graft combination than if you take an individual cutting.

MR. JIM WELLS (Red Bank, N.J.): First of all, how do you determine that there are four cofactors? Are these clearly separable?

DR. HESS: To answer that, Jim, and if it is all right, I will show you our procedure of extraction which is necessary to answer your question.

The leaves are the source of rooting cofactors because we can take isolated leaves of the juvenile form and root them without any trouble at all, and we have not been able to root the mature. So we can go back as far as the leaves and get the cofactors present in the juvenile form. These, of course, have been treated. When we make the extract, we use primarily the leaves. If we threw stems and buds in there we would have a lot more difficulty in determining what the actual sources are.

We bring the cuttings in, take the leaves off, and dry freeze them in a process called "freeze drying." The reason for this is to prevent any chemical reactions going on in the tissue during the extraction. After it has been freeze dried or lyophillized, we take a sample and extract it with alcohol. After a couple of hours of extraction we evaporate the alcohol extract to just about a dry condition, and we then add a small amount of alcohol to take the mixture back up into solution. The extract in a hypodermic needle is spotted on a piece of filter paper. This is called technically a chromatogram, which is hung in an economy sized test tube. We allow this filter paper to hang above the solvent for 18 hours and then lower it into the solvent. The solvent moves up the filter paper and after it reaches a certain point we take the chromatogram out.

In this spot are substances which have different solubilities in the solvent we use. As the solvent moves up this piece of filter paper, those substances which are most soluble will stay right in the original spot.

What we have done simply, then, is to take a mixture and separate it into several substances, by means of a chomatogram. This is cut into strips and placed in vials with Mung bean stem segments. This tells us where on this strip we find the substances stimulating rooting.

These Mung bean cuttings produce a number of roots without any treatment at all, and therefore we can also measure inhibition. In other words, there is something in the extracts that would block rooting, it will also show up.

In extracts from the red, or easy-to-root variety we had four areas in the chromatogram which promoted rooting. In extracts from the difficult-to-root white variety there were three segments which inhibited rooting and one which promoted it.

MR. WELLS: Thank you very much, Charlie. That is very complete and clear.

Is it possible to take leaves of a plant which will root easily as a vigorous soft-growing shoot and to extract from those leaves in a simple manner and freeze that material and use it on a dormant cutting? Have you done that?

DR. HESS: No. You have to first separate these components and purify them. If you use the total extract you will have both inhibitors and promoters present. Whatever effect you will get will be the net between the activity of inhibition and the activity of promotion. So far in all lyophillized extracts we have been successful in getting the stimulating effect only after we have purified and separated promoters and inhibitors.

I doubt if it will be possible to take an extract of an easy-to-root plant and apply it to hard-to-root one until it has gone through some steps of purification. This would be a nice direct application but it needs a little more purification before it is possible.

MR. WELLS: Cannot a balance of cofactors be transmitted to the same type of cutting but at a different stage in its growth?

DR. HESS: It may be possible with a combination of leaching to remove the inhibitors from a hardwood cutting and then the application of an extract from a leafy softwood cutting to get promotion. I still say I am afraid you will have to do some purification of the extract from the softwood cutting before you will get the desired effect.

MODERATOR LANCASTER: Gentlemen, if any more of you have questions, keep them in mind for the question box.

We will carry on with our program, going on to a panel discussion on quick dip application methods. Dr. Hess is going to give us some preliminary results on some work he has done. (Applause)

A COMPARISON BETWEEN THE QUICK DIP AND POWDER METHODS OF GROWTH SUBSTANCE APPLICATION TO CUTTINGS

CHARLES E. HESS
Purdue University
Lafayette, Indiana

Last year, as you will remember, we had a brief discussion as to whether the concentrated dip or the talc method would be better for the application of root promoting chemicals. As a result of this discussion we decided to see if there were any differences. We ran two experiments, one with *Taxus* and Pfitzer junipers and another one with *Rosa manetti*. In these tests we used talc and a concentrated dip at a conother words, there is something in the extracts that would block rooting, it will also show up.

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We found very little difference in the per cent rooting between the no treatment, the concentrated dip, or talc applications. We did find some difference in the quality of rooting. We found that with no treatment we had an average of 6.2 roots per cutting. With the concentrated dip treatment we had 9.5 and with talc 6.5 roots per cutting. With the Pfitzer the same response was obtained, i.e. 4.4 roots per cutting with no treatment; 10.4 with concentrated dip, and 7.2 with the talc application.

In the rose, no treatment averaged 10.6 roots per cutting, the concentrated dip treatment averaged 30.7, and the talc averaged 11.9 roots per cutting. We had quite a significant increase from using the concentrated dip treatment.

We believe that the increased response we are getting from the concentrated dip is the result of more uniform application, since the liquid can surround all of the cuttings as soon as they are dipped into the solution, and in addition more of the root promoter is retained on the cutting than with talc treatment. You will remember that with the Pfitzer and the *Taxus* we had an increase of only three roots per cutting when the concentrated dip was used. These stems are somewhat rough when you compare them to the rose. With the rose, you remember, we had a very large difference in the rooting response of cuttings treated with concentrated dip as compared with talc. Apparently, the smooth rose stems did not retain the talc but did retain the liquid from the concentrated dip treatment. In additon, the hormone in the concentrated dip is in a form which is ready to go into the cutting, whereas in the talc, it is essentially a dry chemical and takes a while before it goes into solution.

Both methods gave us approximately the same per cent rooting. The results differed only in the number of roots produced. Whether a concentrated dip treatment is better than talc is difficult to say, because you do have some disadvantages from the use of a concentrated dip. For example, the alcohol may evaporate off and you will have water left. When this occurs the root promoter that will precipitate out of it is in the acid form which is not very soluble in water. Also, light can destroy the active chemical in the concentrated dip solution faster than it can in a talc carrier. All these factors have to be taken into consideration when deciding upon which method of application is to be used. Thank you very much.

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MODERATOR LANCASTER: Thank you, Charlie, for a very interesting discussion.

We will now go right on with our panel discussion on the quick-dip method for applying hormones to unrooted cuttings. The first gentleman we are going to hear from is Mr. Harvey Gray of the Long Island Agricultural and Technical Institute, Farmingdale, New York. Mr. Gray! (Applause)

THE QUICK DIP, ALCHOLIC SOLUTION AS AN AID TO ROOTING CUTTINGS

HARVEY GRAY
Long Island Agricultural and Technical Institute
Farmingdale, New York

My short discussion on the quick-dip alcoholic solution as an aid to rooting cuttings is based on the work that we have done with this method of application at the State Institute at Farmingdale. I must hasten to add that the bulk of our work is based on the report of Drs. Hitchcock and Zimmerman which appeared in the Contributions of the Boyce Thompson Institute, back in 1939. This material will be found in Volume 10 of this publication.

Our quick-dip liquid treatments make use of a two per cent stock solution made by taking two grams of indolebutyric acid and dissolving this in 100 cubic centimeters or milliliters of 95 per cent ethyl alcohol.

The indolebutyric acid is made available to us at approximately one dollar a gram from the Eastman Organic Chemicals Co., Rochester, New York.

A simple way of making up a stock solution of two per cent is to order a five gram quantity of the material and place it in a dark glass, stoppered bottle. To this would be added 250 c.c. of the ethyl alcohol. The stock solution bottle is then placed in our refrigerator running at 41 degrees Fahrenheit.

If we use the stock solution as is, we will be working with a 20,000 parts per million concentration. This is, of course, a very strong concentration for practically anything that you would attempt to root. About the only thing that we find this concentration has value for is such things as the rhododendron. For treating cuttings of other plants where lesser concentrations are advisable, we dilute this stock solution.

In diluting this material, we might estimate that we need 60 cubic centimeters of a 10,000 parts per million solution to treat a certain batch of cuttings. We would then take 30 c.c. of the stock solution and an equal amount of water to bring it to 10,000 p.p.m. If we were desirous of having, let's say 5,000 parts per million, which in a sense would be somewhat comparable to Hormodin No. 2 in the powder form, we would take, let's say, 30 c.c. of the stock solution and then we would take 30 times three, or 90 c.c. of tap water to make up our working solution.

Now, no more stock solution is taken from the stock solution bottle than is required for the treatment of a certain batch of cuttings. The treatment is made by submerging the basal ends of the cuttings in our working solution for just a moment, say three to five seconds. Then we remove the cuttings and tap the excess back into the working solution container.

Now when we have reached the end of this batch of cuttings and we do not foresee any more use for this solution for the balance of that day or if we have finished the job, this material is thrown away. There is no serious dilution during the course of treatment, since the stock solution is tightly stoppered in our stock solution bottle and we make up no more material than what we figure is needed to do the job.

We use the alcoholic quick-dip treatment on genera considered to be difficult to root. However, we are not always assured of success, for we have obtained both positive and negative results. Specific concentrations do not produce uniform results from year to year nor from season to season. Negative results often show up as follows:

1. Excessive rooting. This oftentimes is followed by a retardation of root development.

2. The buds are affected by what I choose to call deep sleep or a state of extra dormancy. This is particularly true in the case of cuttings from those plants that are in the dormant condition.

3. An actual killing of the treated area at the base of the cutting.

Now although we have had good results with the quick-dip alcoholic solution treatments with a variety of plant materials we still prefer the powder treatment of cuttings. Our use of alcoholic solutions is pretty much limited to instructional and demonstrational tests rather than a recommended practice. Thank you.

MODERATOR LANCASTER: Thank you Harvey.

Our next speaker on the panel will be Thomas S. Pinney, Jr. from the Evergreen Nursery Company, Sturgeon Bay, Wisconsin. (Applause)

Mr. Pinney then presented his paper on the procedures he uses to treat cuttings by the quick-dip method.

THE METHOD OF QUICK DIP HORMONE TREATMENT OF CUTTING WOOD AT THE EVERGREEN NURSERY CO.

THOMAS S. PINNEY
Evergreen Nursery Company
Sturgeon Bay, Wisconsin

Since this discussion is limited to five or six minutes, my remarks will be brief and concerned with the generalities of our quick dip hormone program. If anyone is interested in further detail, I would be glad to discuss it with them at their convenience.

Through trial and error we have found that indolebutyric acid has been the most satisfactory chemical for our purpose. We have used alpha naphtaleneacetic acid and napthaleneacetamide in test work only. They have proved to have a very narrow effective range while IBA has a much wider spectrum. A wider range means less chance of injury due to inadvertent errors. The results obtained from the three chemicals were quite similar.

We use 95 per cent ethanol as the solvent but are endeavoring to find another carrier not subject to the beverage tax which will act as a solvent for IBA and still be miscible with water.

The general formula for making up the concentrate is one gram of IBA per 100 C.C. of 95 per cent ethanol. This results in a 10,000 ppm IBA concentrate. It is of prime importance to add the ethanol to the IBA, not the reverse. The concentrate can be stored up to three months in a dark place in a sealed brown bottle at 40 degrees Fahrenheit. It may be possible to store it for a longer period, but at the pre-

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The general formula for making up the concentrate is one gram of IBA per 100 C.C. of 95 per cent ethanol. This results in a 10,000 ppm IBA concentrate. It is of prime importance to add the ethanol to the IBA, not the reverse. The concentrate can be stored up to three months in a dark place in a sealed brown bottle at 40 degrees Fahrenheit. It may be possible to store it for a longer period, but at the present time we know that this storage period results in a very negligible change in the concentration.

We use a range of concentration between 1,000 ppm and 2,500 ppm, depending on the cutting material. This varies with the species as well as the physiological and anatomical status of the cutting wood. The concentrate is diluted through the use of distilled water. We have made up a detailed chart giving the exact proportions of the concentrate and distilled water necessary to make a given volume and concentration. Again, it is important to add the distilled water to the concentrate, not the reverse. We feel that accuracy is extremely important so as to keep to a minimum the possibility of errors. We also add a fungicide such as Captan to this solution. We have experienced difficulty at various times with flocculation which results in the precipitation of the IBA. The chemistry of this particular solution unfortunately is not too well developed, and as a result it is hard to predict when or if the problem will occur. If difficulty is experienced, either additional ethanol may be substituted for a part of the distilled water or the temperature of the solution may be raised.

The application of the hormone is simple. The first step is to place two to three inches of the solution in a large open dish. Next, the ends of the cuttings are cut off even on a paper cutter and dipped into the solution for one second. They are then handled in the usual manner and stuck in perlite. The dish containing the solution for dipping is never allowed to stand exposed for over two or three hours due to the possibility of change of concentration through evaporation. There is no way that we know of detecting how rapidly the concentration of solution changes in the open dish, so we take all precautions that are economically feasible to keep this change to a minimum. We do not feel that it is a very serious problem since when we get down to an inch or so in the container, which is normally two to three hours dipping times, we throw it out and put in fresh material. We always wash the container thoroughly before adding any fresh solution. This also keeps to a minimum the possibility of transferring disease, which is another reason why we add a fungicide.

We have found this method to be rather effective on most types of junipers, *Taxus,* and arborvitae. It may only increase the percentage by a small amount over common type power hormones, but the real value appears to be in the quality and extensiveness of the root system. It also is very flexible in allowing us to change our concentrations whenever we feel we can benefit by doing this, and it lends itself well to experimental work. Our experiments contain at least 1,000 cuttings and usually 5,000 per test. It cost us last year about $60.00 to treat 144,000 cuttings, which represents our total evergreen cuttage operation. We feel this is rather economical.

The advantages of this method in our small operation are, — One, we know very nearly the concentration we are applying, whereas with powder hormones very often they have been on the shelf for a long time and their effectiveness could be greatly decreased, which results in an erratic performance from year to year. Secondly, we have been able to develop a good enough quality root system on such plants as Pfitzer juniper in seven months (69%) as to allow us to plant the cuttings directly in the field under irrigation with a great saving in labor.

Another factor is that we nurserymen all want to restick, we don't want to throw a cutting away. Well, you never have to bother to restick after using the higher concentrations. It is either rooted or dead. This makes our decision quite simple. Thank you.

* * * * *

MODERATOR LANCASTER: Our next speaker is John Roller, Verhalen Nursery Company, Scottsville, Texas, which incidentally is in the second largest state.

MR. JOHN ROLLER: It is the largest state in the Union without polar bears.

Mr. John Roller presented his discussion on the use and effects of the quick-dip method for treating cuttings. (Applause)

PREPARATION AND USE OF QUICK DIP SOLUTIONS ON CUTTINGS

JOHN B. ROLLER
Verhalen Nursery Company
Scottsville, Texas

We have been using this quick dip method for five years now, and the way we mix our solution is quite similar to that described by Mr. Gray and Mr. Pinney. The only difference is that we use two grams of indolebutyric acid and two grams of napthaleneacetic acid in order to get a little wider range for plants which might benefit. Now this is mixed in 200 c.c. of isopropyl alcohol, or the common old rubbing alcohol which costs about nineteen cents a pint. We went through the red tape to obtain ethanol and we finally came to the conclusion that we could see no difference whatever in the results between isopropyl and ethyl alcohol

Although we have been using this quick dip method for a relatively long time I have had the same results as Harvey Gray has had, that is, inconsistent rooting.

For one of the concentrations that we use, I take 10 c.c. of the stock solution and mix this with 90 c c. of tap water We use five, ten, and twenty per cent solutions.

Our cuttings are made, dipped and stuck I have had 100 per cent rooting on some types of cuttings which for me were usually difficult to root. For example, we have a dwarf blue Pfitzer which would take sometimes 18 months to root, and then with a very low percentage. By actual count we were able to root 100 per cent in small batches.

I am not going in too much detail about mixing these solutions since it is quite similar to what you have already heard. I have found develop a good enough quality root system on such plants as Pfitzer juniper in seven months (69%) as to allow us to plant the cuttings directly in the field under irrigation with a great saving in labor.

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I am not going in too much detail about mixing these solutions since it is quite similar to what you have already heard. I have found that with cuttings that have been handled every year over this five year period I could expect anywhere from 29 per cent to 100 per cent rooting. I do not know why this occurs. Consequently, I do not recommend the use of the quick dip except as a trial on something that is really giving you trouble. It has been of benefit to us on certain species of cuttings at certain times of the year, and it has speeded up the rooting of Pfitzer juniper cuttings. One year juniper, for instance, gave us 72 per cent rooting and were ready to pot in six weeks. It never happened again. Thank you.

*   *   *   *   *

MODERATOR LANCASTER: Thank you, John.

Our next and final panel speaker is Mr. E. Stroombeek, from the Warner Nursery Company, Willoughby, Ohio.

Mr. Stroombeek presenter his prepared paper, "Hormone Application by the Quick-dip Method." (Applause)

HORMONE APPLICATION BY THE QUICK DIP METHOD

E. Stroombeek
Warner Nursery Company
Willoughby, Ohio

We at the Warner Nursery decided to give the so-called "quick dip" method a try in the summer of 1953. We had been using the Hormodin powders No 2 and 3 exclusively and had found their range to be quite limited We were looking for a stronger concentration of growth substance, as for example, especially 2 per cent indolebutyric acid Since this was not commercially available we bought a small quantity of pure crystals in order to prepare our own solution.

When this substance was obtained we made some tests, diluting crystals in alcohol in approximately the same percentage range as the Hormodin powders, namely ½, 1 and 2 per cent It turned out that dipping in these straight alcohol solutions was not satisfactory and resulted in considerable burning. Adding small quantities of water to these solutions gave more encouraging results but we soon found out that adding too much water to the 1 per cent and 2 per cent alcohol solutions resulted in the recrystallization of the indolebutyric acid. This rendered the solution useless. At the same time we also found that indolebutyric acid diluted in alcohol in the lower percentage range was more effective than the higher percentages available in powder form For instance ¼ per cent indolebutyric acid in solution in alcohol plus water, was more effective than Hormodin No. 3,

From this point on we concentrated on these lower percentage solutions and had increasingly good results using them on evergreen as well as various softwood cuttings. We gradually used less powder formulations, and in 1955, after giving the controversial chloromone a that with cuttings that have been handled every year over this five year period I could expect anywhere from 29 per cent to 100 per cent rooting. I do not know why this occurs. Consequently, I do not recommend the use of the quick dip except, as a trial on something that is really giving you trouble. It has been of benefit to us on certain species of cuttings at certain times of the year, and it has speeded up the rooting of Pfitzer juniper cuttings. One year juniper, for instance, gave us 72 per cent rooting and were ready to pot in six weeks. It never happened again. Thank you.

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From this point on we concentrated on these lower percentage solutions and had increasingly good results using them on evergreen as well as various softwood cuttings. We gradually used less powder formulations, and in 1955, after giving the controversial chloromone a try, we switched our entire hormone application to the quick dip method, using ½ per cent indolebutyric acid in alcohol as the basic solution.

Before going into more detail about the solutions we use I want to point out that in our approach to the problems connected with the quick dip method we didn't use the "scientific approach." We did not have the necessary background in chemistry or the precise measuring equipment required for this type of research However, we were convinced of the feasibility of this type of application At the same time we kept the basic requirements, necessary for mass application to cuttings, foremost in mind The necessary requirements, besides good results are: (1) simple preparation, (2) ease of handling by employees, and (3) guaranteed stability of solution during mass application over an unlimited length of time

Now I would like to go into more detail about the solutions we use. As mentioned before, our basic solution consists of ½ percent indolebutyric acid in alcohol. After buying the crystals in 50 or 100 gram parcels, from the Nutritional Biochemicals Corporation, in Cleveland, we take them to a druggist who weighs the crystals into 2 gram quantities which are kept in sealed plastic containers under refrigeration. We have kept some of these chemicals in containers for years and have never experienced any loss in strength.

By adding 2 grams of crystals to 400 c.c. methyl alcohol we establish our basic solution. With this basic solution we prepare four different concentrations, which cover our whole range of cuttings; i.e. for softwood cuttings during the summer in intermittent mist frames, as well as in foghouse and for evergreen cuttings propagated during the fall and winter in the conventional greenhouse method of propagation. We arbitrarily named the work solutions, strong, regular, weak and extra weak (Table 1).

The dilution of the indolebutyric acid in these solutions might appear to be rather severe, but the consistently good results we had over a number of years have proven these low percentage solutions to be superior to their powder counterparts. The only explanation we have is that indolebutyric acid becomes more readily available to the cutting when in liquid solution than when in powder form. It may be that the talc carrier itself might obstruct the direct absorption of the hormone.

Table 1.—Preparation of quick dip work solutions

Work Solution	Method of Propagation	% Active Ingredient
Strong	1 part basic solution, plus 1 part water	¼
Regular	1 part basic solution, plus 1 part alcohol, plus 1 part water	1/6
Weak	1 part basic solution, plus 1 part alcohol, plus 2 parts water	⅛
Extra weak	1 part basic solution, plus 2 parts alcohol, plus 6 parts water	1/12

I would like to point out that these solutions have a relatively large amount of water in them It is the water that acts as a stabilizer, making these solutions suited for mass production at room temperature. If we attempted to keep a solution consisting mainly of alcohol on the workbench and were to dip 4 to 7000 cuttings a day in it, it would soon become quite concentrated. In other words, because alcohol is quite volatile we would be using a higher concentration later in the afternoon than we were early in the morning This could naturally have adverse results. By using the rather large amounts of water we have never noticed any important change in the concentration of our solutions, as evidenced by erratic rooting.

We keep an instruction chart in the workroom to guide the person who is in charge of preparing the solutions We use wide mouthed, black painted jars to hold the various solutions, which are placed on the bench between two workers. After making the cutting, the worker keeps the finished ones in his hand, attempting to hold the basal ends as even as possible. After making 10 to 25 cuttings, he lifts the cover from the jar, dips the cuttings, shakes them quickly and puts the bundle, upside down in a box where they remain until the basal ends are dry This seems to be quite important, since it assures a uniform absorption of the hormone by the cuttings. If these were stuck while wet, the solution covering the base could be diluted by the moisture available in the medium. As soon as the work solution in the jar runs low we simply add a fresh quantity to it This practice, which is repeated every 2 or 3 days gives added assurance that the work solution remains at a given concentration Sometimes we will not use a certain solution for weeks or months during which time it is kept under refrigeration. We have never noticed any decreased effects from this practice.

One of the major advantages of the quick dip method shows up while sticking the cuttings, in that there is no worry about the amount of powder covering each cutting or need to make a furrow. There is no chance of stripping off the powder and no chance of diluting or washing off the powder when watering or turning on the intermittent mist. Another advantage of the quick dip method is the fact that the relatively large amount of alcohol in the solutions acts as a perfect fungicide.

A bottle containing 400 c.c. of basic solution of ½ per cent indolebutyric acid in alcohol will be sufficient to treat between 25 and 35,000 cuttings. The price of 1 gram of indolebutyric acid varies between 45

Table 2.—Use of various work solutions to promote the rooting of cuttings

Work Solution	Type of Cutting Treated
Strong	American holly, hard English holly, hard, ripe wood of some of the red hybrid rhododendrons
Regular	*Taxus,* ripe wood of rhododendrons, English holly, softwood cuttings of *Cotoneaster* varieites, Red maple, Pink dogwood, and Hetzi juniper.
Weak and Extra Weak	Softwood cuttings of hybrid rhododendrons, viburnums, *Magnolia, Pyracantha, Ilex* vars, Red plums, Smoke bush, and boxwood

and 60 cents. In order to give you some idea how we use the work solutions, I will mention some of the plant material which is treated with each concentration. (Table 2).

I have never believed in over-emphasizing the importance of hormone application since it is just one of the many factors that has to be taken into account when making cuttings. However, provided all those other factors are taken care of, proper hormone application usually makes the difference between a lightly rooted cutting and one with a heavy and well branched root system. While using these hormones, we at Warner Nursery have found through the last four years that the quick dip method consistently gives better and quicker results than the powder forms. Thank you.

MODERATOR LANCASTER: If agreeable with the members of the Society, and the panel, I am going to ask that if anyone has any questions please write them out and bring them to the Question Box, Friday night.

Leaving the panel discussion of the quick-dip method of hormone application, we will go on to the "Budding of Dogwood in the Field" by Hoskins A. Shadow, Tennessee Valley Nursery, Winchester, Tennessee. Mr. Shadow.

Mr. Hoskins Shadow presented his prepared paper on "The Budding of Dogwood in the Field." (Applause)

THE BUDDING OF DOGWOOD IN THE FIELD

HOSKINS A SHADOW
Tennessee Valley Nursery
Winchester, Tennessee

It is my desire to give you as near as possible the procedure we follow in the field propagation of dogwood on a commercial basis.

Our source of seed is from the native dogwood, which is abundant in our area. These berries are gathered in the early fall and are brought to our packing shed where we buy them, from collectors, by the pound.

We prefer that the berries be well ripened and find that the best test is to press the berries between the thumb and fore finger If the seed presses out freely, the berries are ripe and are ready to be cleaned. We use a Dybvig Seed Cleaner for this process and find it very satisfactory.

After the seeds are cleaned, they are placed in the open air and sun to dry for a few hours and are then stored in bags in lots of 25 lbs., which is a convenient quantity to handle, since it will not mold, if hung from a rafter.

When weather permits in late October and early November, we plant in a fertile, well prepared seed bed directly in the field. Our standard row is 42 inches, and the seed are placed in a "V-shaped furrow about one to one and a half inches deep. This furrow is then filled with well decayed hardwood sawdust and firmed with a roller or Cultipacker. We find this desirable, as it prevents, to some degree, the loss of sawdust by wind erosion.

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Germination usually takes place between April 1st and 15th. If we have not been able or have not desired to plant all of our dogwood seed in fall and early winter, we will stratify them by January 15th.

Our method of stratification uses equal parts by volume of sand and well decayed sawdust. The seeds are poured on this mixture and hand mixed on a concrete floor The mixture is then placed in steel barrels and stored at a temperature of 40 degrees F. for 60 to 75 days. I might add that our mean average temperature, at that season of the year, is about 40 degrees; consequently we have had good results by storing these barrels outside on the north side of a building.

At planting time the seeds are taken out of this stratification mixture by running it over a 1/4 inch screen which separates the seed from sand and sawdust. These are then planted as previously described Under favorable conditions, these seed will usually germinate within two or three weeks.

The little seedlings are very weak when they first emerge and very good care must be taken of them in these early stages of growth. Irrigation is desirable. After the seedlings are well established and the stand can be determined, they are ready to be thinned to a normal stand, which, for us, is about three inches apart in the row. This thinning is usually done from the 1st to the middle of July, or after the seedlings have a fairly well established root system. Our budding operation usually begins between the 1st and 15th of August, or as near to that time as is practical.

You will remember that we have a very tender seedling and consequently we must also have budwood which is in a similar condition. In other words, we have a small, tender seedling; we want a small, tender bud. It takes a great of skill and dexterity to handle these tender buds and seedlings.

I might mention here. that we formally budded our dogwoods on transplanted seedlings After using both methods, we much prefer the budding of one year old seedlings in the field, and root pruning them, to the method of budding transplanted seedlings. The former makes a much stronger union and eliminates the need for staking.

We use the shield or T-bud methods placing the bud on the seedling as low as is practical and on the southwest side of seedling Although this is the direction of prevailing wind in our area it makes a straighter plant.

In removing the bud from the bud stick, there is a small piece of wood that remains in the bud. We make no attempt to remove this, as more damage is done to the bud by trying to remove it than it causes. The bud is then tied firmly in place with raffia. This is done by wrapping three rounds of raffia around the seedling just below the eye or bud, and four rounds just above the eye. The raffia is twisted into a rope above the wrap, and tied on the wood of seedling instead of on the raffia itself This tie will hold the bud firmly. The bud will usually stick immediately. The seedlings should be watched carefully and within 10 days to 2 weeks, the tie should be cut on back side before it girdles the seedling.

About November 15, or as soon as the plants are dormant, these seedlings, with the live bud in them are root pruned to induce the development of a fibrous root system. The following spring, just before the bud starts growth (about April 1st), the tops of the seedlings are removed by cutting them off just above the bud. All suckers must be removed and the bud given an opportunity to grow. By the end of the first growing season, we will have plants from 12 to 36 inches in height.

When well ripened and dormant, we run the digger, with a root pruning blade flat, in order to prevent tilting, under these one year plants. This permits us to remove all the plants we desire to move, leaving well spaced plants two feet or more apart in the row for growing on the second year We are able to produce 3-4 and 4-5 foot plants the second year, usually with bloom buds to be dug B&B. To increase a desirable quantity of bloom buds, we find that irrigation is very helpful.

This method produces a well formed, straight trunk, with perfect compatibility between scion and stock which increases the chances for survival for each plant Thank you.

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

MR. CASE HOOGENDOORN (Newport R I): What is the reason for covering your seed with sawdust instead of soil?

MR. SHADOW: Well I guess you learn a little bit by experience. We find we get good stands by using sawdust and we don't by using soil.

Our budding crew consists of three budders, three tiers, one man preparing the seedlings for budding.

MODERATOR LANCASTER: Thank you very much, Mr. Shadow, for a very interesting discussion on the propagation of the dogwood.

Since Mr. Shadow did not use his allotted time of 30 minutes we have time for several questions Mr. Flemer.

MR. WILLIAM FLEMER (Princeton, New Jersey): I would like to ask if you have tried plastic budding strips on your dogwoods?

MR. SHADOW: No, Bill, I have not. I would be rather reluctant to try them in any quantity since the bud is very, very tender. If it were a larger bud or of the type that you were putting in a transplanted seedling, then I think probably they would be satisfactory. I question the advisability of using them on a tender bud.

MODERATOR LANCASTER: Thank you

Our President Roy Nordine has several announcements. We thank all of you for participating in this session this morning. We hope everyone has obtained some valuable information. (Applause)

PRESIDENT NORDINE: There are a number of committees to be appointed We will at this time name only those that will function during the course of this meeting.

The Nominating Committee shall consist of Roger Swingle, Chairman, Frank Turner, and Roger Coggeshall.

The Auditing Committee shall consist of Tom Dodd, Chairman, and Hans Hess.

The Resolution Committee shall consit of Leslie Hancock, Chairman, and Alfred Fordham.

Other committees will be appointed at a later date.

The meeting this afternoon will start on time, since we have now set a precedent for this Society by starting on time this morning. Thank you.

The session recessed at twelve o'clock

THURSDAY AFTERNOON SESSION

December 10, 1959

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

PRESIDENT NORDINE. You will notice from your program that we have a full session this afternoon, composed of a great many topics which should be of interest to everyone. We are therefore anxious to start on time in order to allow the speakers sufficient time as well as to allow for a period of discussion which is always so important.

The moderator for this afternoon is Richard H. Fillmore We will call him to the podium at this time.

Mr. Fillmore assumed the chair (Applause)

MODERATOR FILLMORE: Fellow Members and Guests of the Plant Propagators Society: The session this afternoon will be devoted to three topics: Namely, the propagation of varieties of honeylocust, the rooting of conifers under intermittent mist and under plastic and to the rooting of junipers in the open field

We shall begin this afternoon with Mr Hubert Nicholson Commercial Nursery Company, Decherd, Tennessee, who will discuss the "Propagation of Varieties of Honeylocust. Mr. Nicholson, will you please come forward? (Applause)

(*Editor's note*: Mr. Nicholson integrated his discussion with a series of colored slides which depicted the sequence used to propagate varieties of honeylocust.)

PROPAGATION OF SELECTED VARIETIES OF HONEYLOCUST BY BUDDING

HUBERT NICHOLSON
Commercial Nursery Company
Decherd, Tennessee

I will not attempt to tell you how to propagate honeylocust varieties by budding, but rather will briefly describe a procedure that we are successfully using in Tennessee. Our soil is primarily a clay loam. In th past we have selected lower sites to take advantage of all rainfall, since we do not have field irrigation facilities available. However, in seasons of ample rainfall, such as we have had the past two or three years, our one year buds of honeylocust have become too large and therefore, this year, we budded on seedlings planted on higher soils In either case, we try to select soils of high fertility, and with good internal drainage.

We do not produce our own seedlings but rather buy 18 to 24 inch, 3/16 - 1/4", caliper seedlings. We prune the roots severely, leaving only four to five inches of the original root. Side roots, if any, are also pruned back severely. The tops of the seedlings are cut back with a band saw so that not over 18" of top is left above ground after planting. This uniformity of tops makes the seedlings easier to handle when transplanting and prevents the transplanter from tipping the seedlings in the row These seedlings are planted 14 inches apart in well prepared soil with a reforestation type transplanter. Rows are spaced 48 inches apart. Soil is plowed up to the seedlings immediately after planting. We generally plant our seedlings in December, weather permitting. The earlier they are planted, the more uniformly they will start growth the following spring. Seedlings which are slow to start represent one of our major problems.

When the seedlings begin to grow in the spring we keep a sharp watch out for blister beetles or any other leaf eating insect. Control is usually effected through the use of DDT. If these insects are not controlled the development of the seedlings will be retarded, thus preventing budding as early as would otherwise be possible Our seedlings are not fertilized at the time of planting or during the following summer.

We have found that early budding is one of the most important of the many factors affecting our stands We prefer to start budding by the first of June, if possible. This in part is determined by the condition of the budwood which should be green. I would again emphasize this latter point, that is, the use of green budwood After the budsticks begin to take on shades of gray and brown, the bud does not come off the budstick properly and is too ripe for us. We cut large buds, sometimes 1½″ long and "pop" them off the budstick, leaving the wood under the bud, attached to the budstick If we have sufficient budwood available we will not use a bud that does not "pop" off the stick. We have found that our stands are not as good where we slice the bud off the stick and then remove the wood from the under side of the bud in a separate operation.

In making the incision on the understock we make a vertical slit on the seedling starting about 2″ above the ground The cross or "T" cut is made about 1″ up on this vertical slit with a rolling motion of the knife blade and slanting slightly upward. The knife tends to open the vertical cut as it rotates around the seedling. The seedling is now ready to receive the bud which is not "popped" off the budstick until after the seedling has first been prepared. The bud is then carefully inserted in the slit on the seedling and forced downward until the nose of the bud rests under bark which has not been slit with the knife. This assures a tight fit on the nose of the bud with the rest of the bud lying flat on the seedling, the edges being covered by the bark of the seedling. When the bud is in place it is well if the top extremity of the bud coincides with the cross or "T" cut. This gives a more perfect match of the cambium layers.

Wrapping is performed with 5″ rubber bands which are started at the top of the bud and wrapped down. We insist on a minimum of three wraps above the leaf stem of the bud, which incidentally is pulled pretty tight Wrapping in this manner flattens the "hump" of the bud down against the seedling. This so called "hump" of the bud is that portion where the thorn would be if it were a thorny locust. We complete the wrapping process by taking 2 or more turns below the bud, still exerting some pressure on the rubber bud strip The wrap is tied at about the base of the vertical cut. We believe that this "wrapping down" process is a very important phase of successful budding. Using large green buds on sappy seedlings it is very easy to force the bud up out of the "T" slot if you try to wrap it in the conventional manner, starting at the bottom and wrapping upward. We no longer bother to cut the wraps, since they deteriorate before they can do any harm.

If everything goes well, the perfect union consists of a big bud, flat on the seedling, with a continuous knit all the way around. However, not all our buds follow this perfect pattern and we find various forms of unions, some of which tend to promote poor stands. Quite often, by the following spring, the upper portion of many of the buds has dried up down to the area where the leaf stem was originally located As long as this leaf stem area is alive, the bud will force out in the spring.

One of our biggest troubles results from the seedling overgrowing the bud. If the understock completely covers the inserted bud, it is likely that the bud is dead. If the center portion of the incision remains open far enough for the bud to emerge there is a good possibility that the graft will be successful. Early budding, as well as ample rainfall following budding encourage this type of overgrowth. Rapid growth after budding will sometimes cause the rubber budding strip to cut into the seedling, although this apparently causes no serious harm. Some of the buds will force within two weeks after budding This new growth ranges from a cluster of leaves to shoots three to four feet long. In the event that a shoot forms, we always cut it back to the bud the following spring By the end of the summer after budding, the seedlings are normally around three feet tall. The past two years, however, we have had seedlings as tall as six feet and over one inch in caliper. If the bud lives on these more vigorous seedlings and doesn't become buried, it will make a big tree next year.

Before growth begins the next spring the top of the seedlings above the bud are removed. This is done by making a sloping, 45° angle cut extending from top of the bud to rear of seedling.

The first flush of growth pushes one or more buds of the selected variety into growth It has been our observation that the bud and shield of the selected variety contains several latent buds. Usually two or three of these will force at the same time, which makes it necessary to remove all but one at the first disbudding operation. In addition to the removal of these extra growths, all shoots that have forced out on the stem of the seedling are also taken off. The remaining bud grows rapidly. If it should blow off or be accidentally broken off, other latent buds will be forced out of the original bud area to take its place. I have personally seen as many as six or more buds force from a plate, after the original bud had been accidentally broken off after reaching a height of five or six feet. This characteristic works to the advantage of the grower, as you can readily see.

When our new bud reaches a height of 12 to 18 inches we generally fertilize with a 10-10-10, complete fertilizer. This is banded on each side of the row, after we have finished weeding the row. By late June or early July, if the buds are not growing as rapidly as we feel they should be, we side dress with ammonium nitrate. By the first of July our buds should be in the neighborhood of six feet tall.

Pruning is confined primarily to getting the young bud off to a fast, straight start If all side branches are kept off the shoot until it is four or five feet in height, you will be quite sure of getting a straight tree. Ninety per cent of the crooked trees we have are a result of leaving on side limbs to furnish budwood. We have on occasion topped six to eight feet whips in July in an attempt to stimulate branching but this has given us inconsistent results. Apparently the earlier you are able to top the whip, the better the chances of producing a branched tree.

For the past couple of years the average height of our block of one year buds has averaged about eight feet, with many trees topping ten feet. Most of our trees are sold as one year trees, although a few are grown the second year. At the beginning of the second year those trees which are retained are topped at 7 to 7½ feet. They make beautiful heads that growing season, and put good caliper, some reaching 1½" by the end of the second growing season Thank you.

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MODERATOR FILLMORE: We thank Mr. Nicholson very much indeed for this presentation on the propagation of varieties of honey-locust by budding. I am also personally very glad to hear a discussion of budding. I regard budding as the most advanced plant propagating technique that we have, particularly in the sense that every solitary bud on the plant becomes a potential new plant instead of having to use perhaps 15 buds, as we frequently do on a leafy cutting.

Are there any questions for Mr Nicholson?

If not we shall now proceed to "The Rooting of Conifers Under Intermittent Mist" by Dr. Stuart H. Nelson, who is in plant propagation and nursery management research at the Plant Research Institute, Ottawa, Canada. Dr. Nelson.

Dr. Nelson presented his talk in two parts, which covered the seasonal propagation of evergreens under mist. Tabular data was presented by means of slides. (Applause)

THE SUMMER PROPAGATION OF CONIFER CUTTINGS UNDER INTERMITTENT MIST*

S. H. Nelson

Plant Research Institute Experimental Farm

Ottawa, Ontario, Canada

Conifer cuttings are usually collected in the winter months after sticking and root very slowly, even under greenhouse conditions. Rooting periods six to eight months in length are not uncommon for some

*Contribution No 38 from the Plant Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ontario

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species. In view of this, successful evergreen propagation outdoors in the relatively short summer season was not anticipated Limited tests, however, with small numbers of cuttings gave encouraging results under mist during the 1955 to 1958 seasons. When the results were evaluated, it was apparent that this type of propagation had promise, but the data lacked the scope and continuity to establish definite trends. Accordingly, in 1959, experiments were initiated to establish hormone and propagation bed requirements.

There is some evidence in the literature to support the use of mist for the propagation of conifers during the summer. Fillmore (1) reported on the successful rooting of *Chamaecyparis pisifera* under mist outdoors in Nova Scotia. He also reported 100 percent rooting of *Taxus media hetzi*. Ward (4) reported fair results with two species of *Thuja* under intermittent mist in Iowa, while Steavenson (3) in Missouri reported relatively low rooting percentages with *Juniperus* when the outdoor mist beds were shaded with lath.

RESULTS AT OTTAWA

In 1959, all combinations of five hormone treatments and three types of propagation beds were tested. The hormone treatments, included a check, Hormodin No 1, Hormodin No. 2, Hormodin No. 3 (0.1, 0.3 and 0.8 percent indolebutyric acid in talc, respectively) and Chloromone (an alfalfa extract of unknown consistency). The three mist propagation beds consisted of an open bed without bottom heat, an open bed with bottom heat of 65 degrees F. and a polyethylene covered bed with no bottom heat. The latter received four seconds of mist every minute during the daylight hours, while the open beds received only eight seconds of mist every five minutes during the daylight hours. The construction of these frames has been fully described by Nelson (2).

The results are most conveniently tabulated according to genus and the treatment, the code for which is as follows:

Ck—Check treatment
H#1—Hormodin #1 (0.1 per cent indolebutyric acid in talc)
H#2—Hormodin #2 (0.3 per cent indolebutyric acid in talc)
H#3—Hormodin #3 (0 8 per cent indolebutyric acid in talc)
C—Chloromone (an alfalfa extract of unknown consistency)
IMO—Intermittent mist outdoors, 8 seconds of mist every 5 minutes
PTO—Polyethylene tent outdoors, 4 seconds of mist every 5 minutes
BH—Bottom heat of 65 degrees F.
NBH—No bottom heat.

Chamaecyparis As shown in Table 1, no difficulty in rooting was experienced with the three species listed. Hormones, bottom heat or the high air temperature in the polyethylene tent were not required for 100 per cent rooting It should be noted, however, that all the cuttings treated with Chloromone in the open frame without bottom heat could have been transplanted by the end of six weeks, while a period of eight weeks and longer was needed for the other treatments. Increased strengths of Hormodin increased the rate of rooting slightly Bottom heat was not apparently beneficial, although this was expected, since temperatures below 65° F. were uncommon between June 15 and August 15. There were, however, indications that the combination of bottom heat and strong hormone treatments were detrimental, this was quite obvious in the polyethylene tent. In the latter, high concentrations of hormone increased the speed of rooting. Although it also increased the occurrence of rot, which resulted in a lower rooting percentage, *C. pisifera plumosa aurea* was the most severely affected.

Table 1.—Percentage rooting of **Chamaecyparis spp.** under intermittent mist outdoors

Plant Material	Propagation Bed	Hormone Treatment				
		Ck.	H#1	H#2	H#3	C
C. pisifera plumosa argentia	IMO-NBH	100	100	100	100	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	80	90	100	80	60
C. pisifera plumosa aurea	IMO-NBH	100	100	100	100	100
	IMO-BH	100	100	100	100	90
	PTO-NBH	60	60	40	10	0
C. pisifera squarrosa	IMO-NBH	100	100	100	90	100
	IMO-BH	90	100	100	100	100
	PTO-NBH	90	100	100	100	90

Juniperus. This genus was quite slow to root. The results presented in Table 2 represent the amount of rooting up to October 1, 1959.

As found in the winter propagation, there was also a great varietal difference in ability to root in the summer. In addition, there was a marked seasonal variation in rooting.

In 1957, *Juniperus chinensis hetzi* gave 90 and 80 per cent rooting respectively, with Hormodin #3 and the check treatment, each with bottom heat in the open mist bed. However, under similar treatments, (Table 2), the rooting was much reduced in 1959. Use of polyethylene tent reduced rooting in both years. The cuttings, this year, were still in good condition on October 1st and would likely have rooted. On the other hand, *J. chinensis keteleeri* was very subject to rot and only a few rooted cuttings escaped the rot.

The 1956 results with *Juniperus chinensis pfitzeriana aurea* showed the same trend in rooting as that observed this year, although at a lower level. The use of hormone tended to decrease the rate of rooting, even though the ultimate rooting in the polyethylene tent was higher.

The results with *J. communis depressa aurea-spica* were complete by the middle of September. The occurrence of rot was very high in the polyethylene tent. There were slight indications that hormones increased the rapidity of rooting, although bottom heat was unnecessary at this time of the year.

With cuttings of *J. horizontalis douglasi* and *J. h. plumosa,* the polyethylene tent resulted in the fastest rooting, which reduced the effects of hormones. This was apparently the best treatment for the spe-

Table 2.—Percentage rooting of **Juniperus spp.** under intermittent mist outdoors.

Plant Material	Propagation Bed	Hormone Treatment				
		Ck	H#1	H#2	H#3	C
J. chinensis hetzi	IMO-NBH	10	10	20	10	30
	IMO-BH	10	10	10	40	10
	PTO-NBH	20	0	20	30	.20
J. chinensis keteleeri	IMO-NBH	0	10	10	10	0
	IMO-BH	0	0	10	0	10
	PTO-NBH	0	0	10	0	0
J. chinensis pfitzeriana aurea	IMO-NBH	30	30	50	50	40
	IMO-BH	100	80	90	90	80
	PTO-NBH	80	90	100	100	100
J. communis depressa aurea-spica	IMO-NBH	100	90	100	100	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	10	20	0	0	0
J. horizontalis douglasi	IMO-NBH	90	90	100	90	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	100	100	100	100	100
J. horizontalis plumosa	IMO-NBH	90	100	80	50	100
	IMO-BH	100	80	70	90	100
	PTO-NBH	100	100	100	100	90
J. sabina	IMO-NBH	60	50	30	40	100
	IMO-BH	20	60	50	20	90
	PTO-NBH	50	50	50	40	20
J. sabina tamariscifolia	IMO-NBH	10	20	0	0	20
	IMO-BH	20	0	10	10	20
	PTO-NBH	60	30	30	40	20
J. scopulorum	IMO-NBH	30	10	10	0	10
	IMO-BH	0	10	10	0	0
	PTO-NBH	0	0	0	0	0

cies. Hormone effects were greatest in the open bed with no bottom heat, yielding increased rate of rooting with increased strength.

Juniperus sabina and *J. s. tamariscifolia* were relatively difficult to root. *J. sabina* responded favorably to Chloromone in the open beds but was adversely affected in the high temperature of the polyethylene tent. However, in 1958, the Hormodin powders were all superior to the check and Chloromone treatments. The same situation existed in 1958 with *J. s. tamariscifolia* where 96 per cent rooting occurred in the open propagation bed without bottom heat, and was extremely poor in the polyethylene tent. Since many of the cuttings were not rooted in 1959, but still in excellent condition, there must have been something connected with the season which resulted in poor rooting. In 1959 the mean air temperature was much higher than in the preceding year, and cloudiness more prevalent. More precise information at propagation bed level, however, would be required to explain these results.

Juniperus scopulorum was a difficult plant to root under most conditions. However, in 1956 and 1958, 60 and 90 per cent rooting, respectively, was obtained with Chloromone in the open bed with bottom heat. This treatment was superior to the Hormodin powder and the check treatments. In 1958, the results in the polyethylene tent were also very poor.

In summary, there were a few junipers that rooted readily and quickly, but for the species that were more difficult to root, more specific information is needed about seasonal variations in order to explain the wide variance in rooting over the years.

Taxus. Branched, two-year old cuttings were the only type available this year and their rooting ability was known to be inferior to that of current season's wood. The results were further influenced by chlorosis which developed on cuttings in the mist propagation frames. The results, as shown in Table 3, for this type of cutting have been similar in 1955, 1957 and 1958. In general, over the years, bottom heat and strong hormones have been beneficial on cuttings in the open beds. The polyethylene tent, however, yielded poor results, primarily because of rots.

Table 3.—Percentage rooting of Taxus spp. under intermittent mist outdoors

Plant Material	Propagation Bed	Hormone Treatment				
		Ck	H#1	H#2	H#3	C
Taxus baccata	IMO-NBH	20	40	40	60	10
repandens	IMO-BH	10	80	70	70	50
	PTO-BH	20	50	60	30	40
Taxus cuspidata	IMO-NBH	80	80	70	80	40
	IMO-BH	40	20	30	70	70
	PTO-BH	20	40	30	10	30

Thuja. The 1959 results are presented in Table 4, and, in general, *Thuja* was easily rooted under intermittent mist outdoors. Bottom heat was not necessary and hormones did not increase the percentage rooting. However, Chloromone increased the rate of rooting markedly in the open beds with the cuttings being transplanted in six weeks. The polyethylene tent was inferior to the other propagation facilities and the reduced rooting and prevalence of rot varied with varieties.

The poor results obtained with *T.o.* "Columbia" could not be explained. Immediately after the cuttings were placed in the mist beds, about one inch of the foliar margin of all cuttings turned brown and rot later became a problem. In 1958, this browning did not occur and 70 per cent rooting occurred from the Chloromone treatment located in the open mist beds.

In summary, *Thuja* were very successfully propagated under mist at Ottawa. Hormones, especially Chloromone, increased the rate of rooting and bottom heat was not found to be necessary. The polyethylene type of propagation facility was inferior to open mist beds for cuttings of *Thuja* at Ottawa.

Table 4.—Percentage rooting of **Thuja occidentalis** varieties under intermittent mist outdoors.

Plant Material	Propagation Bed	Hormone Treatment				
		Ck.	H#1	H#2	H#3	C
T.o "Columbia"	IMO-NBH	30	10	10	20	30
	IMO-BH	20	20	20	10	30
	PTO-BH	0	0	0	0	0
T.o. ellwangeriana	IMO-NBH	100	100	100	100	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	90	90	70	70	40
T.o. hollandica	IMO-NBH	100	90	90	80	90
	IMO-BH	70	60	50	80	90
	PTO-NBH	30	20	20	30	40
T.o. hoveyi	IMO-NBH	80	80	100	100	100
	IMO-BH	80	70	100	80	100
	PTO-NBH	50	30	30	30	30
T.o "Little Gem"	IMO-NBH	100	100	100	100	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	20	30	60	90	40
T.o. lutea (elegantissima)	IMO-NBH	70	90	100	100	100
	IMO-BH	100	100	100	80	100
	PTO-NBH	90	100	100	90	30
T.o. "Patmore"	IMO-NBH	100	80	100	100	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	60	80	90	100	60
T.o. pyramidalis	IMO-NBH	100	100	100	100	100
	IMO-BH	100	100	100	100	100
	PTO-NBH	70	90	100	80	30
T.o. "Rheingold"	IMO-NBH	100	90	100	100	90
	IMO-BH	100	90	100	100	100
	PTO-NBH	10	0	20	20	20
T.o. saundersi	IMO-NBH	60	70	80	80	90
	IMO-BH	70	90	90	100	90
	PTO-NBH	20	0	10	10	0

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MIST PROPAGATION OF EVERGREENS IN THE GREENHOUSE DURING WINTER*

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Horticultural forms of most evergreens have been relatively difficult to propagate and slow to root. Because of the relatively long period of time cuttings must remain in the propagation bench, greenhouse production costs have been very high. With the introduction of mist propagation equipment, however, much of the labour cost could be removed and the time element diminished if this technique could be applied to the winter propagation of evergreens.

Accordingly, experiments were initiated in the greenhouse in 1956 with cuttings being stuck in late December or early January. Over the four year period the effects of bottom heat, type of cutting, size of cutting, wounding, interval of mist and shade were studied with the variables being adjusted on the basis of current results.

In addition to the intermittent mist bench, cheesecloth, and in some instances, polyethylene covered propagation beds were used for purposes of comparison These propagation benches were installed on the standard bench used for regular greenhouse production. Thus, since humidity was a problem with the larger air volume, this was a more difficult test than would have occurred in a low air volume propagation house. Humidity was supplied by syringing the cheesecloth three or four times daily while the polyethylene tents were watered weekly.

The numbers within treatments (10 to 25 cuttings) and the number of treatments for a given variety was dependent upon the availability of cuttings on specimen plants in the ornamental plantings.

A medium of two-thirds sand and one-third peat moss was used in all propagation benches. The hormone powders used were Hormodin #1, Hormodin #2 and Hormodin #3, which contain 0.1, 0.3 and 0.8 per cent indolebutyric acid, respectively. Chloromone, a liquid extract of alfalfa with unknown active ingredient, was also tested.

ROOTING OF SPECIES OF JUNIPERUS

The only reference to mist propagation of *Juniperus* in winter has been by Snyder (6), who reported excellent success with *Juniperus chinensis pfitzeriana* under intermittent mist. Snyder (5) also summarized some 20 references related to the propagation of junipers.

Experiments with *Juniperus* spp. were initiated at Ottawa in 1956 and over the four-year period fifteen species and varieties were tested. Junipers, in general, showed a considerable difference in their reaction to the variables applied in the experiments. These responses and trends permitted us to draw a few generalizations.

Effects of Shade. Second only to the inherent ability of a species

*Contribution No 39 from the Plant Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ontario

to root, light was the most important single factor in the successful rooting of juniper cuttings under intermittent mist during the winter months in the Ottawa area. Two years of poor results, following a very successful operation in the initial year coincided with the installation of lath shades on the propagation house. After this shade was removed in the fourth year, the rot problem practically disappeared and the best results were obtained without lath or shading compound in the winter months when light conditions were otherwise poor. For example, with *J. chinensis pfitzeriana aurea* and *J. sabina tamariscifolia*, 90 and 100 per cent rooting was easily obtained in a number of treatments before the shade was used. After it was removed, but during the two years where lath was used, practically all treatments yielded below 50 per cent rooting The rot usually started at or near the base of the cutting and affected the cambium, causing the bark to deteriorate and slough off.

During the second year of shading, regular Fermate sprays were applied as a rot preventative measure, but the results were inconsistent, and, in general, no control was obtained As shown in Table I, there was a considerable varietal difference in the occurrence of rot.

Table 1.—Susceptibility of **Juniperus spp.** to rot under intermittent mist in the greenhouse during winter

Highly Susceptible	Medium	Low
J. chinensis blaauwi	*J. chinensis* "Ramlosa #5"	*J. chinensis hetzi*
J. chinensis "Obelisk"	*J. chinensis* "Ramlosa #6"	*J. sabina tamariscifolia*
J. chinensis pfitzeriana aurea	*J. chinensis "Skeena #10"* *J. horizontalis douglasi*	
J. horizontalis plumosa		
J. sabina		
J. scopulorum		
J. squamata meyeri		
J. virginiana (canaerti)		

Effects of Type of Cutting. As reported in the review by Snyder (5), no over-all trend was established where comparisons in types of cuttings were made. Apparently from the results at Ottawa, lateral and terminal cuttings, with and without a heel, rooted quite similarly under mist. Lateral cuttings with heels are commonly used, since a small heel forms naturally as the cuttings are pulled from the parent branch.

Effects of Size of Cutting. With most junipers larger cuttings that were not treated with hormones rooted in higher percentages and more rapidly than smaller ones similarly treated. However, since larger cuttings (10 to 18 inches) present a greater problem in maintaining stock plants and in shaping the subsequent tree after the cutting has rooted, small cuttings (5 to 8 inches) should be used in most instances. Satisfactory rooting with small cuttings could be obtained provided the proper hormone treatment was applied.

Effects of Wounding. Admittedly, as reported in Snyder's review (5), wounding of the basal portions in many instances also increased the number of roots per cutting and gave higher rooting percentages at Ottawa. However, equal results can be more easily obtained by using strong hormones and the unilateral rooting caused by wounding is avoided.

Effects of Hormone Treatment. From our results at Ottawa, it was obvious that Chloromone is a beneficial aid for the rooting of junipers. Both the rapidity and percentage of rooting were increased by Chloromone, but the variability in results with Hormodin powders suggested that these preparations were not strong enough for junipers (Table 2).

Table 2.—Effects of hormone on the rooting of juniper cuttings under intermittent mist

Plant Material	Size in Inches	Bottom Heat	Check	H#1	Hormone Treatment H#2	H#3	Chloromone
Juniperus chinensis	6-8	None	70	80	50	50	100
pfitzeriana aurea	-	65° F	60	40	70	50	100
	8-10	None	50	70	90	70	100
	-	65° F	90	50	80	80	100
Juniperus sabina	6-8	None	30	40	60	40	100
tamariscifolia	-	65° F	70	80	80	100	100

These results were obtained with one and one-half seconds of mist per minute during the daylight hours. Although not shown in tabular form, dilutions of Chloromone down to one-quarter strength with water did not reduce its influence on rooting. A further survey of the most concentrated Hormodin powder was made in 1959 to ascertain its effects on rooting. However, the increased rooting of the check treatments under the conditions existing in 1959 minimized the effects of hormone and beneficial results were obtained in only a few instances as shown in Table 3.

Effects of Bottom Heat Under the less favourable propagating condition, the effects of bottom heat were variable, but, as shown in Table 3, bottom heat was beneficial in 1959. The relative response varied with the plant material used.

Effects of Mist Interval. As shown in Table 3, six intervals of eight seconds per 30-minute cycle gave increased rooting as compared to three intervals with most materials. Thus a change from the one- and one-half seconds of mist per minute used previous to 1959 to six intervals of eight seconds of mist per 30-minute cycle increased rooting. Even though the amount of water was approximately equal, the longer intervals of mist in the latter allowed more runoff and the five minute inter-

Table 3.—Percentage rooting of **Juniperus spp.** in 1959

Plant Material	Lateral or Terminal	Size	Hormone	IMI BH MIA	IMI BH MIB	IMI NBH MIA	CTI BH	CTI NBH
Juniperus chinensis blauwi	T	6-8	H #3	60	30	50	—	—
			Check	0	30	30	—	—
	L	6-8	H #3	20	—	—	—	—
			Check	0	—	—	—	—
	L	3-5	H #3	10	10	0	0	0
			Check	0	10	0	0	0
Juniperus chinensis hetzi	L	5-8	H #3	84	98	55	10	0
			Check	86	100	80	25	0
Juniperus chinensis pfitzeriana aurea	T	5-8	H #3	20	100	0	—	—
			Check	10	90	0	—	—
	L	5-8	H #3	10	100	—	—	—
			Check	0	80	—	—	—
	L	3-5	H #3	25	100	25	15	0
			Check	50	100	25	20	5
Juniperus horizontalis douglasi	L	6-8	H #3	95	90	70	5	5
			Check	85	95	80	10	5
Juniperus horizontalis plumosa	T	5-7	H #3	40	70	10	20	20
			Check	20	30	20	10	0
	L	5-7	H #3	65	80	—	—	—
Juniperus sabina	L	3-6	H #3	64	58	35	10	5
			Check	44	28	20	10	0
Juniperus sabina tamariscifolia	L	5-8	H #3	80	90	45	0	0
			Check	55	90	40	5	0
Juniperus scopulorum	T	5-7	H #3	0	10	0	0	0
			Check	10	0	0	0	0
Juniperus squamata meyeri	T	6-8	H #3	75	90	55	55	15
			Check	75	95	70	—	—
	L	4-5	H #3	60	50	—	—	—
			Check	90	100	—	—	—
Juniperus virginiana canaerti	T	5-8	H #3	0	0	—	—	—
			Check	10	10	—	—	—
	L	5-8	H #3	0	0	0	—	—
			Check	0	0	0	—	—
	L	3-4	H #3	0	0	—	—	—

IMI—Intermittent mist indoors; CTI—Cheesecloth tent indoors; BH—Bottom heat; NBH—No bottom heat; MIA—Mist interval "A" = 3 periods of 8 seconds per 30 min. cycle, MIB—Mist interval "B" = 6 periods of 8 seconds per 30 min. cycle.

val between mistings allowed the foliage to become drier than when mist was applied for a shorter period every minute

With the more difficult to root material such as *J. chinensis blauwi* and *J. sabina* a further reduction in moisture to three intervals of eight seconds per 30-minute cycle was apparently beneficial. Whether this was a real effect of mist or whether it is confused by the poor and slow rooting potential was difficult to ascertain from these results. Of course, the results with *J. scopulorum* and *J. canaerti* are governed by a poor rooting potential under winter conditions.

Effects of Mist as Compared to Other Propagation Frames. Although better results than those shown in Table 3 were obtained in the cheesecloth covered beds in other years, the percentage rooting never approached the results obtained under mist in 1959.

The use of the polyethylene covered propagation beds was practically a complete failure. Unbleached cheesecloth bandage was used as a liner to provide shade and conserve moisture. However, the cheesecloth proved to be an excellent substrate for mould growth. This mould finally spread to the cutting, although most of the loss was due to scorching. The cuttings treated with hormones were the most severely affected.

In summary, the inherent ability of a given species or variety to root was the most important factor in rooting junipers under intermittent mist in the winter months. *J. chinensis hetzi, J. chinensis pfitzeriana aurea, J. horizontalis douglassi, J. sabina* "Arcadia," *J. sabina* "Scandia," *J. sabina tamariscifolia* and *J. squamata meyeri* could be classed as easily rooted, while *J. chinensis blauwi, J. horizontalis plumosa,* and *J. sabina* exhibited a medium rooting potential. *J. scopulorum* and *J. virginiana canaerti* were very difficult to root during the winter. *J. chinensis* "Ramlosa #5," *J. chinensis* "Ramlosa #6" and *J. chinensis* "Skeena #10" gave medium rooting under conditions where rot was prevalent and it was felt that increased rooting would be obtained under more favourable conditons.

It was clearly demonstrated that no shade should be used with mist propagation under the poor light conditions existing during the winter months. Rot was a severe problem with most varieties when shade was used.

In general, lateral and terminal cuttings rooted equally well. Although heel cuttings were normally used, they were seldom superior to those without heels.

Large cuttings rooted faster and more abundantly but this practice was of questionable application since there was a problem of maintaining stock plants and training the plant after rooting had occurred. With suitable hormones, smaller (5 to 8 inch) cuttings were quite successful.

Wounding was beneficial, although similar results could be obtained more easily by the use of strong hormones. This latter treatment circumvents unilateral rooting caused by wounding.

Although not all species and varieties needed hormones to give good rooting percentages, in general, quicker rooting and better root systems occurred with concentrated hormones. Chloromone yielded the greatest rooting response, while Hormodin #3 was strong enough for some junipers and not for others.

The relatively high rooting and the superior results under intermittent mist compared to those obtained in other propagation beds established the feasibility of mist propagation. Bottom heat and six intervals of eight seconds of mist per 30-minute cycle generally gave the best results.

ROOTING OF THUJA OCCIDENTALIS VARIETIES

The rooting of *Thuja* commercially is generally not considered difficult. Chadwick (2) reported that the cuttings could be taken in early winter (December and January) and handled in the greenhouse, or taken in March, April or August and rooted in frames. De Groot (3) reported on the beneficial effects of a strong hormone such as Chloromone on the rooting of *Thuja* stuck in frames.

There is little information in the literature on the mist propagation of *Thuja*. Snyder (6) reported that intermittent mist was superior to the open bench type propagation and hormones increased rooting to 71 per cent as compared to 41 per cent for the untreated check. Although not exactly a mist propagation bed, Bailey (1) reported an overall 80 per cent rooting with a number of varieties in a greenhouse where a high humidity was maintained with a Binks nozzle system.

Experiments with *Thuja* were initiated in 1957 at Ottawa. However, with the lath shade and one- and one-half seconds of mist per minute the results were not indicative of the potential and were further confused by the occurrence of rot. The rot affected the tops of cuttings instead of the bases as with the junipers. Under the poor light conditions the tops were soon reduced to a slimy gelatinous mass and regular Fermate sprays in 1958 did not control this rot. Essentially the only results obtained in these two years was an index of varietal susceptibility to rot as shown in Table 4

Table 4.—Varietal differences in susceptibility of **Thuja** to rot under intermittent mist

Highly Susceptible	Intermediate	Low
T o. globosa	*T o fastigata*	*T o. hoveyi*
T o "Patmore"	*T o lutea (elegantissima)*	*T o* "Rheingold"
T o. robusta	*T o lutea douglasi*	*T o spiralis*
T o rosenthali	*T o. lutescens*	
T. o saundersi	*T. o pyramidalis*	
T. o. verveaneana		

Under the poor propagating conditions there was practically no hormone effect and wounding did not increase the rapidity of rooting to overcome the onset of rot However, even under these conditions, it was apparent that poorer rooting and more rot occurred when the cuttings were taken from older, less active trees.

As with *Juniperus*, there was a marked improvement in rooting, when the shade was removed. The 1959 data are presented in Table 5.

It was felt that the recorded rooting percentages in 1959 were more indicative of the rooting potential of *Thuja Species*. Of more importance, however, was the elimination of rot even with the mist usage of

Table 5.—Percentage rooting of Thuja spp. in 1959

Plant Material	Terminal or Lateral	Size	Hormone	IMI BH MIA	IMI BH MIB	IMI NBH MIB	CTI BH	CTI BH
Thuja occidentalis ellwangeriana	L	4-6	H #3	100	100	100	70	60
			Check	100	100	100	30	30
Thuja occidentalis filiformis	L Single	4-6	H #3	60	20	40	0	10
			Check	60	10	40	0	0
	L Branched	4-6	H #3	80	60	60	0	10
			Check	100	100	90	30	0
Thuja occidentalis globosa	L	3-5	H #3	90	100	100	70	10
			Check	80	100	100	80	30
Thuja occidentalis boveyi	L	3-5	H #3	75	95	90	70	30
			Check	85	95	60	60	60
Thuja occidentalis "Little Gem"	L	3-5	H #3	92	95	100	80	45
			Check	100	94	100	55	25
Thuja occidentalis lutea	L	3-5	H #3	75	70	60	50	10
			Check	95	55	50	20	10
Thuja occidentalis lutea (elegantissima)	L	3-5	H #3	95	100	70	10	0
			Check	75	100	70	10	0
Thuja occidentalis "Patmore"	L	3-5	H #3	90	100	95	50	25
			Check	100	95	100	35	15
	T	5-7	H #3	100	100	—	—	—
Thuja occidentalis pyramidalis	L	3-5	H #3	100	60	100	40	20
			Check	95	85	100	40	40
Thuja occidentalis robusta	L	4-6	H #3	95	75	80	60	20
			Check	95	80	60	50	40
Thuja occidentalis saundersi	L	4-6	H #3	100	100	100	50	10
			Check	100	100	100	0	0

IMI—Intermittent mist indoors; CTI—Cheesecloth tent indoors; BH—Bottom heat; NBH—No bottom heat; MIA—Mist interval "A" = 3 periods of 8 seconds per 30 min. cycle, MIB—Mist interval "B" = 6 periods of 8 seconds per 30 min. cycle.

six intervals of eight seconds per 30-minute cycle when all shade was removed.

Taking the varieties as a whole, hormones were not beneficial and the differences in mist interval had little effect. Bottom heat was apparently beneficial to only a few varieties.

In the cheesecloth covered propagation beds, there was a greater varietal difference in response to bottom heat and hormone; both being beneficial. In general, combinations of Chloromone and bottom heat yielded reduced rooting in previous years. It should be noted that the results, in most cases, were far below those obtained with intermittent mist.

The results in the polyethylene tent were a complete failure for reasons previously explained for junipers

In summary, *Thuja occidentalis* is easily propagated under intermittent mist in the greenhouse during winter if all shade is eliminated. Hormones are, in general, not needed and bottom heat unnecessary. Only a few varieties showed a preference to a certain interval of mist, but, for the most part, the two intervals, namely, three and six seconds per 30-minute cycle did not influence rooting. The use of mist was superior to open frames covered with cheesecloth which was kept moist.

ROOTING OF TAXUS SPECIES

Considerable work has been carried out with *Taxus* over the years. One of the better reviews on *Taxus* propagation was made by Keen (4), in which he cited numerous references. Subjects such as rooting medium, date of sticking, type of cutting, size of cutting, bottom heat and hormone treatments were discussed. De Groot (3) also reported upon the beneficial effects of Chloromone when the cuttings were rooted in frames outdoors. These subjects will not be elaborated on at present, but items pertinent to mist propagation in winter will be discussed.

No specific reference to the mist propagation of *Taxus* was found. The experiments which were begun in 1956 and carried through to 1959, illustrated clearly that *Taxus* was not subjected to reduced rooting when lath shade was used. This is contrary to the general results with *Chamaecyparis, Juniperus* and *Thuja*.

Effects of Age and Size of Cuttings. This is one of the more important factors in the propagation of *Taxus* As shown in Table 6 the terminals, usually unbranched, rooted far faster and in greater percentages than the older cuttings. Generally, the rooting dropped off with two-year-old cuttings but then increased with increasing age of the basal portion of the cutting which was usually accompanied by increased size of cutting.

Table 6.—Effects of size and age on the rooting of **Taxus** cuttings under intermittent mist

Age	Size in Inches	Percentage Rooting	
		T cuspidata	T bacoata repandens
1	6-8″	100	100
2	6-8″	40	70
2	8-10″	70	—
3	8-12″	90	70
4	10-14″	—	80

Effects of Hormone Application. As shown in Table 7, hormones were not necessary with the current season's wood but were beneficial on cuttings of older material.

Table 7.—Effects of hormones on the percentage rooting of **Taxus baccata repandens**

Type of Cutting	Check	Hormone Treatment			Chloromone
		H#1	H#2	H#3	
Current terminals, no heel	90	100	80	100	100
3-year-old with heel	50	40	70	40	100

Effects of Wounding As would be expected, wounding was of slight benefit to the current season's tips, which rooted readily. With older cuttings, however, wounding did increase the number of roots per cutting and the percentage of rooting. For example, with *Taxus baccata repandens,* the unwounded material rooted 50 per cent, the cuttings with one and two wounds 90 per cent and those with three wounds 100 per cent. However, as with other plant material, it is felt that these results can be more easily obtained through the use of strong hormones.

Effects of Bottom Heat Although the effects were small, in general, cuttings rooted slightly better where bottom heat was supplied. This may not always have been exhibited as a greater percentage of rooting but rather an increase in the rapidity of rooting.

Effects of Mist Interval. With the recommended one-year-old tip cuttings, the three intervals, namely, one and one-half seconds per minute, three intervals of eight seconds per 30-minute cycle and six intervals of eight seconds per 30-minute cycle, yielded practically no differences.

Effects of Mist as Compared to Other Propagation Frames. *Taxus* was relatively easily rooted from current season's wood and this type of wood also rooted well under the cheesecloth covered beds whether at 48, 53 or 60 degrees F. Hormones and bottom heat were generally beneficial under these conditions

In summary, *Taxus* is very easily rooted from the current season's wood. This type of wood roots readily and responds less to hormones, wounding and bottom heat than older wood. Discounting the current season's wood, the larger and older cuttings gave increased rooting and response to hormone, bottom heat and wounding. Of the four genera, *Taxus* exhibited the smallest difference between mist and other forms of propagation.

ROOTING OF CHAMAECYPARIS SPECIES

Practically nothing was found in the literature concerning the propagation of *Chamaecyparis.* Snyder (6) reported that two species were tested but he failed to give the results.

Only a few tests have been conducted with this genus at Ottawa. In 1956, *C. pisifera plumosa aurea* rooted 85 per cent with Hormodin #2 and only 15 per cent with the check. Rot was not a problem when no shade was used and the interval of mist was one and one-half seconds per minute. *C. pisifera plumosa argentia* rooted 75 and 15 per cent with Hormodin #2 and check, respectively under the same conditions.

However, in 1958 top and stem rot was a severe problem with *C pisifera plumosa* "Golden Spangle" and practically no rooting occurred even though regular Fermate sprays were used As with the other genera lath shade was used in 1958.

Chamaecyparis pisifera filifera aurea and *C. p f. nana* yielded 100 and 80 per cent rooting, respectively, with bottom heat in 1959. The former doubled its performance from 1958 where lath was used while the latter remained the same In 1959, both yielded better results with six intervals of eight seconds of mist per 30-minute cycle than with three intervals and hormones were not beneficial. A test without bottom heat was used with *C. p. f. nana* and the rooting was slightly reduced.

Chamaecyparis pisifera squarrosa, tested for the first time in 1959, responded to Hormodin #3 and six intervals of eight seconds of mist per 30-minute cycle. A reduction in mist or the use of no hormone each reduced rooting by 30 per cent.

From the meager results, it is suggested that clear glass, bottom heat and a mist schedule approaching six intervals of eight seconds per 30-minute cycle be used. Hormones were beneficial to *C. pisifera plumosa* and *C. p. squarrosa* but not to *C. pisifera filifera.*

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MODERATOR FILLMORE: We thank Dr. Nelson for his discussion on the rooting of conifers under intermittent mist, and we shall now hear from two practical growers who are also very much interested in this problem. The first of these is Mr. Albert Ferguson, Linn County Nurseries, Center Point, Iowa. Mr. Ferguson!

Mr. Ferguson presented his discussion on the use of outdoor mist to propagate junipers, arborvitae, and yews. (Applause)

USE OF MIST FOR THE PROPAGATION OF EVERGREENS

ALBERT FERGUSON
Linn Couty Nurseries
Center Point, Iowa

It was in 1954 that we started our first work with mist propagation. At that time we used constant mist which was applied to two parallel beds about five feet wide. We used the Florida nozzles spaced about 50 inches apart. I believe they should have been spaced closer together. Sand was used as a medium and it had a four-inch drain tile underneath it for drainage. Thirty-inch boards were used for framing the beds.

The following year we liked the system so well that we increased the facility to measure four lines wide, without dividers. Burlap was placed around the sides which let through a little too much air, thus giving us poor coverage along the edge. These were five foot beds with about a ten-inch walkway in between them.

The following year we changed over to the electronic leaf control. We had quite a little trouble with this system at times, so we changed over to the interval timer in 1957. We used Florida mist nozzles primarily, although we had to use a few John Rust nozzles. These latter nozzles shoot out to the side at about a 20 degree angle and were spaced alternately down the pipe. We liked this system so well, that we changed over and put our line along one side with the pipe and nozzles crosswise. They overlapped some in the spray pattern but this gave a nice even coverage. I wasn't altogether satisfied, however, with the timing. On cloudy days we got more water than we should have If we had used the Florida nozzles and spaced them closer together I think that we would have been just as well off.

Cuttings were stuck early in June occasionally during the last few days in May. We want to get through by the latter part of June or at least by early July. Junipers gave us around 90 per cent rooting by early October, at which time they were transferred out of the propagation bed into outside beds or placed in rows about a foot apart.

With arborvitae we got roughly the same results. We generally stick them after we get the junipers in, which would be in late June.

The *Taxus* were put in generally after the arborvitae We didn't get quite as good results with this plant since they were subject to heavy bleaching. It didn't seem to affect the cuttings much since they rooted well by late October. However, we weren't too successful in carrving them over the first winter

With the junipers and arborvitae, if we didn't run into too severe a weather at the time of transplanting we had quite satisfactory results. In 1958 our results were not quite as good as we had the year preceding, perhaps because we did not change to sand.

In 1959 we did most of our evergreen propagation in a polyethylene greenhouse. Our results with this unit have been quit satisfactory. However, to increase our production I think we will go back to the outside mist beds next year in order to propagate our junipers and arborvitae. For the yews I think we will depend on winter propagation primarily.

MODERATOR FILLMORE: We thank Mr. Ferguson, and we will go on to the concluding speaker on this section, Mr. Donald Wedge, Wedge Nurseries, Albert Lea, Minnesota.

Mr. Donald Wedge presented his paper entitled, "Summer Propagation of Evergreens Under Mist." (Applause)

SUMMER PROPAGATION OF EVERGREENS UNDER MIST

DONALD WEDGE
Wedge Nursery
Albert Lea, Minnesota

An article on propagation under mist by Edward J. Gardner, in the May 1st, 1941 issue of the American Nurseryman, was responsible for our starting mist propagation. From that date on, until the 1950's, when many articles on the subject started to appear, we were on our own, isolated you might say, as to what others were doing. The evolution of this idea with us resulted in a mist system which differs in some respects from any other system with which I am familiar.

In 1941 and 1942 we experimented on a small scale in a covered cold frame, using a constant spray from Hudson type spray nozzles. The results were just encouraging enough to continue experimentation.

In 1943 and 1944 we experimented with a small, head-high structure, completely covered with lath shade fencing, using a continuous spray from short throw greenhouse nozzles, fitted on two stationary pipes hung along the upper two sides. This time the results were more satisfactory and warranted the added expense of setting up for increased production the next year. Today we are still using the same basic set-up used in 1945. In describing it to you remember that it was devised 14 years ago when we had to make our own controls, and adopt available mist nozzles. This system has given us good results over the years and consequently we have continued to use it.

We now have two identical propagation houses, side by side, 220 feet long and 26 feet wide, with a ¾ inch pipe line running the length of each house. This pipe, powered by an electric motor, oscillates a 150 degree turn every second, covering four, 4 foot wide beds. This line has Skinner, 70 degree deflector greenhouse nozzles every 4 feet, which makes a 50 degree fan of mist which settles down on the cuttings like a fog. Each nozzle takes care of 64 square feet of bed area.

The interval timer, which controls both the pipe oscillator and the solenoid valve in the water line, was made out of Fairbanks Morse stoker timers, on which we can change timing discs. We exclusively use a disc which is notched to give us one minute of mist out of every five. Hooked in ahead of this in the system is a day-night clock set to come on at 6 A.M. and to go off at 9 P.M. until about August 1st, when the mist is withdrawn gradually until by September 15th it is only operating a few hours during the middle of the day.

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We used an electronic leaf the first year they were offered, but found it acted too erratic under our setup. Maybe some of the new developments in electronic leaves or softer water would work more satisfactorily.

The structure around these beds was built with a framework of pipe and industrial rails. The seven foot sides are covered with lath shade fencing to break and diffuse the winds. We soon found top shading was also necessary.

Washed plaster sand is used as the rooting medium. This sand has been changed every 4 or 5 years, although it could be used longer since we have had no damping-off or other fungus troubles.

In planting, we use a four foot long oak planting board marked with 25 notches which is the spacing we give our cuttings. A wide slicing blade is run along the planting board to form a deep groove in which to insert the cuttings. We formerly firmed the sand around the cuttings by tapping the planting board with a rubber headed mallet. We have since found that this operation can be eliminated. One man plants from 8 to 10 thousand cuttings per day.

The planter works in a light, canvas covered framework which protects him from the mist. This can be easily moved from the inside after planting every 3 feet of bed which allows the new planted cuttings to receive benefit of the mist.

The only problem we have in our setup is that we would like the mist line to operate more frequently and for shorter periods of time, say, 10 to 15 seconds out of every 2 minutes. The notches on our present timer disc are almost as close as they can be made. We have therefore planned to install new automatic timer controls this coming season. Because of the length of our beds it will be necessary to feed the mist line from both ends, in order to secure more even distribution within the frame.

Since all the cuttings we root are used to produce finished plants in our own fields and since they are not for sale as lining out stock, the shrubs which root more quickly and strongly are transplanted directly to the open field in August and early September. The evergreens and slower rooting shrubs remain in the beds over winter and are given a good covering of marsh hay for winter protection.

Between May 1 and 15th, the rooted evergreen cuttings are lined out 4 to 5 inches apart in rows two feet apart, under overhead irrigation. These plants are left in place for two growing seasons, where they develop into 12-18 inch heavy liners. They are then transplanted to the open field, check rowed 3½ feet each way to permit cross cultivation and where they are ready to grow into finished stock.

The yews are left in the beds until early June, as most of the rooting seems to take place in May. I have been wondering if we would have better success if cuttings were inserted in the fall or early spring?

Now as to more specific information on our evergreen propagation. Cuttings are taken in the period from June 20th to July 15th. We prefer the larger cuttings, 6 to 8 inches in length, which are stuck 2 to 3 inches deep in sand. On arborvitae we have had the best rooting where some of the foliage is also in the sand. On junipers and yews the lower foliage is stripped off. The yew cuttings were made with some 2 year old wood at the base.

Pfitzer juniper, Siberian arborvitae and yews are wounded with a razor blade wounder and treated with Hormodin powder #2.

Pyramidal, Globe, and American arborvitae; Savin, Andorra, Golden prostrate, and Bar Harbor junipers are rooted without any treatment.

After hearing and reading reports of 90 to 100 per cent rooting in these evergreen varieties, I hesitate to inform you of the percentage of rooting we are able to secure. I can report that we get these high percentages in many of our shrub varieties. The percentages I am going to give you are based on the counts as taken in the early fall in the 1 year transplant rows rather than the usual comparison of number of cuttings actually rooted compared to cuttings originally stuck.

Table 1.—Field survival of various types of evergreens.

Stand	Plant Material
50 to 65 percent	Pyramidal arborvitae Andorra juniper Savin juniper Golden prostrate juniper
40 to 55 percent	Globe arborvitae American arborvitae Bar Harbor juniper
30 to 45 percent	Siberian arborvitae
20 to 30 percent	Pfitzer juniper
10 percent	Taxus cuspidata*
5 percent	Maney juniper

*Considerable winter killing

I realize that we have a lot to learn in connection with timing and the position on the plant from which to select propagating wood. We need to do more careful experimentation also, in order to find the best root-inducing chemicals, wounding treatments and rooting mediums for each variety of plant we propagate. Thank you for your attention.

MODERATOR FILLMORE: We thank Mr. Wedge very much, indeed. I wonder if there are any questions now on the first portion of the program which had to do with the rooting of conifers under intermittent mist.

MR. MARTIN VAN HOF (Newport, R.I.): I would like to ask Mr. Wedge if he takes one-year old or two-year old wood?

MR. WEDGE: We try to select one-year old wood.

MR. VAN HOF: What kind of stands did you get with Pfitzer juniper and when did you stick them?

MR. WEDGE: We had a 20 to 30 per cent stand and they were put in the latter part of June or early July.

MR. VAN HOF: You must get earlier growth than we do in Rhode Island, because we couldn't possibly put them in at that time, since they are too soft. We stick them around the middle of July and probably a little later, and we have about a 90 per cent stand with outdoor, intermittent mist.

MR. JACK BLAUW (Bridgeton, N.J.): Did I understand you to say that you used sand for four or five years without changing?

MR. WEDGE: Yes, and we had no fungus troubles.

MR. BLAUW: We like to change our sand at least once a year. Do you use it for this length of time even for your evergreens?

MR. WEDGE: Yes, and we seem to have very little trouble.

MODERATOR FILLMORE: Are there any other questions or does anyone on the panel have anything to offer?

MR. HANS HESS (Wayne, N.J.): I would like to ask Mr. Ferguson at what time of the year he puts his *Taxus* cuttings in under mist.

MR. FERGUSON: They were made the latter part of June, and were rooted by late September and early October.

MR. HESS: Did you leave them outside over winter, and if so with what results?

MR. FERGUSON: Yes, they were overwintered outdoors. The roots were rather tender at the time of transplanting and many snapped. They were put in rows in the field and were banked with straw. There was not over 25 per-cent survival.

MR HESS: Of those that survived, did they come out of that leached condition satisfactorily?

MR. FERGUSON: Yes. I imagine the leached condition was one reason we had rather poor survival, although they rooted well.

MODERATOR FILLMORE: Mr. Wedge wants to correct an earlier statement he made. Please go ahead, Mr Wedge.

MR WEDGE: I was asked whether it was one year or older wood that we used for cuttings. Answering rather quickly, I said new wood. I was thinking of the new growth on the ends, which at times, of course, had older wood at the base.

MR. VAN HOF: Try some cuttings a little bit later and you will probably have better success.

MR. ROLAND DE WILDE (Bridgeton, N.J.): I am interested in this idea of using the sand five years in succession. It has been my personal experience that outside of the sanitation requirements, which I think are best served by changing it practically every crop, there is also the problem that in the course of time you may acquire an inhibiting factor against rooting in sand I have found that many times, if you have difficulty in getting a certain item to root, take it up and restart it in a new batch of medium. It will usually bring roots out almost immediately. I would figure changing the sand with every crop would be a paying proposition.

MR. MILTON D. SPANGLER (Hammonton, N J.): I had an experience this past winter with cuttings of *Taxus,* which turned yellow and brown and finally died. Most of the cuttings grew and rooted well. I was since told that some of the plants from which I collected my cuttings had stood in water Whether this caused the yellowing and death of the cuttings, I do not know.

DR. NELSON.: Mr. Hoogendoorn wanted to know if the *Taxus* leached or turned yellow and whether it was persitent.

In practically all instances we had yellowing of *Taxus* under mist, whether in the winter time or in the summer In 1957 and 1958 we had less trouble with leaching or chlorosis in the greenhouse, since we were shading.

We tried various treatments this year and found that where we supplied short days or shade, we did not get the chlorophyll killing or yellowing. The cuttings were actually greener I think at the end of the season than when they were put in. Now, short days are not necessary in this case, since shade is enough to stop this chlorosis The yellowing persists only in that portion which is affected and fortunately the new growth that comes out is green again. I have never seen any material where the yellow portion has ever turned green again..

(*Editor's Note*: The membership recessed for a period of ten minutes and then resumed the session.)

MODERATOR FILLMORE: We have heard a discussion this afternoon on the rooting of conifers under intermittent mist. The rooting of conifers by any method is a matter of interest to everyone in this group. Rooting under plastic is one of the newer techniques and to discuss this general subject we have Hugh Steavenson of the Forrest Keeling Nursery, Elsberry, Missouri. Hugh will discuss the "Propagation of *Juniperus* and *Taxus* in a Closed Plastic House" Mr. Steavenson.

Mr. Steavenson presented his prepared paper on the use of the closed plastic house as a propagating facility for evergreen cuttings. (Applause)

PROPAGATING TAXUS AND JUNIPERUS IN A CLOSED PLASTIC HOUSE

Hugh Steavenson
Forrest Keeling Nursery
Elsberry, Missouri

This is a very simple type of propagating structure and procedure, especially suited to folks like ourselves who have a bewildering array of other production and sales problems to worry about.

The system is essentially a cold frame type rooting procedure with provision to permit the rooted cuttings to grow on and develop a full season without disturbance.

Initially, let me say that just about every idea that we have incorporated in this procedure has been borrowed from other members of the Plant Propagators Society I want to mention Harvey Gray, in particular. A few years ago I took rather vociferous exception to Harvey's poly tent device because of the problems which existed under my parand brown and finally died. Most of the cuttings grew and rooted well. I was since told that some of the plants from which I collected my cuttings had stood in water Whether this caused the yellowing and death of the cuttings, I do not know.

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THE STRUCTURE

The structure makes use of the simplest sort of gable frame construction and is 16 feet wide to allow for two ground "benches" 7 feet wide, with a center 2 foot path. Although the structure can be any length, ours happens to be 172 feet, which accommodates 100,000 cuttings The foundation is made from 5 inch creosoted posts which are sunk 4 feet in the ground. All wood members, including trusses, plates, ridge and side boards, are pressure penta treated. (Just a word of caution on penta or creosote treated wood, be sure such members are thoroughly "baked out" over an entire summer before enclosing with plastic. If this can't be done it would be better to use heart redwood or cypress.) It is a very rigid frame which will withstand any gale and which should prove resistant to decay and termites for at least 20 years. No doubt it will be obsolete long before them. In fact it already is. Since viewing the Quonset-type structure originally developed, I believe, by Cunnigham at Waldron, Indiana, I do believe it is an improvement over our own.

Actually, I do not think that it is possible to build a durable structure more economically than our own. It is down to about 50c per square foot, ready to go. The Quonset salesmen have me convinced that they can apply and remove polyethylene sheets at a considerably greater saving than I can. We spend too much time each spring and fall performing this operation. High on our windy hill we find we have to batten down the polyethylene at about two foot intervals to make it gale-proof The Quonset engineers claim this isn't necessary and I hope they know what they are talking about.

We use a double layer of polyethylene separated by battens, with taut chicken wire down over the frame to support the lower layer of polyethylene sheeting. We feel the double polyethylene layer is important for added insulation. Furthermore, a single layer, whipping against the chicken wire, will be cut before the winter is over. We use 2 mil. polyethylene for the inner layer; 2 or 4 mil. for the outer layer. As Harvey Templeton points out, thickness doesn't make too much difference, as the material has only a life of one season at any rate. When it is removed, it is still usable as a stock shipping wrap.

We have installed frost-proof hydrants at 50 feet intervals, which allows a 25 foot section of hose to reach all corners of the house.

CUTTINGS AND MEDIUM

Yews are taken and stuck in early October while junipers are placed in the bench in December, when our fall shipping has been completed. We use the Fillmore method of making the cuttings in the field, treating them as they are made, and taking them directly to the propagating structure We believe this method saves time, saves confusion and chance of variety mix-up, and it reduces opportunities for infection. It is true that this procedure is not too practicable under zero conditions, but it is fine whenever the weather is reasonably mild.

We like a short, stocky cutting, usually of one-year wood although we are not concerned if we get back into two-year wood. We do avoid the light tip growth. In other words, we want to come up with a stocky, husky liner and believe it is important to have a cutting of this character on which to build Three girls in an eight hour day can prepare 15,000 cuttings, ready for sticking.

Hormodin powder is used for treating both yews and junipers. We have continued to check against a 5 percent I.B.A. quick dip, but have had no apparent differences in results. We have also checked against Chloromone without any startling differences being evident. The question has arisen whether in a cold-frame type procedure any hormone treatment is of value. From our observations we believe it is.

Because the rooting medium is also a growing medium, we use the existing soil into which is incorporated almost equal parts of peat and sand. Our soil is a deep well-drained loess, famous in song and story for growing plants. We figured if Templeton could do such a good job rooting cuttings in his Mississippi mud we should be able to do alright in our good Missouri loess. Each season we test our medium for fertility and pH. We maintain a high level of fertility and a pH of 7 or somewhat higher (this pH level is in agreement, incidentally, with recent Illinois recommendations). After working in our peat and sand additions, we top with a 1½″ layer of U.C mix, 50-50 sand and peat with nutrients added. Over this we have used a light layer of vermiculite which we think helps maintain a better moisture condition in the house.

Medium and house sterilization has been accomplished by chemical treatment, since we do not have steam sterilization facilities In a sealed house of this type, chemical sterilization is easily accomplished as the gas, or vapor, is readily confined. The one year we used methyl bromide, rooting of *Taxus* was slow and erratic. White root tips were repeatedly burned which was accompanied by the formation of numerous "wire" roots We are convinced that the methyl bromide created a toxic condition for the yew cuttings. Since this experience, we have used allyl alcohol, which is recognized as a pre-emergence herbicide, not a fungicide. With the heavy applications we have used (about 2 gal. per 100 square yards in a one to 50 water solution) we are inclined to believe that most living organisms in the house and in the soil to a depth of a few inches must be killed. At any rate the house must be aired for several days before anyone can work in it. Cuttings are stuck shallow (about one inch deep) and at the rate of 40-45 per square foot They are simply inserted using a notched 1″ x 2″ board guide without any firming.

FALL, WINTER, SPRING MANAGEMENT

Theoretically, in a sealed polyethylene house, there should be no moisture loss. Nevertheless, there is some and we do sprinkle daily during the warm autumn days to maintain a humid, moist condition in the house without flooding the soil. As colder weather becomes more common, waterings are reduced to two or three times a week with very infrequent sprinklings during the winter months. By this time of the year (early December) all of the yew cuttings have callused nicely.

As we get into the lengthening days of late February and early March, closer attention must be given to watering and shading. Even at the outset of the operation (October) we find it necessary to shade the west side and south end of the house and we keep some shade on the west and south sides throughout the winter. As the bright days of late March approach, it is remarkable the heat build-up that occurs in a house of this type. With a maximum of 60° or 70° F. outside, inside temperatures may zoom to 100° F. In fact, I think our all time high was 130° F. Now cuttings will be killed along the west and south edges of the house unless careful attention is given to shading and watering. It has always been a source of wonder to me how plant tissues can survive the terrific diurnal temperature fluctuations that occur in a house of this type. Minimum night temperatures will approach those of the outside. In March we have observed the temperature in the house plunge from 100° F. to nearly 0° F. with no apparent ill-effect on the plants (even broadleaf evergreens take this extreme fluctuation as long as moisture conditions are satisfactory). Nevertheless, the spring period is the most critical for this operation. We are anxious to build up the soil temperature to induce early rooting, although at the same time, great care is required to avoid "burning up" the cuttings. Watering becomes much more frequent; perhaps repeatedly during the day on warm sunny days. Shade is added as we get into March and April By late March we begin cutting holes in the polyethylene near the ridge to release excessive heat. This also releases moisture which means extra sprinkling. Air movement and drafts are controlled by stretching light burlap over the holes in the polyethylene. By June 1 rooting is largely accomplished, particularly with the yews, and at this time all the polyethylene is removed and replaced with approximately 60 per cent shade. During this "shock" period, waterings are more frequent but are again reduced as the plants become accustomed to outdoor temperatures and humidity conditions.

SUMMER CARE

Throughout the summer, natural precipitation is supplemented with hose waterings as required to maintain a good moisture level in the beds. Maximum growth is encouraged by monthly feedings. For this purpose we use a dry feed consisting of 5 lbs. hoof and horn, 4 lbs. single superphosphate and 1 lb. potassium chloride, mixture applied at the rate of 2½ lbs. per 100 sq. ft. As this is slow pay-out material there is little danger of burning and our well-buffered medium gives further protection. You will observe that this is heavy fertilization, that is, equal to 2½ tons per acre, and it does make for strong, dark growth. The cuttings are pruned back heavily in mid-summer to encourage stockier growth.

CUTTING REMOVAL

By mid-September we have a strong, one-year rooted cutting-liner, which are ready for the transplant bed. The house is cleared and we are ready to start the next crop

(Editor's note: Mr Steavenson reviewed his talk by showing a series of colored slides which illustrated the principle features of his discussion).

MODERATOR FILLMORE: We thank you, Hugh Steavenson, very much.

We will proceed now to the next two speakers and there will be a brief question period following the addresses by Harvey Gray and John Roller Mr. Harvey Gray, please.

Mr. HARVEY GRAY: I fear this might be a little bit hard on you fellows to have a double take as far as my presence is concerned, although I hope you will bear with me on the subject of yew and juniper cuttings under what I propose to call a vaporproof chamber.

Mr. Gray discussed the subject of rooting evergreens in a vaporproof chamber. (Applause)

THE VAPORPROOF CHAMBER

HARVEY GRAY

Long Island Agricultural and Technical Institute
Farmingdale, New York

What I have in mind as a vaporproof chamber, I think was brought out a year ago in Cleveland. However, for those who were not there I would just briefly make a statement as to what my conception is of a vaporproof chamber.

A vaporproof chamber, as I visualize it, is made of polyethylene plastic, as was first brought to the Society's attention in Cleveland several years ago by Roger Coggeshall I have modified some of the points that were originally presented by Roger in an effort to make sure that the area is really vaporproof.

I mean to say that if this case, which is rarely ever 12 inches high (the width and length of the case is immaterial, but the height I feel is quite important) is down on the ground, as in the case of a ground bed, then we are only concerned with sealing this vaportight by stretching our plastic to the ground over the top, over the ends, and sealing it with soil.

However, if it is on an elevated structure, such as a bench, with wet pipes quite likely underneath for bottom heat, the plastic will go on the bench bottom before any media is placed in it. The plastic will come up the sides and then over the top as well as across the ends and sealed as tightly as it is humanly possible. This is my concept of a vaporproof chamber.

Now that this chamber has become vaporproof, no water can escape except for the extremely minute amount that can and apparently does pass through the plastic itself.

Now on the subject of rooting of yews and junipers in such a chamber; two years ago we set out some trials with yews in the summer time. The *Taxus* cuttings were made when the plants had produced about eight inches of growth and were treated with a growth regulator.

One batch of cuttings was placed under intermittent mist. The other batch was placed under this vaporproof chamber. The vaporproof

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One batch of cuttings was placed under intermittent mist. The other batch was placed under this vaporproof chamber. The vaporproof chamber was placed in a position to take advantage of the coined term "north light". This implies, then, that there is no direct sun's rays falling on the case. Therefore, the temperature that would be generated in this case could be no more on the inside than it is in the shade on the outside of the case. This is to say, if it is 70°F. in the shade out of the case it will be 70°F inside the case The amount of light that falls on the case under the plastic with this north light, of course, varies with the amount of light intensity that particular day and hour. On bright days, naturally, the foot candle power would be higher than on dull days. With the photographic lightmeter we were able to ascertain about 1,000 foot candles on a very bright day in this shaded area of north light

At the same time, a comparable batch was placed under glass in a greenhouse with the intermittent mist. At the close of the fall season, both batches were checked. We noticed that under the intermittent mist, in the greenhouse which was not shaded, we had some very nice rooting of the *Taxus* cuttings, in spite of the fact that they were as yellow as if they might have been painted with a yellow paint They, nevertheless, were well-rooted

The material placed in the plastic vaporproof chamber also rooted, but rooted less well. The roots were not as long nor was the percentage as good as it was in the case of the intermittent mist in the unshaded greenhouse.

In another study a number of *Taxus* cuttings were made in the conventional manner in November and placed in the greenhouse We had three different areas for study, ie, (1) where the cuttings were handled on the accepted manner by syringing, (2) another, where intermittent mist was used and (3) where a group was under the polyethylene vaporproof chamber.

This work was done two years ago, so I cannot give you the exact figures. However, I recall that of these three different batches of cuttings, the one that gave us the best results in the end was the old method where we stick the cuttings in a good grade of concrete sand, placed them in a bench with bottom heat and our percentage of rooting was quite acceptable and favorable, ie., 90 per cent or better.

In the case of the polyethylene tent the results were miserably poor, as was true of the misting trial.

Now I would like to reason out why we had such poor results with the material in the vaporproof case and under mist. Apparently, there is a very close correlation between water application, the media, and the latter's ability to hold water and air The more misting we do, the more we close up our pore space in the medium which results in difficulty.

In the case of the polyethylene chamber, let us say that at a temperature of 50 degrees Fahrenheit, there is sufficient space to hold one ounce of water in the vaporized form. Now let us assume that the temperature goes up some 25 degrees inside the case As a result another ounce of water will find its way into this atmosphere inside the chamber This moisture naturally is going to come out of the foliage, off the foliage, off the medium or out of the medium.

As the temperature arises to 90 degrees I am told there will be three times the amount of water lost that was lost at 50 degres In other words, there will be three ounces of water in vaporized form in this chamber. Where did it come from? Again, from the source that I have indicated.

Now the speed at which water moves from the liquid to the vapor phase, of course, is related to the temperature rise. If the temperature jumps rapidly there is naturally going to be a drop in the relative humidity.

This fact suggests that in propagating with the vapor chamber that we should never tolerate rapid temperature fluctuations It also suggests with a quick drop in temperature this water will also go back into a liquid form. This first collects on the wall of the case or the plastic.

Now if this plastic is concave, there is a pretty good chance that the water will run to the lowest point, which is in the middle of this case. On the other hand, if it is convex, the water will run to the sides. We would find that after an interval of time, say some two months without opening the case, either the center of the bed is pretty well dried or the sides are dried, depending on the shape of the polyethylene cover.

This presents a partial answer to some of the problems that we run into with this so-called vaporproof chamber.

Now I don't want to steal any of Roger Coggeshall's talk, but I do want to bring this to the group's attention, as I feel it has an effect on the operation of the vaporproof chamber. In the original description of this chamber mention was made of the use of cheesecloth, which was placed under the plastic. It was the originators idea, I believe, for this cheesecloth to serve as a device for shade. My concept on the need for this cheesecloth is different. I believe that this cheesecloth acts as an absorber for this condensing water, which in turn prevents uneven distribution of water in the medium.

And so I would go on record as saying that the cheesecloth or gauze that is put under the plastic acts as a holding or wicking device. The moisture as it moves from the liquid to the vaporized form within the case will move off the cheesecloth or gauze rather than out of the cuttings or medium. The loss of water will first take place from this device rather than from the cutting or medium.

These observations may be taken for what they are worth in relation to this particular business of rooting evergreen cuttings in the vapor chamber.

I would like to add one more comment relative to the rooting of *Taxus* and juniper cuttings. It has been my observation that regardless of the system used to propagate these plants that a good grade of clean, sharp, sterile sand, possibly of the so-called concrete grade, has given us our most uniform rooting results. Thank you

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MODERATOR FILMORE: Now we will hear again from John B. Roller. He is sure to have some good ideas on this airtight polyethylene enclosure. John Roller of Scottsville, Texas.

Mr. John Roller discussed the topic of rooting cuttings under the polyethylene tent. (Applause)

THE POLYETHYLENE TENT

J. B. Roller
Verhalen Nursery Co
Scottsville, Texas

After seeing some of these polyethylene structures that Hugh Steavenson showed us, I am wondering what is meant by a polyethylene tent. In our situation we do not have any greenhouses as such, although polyethylene enclosures in a small measure serve as a substitute. We have had a little experience with juniper, yew and arborvitae, and quite a bit with broadleafs under what I would call a plastic tent

This tent is constructed just as Harvey Templeton's tent is constructed, using the concrete reinforcing steel with plastic stretched over the top and sides.

We use beds that are made on the ground, and since our propagation is conducted under a lath shade structure, these tents are located underneath this unit. Now this works out quite well for us because we don't have the extreme cold to combat. We have used these tents both with and without bottom heat.

Now the medium that we use is made quite simply. We go out into the field and pick a sandy spot This is hauled in and worked with about two bales of Canadian peat for every 300 to 400 square feet of bed space. After each crop of cuttings is removed we again work in an additional quantity of peat. We also use some sand and peat mixtures. Our cuttings either are stuck right into beds or into flats, depending on whether or not bottom heat will be used These are then covered with an arch of reinforcing steel which in turn is covered with polyethlene.

Some of the varieties of conifers that we have rooted in these polyethylene tents nclude the Italian cypress. It is not a hardy plant. The cuttings that were stuck under this tent were taken in the early spring after growth was just beginning. They were small heel-like cuttings which were pulled off with the ball still on them. These were then treated with indolebutyric acid and mud slurry These cuttings were made the latter part of February and in the first two weeks of March. In 60 days the cuttings were ready to be potted although they hadn't made any top growth. By the following fall they averaged about 10 to 12 inches in height

We have also tried some *Taxus cuspidata* which were also treated with the same mud solution of indolebutyric acid. On the 8th of January we stuck 830 cuttings in a bed on a heated cable with our regular field soil and peat worked in. On April 17th, 800 well-rooted cuttings were potted, five had not rooted and 25 were weakly rooted out of the 830. On the same day, January 8th, we stuck 3,320 cuttings treated in exactly the same way, except they were stuck in a polyethylene tent with no heat. On May 8th, 2,925 of these were potted and were well rooted; 395 of these were restuck in open bed under shade without any polyethylene covering, and most of them went ahead and rooted.

Now I usually soft pedal this alcoholic quick-dip treatment that we were talking about this morning, but here is an example where it worked well. We have a dwarf blue pfitzer that has given me lots of trouble. On January 8th, along with the yews, we also stuck 75 Blue Pfitzer cuttings in a 50 per cent sand and peat mixture in flats Now these cuttings were treated with a 20 per cent dip, ie, 20 per cent solution, 80 per cent water. They were given bottom heat from 70 to 75 degrees by means of a heat cable On February 4th, 72 of those were strongly rooted and were potted. We stuck 75 others with a 10 per cent solution, under the same tent. On February 14th, all of these were strongly rooted and potted.

Now we have had varying success with arborvitae under the polyethylene. Fungus is really a problem with us and it seems to be worse with arborvitae than any of the other conifers that we have worked with. However, with the Brewer's hybrid, which is commonly called an upright Bonita, we were able to get percentages in the upper eighties, without bottom heat, using the polyethylene tent Here again, from the time they were struck until they were ready to pot we ran into a little trouble hardening them off. The weather was hot and we were busy and couldn't pot. Actually, the polyethylene tent didn't prove to be much benefit to us in the rooting of most of our arborvitae.

For rooting certain broadleafs the polyethylene tent is an indispensable item. We also have a dwarf globe pfitzer which we like to root in it. I don't want to mislead anybody about this alcoholic quick dip solution, but under these polyethylene tents, with bottom heat, we were able to secure 96 per cent rooting with one hormone treatment, 86 per cent with another hormone treatment and 79 per cent with still another when the cuttings were struck in straight sand.

The 86 per cent rooting was obtained with a 5 per cent solution and the 92 per cent rooting with a 10 per cent quick dip, the cuttings being stuck in sand and peat

Polyethylene, I think, is one of the most versatile aids that the propagator has yet come across. It can fit into most all of our operations, whether we be in the north or the midwest or south or southwest. I think it is a cure for many of our problems

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MODERATOR FILLMORE: Now very briefly I have been asked to explain my idea that making one cut on the cutting is better than making two or more cuts That idea goes back to about 1935 when Dr. William Cooper, who was one of the pioneers in the research on the effect of hormones on rooting cuttings, found that if he took lemon cuttings and treated them with hormone and let them stand a few hours and cut off the lowermost inch of the stem that he lost a good deal of the rooting effect of the hormone. He was one of the pioneers responsible for the development of the cofactor theory, which Charles Hess was talking about this morning. Dr. Cooper assumed that he was losing something when he made the second cut. He theorized that he was losing some natural and presumably irreplaceable substance formed by the plant which accumulated at the base of the cutting following the first cut. A second cut might cause the loss of that accumulation.

Now have we questions for any of the panel members?

MR. VERKADE: John Roller, did I understand that you were using a 20 per cent IBA quick dip or a 2 per cent solution?

MR. ROLLER: Well, that wasn't clear, but I dissolve 2 grams of indolebutyric acid and 2 grams of napthaleneacetic acid in 200 c.c. of alcohol. Now I use a 20 per cent or 10 per cent or 5 per cent solution from that base.

MR. EDWARD W. AMBO (St. Louis, Mo.): We would like to have Mr. Roller explain his mud slurry solution.

MR. ROLLER: The mud slurry solution is used just as a matter of convenience. Like I say, we don't have greenhouses and we operate under lath. We make cuttings the year round. I use 10 c.c. of the base solution in a quart of water, which is added to our red clay to make a mud. The cuttings are dipped to facilitate keeping the base of the cuttings moist until such a time as we can stick them, which might be in two or three days because of weather conditions.

MR. ALBERT LOWENFELS (White Plains, N. Y.): Harvey, didn't Guy Nearing use a northlight cold frame with success on rhododendrons?

MR. GRAY: My answer to that is yes, but what is the point of the question?

MR. LOWENFELS: It seems to me when you close something in, you are liable to get disease because of this same moisture condition that you are talking about. If we have a plain cold frame, as Guy Nearing uses, you don't have all these problems. What is this trouble with the polyethylene?

MR. GRAY: My answer to that is, neither do I have any problem of disease entering into the frame.

MODERATOR FILLMORE: Any other questions for these gentlemen?

DR. NELSON: I tried polyethylene enclosures also and with disastrous results. It was not the fault of the polyethylene but the fault of the wick that Harvey has mentioned. I made use of cheesecloth and this proved to be an excellent substance for mold growth and this in turn spread to the cuttings. I am reporting that so no one else makes the same mistake I did.

MR. GRAY: That is an excellent point that was just brought out by Dr. Nelson. Unbleached muslin or fabric always contains a certain amount of starch which is an excellent medium for molds. This may be taken care of by soaking it in water with a very dilute concentration of copper sulphate.

MODERATOR FILLMORE: Thank you. Now if you have further questions will you please reserve them for the question box?

The final speaker this afternoon will be Mr. Henry Homer Chase, of the Chase Nursery Company, Chase, Alabama, who roots junipers very freely in the open field. Will you please begin, Mr. Chase?

MR. HENRY HOMER CHASE: Thank you, Dick.

Following these last two speakers makes me realize how lucky I am to live in Alabama.

To do this thing very simply, I have prepared a text which I will follow.

Mr. Chase presented his paper on "Rooting Junipers in the Open Field". (Applause)

ROOTING JUNIPERS IN THE OPEN FIELD

HENRY HOMER CHASE
Chase Nursery Company
Chase, Alabama

The beginnings of the field production of junipers from hardwood cuttings can be traced back to a wonderful old man who lived in Jeff, Alabama, whose name was Lawson Kelly. He was a part of the firm of J. O. Kelly and Sons Nursery. From discussions with old timers in our neighborhood such as Mr. C J "Pappy" Hayden of Athens and Mr. Lawson Kelly's nephew, Mr. Thompson Kelly, it becomes apparent that "Uncle Lawson" as he was known to all of us, first began his experimental plantings of hardwood cuttings of junipers as early as 1924. We can only assume that his first varieties were of the *J communis* types such as *ashfordi, hibernica* and the *J chinensis* types such as *pfitzeriana* and *excelsa stricta*. By 1928, Mr. Kelly was producing this kind of material in quantities approaching the 500,000 mark and was classing among his customers such people as D. Hill Nurseries of Dundee, Illinois, Onarga Nursery Company of Onarga, Illinois and our own concern, the Chase Nursery Company.

Two factors in our area have strong influences on our propagation of juniper cuttings in the field. First is our 52 inch annual rainfall, and second is our soil which is a heavy, red clay known to geologists as "decatur clay".

This method of propagation is extremely simple and it is done just exactly as we do our deciduous shrubs, except that we attempt to get it done in the fall, usually in September or October. We use a lot of water in the planting operation.

The ground is prepared as it would be for any other crop by breaking it up with disc turning plows, then harrowing with disc harrows, and finally by dragging it with either a drag harrow or a pipe frame. The furrows to receive the cuttings are laid off with a bull tongue plow arrangement mounted on a John Deere tractor. We try to prepare a fairly wide and relatively deep furrow. Water from a tractor drawn tank is poured into the furrow immediately prior to planting. The cuttings are stuck just as close together as it is possible to get them and they are actually planted in the water or in the mud.

The cuttings are taken from the stock block directly to the planting area in burlap rolls. These cuttings are collected from old plants which we have saved for this purpose Some of these stock plants have been producing cuttings for us for as long as 15 years. After the cuttings are placed in the furrow in an upright position as close together as possible, a small amount of dry dirt is raked into the furrow on either side of the cuttings more to hold them upright than anything else. We then follow this with another application of water. It is our belief that this large quantity of water tends to remove all of the air from around the cutting

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As soon as the moisture has been dispelled sufficiently for a tractor or a mule drawn cultivator to run conveniently, we give them an initial cultivation which is usually enough to get these cuttings off to a good start. At this point in the operation, we go through the planting with a pair of hedge shears and cut these cuttings back to within 3 or 4 inches of the soil. The job is then complete except for the control of weeds and grasses throughout the following season.

Approximately a year after these cuttings have been planted we run under them with a small digging blade without a lifter in order to force additional root breaks. At this stage of the game, it is possible to start harvesting the crop, although a more ideal time to transplant the rooted cuttings seems to be in the following spring, prior to bud break.

* * * * * *

(*Editor's note.* Mr. Chase concluded his discussion by showing colored slides of the propagation sequence used to root evergreens in the field.)

MODERATOR FILLMORE: Have we any questions for Mr. Chase?

MR HOOGENDOORN: Do you have to keep the cuttings under constant irrigation?

MR. CHASE: It has been our observation over the years that the poorer the ground you plant these things in, the better they root. No, Case, we do not irrigate them unless we get severe burning, wilting or drought, and then only periodically.

MR. HOOGENDOORN: How about fertilizer?

MR. CHASE. No fertilizer is used

DR. ALFRED M. S. PRIDHAM (Ithaca, N. Y.): Could you tell us how your rainfall is distributed over the year?

MR. CHASE: I can't break it down. It goes from a usual six inches in January to a low of 3.25 inches in May. At times, we don't get any for a crack of six weeks at a time.

MODERATOR FILLMORE: Any further questions? Well, I will now turn this meeting back to President Nordine. I thank you very much. (Applause)

PRESIDENT NORDINE: Again, we have just a few announcements that will only take a minute. Please do not forget to submit questions for the question box, which will be held tomorrow evening. Those of you who have attended these meetings before know the importance of placing questions in the box. Those of you who are new, are invited to submit any and all questions that you might have Jim Wells has suggested that if any of you have slides of any new, different, or peculiar plants, bring them tomorrow night and there may be a chance to show them.

We have maintained an enviable record of meeting on time. Tomorrow morning we have a little different situation. The program begins an hour earlier than it did this morning, but we will still plan to start on time tomorrow morning.

With that, we send you on your way.

The session recessed at 4:30 o'clock

FRIDAY MORNING SESSION

December 11, 1959

The third session convened at 9:00 o'clock, President Nordine calling the meeting to order.

PRESIDENT NORDINE: Good morning, gentlemen. We have a full program again this morning, and we are anxious to start on time. We have as our Moderator this morning Dr. L. C. Chadwick, who is ready to go. Dr. Chadwick.

MODERATOR CHADWICK: Thank you, Roy. Ladies and gentlemen, it is a pleasure to be here

As the President has mentioned, we have a full program both this morning and afternoon. The entire day is devoted to various phases of container production of nursery stock. We have allowed ample time, I believe, for questions which will be brought in to the sessions after each phase has been discussed by a leader and a panel.

When we come to the question part of the program, we hope that you will confine your questions as far as possible to that particular phase of the subject. If you have questions on container production that do not pertain particularly to the phase that is being discussed hold these until the latter part of the afternoon session when we will run a free for all.

Without taking any more time from the speakers, we will begin the program this morning with Dr. John Mahlstede, Department of Horticulture, Iowa State University, who will lead the discussion on "Mediums for the Production of Nursery Stock in Containers". John.

Dr. Mahlstede presented his prepared paper, which was followed by sequence of colored slides (Applause)

MEDIUMS FOR THE PRODUCTION OF NURSERY STOCK IN CONTAINERS

J. P. MAHLSTEDE[1]
Department of Horticulture
Iowa State University
Ames, Iowa

The production of nursery stock in containers differs from general field production in that the volume of root medium per plant usually is greatly reduced. Because of this, the culture is similar to that used by florists for potted greenhouse plants. Depending somewhat on the plant being produced, the degree of culture may vary between systems, but in principle, the raising of pot plants in the greenhouse requires the same basic considerations which the nurseryman must take into account for the production of nursery crops in metal containers. Current systems of container production are further complicated by the inability of the operator to do much about modifying his environment during the summer and winter months. For this reason, the production of a quality

[1]Journal Paper No J-3814 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa Project No 1238

plant product out-of-doors requires very exacting management by a grower who recognizes the complexity of the problem.

One cannot hope to cover the general topic of "media", without overlapping into the general areas of watering and fertilization. If we were to consider only growing media in this discussion, we might simply present a list of the major soil types in the United States and the various organic and inorganic materials which could be used in various proportions therewith.

In propagation we comment that all we need in a rooting medium is that it hold the cutting in place until such a time that rooting has taken place. This is over-simplifying the problem a little, since the rooting medium must also be free from injurious insects and diseases, it must be free from weed seeds, it must have a suitable pH, it must be porous enough to permit drainage of excess water and provide adequate aeration — yet dense enough to hold the cutting without shrinking away from the plant part — and it must have a composition that will permit it to hold some moisture. Once this cutting has produced roots, most plant parts have enough mineral nutrients stored in them to carry them over to the time when they are potted or transplanted into a growing medium. It is this growing medium that we are concerned with at this time.

What does a nurseryman want in a growing medium? To put it simply, probably all he wants is a medium which will permit economical production of salable plants which will satisfy the consumers' wants. The next question that arises, is "What properties must this substrate have to fulfill this simple requirement?" Combing many qualities of a propagation medium, it should be free from harmful organisms and chemicals, have a pH conducive to plant growth, provide support for the plant while at the same time be easily penetrated by roots, provide adequate aeration for the roots and a continuous supply of mineral nutrients and water, and be readily available, cheap, and of uniform quality. Add to a medium meeting these requirements a healthy plant, an environment having ample light for growth, an adequate growing temperature, and good air circulation and you have most of the ingredients that should produce a quality plant product

Unfortunately, preparing a growing medium for plants isn't like mixing up one of these prepared cake mixes, where all you do is add water. In theory, uniformity of ingredients is the logical approach to preparing a medium which will be the same from batch to batch and from year to year However, it has been demonstrated that even peats, which are thought of as being fairly uniform, vary from bog to bog and even within a bog Practically, then, all we can hope to do is approach uniformity in selecting the various ingredients that go to make up our growing medium.

Many and varied materials have been and are being used by nurserymen as media for the production of plant materials in metal containers. Some of these include: sand, peat, sphagnum moss, perlite, vermiculite, shredded bark, sawdust, leaf molds, rice hulls, wood shavings, and soil These materials singly and in various combinations with and without soil represent the majority of materials in use today. Only when straight soil is used do the common problems associated with field soils come into play. Most operators today are using local soil supplies in various proportions in mixes to supply the minor elements necessary for plant growth. While satisfying this factor necessary for growth of plants they are complicating the growing problem by providing a component which might vary in composition or which, if not tested and corrected, might introduce harmful organisms or chemicals

To generalize on media making use of soil as one component, most recommendations suggest a 1-1-1 mixture of soil, sphagnum peat, and fine gravel (pea, roofing or turkey). This is prepared on a volume basis, using soil which has not been subject to weed killers or runoff from calcium chloride treated roads The proportions will vary somewhat with the type of soil available in the locality. After a heavy watering, all the water should drain away from the surface within one minute. If this does not occur, it may be necessary to use a 1-2-2 or a 1-2-1 mixture. It should be recognized at this point that the method of potting as it in turn affects compaction influences how slowly or how quickly water percolates through the soil volume In preparation, the medium should not be over-mixed to the extent that the ingredients are literally pulverized. Mixing is more than a matter of potentially destroying structure, since the hazard of interstice obviation is real. By the same token, a medium that is wet when being used should not be as firmly tamped during the potting operation as a soil which is on the dry side. It has been demonstrated that the structure of a medium seldom improves with age, especially if it was ruined at the time of potting.

After preparing the mixture, it should be pasteurized, preferably by steam, before use. At the time of planting, 1/4 pound of superphosphate and 1/2 pound of dried blood should be added to every 3 cubic foot of soil. In addition, it is good insurance to add terrachlor and captan or maneb at the rate recommended by the manufacturers. These serve as protectants and can be uniformly distributed in the soil volume by first mixing with one quart of dry sand.

Many growers following the University of California's recommendations have eliminated some of the variability introduced by the soil component and have made use of the sand-peat combinations. The U. C. type soil mixes vary in composition from 100 per cent fine sand to 100 per cent peat moss. The most commonly employed mixture, however, is one using 50 per cent sand and 50 per cent peat moss by volume. Depending on the crop being produced, its age, the length of time the crop is to be in the medium, and the length of time between soil preparation and use, various fertilizer combinations are suggested for use with this mixture. The dry fertilizers which are recommended are those forms which are not readily soluble, thus avoiding temporary excesses which might be toxic to the plant.

Research at Cornell University with various combinations of loam, peat, perlite, and vermiculite has shown that loss of moisture from vermiculite and perlite was very uniform. In addition, these two materials had a larger reservoir of water at field capacity than did either soil or sand. Mixtures of these lightweight media, however, required 2 - 3 times as much water to initially bring them to an optimum moisture content than similar volumes did of soil. The use of perlite in sand, soil and peat mixtures greatly improved the waterholding capacity and available water supply. In these experiments, media containing vermiculite were quite subject to settling, which is understandable since the individual particle is made up of many exploded platelets separated by relatively large air spaces.

Studies at Texas A and M., Virginia Polytechnic, Iowa State University, University of Rhode Island and at the Baumlanda Horticultural Research Laboratory with various combinations of light-weight media have shown that combinations of peat and perlite result in media that have excellent growing properties. Fertility is maintained in these mixtures by the application of either slowly available forms of mineral nutrients or by the regular application of minerals in weak solutions. Regardless of what system of fertilization is employed, regular and systematic soil tests are necessary.

Nurserymen, particularly those in the mail order business, are using various combinations of sphagnum moss, styrofoam, perlite, and soil quite successfully. When these are used for the culture of small plants in frames or benches there is little problem of orientation. However, when these light-weight media are used in larger pot sizes, i.e., 6 inch metal containers, ,etc for growing plants with relatively large tops, the problem of keeping the plants upright can be quite serious at certain times of the year. In addition, mixtures using sphagnum moss as the primary ingredient slow up the potting operation, at least until the employees become accustomed to using it. On a cost basis it should also be noted that many of these so-called light-weight materials are higher priced.

To be considered in a discussion of media is the factor of root behavior in the soil volume. The effect of pot binding and the formation of girdling roots was brought to the attention of nurserymen and consumers alike in an article prepared by Dr. R R. Hirt which appeared in the Spring, 1958, issue of Brooklyn Botanical Gardens Record, plants and Gardens One of the disadvantages of container stock, as pointed out by this article, is that main roots become bent and twisted from confinement, resulting in a distorted and tangled ball of roots. As these roots increase in diameter there is a chance that they might strangle one another. On planting, these roots cannot be spread, and seldom form a normal root system. Furthermore, after planting, the root system may be so restricted that insufficient water and nutrients are available to support growth, resulting in poor growth or even the death of the plant. As a remedy to this situation, Hirt suggests periodic shifting and potting up every one or two years. In addition, customers should judiciously prune container-grown plants at the time of transplanting to maintain a balance between roots and shoots while the plant becomes re-established.

It is recognized that different plants have root systems that are more or less characteristic of the species. These roots have an inherent tendency to spread and seldom, on reaching the wall of the container, re-enter the soil mass. The fact that they seldom re-enter the medium suggests that there is a continual force exerted in the direction of growth of the root tips. The distribution of roots in a container is altered by the method of watering, i.e., plants that are subirrigated have root systems that tend to stratify in the upper surfaces, while plants that are watered from the top have the greater portion of their root systems in the base of the container. This, in part, is regulated by the salt content within the medium. Pot binding *per se* does not have a detrimental effect upon growth of plants, since with proper management a plant can be maintained in an active stage of growth long after it has become pot bound. The size of plant that can be grown in a particular size of pot is limited by the economy of maintaining the nutritional and available water supplies. When the top of the plant reaches a size where it requires more water than the medium can supply in a given period of time, say 24 hours, then the plant should be shifted to a larger container.

Now, to simplify the production of ornamentals in containers, we wish to propose two techniques which might have application for the producton of the slower growing ornamentals in light-weight media.

One technique makes use of 6 inch agricultural drain tile plunged vertically so that the top of the tile is even with the surface of the surrounding soil. (Figure 1). This operation can be easily accomplished by using a small selfpropelled tiler or a jeep mounted unit similar to that used by telephone companies to run line. A 6 inch diameter copper fly screen disc is then placed in the bottom of the tile. Six-inch wire net baskets fabricated from 2 x 2⅝ inch, 18¾ gauge, welded, galvanized wire known as perma netting is next placed inside the tile. Plant materials then can be potted directly into the tile using various light-weight media such as 50-50 peat and perlite, sphagnum moss: sphagnum moss (75 per cent) and perlite (25 per cent); as well as soil

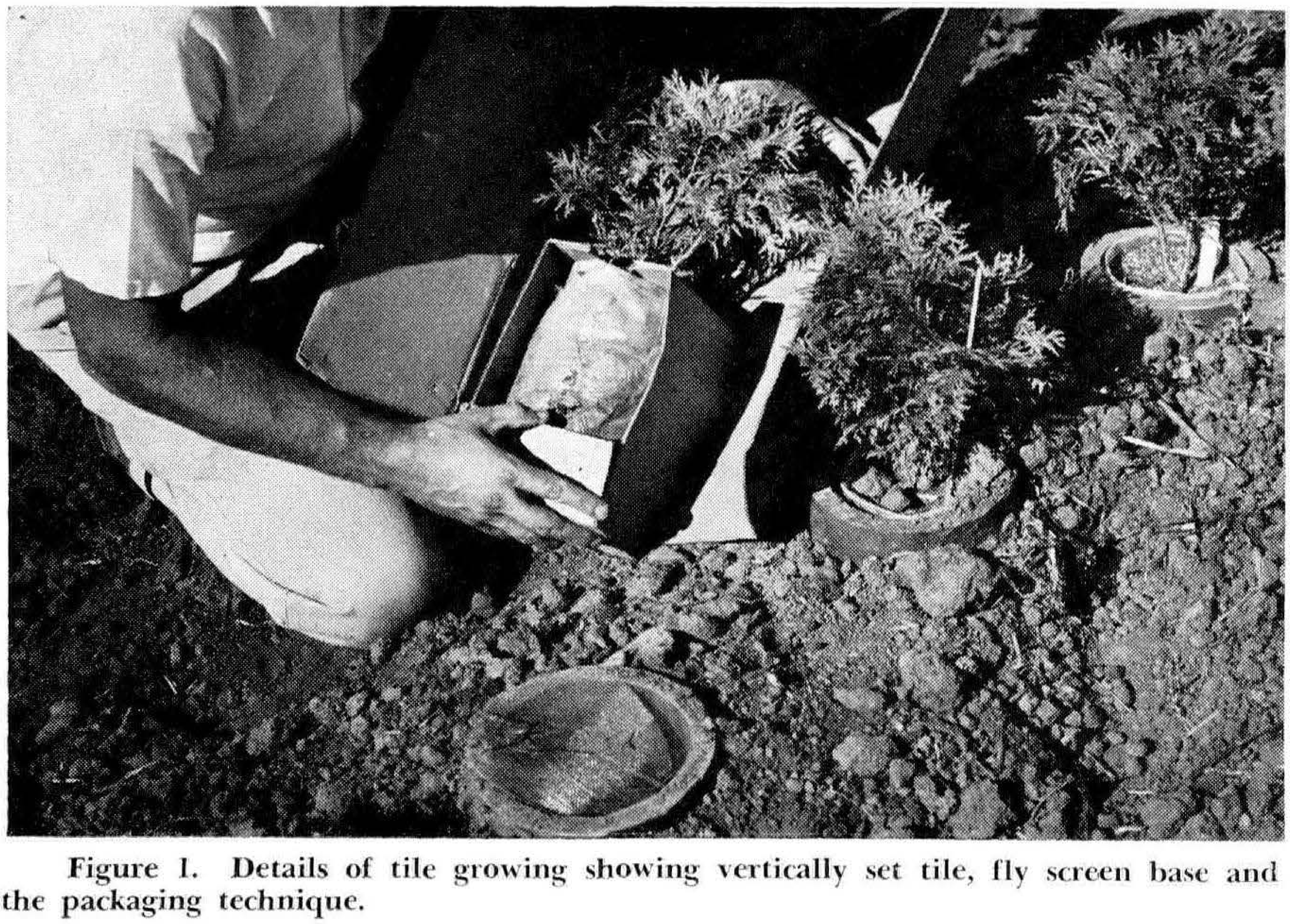

Figure 1. Details of tile growing showing vertically set tile, fly screen base and the packaging technique.

Figure 2. Preparing the wire basket for field plunging. Note that the drainage is provided by melting the polyethylene at the base of the container.

and a 50-50 mixture of sand and peat. Banded liners and once and twice transplanted bare root stock can be used for potting. The plant material quickly established itself in the various mediums and rooted down through the copper screen by the end of the first year. Twice transplanted material was ready for sale by the end of the second growing season and could be easily irrigated if prolonged dry spells persisted. With the exception of *Taxus,* plants needed no artifical protection overwinter.

Another technique makes use of this same 6 *inch welded wire* basket. The wire is generally sold as chicken fencing and comes in varying widths and length rolls. A 36 inch, 150 linear foot roll will yield approximately 300 baskets of two sizes. The wire is easily cut to size with heavy scissors or small tin snips and tied into convenient bundles for winter storage. The baskets can be made at the time of potting by twisting four cut ends along the longitudinal axis of the basket and pressing in the wires at the base to form the bottom of the unit. One and one half mil., 6 x 3 x 18 inch polyethylene bags were used as inserts for these containers. A slightly larger, heavier bag might be desirable if the container will be handled much before plunging. After the basket has been assembled, a 6 inch copper screen disc is placed in the polyethylene bag and the two units placed inside the wire basket. Light weight media can then be used to pot banded liners, or heavy transplants. Drainage is provided in the base of the container by using a Bern-z-omatic torch to melt the polyethylene bag out of the base (Figure 2) . These units are then transported to the field in an area under over head irrigation. A lister plow can be used to open a furrow, the baskets plunged and the finishing touches put on the plunged basket with a disc hiller fitted with a corn cultivator guard (Figure 3). Again, most plant materials establish quite rapidly in the medium, root through the screen and are continually girdled.

Both methods simplify the watering, fertilization and overwintering operations for most plant materials. The copper screen can be removed easily and reused in subsequent planting operations. The plunge technique for growing can be mechanized readily from the point of potting. These systems combine the attributes of field growing with the ease of handling offered by our current method of container production.

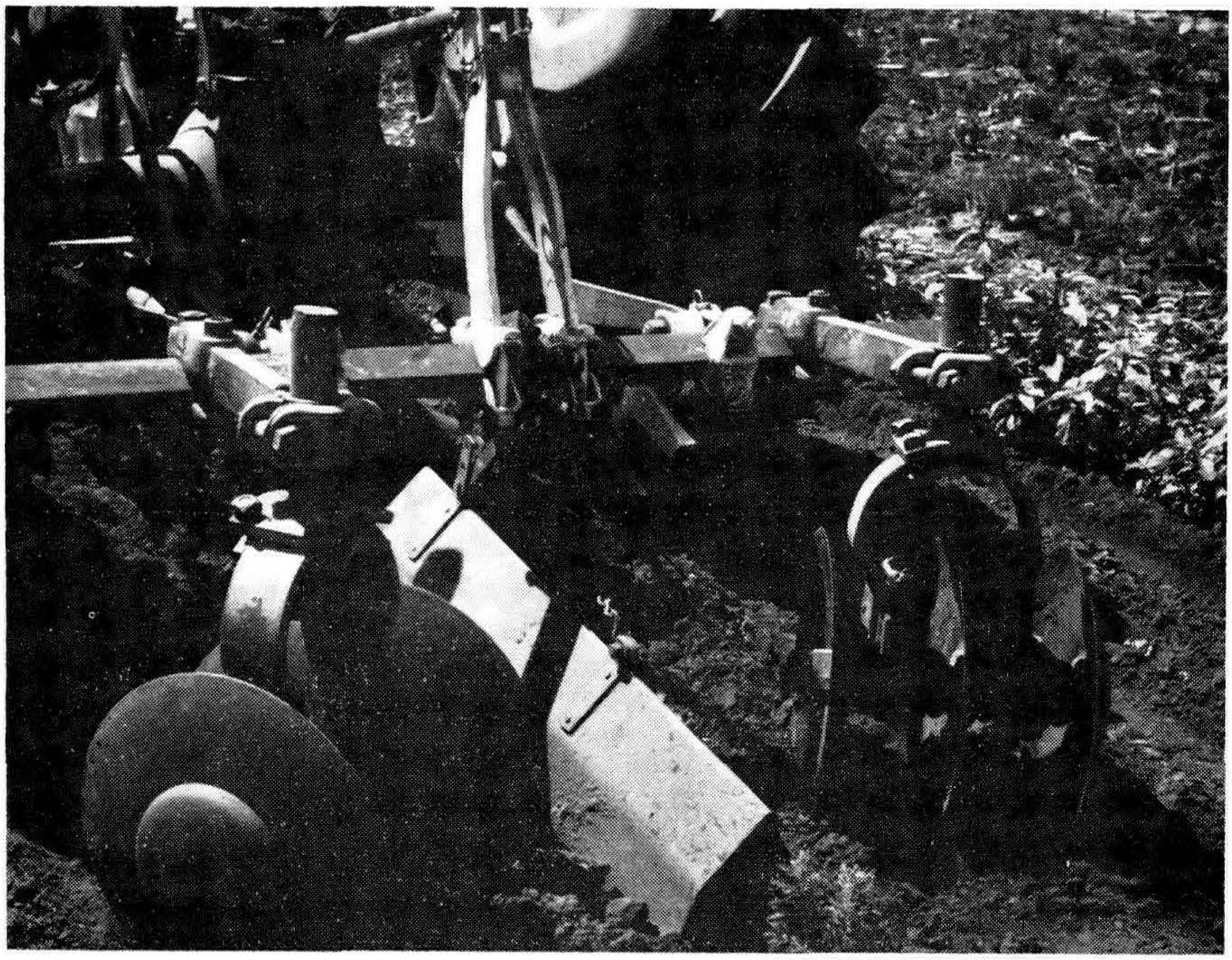

Figure 3. Completing the plunging operation with a disc hiller fitted with a corn cultivator guard.

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MODERATOR CHADWICK. Thank you, John, for that interesting paper. I am sure you have raised several questions that will bring up some response from the group a little later.

Will Bob De Wilde, Jack Hill and Ken Reisch come up to the front now?

You will notice on your program that three men have been asked to head up the panel discussion on mediums Each man will make a few brief remarks relative to their experiences dealing with growing mediums I would like to introduce these men at this time. Robert De Wilde, Perkins De Wilde Nursery, Shiloh, New Jersey; Jack B. Hill, D. Hill Nursery Company, Dundee, Illinois; and Ken Reisch, Department of Horticulture, Ohio State University

We will ask Bob De Wilde to start in this discussion on mediums

MR. BOB DE WILDE (Shiloh, New Jersey): Thank you, Dr. Chadwick. I will attempt to give you a description of our method of preparing container soils and then take you through our entire system of mixing.

The basis of our mix is soil. The geologists tell us that in our area we have one which is classified as a sandy loam. The most important fraction in this soil is the clay fraction, which makes up approximately 20 per cent of it I feel that this is essential in any mix.

The colloidal content of clay gives better aggregation to any mix, better moisture holding capacity, and is essential for good nutrient ex change.

When preparing our soil we analyze for this clay fraction. If the soil has a greater content than 20 per cent clay, we must add additional sand A clay fraction can give you quite a bit of trouble if it is high, or above 20 per cent.

We next select a large, flat, paved area and we spread ths soil in a ribbon five foot wide and six inches deep. Over the top of this is placed an equal volume of sand, five foot wide and six inches deep and above this a layer of peat. This gives you an exact volume of one to one to one, providing your clay fraction is less than 20 per cent. This is then mechanically scooped up and passes through a shreader. It is respread into piles approximately six inches deep and five inches wide.

The mixture next is fumigated with methyl bromide. This is accomplished in the usual way by using the injection method and a polyethylene tarpaulin The reason for fumigating is to control most of your disease organisms, although a few like verticilium wilt cannot be eliminated. It is an excellent herbicide and will keep your stock free from weeds for one year or longer, depending on the rate of reinfestation It is also an excellent nematocide.

After fumigation, the soil is tested and adjusted to a pH of 6.0. This is brought up with ground limestone which will break down slower than hydrated lime and will give you a longer period of optimum pH. Our soil is tested and brought up to a standard of 100 pounds of available nitrogen, 75 pounds available phosphorus and 125 pounds available potassium. This is done by selecting the nearest commercial ratio and then supplementing with muriate of potash.

This soil, now fertilized and fumigated, is mixed one to one with perlite. This is necessary when you are growing plants longer than one year, since the aggregation in the normal one to one mix will not be maintained over a period of three years unless you add something to give you better aeration and better moisture-holding capacity Another important factor is that perlite is extremely light in weight and it reduces the shipping cost of your container.

This is our basic soil mix If you pot holly and some of the other plants which are known to thrive best on a higher organic content medium, more peat should be added. Usually an additional one unit

The average cost of preparing this soil is seven cents a can, including the fertilization This includes all fertilization, fumigation, moving of the soil, and other labor costs involved

This material is then stored in beds behind a mechanical potting machine. We do all our potting during the winter and spring months. We use a hydraulically operated Tailor potting machine, which is made in California We use a "two gallon", Lerio can as our basic container. It comes from Mobile, Alabama The can is filled with soil and placed on a conveyor belt which takes it to the potting machine. Here a hydraulic plunger firms the soil in the can and presses in a die the same size as a two and a quarter inch pot. The can then rotates around to a man who has a flat of plants which have been tapped out from two and a quarter inch pots. He places a plant directly in the hole made by the die, firming it just slightly with his fingers. The plant then slips off the machine onto a conveyor belt where it is watered with an Aqua gro solution This latter solution will help you get better moisture penetration for approximately one year.

The potted plant then travels along this conveyor belt where it receives just a handful of peat to keep the surface from immediately baking dry when placed outside.

On the average ,six men can pot 7,000 plants a day, and I believe this will take us up to our next phase.

MODERATOR CHADWICK Thank you, Bob. We will go on directly to Jack Hill.

MR. JOHN B HILL (Dundee, Illinois) · Thank you Chad. I will try to sum up quickly the set of criteria which we established in choosing the mix which we aré currently using. The medium is a 50-50 mixture of sand-peat, otherwise known as one of the UC mixes

First and foremost in the choice of any mix is the actual quality of that mix. You must have a mix which will produce good plants and produce them uniformly in beds.

We subscribe fully to that monumental John Innes principle which says that under commercial conditions all plants can be grown best in one mix. We do not believe in changing our mix from one plant to another. That comes partially from the fact that our range of ornamentals is somewhat more limited than many of yours. We do not get into those plants liking either the alkaline or acid medium extremes.

One of the principal factors that has always appeared difficult to control in any container operation of any size has been that of uniformity. We discovered early in our trials, six or eight years ago, that however well we might produce one crop in a mix containing earth, the next time we chose earth as a basis for our mix we had to develop a fertilization program all over again for that mix. No sooner had we learned how to manage one batch than we faced the problem all over again with the next batch.

Now, obviously, the British working with a maximum of one or two yards, can come quite close to standardizing a mix involving earth. In our case it was proven next to impossible. Therefore when selecting a medium, we did seek out something where the ingredients were standard and with which the results were 100 per cent reproducible. This single factor, I am sure, contributed a great deal in our finally choosing sand and peat

We also insisted that this mix lend itself to easy sterilization. Methyl bromide never seemed to quite do the job We, therefore, fell back on steam. The sand-peat, does enable complete compounding or mixing, inclusive of the base fertilizer addition. There is no handling required after that mix has been steamed and before it can be used for potting plants.

Last, but not least, in this group of criteria is the low cost. There is a limit to how much can be economically spent on the ingredients that are going to be placed in your container. Sand and peat is not the cheapest by any manner of means although we do have available an almost unlimited amount of low cost dune sand that comes to us from Northern Indiana, which we get laid down for about $1.25 a yard. It is a clean and uniform material.

We began using shredded German peat moss which came in bales It was necessary to break up these bales with a bearcat mill before the peat was usable. We have since changed and are now using the Milford peat which we get already steamed. It comes to us in bulk ready to mix.

In the mixing procedure we first load the components onto a conveyor which deposits it into the ribbon mill. The ribbon mill is in effect a horizontal drum, open at the top and having blades on the inside somewhat like those of a reel lawnmower. It throws the mix from one end to the other, giving us a good mix in a minute or a minute and a half. The medium then goes into a five-eighths yard mixer, which has a trap door on the bottom. It stays here until we are ready to use it

We are attempting to work on a semi-continuous mix method of medium preparation rather than by the batch system. Our base fertilizer is added to the sand and peat at the time and is designed to give us a low but adequately balanced nutrient supply. The pH we shoot at is no more than 6.8. We try to maintain this level although with our high calcium water it tends to creep up.

MODERATOR CHADWICK: Thank you. We will now go to Dr. Reisch of Ohio State University for some comments regarding practices we have found feasible in our experimental work there

DR. K. W. REISCH (Columbus, Ohio): My comments will be quite general and brief

I support Jack Hill's statement that a medium should be reproducible in any given area I don't think that we would state everybody in the world should use sand and peat I do think any grower ought to be able to come up with some components he can use consistently time after time and expect to get approximately the same type of medium so he can regulate his other cultural practices with some degree of accuracy. I think this is a very important consideration.

In the work we have done at the Ohio Agricultural Experiment Station we originally started with a mixture of one-third sand, one-third peat moss, and one-third silt loam. We felt that this was a pretty good medium, although we did have a problem maintaining strict uniformity principally because of the variation in the soil.

Recently we have successfully used peat and perlite and sand mixtures. This past year we conducted a study using mixtures of peat, sand and perlite, sand and perlite, and ground bark, sand and perlite. The results of these experiments, although preliminary, indicate that better growth occurred in the mixtures with the peat moss, primarily because of the fertility factor.

We had better growth in all of these mixtures that had the peat-sand combination rather than the peat-perlite

Although the difference in growth was not great, it was recognizable. We felt that it may have been the result of drying out of the more porous medium. Possibly the fertility level was lower We are continuing with this work.

In closing I would like to call attention to the fact that the volume of the medium, or the size of container is quite important in determining the root and top growth produced by any one kind of plant. Similarly, the consistency of the medium is quite influential in determining the density of the root system produced. For example, the Hetz juniper in a medium of peat and perlite had a more voluminous root system than it had in a sand and peat mixture. The interesting thing about this, however, was the fact that the tops of the plants did not vary to any great extent between the mediums. As these plants grow on there may be some differences which will show up.

(Editor's note: Dr. Reisch supplemented his discussion with colored slides of the Ohio experiments)

MODERATOR CHADWICK: Thanks, Ken. We will now take about 15 minutes for questions. I would like to ask that you confine your questions at this time to the subject of mediums, not getting on to the other phases of container production, since we will cover that later in the meeting. If you have a question, will you rise, give your name, and we will try to get a microphone to you so that you can be heard. If you want to direct your question to some member of the panel, please so indicate.

MR. VERKADE: I would like to ask if anybody has had experience with wintering plants grown in perlite mixtures? Do the plants stand wintering? One of the problems I have in my cans is that the outside roots die during the winter

DR. REISCH: We have done some work and couldn't find any difference in the wintering of plants grown in different mediums

MR. HILL. Perhaps I can add something to this. We didn't run a scientifically controlled experiment but we do know that the well aerated mix tends to entirely fill with roots as opposed to that mix which is insufficiently aerated and which gives you the effect of the hollow cylinder that Ken described and showed you.

MR. EDWARD AMBO: Do you steam sterlize your medium, Mr. Hill?

MR. JACK HILL: Yes, we do. Since we are using this medium both in our container department and in our propagation section, everything is produced with the sand-peat. Everything that goes to the greenhouse is steamed in the container area, except that which is to be used for *Taxus* cuttings. There we do not specifically steam sterilize. Our feeling is, since we get peat already steamed, this sand that comes off the dunes tends to be fairly clean and weed free As far as we know it is disease free.

MR. AART VUYK (Indiana, Pa.): In preparing the soil mix, did any of you fellows on the panel do any tests on the length of time you mix your soil? If you mix it up into too fine a particle, does it make a difference in relation to the structure of the soil?

MR. DE WILDE: Yes, very definitely, you can mix a soil too much, as John Mahlstede brought out. I would say if you shred it with a good soil shredder it will give you an excellent, friable mix which will have the consistency you desire

MR. VUYK: We are using a concrete mixer to prepare a medium consisting of two parts of peat moss to one part of sand. I have found that if we run the mixer too long the particles of the peat moss break up so fine that the medium in the bench of the greenhouse didn't look like peat moss any more. It looked like soil and settled terrifically. I wondered if you fellows had any experience with this in the cans, if your medium became too fine.

MR. DE WILDE: There is no such thing as maintaining a friable mix It will definitely settle and coagulate to give you an aggregate lump, let's say. The addition of perlite will greatly reduce this compaction.

MR. HILL: I don't believe I can add much. Of course, peat can be broken down physically The reason it is peat moss is that chemically it breaks down slowly Of course, it can be rubbed until it is broken down to just dust

MR. ARIE JAN RADDER (Hartford, Conn.): I would like to know a little more about Milford peat and also, did you find any difference between Canadian or Dutch peat?

MR. HILL: Fortunately, the Milford harvesting area is located quite close to us. It is a true sphagnum peat. I don't believe it is a great deal different from any of the Dutch or western European peats. Its pH tends to be a little higher. The German peat tends to run down to 4.0 and this tends to be up in the 5 2 range. It requires a little more manipulation at the time of fertilizer addition

We have not used the Canadian peat for many years. The last time we used it we got too many weeds This was before we were doing any sterilization. We were dissatisfied with it for that reason. I don't think there is any great difference in the choice of peats so long as they hold up. The only criterion is if the peat stands up and remains peat moss. It is peat moss because it resists biologic breakdown and will continue to resist it under your cultural methods.

MR. LOWENFELS: I would like to ask if this discussion applies only to lining out stock rather than growing in containers? It seems to me we talk only about lining out stock rather than growing landscape stock in containers where I would think dirt and peat and other mixes would be better.

MR DE WILDE: I agree. I am outnumbered on this panel as concerns the use of soil. This isn't just a haphazard opinion on our part. We believe we need soil in our mix We have tried these other things and we get better results when we use a soil. Now the main thing that I can attribute this to is the clay fraction which I definitely advocate as being necessary in the medium We don't recommend anything over 20 per cent or you will get into compaction.

We are raising plants to landscape size. We have junipers now which are three to three and a half feet, and they look very fine.

MODERATOR CHADWICK. Bob, is that South Jersey sand?

MR DE WILDE: Yes, it is. The analysis I have here for an average sassafras loam is 15 per cent clay, 5 per cent silt, 55 per cent sand and 25 per cent fine gravel.

MR. HILL: I was just going to add something more. I don't think there is any difference between the production of small plants or large plants. I think the mix that will work on one is probably just as good for the other.

MR. CASE HOOGENDOORN: Did I understand you, Jack, to say you are using the same mixture for greenhouse planting?

MR HILL: We make no alteration in the mix whatsoever. When I say we use it in the propagation operation, I do not mean for the specific purpose of rooting cuttings All we use it for is for potting junipers, for grafting and for the production of banded liners. We use it and like it very much.

MR. HOOGENDOORN: Do you have a lot of trouble from drying out?

MR. HILL: I don't think so, Case, but if we do we can always water.

MODERATOR CHADWICK Lester Freeland from Erie, Pa.

MR. LESTER M. FREELAND: Has anyone tried gypsum in their soil?

MR HILL: Yes, indeed. We incorporate it in the base fertilizer for the purpose of getting additional calcium.

MR. PETER VERMEULEN (Neshanic Station, N. J): We have used styrofoam instead of perlite on a limited scale and think it gives us less compaction It is completely inert. Do you have a comment about that?

MR. HILL: Yes, we tried that in Dundee and it worked very well The cost per pound on shredded styrofoam scares you but when you see how much styrofoam you get in a pound it assumes a different proposition I see nothing wrong with it except it will not stand steam sterilizing Above 200 degrees your styrofoam cooks down and returns back into the polyethylene form.

DR. JOHN MAHLSTEDE: The mail order boys have been using this in conjunction with their potted perennials and house plants. They started out with a styrofoam and sphagnum moss combination but recently have also incorporated a little soil. They feel they are getting a better plant and one that establishes better for their customers.

MR. JIM WELLS: I would like to start a debate. I am bewildered because I have always felt that Jack Hill's system required the continuous addition of nutrients. In comparison, does a 1 to 1 to 1 mix allow you a little more latitude in your fertilization schedule? I would like a comparison.

MR HILL: Jim Well's contention is that with the addition of X amount of earth containing a high nutrient fraction you get a resilience. You have some buffer over controlling the nutrient level exactly if this contention is correct. I believe that this theory is pretty much outmoded. There was a time when even Professor Chadwick felt nutrients leached out from the sand-peat so quickly that you had to stand there with an eye dropper and administer nutrients almost continuously to get an effect I believe that has been pretty much a discarded theory, Jim.

I think our sand-peat holds the fertility at least as well as any mix containing earth that I know of.

MR FORREST BROOKS: I have had a theory for sometime that after the rooting stage that the mix should be a compromise between what the plant has been in and what it is going to be in. If it is going from the container into the ground, then it should have enough soil so it is preparing itself for soil growth. I would like to hear a comment on that.

MR. DE WILDE: I definitely agree with you I think you should have some soil in the mix. Now by the time you have taken peat and sand and added this in equal volume, then mixed the entire mix with one to one of perlite, the clay fraction is no longer of any detrimental effect. It can only be a benefit in our thinking, which was proved by our tests.

MODERATOR CHADWICK: We are going to have to end this discussion period. I know that we could go on for the next three quarters of an hour but to be fair to the remaining speakers on the program this morning, we will have to stop this section at this moment.

We now want to go on directly to the next phase of this discussion of container stock production which deals with water relations. I don't know how many of you commercial people particularly follow the scientific literature on various subjects of plant growth, but if you do, undoubtedly you have formed the opinion that our next speaker is probably the foremost person in the country as far as water relations on plant growth is concerned I have heard Dr. Kramer speak on this subject a good many times, and I know that he is going to have some very worthwhile information for you

It gives me a great deal of pleasure at this time to introduce Dr. Paul Kramer of Duke University. (Applause)

DR. PAUL KRAMER: Thank you, Dr. Chadwick. It is a pleasure to be here and renew some old acquaintances and make some new ones.

I am afraid this is quite a change in pace, however, because after these good discussions on the more or less practical side, I am going to turn to a more or less theoretical discussion of water relations, which I am sure you can apply. This will be better for me to do rather than to attempt to apply it with my somewhat limited knowledge of nursery practice

Dr Kramer presented his prepared paper on "Water in Relation to Plant Growth". (Applause)

WATER IN RELATION TO PLANT GROWTH

PAUL KRAMER
Department of Botany
Duke University
Durham, North Carolina

INTRODUCTION

Everyone who grows plants appreciates the necessity of an adequate supply of water for good growth, but we seldom give much consideration to the reasons why water is essential. This is unfortunate, because the more one knows about the role of a factor such as water in plant growth the easier it is to manage it efficiently and deal effectively with the problems which arise in connection with it.

There are two principal aspects of plant water relations, that is the effects of too much water, and the effects of too little water. I will deal first and in most detail with the effects of too little water, that is, the effects of water deficits on plant growth, because this is the most common problem.

I will deal with the problem under three headings; (1) why water deficits injure plants, (2) why water deficits develop in plants and (3) how to measure and prevent water deficits

Most of the illustrations must come from crop plants because little research has been done on ornamentals other than roses. Even the information on roses seems to be rather inadequate, compared to that for apple trees.

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Most of the illustrations must come from crop plants because little research has been done on ornamentals other than roses. Even the information on roses seems to be rather inadequate, compared to that for apple trees.

It is obvious that we need much more research on the physiology of ornamental plants, including some on plant water relations.

WHY WATER DEFICITS INJURE PLANTS

It is a basic biological principle that the quantity and quality of plant growth is controlled by its hereditary potentialities and its environment, acting through its internal physiological and biochemical processes. The only way in which cultural treatments or environmental factors such as light or the water supply can affect plant growth is by affecting its internal processes and conditions. In order to understand why water deficits reduce plant growth it is necessary to understand how they affect the internal processes which control growth

Water serves the following four general functions in plants:

1. It is an important constituent, comprising about 90 per cent of the fresh weight of young leaves and stem tips and over 50 per cent of the fresh weight of trees. Any serious reduction in water content of protoplasm always results in reduced physiological activity.

2 Water is a reagent in processes such as photosynthesis and starch digestion.

3. Water is the solvent and the medium in which salts, sugars, and other solutes move from cell to cell and organ to organ.

4. Water is essential for the maintenance of turgidity. A certain minimum turgidity is essential for the enlargement of cells and the maintenance of form of unlignified tissue. Loss of turgidity reduces or stops growth.

I wish to repeat that the only way in which water deficits can reduce growth is by affecting the internal processes and conditions of the plant which control its growth. It is probable that every process which occurs in plants is more or less unfavorably affected by water deficits and I will discuss a few to illustrate this fact

Growth is particularly sensitive to water deficits because a certain degree of turgidity is essential for cell enlargement. Thut and Loomis concluded that the supply of water to the growing points (i e , buds) is the most important factor affecting the rate of growth. Apparently water deficits are caused more often by excessive water loss than by deficient soil moisture This explains why many plants grow more during the night than during the day in clear, hot weather. It also explains why many plants grow better under partial shade than in full sun.

Water deficits not only reduce total growth, but they also change the pattern of growth. The root-shoot ratio often is changed, and the distribution of dry matter among roots, stems and leaves is affected by even moderate wilting in barley

Even small water deficits, too small to be visible to the eye often measurably affect plant processes and growth. Australian workers found that short periods of moderate wilting affected growth and metabolism in herbaceous species. Goode, in England, found that small decreases in soil moisture tension which had no visible affect measurably reduced the growth of apple trees. It seems probable that herbaceous plants never completely recover from severe water deficits, and it is doubtful if woody plants recover very rapidly. It probably is a serious mistake to assume that no damage is done to plants by allowing them to dry out until they are visibly wilted

More study is needed on the complex relationships between mineral nutrition and water relations. It is often stated that fertilization increases the efficiency of water use by crops. In some cases this seems to be true, possibly because the leaf area decreases in proportion to other parts of plants, so the amount of water lost per unit of dry matter produced is decreased. It has been claimed that an abundance of nitrogen increases the water binding capacity of the protoplasmic colloids and decreases the rate of water loss, thereby increasing drought resistance.

Stomatal opening is a very sensitive indicator of internal water deficits. As the soil dries out, the stomates of many species of plants close earlier each day. Premature closure of stomates reduces water loss by transpiration, which is desirable, but it also interferes with the entrance of carbon dioxide needed for photosynthesis, which is undesirable. The relation of stomatal behavior and leaf structure to efficiency of water loss deserves further study.

Plant water deficits reduce photosynthesis directly by reducing the photosynthetic capacity of the protoplasm and indirectly by reducing stomatal opening. Some studies show reduction in photosynthesis before visible wilting occurs and all studies indicate a serious reduction after wilting occurs. This cuts down the supply of food available for growth.

Moderate water deficits often increase respiration. Increased respiration, combined with decreased photosynthesis, might seriously reduce the food supply.

Water deficits often change the course of various biochemical reactions, resulting in changes in chemical composition. The decrease in ratio of starch to sugar in plants subjected to drought, caused by hydrolysis of starch, is well known. In tobacco, water deficits often increase nicotine and nitrogen content, and decrease sugar and burning quality. Even moderate wilting of tomato plants decreases uptake of nitrogen and phosphorus and causes changes in leaves resembling senescence. You are all familiar with the premature death of the lower and older leaves on plants subjected to severe water deficits. Apparently water deficits seriously disturb the nitrogen metabolism of plants. Gates and Bonner, for example, found that water deficits speed up destruction of RNA and decrease its accumulation This is one reason for the deterioration of leaves on wilted plants.

Occasionally a moderate water deficit produces desirable changes in chemical composition. For example, the rubber content of guayule plants is increased by a moderate water deficit. The aroma and body characteristic of Turkish type tobacco is obtained only if the plants are subjected to water deficits. Tobacco grown in the shade and high humidity for cigar wrappers is deficient in aroma compared to that grown in full sun. Some kinds of fruits are higher in sugar when grown with moderate water deficits than when given an abundance.

It is doubtful if water deficits are ever helpful to ornamental plants.

WHY WATER DEFICITS OCCUR IN PLANTS

Water deficits and water stress' develop in plants because the loss of water by transpiration tend to exceed water absorption, even when plants are growing in moist soil.

Crop plants lose an amazing amount of water by transpiration. A single corn plant may lose 50 gallons of water during a season, and this means that it loses over a gallon each day during hot, sunny weather. A tree can easily lose a barrel of water on a sunny day and the water loss from large plants in containers must amount to several quarts per day. Often there is a complete turnover of all the water in a plant on a sunny day.

The water balance of a plant is fluctuating and unstable, because it depends on the relative rates of water absorption and water loss. The rate of absorption depends on; (1) the rate of transpiration, (2) the extent and efficiency of the root system, (3) the amount of available water in the soil, (4) soil temperature and (5), soil aeration, because they affect efficiency of roots as absorbing surfaces. The rate of transpiration depends on, (1) plant structure, (2) stomatal opening and (3) atmospheric factors affecting evaporation.

It is not surprising that two processes which are partly controlled by two different sets of factors do not always keep in step. Even when the soil is moist, absorption tends to lag behind transpiration because of the resistance to water movement which exists in the roots On hot, sunny days, even plants in moist soil often suffer from temporary water deficits because transpiration greatly exceeds absorption, although on cool, cloudy days plants in a much drier soil may be subjected to relatively small water deficits because the rate of water loss is so low.

This explains why the behavior of plants cannot be explained fully by either soil moisture or atmospheric conditions. Plant growth really is controlled by its internal water balance or water stress, not by soil or atmospheric factors The latter are important only to the extent that they modify the internal water balance

It might be interesting to know that when water deficits develop in plants there is competition for water among the various organs and tissues. Growing stem tips and young leaves usually can obtain water from older leaves: Very young fruits can compete with leaves, but older fruits lose water to leaves.

HOW TO PREVENT WATER DEFICITS

The obvious way of preventing water deficits is to water plants adequately. This is more easily said than done How can we know that we are watering plants adequately? If we water too frequently injury can result from poor aeration of the saturated soil, and at the least, water and labor are wasted. If we water too little, growth will be retarded by water deficits.

I wish to remind you in connection with watering plants that any given mass of soil can hold only a certain amount of water which is available to plants. If a surplus of water is added it displaces the air from the noncapillary pore spaces and roots suffer from lack of oxygen, unless the water is drained away promptly. If there is good drainage the water content quickly falls to the field capacity. Any further decrease in water content results from evaporation and removal of water by the plants growing in the soil. As the water content decreases, the remaining water is held more firmly in the smaller capillary pores and in the thinner and thinner films around the soil particles The rate of absorption decreases until it finally falls so far behind the rate of transpiration that the plants remain permanently wilted The water available for plant growth, that is the water between permanent wilting and field capacity, varies with the type of soil.

A cubic foot of the following soils, (about 7 5 gallons) will contain· (1) about one quart of water for sand (3 per cent of volume). (2) about three quarts for sandy loam (10 per cent of the volume), and about (3) 6 or 7 quarts for a silt loam or clay (25 per cent of the volume).

Obviously, sandy soils must be rewatered more often than silt or clay soils.

There seems to be four approaches to the problem of watering plants, ie,. (1) measure water loss from container in which plant grows, (2) measure the rate of evaporation and calculate the water loss, (3) measure the soil water stress and (4) measure the plant water stress.

Let us examine the advantages and disadvantages of each of these methods.

1. Measurement of actual water loss from plants is possible only if the plants are grown in containers. It is very precise, but it requires weighing of large containers and generally is impractical, except for research projects.

2. Calculation of the water loss from soil by evaporation and transpiration has proven fairly successful in some experiments and even in field operations. Thornthwaite in this country and Penman in England claim that water loss from an area of land covered with vegetation is determined chiefly by the solar energy it receives because most of the energy is used in the evaporation of water. This means that the loss of water would be the same from all kinds of low vegetation, provided that it covers the soil completely, it is rooted to the same depth, and it has the same color. If this assumption is correct one can calculate the rate of water loss by evapotranspiration (ET) from the average rate of evaporation. There are some errors in these assumptions but it is a usable method under some conditions.

For example, the average rate of evaporation of, water in the Raleigh, N.C. area is 0.2 inches per day in midsummer If a certain kind of plant occupies a soil mass to an average depth of 12 inches and this mass holds 1 4 inches of available water, then it is obvious that after a week without rain, irrigation would be necessary. If rain falls, the amount of precipitation is deducted from the possible loss by evaporation. This system of controlling irrigation has worked well on tobacco in the Carolinas and it probably has other uses

3. Another approach is to measure the soil water stress Measurement of water content is not satisfactory because 20 per cent of water by weigh may mean saturation in one soil and below the permanent

wilting point in another soil. A number of tensiometers, irrigation meters, and resistance block devices are on the market to measure the soil moisture tension and indicate when water should be added. The principal difficulty with these gadgets is their initial cost and the problem of locating them so they indicate the water stress in the soil area from which plants are absorbing water. In soils drier than field capacity water moves quite slowly, so water is removed only from those regions which are occupied by roots Unless these instruments are installed in the root zone they may give a misleading picture of the soil moisture situation.

4. Measurement of plant water stress is at least theoretically the best measurement, because it is the water stress in plants themselves which really controls growth.

Unfortunately, this is rarely measured except in research projects, because it is somewhat difficult to determine.

Too often we wait until the plants are visibly wilted before watering them, simply because we have no other way of measuring their condition. This is too late for best results, because growth has already been retarded by an invisible water deficit before any visible symptoms exist. We need a good indicator to predict the approach of a water deficit so it can be avoided by adequate watering.

In Hawaii certain sugar planters control irrigation of sugar cane by measuring the water content of a selected leaf sheath. In Israel, irrigation of citrus and other crops sometimes is controlled by measuring the stomatal opening. As mentioned earlier, stomates tend to close prematurely in the morning when plants are suffering from water deficits. This premature closure can be detected by failure of kerosene, turpentine, benzene, or some mixture of liquids of low surface tension to infiltrate the leaves when applied to their lower surface.

What we really need is some kind of electronic moisture meter which can be carried out in the field or nursery and which when slipped over a leaf will give a reading of the water content.

For research purposes we need a measure of plant water stress expressed as DPD so it will be in the same units used for expression of the soil moisture stress One serious failure of our research projects up to date is that we have not measured plant moisture stress. This failure is responsible for many contradictory conclusions and inconclusive experiments on the relation between soil moisture and plant growth and plant processes.

SUMMARY

1 The essential factor in plant water relations is the internal water balance or water stress in plants, because this affects the internal physiological processes and conditions which control growth More research is needed on the relation between plant water stress and plant processes.

2. Water deficits develop in plants because the rate of water loss by transpiration tends to exceed the rate of absorption, even in moist soil. In dry or cold soil water absorption is greatly decreased, resulting in serious plant water deficits.

3. Water deficits sufficient to reduce growth often develop before plants are visibly wilted. We therefore need methods for predicting the need for irrigation before plants have wilted. This is being done more or less successfully by measuring changes in soil moisture with tensiometers and by calculating water loss from rates of evaporation.

4. The best indicator of plant water stress and need for irrigation is the degree of water stress in the plant itself, since it is plant water stress which really controls plant growth. Such measurements have been made on a few crops, chiefly by measuring stomatal aperture. We need to develop better methods for making such measurements, including some kind of electronic moisture meter.

5. Finally, those carrying on research on water relations of plants should measure the plant water stress by measuring the relative turgidity or DPD of the plants. Quantitative measurements of the water stress in plants are essential to an understanding of how plants respond to various water regimes.

* * * * * *

MODERATOR CHADWICK: Thank you, Dr. Kramer, for that very fine discussion on water relations both in plants and in soil.

For the next part of this panel discussion we are going to ask each one of these men to say just a few words on the techniques that they are following in watering container stock. After this we will plan to spend the rest of the morning on questions.

Bob De Wilde, do you want to start in on your comments?

MR. BOB DE WILDE: All right, Dr. Chadwick, I will attempt to tell you a little bit about water and its relation to our container operation. First of all, I would like to say something about environment.

We place our cans in a large wooded area which has been cleared and thinned. The trees in this area definitely modify the climate and, consequently the water relations of plants By using the woods as a shade area, we get less air movement and less evaporation.

When placing the plants in beds which are six feet wide, they should be grouped in accordance to their water requirements. For example, all of your shubbery material should be placed together. Your yews should be separate Your two-year junipers are very different from such plants as viburnum and cotoneaster The leafy material must be watered much more frequently.

The next consideration is the surface upon which you place the plants. This is very important, and I think it is one of our biggest problems. The surface should provide excellent drainage because you must apply large quantities of water to these plants. If you cannot drain the surface upon which your plants are resting, the water cannot filtrate through the potting mixture, and leave the can. The air spaces in the medium after you have irrigated will be gone, and you will in effect get a drowning of the plant.

We use the California irrigation type system, with the aluminum pipe and Skinner rotary nozzles for our entire watering system. They are placed at 40-foot intervals. Our laterals are 40-foot and the water source is a spring-fed pond that we have. We use a Fairbanks-Morse pump and it pumps water through a four-inch main to our laterals which run parallel to the beds. The rotary type nozzles give you an overlapping pattern which I am sure you are all familiar with. We operate at a constant pressure of approximately 125 pounds. We are putting on an acre of water in three hours. We irrigate approximately two acres at a time. It does a very good job of distributing the water. We have applied hydrated lime to this water and raised the pH one point. Just by observing the way this lime falls you can tell the very fine and even distribution which you receive.

Being in a woods area trees occasionally block the rotary pattern and we must hand-water where we have a few plants which are missed by the nozzles. You can always figure that you probably will have to do some supplemental hand-watering

As far as determining when to apply water is concerned, we use moisture-resistance blocks, which are imbedded approximately in the center of the cans, which in turn are located at what we consider strategic points throughout the area They are placed with regard to the variety of plant or a large group with similar water requirements. For example, we have one for yews, one for viburnums, and one for junipers, etc. We have about 15 or 20 of these scattered throughout our area, which through experience give us a fairly good indication of when to water before the plant actually shows that it needs water.

We have also used the old rule of thumb method on a shrub such as *Pyracantha,* which will exhibit a slight drooping at the tip It seems to be our first plant which exhibits signs of the need for water.

MODERATOR CHADWICK: Thank you, Bob. We will go right on to Jack Hill.

MR J. B. HILL: I should like to start by agreeing entirely with Dr. Kramer on this matter of plants being almost irreparably damaged by wilting. I want to assure you that once a pfitzer juniper has wilted it just never comes back. It may continue to grow a little bit, but it never really regains the vigor it once had.

Next, I would like to disagree with Dr. Kramer over this matter of water availability. It is my understanding that for all practical purposes in any given volume of soil, despite variations in mixture which might range from glass marbles to very finely shredded peat moss, there will be found the same amount of water available to the plant. In the peat moss there is so much water held hydroscopically, in the glass marbles there would be almost none. There is however, almost the same amount of water available to the plant even though the mixes themselves hold entirely different quantities.

To get on to what we shoot for in Dundee, I would like to deal first with this matter of determining when you should irrigate. We have tried moisture blocks and potentiometers. We finally came down to a very good system, which was suggested to us by a gentleman of

German extraction who visited our nursery one time He referred to it as the "fierct knuckle" method. you stick your finger into the can up to the first knuckle and you can tell whether or not it needs water.

Without being facetious, though, we use the medium to tell us when to water We simply knock a few plants out and look at the medium. You also get so you can almost tell by lifting one whether or not you actually do need water in those containers at that time. Therefore, our determining when to irrigate is anything but scientific, very much a rule of thumb. The white-smocked scientists which Jim Wells referred to sometime ago, turned out to be all brown and don't speak English They speak a sort of a Spanish and they are able to do a pretty good job

In our method of applying irrigation water we have felt uniformity of application was of prime importance. Admittedly we went to a good bit of trouble in the setting up of various fixed head sprinkler systems to determine whether we could get the uniformity that is required under these growing conditions Quite frankly, we were not able to do so. Since water is admitted to be one of the really prime factors in growth rates, this uniformity is entirely essential.

We have gone to this little moving sprinkler. It is a tool that has to be used carefully, as any tool must be If it is used correctly, the savings realized are almost unbelievable For example, one man can literally take care of the irrigation and feeding requirements of four acres of container stock. Now the economics involved in this are quite obvious.

We are currently irrigating all our one-gallon containers automatically with the moving sprinkler. This unit gives us exactly the same amount of water in each can We adjust the nozzle opening on these sprinklers to the point where they are applying approximately three quarters of an inch of water on each application. The three-quarters of an inch of water gives us some leaching through the bottom of the can. We do not want to take a chance on accumulation of soluble salts in the container, so we figure to leach a little with each irrigation

What we call five gallon cans — they are technically an egg can and are not five gallons any more than a No. 10 envelope is 10 inches long — are watered by hand. At one time we thought that we would irrigate these by mechanical sprinklers by making multiple runs up and down the beds. That has turned out not to be practical under our conditions. Our frequency on these is about every five days. Our one gallon containers are irrigated on the frequency of four times a week throughout the entire season. Very early and during the hot season they are irrigated every day. When growth slows down they are irrigated every other day or perhaps every two days. Thank you.

MODERATOR CHADWICK: Thank you, Jack. You will notice there is some disagreement among the experts. We will go back to Dr. Kramer in a few minutes to comment on the point Jack has raised. We will have a comment from John Mahlstede now

DR. JOHN MAHLSTEDE· As has been discussed, the application of water to ornamental plants growing in containers on top of the ground can be either from overhead or from a ground or sub-irrigation facility. Even though the grower has what he believes to be uniform stock, growing in a medium of uniform consistency, there are pockets and areas within a block which require more water than adjacent areas or individual containers. There is no machine yet that can be set to operate mechanically to apply just that amount of water which is optimum for each plant within each container. Generally there has been no substitute for spot watering by an operator with a water wand or similar gadget.

Using either the tile or plunge technique for growing, containers are brought to field capacity after planting, or prior to plunging. In our experiments all stock placed in wire baskets (having the polyethylene bag either on the outside (for tile growing) or on the inside (for plunge) was held for a period of one month, in a shade area, on top of the ground. This allowed for establishment before field placement. Most of the stock was well rooted by this time and little loss was sustained in the planting operation. Both systems were located under overhead irrigation lines, where water could be uniformly applied over the entire experiment. Most groups, however, required little supplemental irrigation since they rooted out into the surrounding soil area where rainfall supplied sufficient water for growth during the 1958-59 seasons.

In the plunge system, where plants were plunged in baskets, it was quite important to locate the surface of the medium just below the surrounding soil line. If this was not done, stock growing in such mediums as sphagnum moss and sphagnum moss and perlite would dry very rapidly. These mediums literally serve as wicks, which fanned by drying winds rapidly deplete the moisture supply within the medium. By the same token a light mulch, on sphagnum containing mixtures plunged in tile is also warranted, especially during the first year when stock is becoming established and the medium receives little shade from the growing plant.

MODERATOR CHADWICK. Thank you, John. We will go on to Ken Reisch for his comments

DR. KENNETH REISCH: Just one comment here about the general factors involved in irrigation techniques. Certainly, we have to consider the economics since this is the basis for selecting a particular commercial operation. I think logically we can do a better job hand-watering a lot of this material because we would give it better and more constant care.

We have to worry about money occasionally at Ohio State University and have not been able to afford to hand water 10,000 or 12,000 containers. As a result we have used a couple of techniques Although we haven't run any research studies on it, we have observed that the rotating sprinkler has given us uneven coverage. That is, we have an excessive amount of water in the interior part of the run and so often not a sufficient amount on the outer edge We had an excellent example with firethorn, which were all yellow towards the center of the circle from continuous leaching but were excellent around the outer edge of the spray pattern

With an automatic system we run into the problem of controlling the amount of water applied to the plant. I think under and over-watering is critical, as has been indicated earlier by Dr. Kramer, and should definitely be controlled in some way, whether by the first knuckle or some other technique It is not something you can leave on and go fishing and come back on Monday and expect the plants to be all right. It is quite different from handling plants growing in the field.

In a study several years ago we found that on a sunny day in Columbus, it takes about four hours for an average plant, growing in a gallon container, to reach a point close to the wilting condition. It was found that these plants required a morning and afternoon watering during the summer and on extremely hot days.

We do want to bring up one point, and that is on the use of a traveling sprinkler like Jack Hill has described. We have used it and think it is an excellent means of watering containers We have had some trouble with compact or dense crowned plants. It is very difficult to get water into the container proper, particularly where you have a moving sprinkler and the water is there for a relatively short time. Maybe Jack can give some comments on that in a moment.

Some nurseries in Ohio (one in particular) has used subirrigation, using plants in a bed lined with polyethylene plastic. I think many of you realize that is a good way to water, but you do run into disease problems, since the water spreads diseases. However, this has been tried and the operators feel it is very economical and very effective, particularly in sales areas where they have the plants ready for sale.

One other point, back to this discussion of polyethylene. We did use a polyethylene bag for marketing purposes and found we could maintain adequate water in the medium by taking the plant out of a can and putting in a bag and closing the top. It worked out very effectively as a means of marketing the plant It was lighter, cheaper, easier to handle, and a good means of maintaining the moisture.

MODERATOR CHADWICK· Thank you, Ken.

I would like to have the microphone passed down to Dr. Kramer now for comment on this point Jack Hill brought up.

DR. KRAMER· I don't happen to have any data on the water-holding capacity of marbles I do have in mind data from some California studies indicating that a particular sand, held about three-tenths of an inch of readily available water In a silt loam and clay they were working with, 2.8 inches and 3 inches per vertical foot of water was held in a day. In other words, a very considerable difference.

Would you care to elaborate a little bit on your question?

MR. HILL: I will restate the hypothesis I had in mind. This is that a given volume of medium will hold almost the same amount of water available to the plant as will another medium. Is that correct?

DR. KRAMER: I disagree From my experience with soil I don't believe it at all.

MR. HILL. The background of the statement partially traces to Mr Hoogendoorn's question earlier, ie, "Does not the sand and peat dry out rather readily in our greenhouse bench?"

It has always been our feeling that porosity as such in a growing mix does not necessarily increase the frequency of irrigation. Obviously, the plant is only going to get so much out of it.

MODERATOR CHADWICK. We may have to put these two men off in a corner this afternoon to talk this things over.

Before we open this session to questions, I want to call your attention to one part of the program that was omitted The last phase of this discussion this afternoon will be on winter protection of container stock. Dr. Reisch will lead off and then will be followed by the panel.

Now if we can proceed to the questions, and here again I would suggest that you confine your question as much as possible to water relationships.

Now, Case, you started here about half an hour ago to get up. We will let you have the first question.

MR HOOGENDOORN: I would like to direct my question to Dr. Kramer. I want to say I am very happy that we have a moisture expert on the program for a change. The question I am going to ask him is the old perennial question that has been in controversial for years. When we get a dry spell do you suggest that we stop, or continue cultivation?

DR. KRAMER· I doubt that I am the most competent one to answer that question. I doubt that cultivation saves much water, if that is what you have in mind, because the surface is dried out so very quickly It will dry out whether it is either cultivated or uncultivated. As to the importance of a dust mulch, so far as I know, if you would like to quote someone, several years ago you might as well have sat on the porch as to try to conserve what was in many soils.

MR. HOODENDOORN: If you don't cultivate, your ground bakes and will crack. If you dig anything during a dry spell, you will find out that you will have more moisture where the surface was loose rather than where the surface was baked

DR. KRAMER: It is certainly true that if the ground cracks badly this does increase water loss. Some soils I know in Texas are rather bad and they do dry out faster. This may be of some importance there. I wouldn't want to generalize about the effect of mulch. This data that are available are rather contradictory, and that is why I would say I wouldn't bother to cultivate. There is some movement of water in soil in the form of vapor toward the surface, under certain conditions. How important this would be in our climate is rather difficult to say; it is doubtful. In some dry climates this is quite noticeable, although it isn't likely to be important in the summertime because the temperature gradient isn't right for it.

MR. JIM WELLS: I would like to ask Dr. Kramer to elaborate on this paraffin test on leaves. I would like to know the time of day that it is best used, the best type of leaf to use it on, how much paraffin to apply, and what do you look for?

DR. KRAMER: This test is based on the assumption that the stomata, the little miscroscopic pores in the leaves, tend to close prematurely when a plant is suffering from a water deficit. Therefore the test is usually made in the morning, say around 9.00 o'clock, because the stomata on almost all plants are open at that time of day. If they are suffering from a water deficit they may have begun to close by that time.

In the case of several of the plants, citrus, for example, kerosene oil was used for a good while. They are using turpentine and they are using a mixture of kerosene and turpentine, I believe, with a heavier paraffin oil. Ordinary mineral oil can be bought at the drugstore to get various viscosities. It has been used on coffee trees successfully and on wheat and on corn with different mixture The trouble is, I can't give you a general recommendation for all crops since there is so much variation in leaf characteristic. After you have selected the most suitable material you can tell whether or not infiltration is occurring because you will have a water-soaked appearance, if it goes in. If it doesn't go in you won't get that appearance and obviously the stomata are closed.

MR WELLS: Is the infiltration quite quick?

DR. KRAMER: It is practically instantaneous.

MR. WELLS: Do you use it on a mature leaf or a young one?

DR. KRAMER: Principally a mature but not over-age leaf. You should stick to leaves of the same age. Obviously, you are going to kill a little spot in the leaf with the infiltration.

MR. FLEMER (Princeton, N.J.): I would like to describe a potentiometer which we use very successfully for broadleaf plants at our nursery.

They cost 15 cents apiece and they are saleable at the end of the current season for 60 cents apiece. It is *Hydrangea macrophylla* the common florists hydrangea. We place this species in our blocks out in the field and also use it in our limited container operation

Our experience has shown that this variety of hydrangea exhibits wilting when the field is below optimum conditions for the rest of the plants, and should be irrigated It seems to be very accurate. The hydrangea hardens off as it gets older just as we want our field plants to harden off. We are able to accurately irrigate right up to the close of the growing season.

If it is extremely dry, this variety will even wilt in early September. We find that we sometimes have to water late If the soil is only moderately dry, it doesn't wilt and that means optimum conditions for broadleaf plants at that stage of their growth.

MR VERKADE: Bob, you very briefly went by something in your talk about water. What is wetter water. and I was wondering how it is applied and how beneficial it is?

MR. BOB DE WILDE: The question was, "How beneficial is the water wetter, commercially known as Aqua-gro?"

It is a water wetter just exactly as the name says; it makes water wetter. It enables the water to penetrate the soil more rapidly and more thoroughly We applied it in one application in July. This, we feel, is definitely beneficial. It obviously gave us more rapid penetration, better water distribution throughout the soil mix It has been used a great deal on golf courses, and so forth.

Also, I would like to add that in order to apply moisture more effectively, we do a lot of night irrigation.

MR. WALTER F. GRAMPP (Red Bank, N J.): How do you apply it?

MR. DE WILDE: It is applied directly through the irrigation system It is injected into the irrigation system.

MR GRAMPP: Do you think this characteristic would remain in the soil?

MR. DE WILDE: It is not a lasting effect that will remain forever in your medium.

MODERATOR CHADWICK: I believe Hugh Steavenson has a question.

MR. STEAVENSON: I would like to ask a question concerning water. We have two sources of water, that is from deep wells and from pond water which is derived from hillside runoff. Our deep well water is not satisfactory because of the mineral content and its build-up in the cans over a season. Our concern with the surface water comes from the University of Californias' bulletin in which caution is made concerning the presence of water molds in surface water. While we haven't been able to observe any detrimental effect but I wonder if that is an actual or potential danger?

DR. KRAMER: We do know that diseases are spread in surface water in tobacco, for example, and this is a definite problem in irrigation. That is the only contribution I can make

MR. HILL: I wonder if Mr. Steavenson can tell us what the mineral content of the deep well is that renders the water unsuitable for irrigation. Is it sodium, potassium, carbonate, or a bicarbonate product?

MR. STEAVENSON: It has been analyzed, but I can't recall it's analysis. It is a hard water. For field irrigation it is all right, but for container growing we get an accumulation of salts during the season and rapid elevation of pH beyond what we want. Furthermore, in sprinkling, we get a deposit on the foliage which is, of course, not beneficial. Our pond water, thus far seems to be excellent, although I have been concerned about the possibility of molds. I can't observe any trouble. I just wondered if anyone had a problem from using runoff water in container irrigation?

MR. HILL: We use nothing but well water. Toward the end of this season we did find it necessary to run an analysis on the water we are getting from our well. The results indicated we had a rather high bicarbonate fraction in this water, so for the upcoming season we are going to use iron sulphate right with our fertilizer and I hope it will work out most of that problem

DR. CHARLES HESS: Jack, I don't think you answered the question Ken Reisch posed before, as to the watering difficulties with an automatic sprinkler on plants which form a canopy over the top of the can.

MR. HILL. We use the Rain King manufactured by Sunbeam, K-20B is the model number.

The water emerges from a rotating sprinkler held some 24 inches above the ground on the stem. This entire sprinkler moves automatically at a rate determined by the function of both water pressure and water flow. Therefore, the application to an individual can within the radius is automatically controlled.

Now we feel because the pattern of water from this sprinkler moves as the sprinkler approaches a plant, the first drop of water enters that can rather obliquely from one side As the sprinkler passes that plant, and is retreating, the last drop enters from the other side. Therefore, where it may not do an adequate job of watering a plant which has an absolutely tight canopy, it will come closer to doing a better job than any fixed head or anything short of hand watering the can.

We, in truth, have had no trouble in getting adequate water on some compact pfitzer junipers. With the typical conifers that produce that canopylike growth we have never felt that watering was a problem with this type of sprinkler.

DR. REISCH: We are using the same type of sprinkler and I will agree with Jack Hill. I think it is probably the best you can get.

MR. LANCASTER (Portsmouth, Va.): For a long time we thought hand-watering was the only way We have reverted now to a square head sprinkler and it will do a very good job. I think the capacity of this particular head is five gallons per minute, so you can see that a lot of water is coming out.

DR. SIDNEY WAXMAN (Storrs, Connecticut): I would like to direct this question to Dr. Kramer. Would you care to comment on the relative rates of water loss from plants exposed to sunlight on a quiet day as compared to the rate lost on a windy, cloudy day?

DR KRAMER· I don't have any quantitative data in mind on this question There is no doubt that wind increases water loss. The worst day, as you all know, is a sunny, windy day. I can't give you the relative rates of water loss, however, on a windy, cloudy day as against a bright, sunny day.

I would like to follow up the point of the efficiency of night irrigation. I think the efficiency of night irrigation is greatly over-estimated. What water is evaporated during the day while you are putting it on is simply water that is evaporated from the mist. This water would probably have been evaporated anyway to a large extent. From the standpoint of water, you don't save as much as you think you might by irrigating at night. As Mr DeWilde has pointed out, it is sometimes quieter at night and, therefore, more efficient, but I doubt if you save very much water.

MR. DE WILDE· There is one thing I would like to add. I think we are all in accord that no matter what watering technique we use, it can still be improved upon. I will not defend our rotary type system as being highly efficient, but we do use extremely high pressures and we do get a smaller droplet than the ordinary rain droplet. The Skinner head has come up with a few modifications which improve it considerably over their older type They have a spring loaded head now which keeps the rotation at a constant speed, we use complete overlapping.

MR FLEMER· I would like to disagree with Dr. Kramer obout night versus day irrigation, particularly where you are growing crops. We have a large area exposed to the air. We have actually placed square pie pans under dense shrubs that we irrigated during the daytime and irrigated again at night. Of course, there was more wind during the day, but on putting down an inch of water we found we gained an eighth of an inch by irrigating at night. That doesn't seem like very much, and when you are pumping water and moving the pipe around, that really small amounts mounts up by the time you are through.

DR. KRAMER: But where did that eighth of an inch of water go? If you didn't lose it by evaporation from the irrigation system you lost it from evaporation by the plants during the day. This is just a matter of energy balance. I think we really kid ourselves about this a good deal, and I doubt there is really enough water saved to make it worthwhile.

The point I am trying to make is that if the plants were not irrigated during the day they would lose the equivalent of an eighth of an inch more or less of spray water As soon as you turn on the water you will stop transpiration. In the night instead of the water coming from the plant, it is evaporated from the plant This is my line of argument.

MR. FLEMER: My line of argument is that you want the water in the soil and therefore I would like to know if those plants really would evaporate a full eighth of an inch during one sunny day.

MODERATOR CHADWICK: We want water in the plant, not in the soil.

MR. HILL: We regard the creation of a specific climate around those plants when they are most active, as being very important This is why we actually want water evaporating in the air. I think the daytime is best.

MODERATOR CHADWICK: When Harvey Templeton set up the program, I was informed that we should stop at 11:40 One announcement, however, before we adjourn, Mr. President.

PRESIDENT NORDINE: Because of the great numbers of new people attending the meetings for the first time this announcement concerns how the Plant Propagators Society operates relative to membership. Visitors are invited to attend one meeting as a guest, the invitation being obtained from a member. They then can obtain an application blank from our Secretary and apply for a membership. Rather than to take time at this particular time to read the rules in regard to membership, we will refer you to the Secretary for further qualifications

I believe that is all at this time Remember that the meeting begins this afternoon at 1:30.

The session recessed at 11:45 o'clock

USEFULNESS OF VARIOUS DIAGNOSTIC METHODS IN DETERMINING NUTRITIONAL DISORDERS

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When the plant propagator sows seed or makes cuttings as the initial step in producing new plants, he consciously or sub-consciously wonders whether or not they will grow properly. He may be concerned with seed viability, breaking of seed dormancy, seed germination, or the selection of wood or plant parts for cuttings In the seed bed, propagation frame or nursery field, he concerns himself with soil texture, soil moisture, soil aeration, soil fungi, soil bacteria, soil insects, soil nematodes, etc. Sooner or later, he may become concerned with plant nutrients or soil fertility and wonder whether or not the plants will develop deficiency symptoms or show instances of toxicity while in the container or nursery row.

Years of experience has taught many of you the technique of preparing a seed bed, propagation frame or nursery field. You can prepare them in such a way as to insure most of the physical features desired for best plant performance. Obviously, we don't all do it the same way. We can visually judge soil condition as related to drainage, moisture holding capacity and aeration but it is next to impossible to visually judge the soil as regards fertility or nutrient supply. Characteristically peat, manures or other forms of organic matter are added to the soil or grown on the field and later incorporated into the soil to improve soil texture. However, manure is not always as good as it might be. Both manure and organic residues of crops are only as good as their source. For example, growing a cover crop on a field that is deficient in a particular nutrient is not likely to correct the deficiency unless the deficient nutrient is added.

In order to prevent nutrient disorders or to detect the development of a nutrient disorder, anyone working with plants needs certain diagnostic tools. We have the diagnostic tools necessary to control the nutritional status of our plants. Such tools are (1) deficiency symptoms, (2) soil tests, (3) soil analysis, (4) tissue tests, (5) leaf or plant analysis, and (6) field trials. These tools are useful However, they are useful only if they are used. (Even the car or tractor is not useful if not used.) Each of these diagnostic tools has its limitations and each has its advantages. We should consider these advantages and disadvantages in order to arrive at a logical approach to controlled plant nutrition.

DEFICIENCY SYMPTOMS

These are useful in determining severe or critical shortages of single, and sometimes double, nutrient-element deficiences. Usually when more than one nutrient-element is deficient there is no visible expression of the symptoms but the plant may not perform normally. Also, by the time deficiency symptoms have appeared, plant growth has already been drastically reduced. However, if the deficiency symptoms develop and are known, there is no other method of diagnosis that is *quicker, easier,* and *cheaper* than the use of such symptoms. Unfortunately, deficiency symptoms are not known for all nutrients for all crops. Still more unfortunately, the symptom for a particular nutrient deficiency may vary according to conditions under which it develops. For example, magnesium deficiency in blueberries show a red color in good light but yellow in poor light.

In addition to identifying a disorder, visual symptoms may distinguish between nutrition, insect and disease disorders. Mr. Zimmerman will show slides of plant nutrient deficiencies As he shows these slides, I would like for you to note the patterns. For the most part, the symptoms will show characteristic patterns as related to the margins or veins of the leaves. Also the pattern will be essentially the same from leaf to leaf for each deficiency. However, the pattern of brown, yellow, or red discoloration will not of necessity be the same for all species or varieties. Regardless of pattern, the symptom will be related to the veins of the leaf. As for insects and diseases, the characteristic pattern does not develop in relation to leaf veins. Insects and diseases do not have any particular regard to leaf veins and their invasion is not consistent from leaf to leaf. By keeping these factors in mind, we can divide our troubles and avoid calling a plant nutrition man when we need an entomologist or a plant pathologist.

SOIL TESTS

Soil tests are useful, mainly to determine or estimate the basic fertilizer applications prior to planting. They are useful, also, as a periodic check upon nutritional conditions during the growing season. Soil tests have had their greatest usefulness on annual or biennial crops that have relatively small or shallow root systems. Such tests have not been too satisfactory for woody perennials that have extensive root systems. Soil tests are rapid and inexpensive. They may be made in the field and necessary correction measures taken immediately.

Unfortunately, soil tests are limited in nutrient coverage. Most soil tests will report only pH, phosphorus, and potassium. If desired, they may include magnesium, calcium, manganese, iron, sulfate, chlorides and total salts Also, soil test values have not been standardized for each crop. For example, we may be able, from soil tests, to suggest safe levels at which no further additions of nutrients are needed. However, the level below which we cannot go and at which nutrient additions should be made is not the same for all crops. Those values prescribed for corn, wheat, oats and alfalfa may not be economically sound on the Horticultural crops we are interested in. Also, it may not be economically sound to maintain a continuous maximum supply of nutrients.

A third handicap for soil tests would be the lack of standardization between methods. As an illustration — it is not possible to compare soil test results with anyone else unless he is using the same soil testing method. Thus, soil test results in Michigan may be different from those obtained in Wisconsin, Iowa, Illinois, Indiana, New Jersey, and other states The difference being due to methods used. Until, soil tests are standardized so we can compare and use results of our associates, there will be much confusion in this method For the present we must each develop our own standards and put them into use Just think of the advantage you would have if you could exchange such information with your associates.

SOIL ANALYSIS

Soil analysis differs from soil tests only in that it is a more precise procedure. It is more precise because the suggested fertilizer additions are based upon the soils ability to hold the nutrients — as measured by exchange capacity. With a known exchange capacity, the amount of necessary fertilizer may be varied accordingly. However, this is only a mathematical calculation and does not need to be as precise as often reported It may seem accurate and precise to calculate fertilizer needs to the nearest pound per acre or gram per container but our methods of application and the plants themselves are not that accurate.

One of the principle advantages of soil analysis is that the laboratory methods are fairly well standardized and comparable results can be obtained by different laboratories. The main attempt to place soil analysis into field operation has been developed in Missouri. This method is used by certain commercial laboratories. However, before we invest an undue amount of time and money in soil analysis, we should consider that the handicaps are the same as for soil tests. Chiefly, we do not have the necessary information for making recommendations specific to the crop in question.

TISSUE TESTS

These tests are primarily useful on plants of a succulent nature. They have not been found to be useful for woody plants. The very nature of tissue tests would indicate a good reason for their failure to be satisfactory on woody plants. Tissue tests are based upon the extraction of plant sap (and woody plants are not very juicy). The leaves and other tissues of woody plants is of such a nature that extraction of the sap is extremely difficult. In addition, the presence of large amounts of tannic substances often interferes with the color expressions on which tissue tests are based

The coverage of nutrients by use of tissue tests is limited mainly to nitrogen, phosphorus, potassium, and magnesium. Chloride excess may be also be detected. For woody plants, a special potassium tissue test may be used when standardized for the crop in question. Most woody plants do not contain nitrate nitrogen and, therefore, the nitrate test is not usable. However, should nitrates be present in woody plants, there may be reason to suspect molybdenum deficiency. Chloride excess may be detected by tissue test on the more succulent tissues by use of a silver nitrate solution. This possibility of testing for chlorides can bear some study, especially where excess salts are likely to accumulate as a result of frequent watering.

LEAF OR PLANT ANALYSIS

Leaf or plant analysis is useful for both succulent and woody plants. As the name implies, an accurate chemical or spectrographic analysis of the composition of the leaf or plant part is obtained. At the present time, leaf or plant analysis is being used for diagnostic purposes for nearly all agricultural crops. Leaf or plant analysis is considered to be the best diagnostic tool for woody plants

What can leaf analysis do for us? Leaf or plant analysis has been used to provide information that identified a nutrient disorder for the first time. They are used to demonstrate nutrient shortages prior to visible symptoms. Plant analyses may correct an erroneous diagnosis of nutrient disorders. Also they may detect the development of nutrient disorders before they become critical.

We often consider leaf or plant composition as a relatively new diagnostic tool. However, it is older than often believed. In fact, the concept from which the use of plant analysis is based was proposed by the great chemist Leibig in 1840 — 119 years ago. During the last 30 years, since 1920, the use of plant analysis has developed very rapidly. Although there are many reasons for this great increase in the use of plant analysis since 1920, some of the more important are:

1. An increased recognition of the importance of trace element deficiencies.
2. An increase in the attention given to Horticultural crops by Agricultural chemists and research workers.
3. The development of analytical methods that would permit the analysis of a large number of samples for nearly all of the essential nutrients.

It would be difficult to decide which of these factors is most important. The choice may well be the development of analytical methods. If we only reflect upon this briefly we can more fully realize the importance of this development. The determination of potassium, for example, used to be one of the more complex methods of analysis. With the introduction of flame photometry the determination of potassium has become one of the more simple determinations.

Spectrographic analysis has been widely discussed during the last ten years. Some of the first uses of the spectrograph for plant analysis was in Sweden and other European countries in 1939. However, in this country, the use of the spectrograph for plant analysis has developed mainly since 1949. The spectrograph permitted the analysis of plant samples for more nutrients in less time. Spectrographic analysis has been approximately ten times faster than chemical methods. More recently, we have drawn upon the experiences of steel, aluminum and other metallurgical plants to make the analysis even more rapid. With the use of a direct-reading spectrograph (known as a photoelectric spectrometer) it will be possible to obtain the analysis for ten elements within five minutes after ashing of the sample. We have just installed such a unit in our plant analysis laboratory at Michigan State University This new unit will permit us to complete the analysis for 12 elements on 60 samples each day using three technicians. Such analysis would require more than 12 competent chemists if chemical methods were used.

Let me further illustrate the importance of flame photometry and spectrographic methods. During the last 12 years the leaf analysis program in the Department of Horticulture at Michigan State University has increased from 600 determinations to 23,100 determinations annually. An increase of 40 times in 12 years without increased personnel.

When a leaf or plant sample is analyzed, what do we get? First, we obtain data on the amount of nutrients the plant has been able to absorb. Such data is obtained on nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, copper, boron, zinc, and molybdenum. These eleven elements may be deficient and additions may be required in the form of fertilizers or other methods. It does not require a great deal of effort to determine the limiting nutritional factor after the analysis has been obtained.

Perhaps unfortunately, standardized values are not available for many of the crops of interest to plant propagators. Such research is underway and will gain momentum. Dr. Harold Davidson, at Michigan State University, for example, has just completed the initial investigation on seven important species. He has data, for the first time, on nine elements that represents the composition of good plants for these seven species. Using these data, he can now initiate trials on diagnosis of nutrient disorders. He, also, has data indicating the level at which potassium deficiency may occur in seven species. This sort of information is being gathered by many research groups, more rapidly than is possible to report, and soon the stage will be set for the use of leaf analysis on all ornamental plants for diagnostic purposes. There is much work to be done on sampling, collection of data useful for diagnostic purposes, and interpretation of the results. However, this can and will be done in much less time than necessary previously.

FIELD TRIALS

Field trials are a necessary part of diagnosing nutritional needs regardless of what other diagnostic tool is used. The use of field trials remains the oldest diagnostic tool. Regardless of the method used to determine nutrient needs, field trials should be used to confirm such results. Unless absolutely certain of the diagnosis, a field trial should be established to prove the need for the suggested fertilizer. The size of such a trial should be based upon your confidence in the diagnosis. If you are confident of the diagnosis leave only a few untreated plants. If you are doubtful of the diagnosis, then treat only a few plants.

If there is difficulty in prescribing a correction measure, different methods should be tried. Only a few plants would be needed for each method. There is much to be learned in the application of essential nutrients. For some nutrients, soil applications are not too efficient. Nutrient sprays applied early in the season, during the season and on dormant plants have been effective and efficient methods for applying certain trace elements. Concentrations of such sprays need confirmation when used on another species.

Field trials can be useful in diagnosing the nutrient need. Different forms of fertilizer, different nutrients and time or amount to apply may supply the necessary information. We should not forget the time proven system of plant injection as a diagnostic method. The suspected nutrient may be injected into the stem, petiole or leaf by use of various techniques and identify or confirm a suspected nutrient disorder. Plant injections may only require a single leaf or a single branch and much can be learned from such studies Equipment may include a soda straw, piece of thread and the solution. Such a study may prove to be of considerable value if the original diagnosis should be in error or if diagnosis cannot be obtained by other means.

APPROACHING THE PROBLEM

To properly control the nutrient supply to our plants we should make full utilization of all diagnostic tools — deficiency symptoms, soil tests, leaf or plant analysis, and field trials but appreciate their limitations.

A constant check for the development of deficiency symptoms should be made. A periodic examinations of the leaves or growing tips may reveal a nutrient disorder not detected in the usual inspection of a nursery field, seed bed or propagation frame. Soil tests should be used to make sure that proper or safe levels of certain nutrients are present. For a more precise contol of nutritional conditions, plant or leaf analysis should be used.

One diagnostic method should not be the only basis for controlling nutritional needs. Often the combination of soil tests with plant analysis is useful. For example, if soil tests in a cherry orchard shows an ample supply of potash and plant analysis shows below normal or deficient level, the grower may suspect nematodes, soil insects, soil diseases or other soil conditions as being the source of trouble.

I would like to refer back to a statement made earlier. One of the reasons given for the rapid expansion in the use of plant analysis in recent years was — "the increased attention given to Horticultural crops by Agricultural chemists and research workers" This is important to you and to your industry. Unless each of you do all you can to create and maintain this interest in your crops and your problems, the Agricultural Experiment Station, and other research groups, will feel that your problems have been solved. With your encouragement and support, it will be possible to advance the field of nutrition of ornamental and nursery crops much more rapidly than previously. The potential is here but industry must help the research workers and keep everyone informed about the importance of its problems. By doing so, your soil fertility or nutritional problems will receive more immediate attention. As a result you will have better plants, happier customers and, of equal importance, more profits.

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MODERATOR CHADWICK: Thank you, Dr. Kenworthy, for that very interesting paper on methods and techniques available to us for determining nutritional deficiencies.

Very closely allied with the methods, of course, will be symptoms that we can use to determine nutritional deficiencies. At this time I would like to call on Mr Richard H. Zimmerman, Department of Horticulture at Rutgers University to discuss that phase of the subject. Mr. Zimmerman.

Mr Zimmerman presented his paper on visual symptoms for detecting nutrient deficiencies in plants, which was also illustrated by colored slides. (Applause)

VISUAL SYMPTOMS OF PLANT NUTRIENT DEFICIENCIES

RICHARD H. ZIMMERMAN
Department of Horticulture
Rutgers University
New Brunswick, New Jersey

A perennial problem in agriculture is the determination of the mineral needs of plants. In attempting to solve this problem, research workers have developed several different methods along the following lines (8):

(1) Soil analysis — in order to determine the supply of minerals in the soil.
(2) Plant analysis — in order to determine needed levels in plant tissue.
(3) Field and pot culture experiments — to compare effects of different fertilization rates.
(4) Direct treatment of the plant, by spraying or injection, in order to induce a growth response.
(5) Diagnosis of nutrient deficiencies by visual symptoms.

When a mineral nutrient element deficiency in a plant is shown by visual symptoms, the deficiency is quite severe. It has been established that low levels of mineral elements can cause a reduction in plant growth without the appearance of visual symptoms.

Before expanding this topic, let us briefly review our knowledge about the essentiality of the nutrient elements. Prior to 1900, ten elements were known to be essential for plant growth. Of these, carbon, hydrogen and oxygen were obtained from the carbon dioxide of the air and from the water in the soil. Six of the remaining seven elements, (nitrogen, phosphorus, potassium, calcium, magnesium and sulfur) have become known as "major" or macronutrient elements because they are needed by the plant in large quantities relative to the other essential mineral elements. The seventh element, iron was the first of the "minor" or micronutrient elements known to be essential. These micronutrient or "trace" elements are needed in very small quantities by the plant.

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From 1900-1920, much research was done on plant nutrition and several additional elements were stated to be essential. However, it was not until the period 1920-1940 that essentiality was definitely ascertained for any other elements. In this period, five micronutrient elements were determined to be essential (4), ie., manganese (1922), boron (1926), zinc (1926), copper (1931) and molybdenum (1939). Since that time only chlorine, in 1954, has been established as essential, and this only for tomatoes.

The correlation of visual symptoms with a specific deficiency dates back at least to 1844 (1) Gris, in France, reported that chlorosis was caused by a deficiency of iron. Several years later, a German scientist, Salm-Horstmar, produced characteristic deficiency symptoms for all the macronutrient elements (and some of the micronutrients as well) on oats. Since that time, especially since 1900, symptoms have been described for all the major and minor elements on many plants.

The use of visual symptoms for diagnosing nutrient deficiencies is based on the fact that abnormal development of the plants occurs when nutrition is not satisfactory This abnormal development may take several forms, the most common of which are chlorosis and necrosis of the leaves. Chlorosis is a lack of chlorophyll, the green pigment of leaves, caused by any means and resulting in light green, yellow or white areas in the leaf. Necrosis is the death of cells in the leaf, usually used in reference to dead spots in the leaves, dying of the leaf margins and tips, etc. Quite often the symptoms of nutritional disorder are characteristic enough to be recognized with some certainty. Once deficiency symptoms for a given element on a given species have been determined experimentally, it is hoped that deficiencies under field conditions can be identified through comparison with the known symptoms. When a nutritional disorder in the field can be diagnosed on this basis, this method is obviously a rapid and inexpensive method of determining plant needs.

This method is not quite so simple as it may sound, however. The type of symptom may vary from species to species and even from variety to variety. It may be affected by the supply of other nutrients, e.g. there may be a deficiency of two or more elements or an oversupply of one nutrient may induce a deficiency of another. Further, deficiencies of different elements may give the same symptoms or the symptoms of a nutritional disorder may resemble those produced by insect injuries, virus and other diseases, drought, etc. Thus confirmation of the deficiency must be made by other techniques in some cases.

As mentioned earlier, another limitation of the method is that symptoms develop only when the deficiency becomes severe and this may be so late as to severely check the growth of the plant before remedial action can be taken. It has been found that nutritional deficiencies may cause diminutions in yield and growth without inducing any visible symptoms. This is known as incipient deficiency and it cannot be detected by visual symptoms

The use of indicator plants has been suggested to overcome this last difficulty. These are plants chosen because (1) they are particularly susceptible to given deficiencies, (i.e., they show symptoms in a short period of time), (2) the symptoms they produce are not easily confused with symptoms from other causes and (3) the deficiencies are especially pronounced.

Wallace (8) gives a rather extensive list of indicator plants to use for vegetable and fruit crops and perhaps some of these might be suitable for ornamental crops as well. Reeve et al. (7) have suggested several crops which are suitable as indicators of low boron contents in soil Turnip is an especially good indicator for boron deficiency under field conditions while sunflower is a good indicator for boron deficiency under greenhouse conditions. It has been suggested that symptoms appearing on common weeds may be used as an indication of a low level of nutrients in the soil which could lead to deficiencies in economic plants (2, 5).

Now that we know some of the background behind visual deficiency symptoms, let us consider the appearance of the symptoms on plants. These symptoms are discussed in several publications (1, 2, 3, 4, 6, 8).

NITROGEN

This is probably the most common deficiency on most crops. The growth of both tops and roots is restricted. Shoots are slender and short, with very few new breaks. The leaves are small and light green or yellow green. As the deficiency becomes more severe, the lower leaves turn yellow, then brown and drop off. Tints of red, orange, or even purple may appear, usually starting with the lower leaves and sometimes appearing in the petioles.

PHOSPHORUS

The effects of phosphorus deficiency resemble those of nitrogen in many respects Top and root growth is restricted and shoots are short, spindly, and upright. Leaves are small and early defoliation occurs starting with the lower leaves. Leaves are a dull, dark green or bluish-green, often developing a purple or bronze coloration. Leaf margins may develop a brown scorched appearance and sometimes the lower leaves turn yellow before dropping

POTASSIUM

Symptoms vary considerably with the severity of the deficiency. Growth is restricted in mild cases and shoots may die back in severe cases. The leaf symptoms are striking and are usually characteristic for the different types of plants. Leaves may be a dull gray-green or blue-green and chlorosis will be evident. Interveinal chlorosis starts at the margins of the lower leaves and spreads inward on the leaf and up to other leaves on the shoot. Following the chlorosis will be tip burn, marginal leaf scorching and/or the development of brown spots, usually near the margins. The scorched margins quite often roll towards either the upper or lower surface of the leaf.

CALCIUM

Symptoms most commonly appear on the young leaves and near the growing points of shoots and roots. Young leaves deficient in calcium are severely distorted with the tips hooked back and the margins rolled. The margins are malformed and ragged, often with brown scorching or spotting Tip leaves become chlorotic, only the veins and leaf tips remaining green and those too turn yellow in time. The terminal buds are often killed. Root systems are poorly developed.

MAGNESIUM

As would be expected since magnesium is part of the chlorophyll molecule, leaf chlorosis is one of the chief symptoms of a deficiency of this element. The interveinal chlorosis starts on the older leaves and progresses upward on the plant Chlorotic areas may become a very pale yellow or even white. Leaf margins may curve upward or develop a puckering effect Either necrotic spots or marginal scorching may appear with the leaves dying soon after. Defoliation becomes severe with the shoots bare save for a few leaves near the tip of each shoot.

SULFUR

Shoot growth is restricted and the stems are thin, stiff and erect. Leaf chlorosis starts on the new leaves, the whole leaf, including veins, turning yellow. The older leaves become affected gradualy and there is a gradation of color from newest to oldest in contrast to iron deficiency. All leaves are light green when the deficiency is severe but the lower leaves do not dry up and drop off as in nitrogen deficiency. Dead areas, purple in color, may appear at the base of the leaves.

IRON

The most important symptom here is the interveinal chlorosis of the new leaves which always occurs with this deficiency. As the deficiency becomes more acute, the leaves may become bleached almost white with the veins remaining green for a long time. In very severe cases, scorching of leaf tips and margins may occur. Die back of branches occurs in some cases.

MANGANESE

Leaf chlorosis is probably the commonest symptom of this deficiency The chlorosis is checkered or mottled with the interveinal areas yellow while even the smallest veins remain green. Necrotic spots scattered over the leaf surface are often present. The chlorosis usually appears first on the new leaves though it may spread to the old leaves also in contrast with iron deficiency.

BORON

The most striking symptoms for boron deficiency are the effects on *the growing points. The terminal bud may die and new leaves will* show considerable distortion Leaves are scorched and curled, thick, brittle and generally chlorotic. The tissue at the base of new leaves breaks down. Stems may be hollow and roughened The stems and the petioles are brittle and frequently twigs and branches die back.

ZINC

Leaf chlorosis is the outstanding characteristic of zinc deficiency in herbaceous plants while abnormalities of twigs and leaves are more important in woody species though chlorosis is present here also. Leaves are small and malformed, quite often very narrow with crinkled margins Necrotic spots develop, usually starting near the tips or margins of the leaves. Foliage on the plant is sparse and leaves are rosetted about the terminal buds. Dieback of shoots and limbs may occur.

COPPER

An early symptom is a dark green color of the leaves, showing a high nitrogen concentration. Interveinal chlorosis of new leaves may occur with the chlorotic areas almost white. Chlorotic leaves may also show mottled green areas. Leaf margins are wavy irregular. As the severity of the deficiency increases, new leaves become small and distorted Defoliation occurs from the tip of the shoot back. Die back of the shoot occurs.

MOLYBDENUM

Symptoms are quite varied for different species. Some plants show a chlorosis or mottling of the leaf. Necrosis follows in most cases. Often leaves develop without a blade, giving the name of whiptail to this deficiency in many crops Frequently the deficiency appears first on the mid shoot leaves Affected leaves eventually drop.

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MODERATOR CHADWICK: Thank you, Mr Zimmerman, for that very fine discussion and those excellent slides I think they told the story very well.

We are going to follow much the same procedure this afternoon as we did this morning relative to the panel and general discussions. The panel members are the same as we had this morning, so we have no need to introduce them again at this time We will hear first from Bob De Wilde on maintaining proper fertility levels in containers

MR. BOB DE WILDE: I feel that you could use any system to determine nutrient levels and get correlation, providing you are consistent in your method of analysis. We use the LaMotte soil test system. It is a colorimetric means of determination for most of the elements. We worked with LaMotte and modified some of the tests to get more accuracy in reading the test. They will be glad to provide you with any of the information and help you establish a system.

We have established some figures, based upon intelligent guesses, as to the nutrient requirements of a plant during a specific growing season. These limits have been set at 100 pounds of available nitrogen, 75 pounds of available phosphorus and 125 pounds of available potassium. We attempt to maintain these levels throughout our growing season, which is from May until the end of August.

We must pick a starting point in the fertilization cycle, so I will start in May. We test our soil according to variety and age of the plant in the container. Our one-year plants, as you will remember, should already have good soil fertility because we added our nutrients at the time we prepared our potting mix. We will therefore start with our two-year old stock. We will first go in and take one combined soil sample from all of our junipers, one combined sample from all of our yews, from all our hollies, et cetera, down our list of families in the various age groups. Since we are on a more or less three-year production schedule, we will have three age groups to test from.

After the tests are completed, we will fertilize, using commercial ratios. This is done through the irrigation system, our primary fertilizer is a 20-20-20, and we apply this mix at approximately two week intervals in small dosages to maintain our standard of 100 pounds of available nitrogen, 75 pounds of available phosphorous and 125 pounds of available potassium. We find this gives us excellent results One of the things that you might attribute this to is our pH which we try to maintain at 6.2.

We don't have to worry about an occasional September frost because we are located in the woods area which gives us a modified climate and the plants are prepared for winter. As they are grouped, each one receives a heaping tablespoon of Uramite to carry it through the winter. Tests with Uramite have proved there is apparently better wintering because of its use. It is a fact that in the springtime this nitrogen will be available to the plant as it starts to grow. We have completed our cycle and will test our soil again in May to carry the plant through its season of rapid growth. Thank you.

MODERATOR CHADWICK: We will go directly to Jack Hill for his comments.

MR. HILL: I really feel there is very little I can add to these two splendid illustrated talks we had earlier. This matter of detecting nutritional disorders is a very difficult thing, as Bob just finished pointing out. They are so frequently disguised and confused that I have lost all confidence in the amateur looking at a plant and saying, "Oh, this is a magnesium deficiency," or "boron deficiency."

Because of the high percentage of peat moss in the mix which we are using we are not believers in micro-element deficiencies The reason we feel that way is that peat moss, after all, came from a living plant, and if that sphagnum had not had pretty reasonable balance, it probably wouldn't have grown well enough to have developed into peat moss.

Most of the micro-elements tend to be in the heavy metal class and as such don't tend to leach readily. We feel we are not likely to run into micro-element deficiencies in our system for maintaining overall nutrient balance.

Currently, we have our feeding program which is entirely liquid, tied in with our frequency of irrigation We are feeding every time that it becomes necessary to irrigate for the third time. By this I mean we irrigate with clear water twice and the third time it is with an application of a soluble fertilizer.

We make up and mix our own solutions We have three basic formulae we are using. No. 1 is a complete fertilizer of approximately 20-10-15, the second one is 20-10-30, and the third one is 10-40-15.

We have reduced the number of soil tests that we made three or four years ago when we were running tests as frequently as one every two weeks. We have now cut it back this last year so I don't think we ran more than three sets of samples through the whole growing season. We feed right up until the water is about to freeze in the pipes We believe in feeding that plant right up to the onset of winter. The reason for that is we feel that the season of growth in our latitude is controlled not at all by available nutrients but rather by daylight, provided that the plant has been held at a level of good nutrition throughout the entire season. Thank you

MODERATOR CHADWICK: Thank you, Jack. We will go on to John Mahlstede for his comments:

DR. MAHLSTEDE: Probably more work has been done with the maintenance of fertility levels in containers than with all other phases of container production combined. Each and every nurseryman has what he believes to be a good fertilizer program, and this is as it should be. When deficiency or toxicity symptoms show up in container grown stock, usually considerable growth is lost during the insuing months or years This is why a grower must experiment and know what a particular fertilization program will do under his specific conditions.

It is almost a must for growers producing any quantity of stock in containers to use a regular and systematic program of soil testing. Spurway type tests should be used to maintain the fertility within the following limits: nitrates 25-75 ppm, potassium one-half the nitrates, phosphorus 2-5, calcium 100-200, chlorides below 50, sulfates below 200, pH 5.5-7 2 depending on the crop, and soluble salts (10-5) 50 to 100 ppm in a 1 to 2 distilled water suspension With leachate extracts the following ratios are advised: nitrates 100-200, potassium one-half the nitrogen, phosphorus 1-5, soluble salts 100-150, chlorides below 100, calcium 50-100 and sulfates below 200.

Starter solutions for soil mixtures vary from state to state. Rapidly growing, succulent plants generally respond better to these solutions than the slower growing broadleaved and narrowleaved evergreens. One such solution is prepared by stirring the following in 10 gallons of water at 70-90° F.: 1 ounce of 15 per cent wettable parathion, 1 ounce of potassium nitrate and 1 ounce of ferbam. Water once and then add the starter solution until leaching starts.

To maintain soil nutrients in the optimum range, the grower can use either dry or weak solution mixtures of the essential mineral elements, or combinations thereof. Again, general maintenance solutions vary in composition, depending on the medium, and location of the nursery. One such mixture applied weekly or at least twice a month to all growing plants in a soil mix so that each pot is filled twice is as follows: for each 10 gallons, 1 ounce potassium nitrate, ½ ounce (food grade) urea, ¼ ounce of ammonium phosphate, and ¼ ounce of magnesium sulfate. It is essential to use regular soil tests with these recommendations, or for that matter, for any program of this nature.

In the plunge and tile system of culture we have found that satisfactory growth is maintained by banding a complete fertilizer in the furrow under the container before placement or by mixing with the soil at the base of the tile before filling Actually if the soil has been properly cared for before culture and is of high fertility, no additional fertilizer program is required to maintain proper growth rates.

For plants growing in a 50-50 peat perlite mixture in containers on top of the ground, experiments using uramite and a 0-20-20 fertilizer have been quite successful. For young stock transplanted into 6 inch containers in Jiffy pots, a mixture of 1½ pounds of Uramite and 1½ pounds of 0-20-20 per cubic yard of mix has given good results. The fertilizer should be added to the growing medium immediately prior to use; it should not stand around longer than a week prior to use. As the plants grow during the late spring and early summer it may be necessary to supplement this fertilization program by the addition of one level teaspoon each of Uramite and 0-20-20 in the late summer or early fall or as tests indicate. Two year stock and older can be fed with two full teaspoons of Uramite and 0-20-20 applied to the surface of the container in the spring These latter observations are based on our experience to date, and are by no means final.

MODERATOR CHADWICK: What have you to say on this subject Ken?

DR. REISCH: I want to make some general comments first relating to general fertilization. Recommendations for fertilization will vary according to the medium that is used, irrigation techniques, amount of rainfall, and many other factors. Any specific recommendation that is given for one area would certainly have to be adopted to yours even if you are using this particular type of culture The methods of analysis would be similar as far as the levels you want to maintain, either in the plant or the soil.

We have conducted a few studies on fertilization practices and up to a couple of years ago we felt that using fertilizers every two weeks was sufficient on container stock. Since then we have changed our mind radically and have come to the conclusion that probably the use of soluble fertilizers as frequently as every watering, possibly at least once a week, is much better to maintain adequate levels of fertilizers in the containers and in the plants.

We have used one ounce of a 15-30-15 soluble fertilizer to 16 gallons of water every watering. The leaf analysis records indicated that with a rate of one ounce to 16 gallons every watering we maintained a higher and more constant level of nitrogen.

As concerns the dry feed we found that the surface application produced a better and faster rate of growth than when mixed in the medium. I think that is probably all I have to say

MODERATOR CHADWICK: We suggest you confine your questions to nutrition on this particular part of the program. Leslie Hancock has his hand up first.

MR. LESLIE HANCOCK (Cooksville, Ont.): I would like to ask Jack Hill if he would care to comment on sources of nutrition from organic versus inorganic components.

MR. HILL: My present feeling is that organic fertilizers are far too expensive for what is in them. Because rates of breakdown are largely beyond your control when you are making applications of reasonable size, and because of the labor factor involved you pretty much lose control when you put that teaspoonful of fish meal or hoof and horn in the top of the can

MODERATOR CHADWICK Any other comments from the panel members on it? Does that answer your question, Leslie, or do you think you had better pin them down a little more?

MR. HANCOCK: I don't know anything about it, although I have always had the idea that it is more difficult for the plant to assimilate organic forms than inorganic.

MR. DE WILDE: I would like to say that we feel it is very important to have both. You need definitely a mineral or inorganic type of fertilizer for rapid availability For carry over, particularly during the winter months and during that early spring season when you get your flush of growth we feel it is definitely important to have some source of organic plant food to carry that plant through. This latter period occurs when you do not have sufficient time to analyze your soil and take care of those plants because of other nursery work We use Uramite.

DR KENWORTHY. This comparison of organic *versus* inorganic sources of nutrients I feel is largely a consideration of the rate of release. You need your inorganic for immediate release and it would be nice to have your organic sources around or have your inorganic tied into your soil so that the release is more slow.

We must keep in mind in all of this that a plant, if you will pardon the expression, is a selective glutton. It will absorb and take into its system almost all the soil nutrients in the solution. If too much is in there, you have toxicity. The organic can more or less diminish this toxicity.

MR. HILL: This is a question from the panel to Dr. Kenworthy. If the determination of organic versus inorganic is to be made on the basis of rate of release why do you want something released slowly? Why not have positive control, since you are irrigating in this container stock on a frequency of four or five times a week during the growing season. Why not utilize something which is available immediately? Why do we want anything which is slow?

I don't agree that you need fertilizer at all in the winter time. True, we need it early in the spring, but I do not think we need it during the winter itself.

DR. KENWORTHY: I think you have answered your own question in a sense. You want control one way or another. If you can't do it by spoon-feeding as you do a baby, though irrigation systems, you need to do it some other way. By and large, when you have plants in a restricted or rather limited environment, it can't forage very much. You have to treat it like a small baby and give it a feeding. We, ourselves, only eat three meals a day and probably would feel better if we would limit that to one or two, but a baby needs five or six The same thing applies to plants.

MR. JIM WELLS: I would like to make a comment and then ask a question regarding this organic and inorganic controversy. I have for years been an organic man, and yet, all reason says that you ought to be able to produce something out of a bag and put it in water, which is short-circuiting the digestive processes in the soil and presenting it in immediate available form to the plant. I have tried to slowly drive myself to accept that theory, with a little help from Jack Hill. Anyway, there was a time about five years ago when a foreman under my control came to me and said, "I want a load of leaf mold." I said, "What for?" He said, "I have to pot my azalea understocks in a soil mixture containing at least half oak-leaf mold."

Now here was an old-time propagator requiring this material with which I was completely in sympathy, but I said, "I am sure you can get just the same results with Michigan peat and a little fertilizer." "No, you cannot," he said. So I set out to prove him wrong. We had the mixture with leaf mold very carefully analyzed. We then made up a mixture from Michigan peat soil and fertilizer, analzyed it and we reproduced the leaf mold analysis exactly. We potted two groups of plants in these two mixtures and they grew beautifully.

They were then grafted by the same man and put into the grafting bench. The group in the synthetic soil, if you like, failed completely and the other took beautifully

Now so much for that My question is about biuret, a by product in the manufacture of some of these slow release nitrogen fertilizers. I understand that it results in serious problems when used on certain plants, particularly ericaceous materials. Does anyone or a member of the panel have anything worthwhile on this?

DR. REISCH: I understand the original material that came out with this by product in it was withdrawn from the market. Actually, I don't believe the material on the market today has any in it.

DR. KENWORTHY: Again, I am going to bring in a little information from an orchard that I think will also work in the nursery row. We can, without exception, tell whether a cherry grower has sprayed his plants with urea or not merely by looking. We don't have to ask him. We get the nicest little yellow margin when urea sprays have been used. On sandy soils the use of urea in any form will also give us this margin on sour cherries. On apple we get no effects. I will not say that this is caused by biuret or not.

DR. JAMES R. KAMP (Urbana, Illinois): I didn't get up to supplement Dr. Kenworthy's discussion here on the effect of urea on plants but we did have some experience in foliar feeding, particularly on roses. We found that whenever we used urea we also got this marginal yellowing on greenhouse roses However, we found that if we sprayed the roses grown out of doors with the same thing we wouldn't get the marginal yellowing. Therefore you can't make a general statement but rather have to refer to a particular plant grown under a specific set of conditions.

What I came up here for was to ask Ken Reisch his feeling about the phosphorus level in his 15-30-15 fertilizer mix. Are you beginning to feel that phosphorus is required by the plant only in relatively low amounts?

DR. REISCH: That is correct.

DR. KAMP: I know we have sort of interpreted it this way. In most of our fertilizer experiments we got such a wide range of satisfactory growth at different prosphorus levels that we have gotten so we don't even bother about phosphorus any more.

DR. REISCH: I think in container production that nitrogen is the critical factor. You have to have an ample supply of nitrogen, and nitrogen seems to be one of the limiting factors.

DR. KAMP: What are you planning to change your analysis to for future work?

DR. REISCH: That is a good question. We haven't decided, but I would say probably one high in nitrogen, low in phosphorus and medium in potassium. What that would be I can't say at the moment. There are plenty on the market with that approximate analysis.

One comment, Chad, in relation to the use of organics versus inorganics. I have mixed feelings on the subject I think there is some merit to the use of organic fertilizers as concerns the rate of release. There are thousands of producers, however, that have never used organic fertilizers who are making money in the florist, nursery and farm crop business.

MODERATOR CHADWICK: Who has the next question?

DR. NELSON: In work at Ottawa this year we found that concentrations of the various salts necessary to support growth in container stock was quite different. For example, *Chamaecyparis* would be killed by concentrations of one quarter the normal rate. By the same token, in arborvitae we got that same spread Some would thrive on four times the concentration of salts that would kill another type. Little Gem, for example, was killed at a very, very low concentration of salts. What are you doing with the segregation of your stock? In other words, do you have a different feeding program for different types of plant materials?

MR. HILL: I am not sure that I can answer that entirely except to point out that the very basis of the system which we are attempting to follow relates to optimum levels of N-P-K, calcium and magnesium, to the water-holding capacity of the mix That is based upon the recognition of the fact that a level of total soluble salts which would be lethal in sand or lethal in my class of marbles, if you please, would be a starvation diet in pure peat. Therefore, some place along there you should be able to plot that relation if it is a straight line. Therefore, measuring the moisture-holding capacity in terms of percentage based on dry weight you should be able to come up with optimum levels.

I, too, have observed the very thing you are talking about, where there are huge differences in the tolerances of plants. Unfortunately, I don't think there has been definite work done on ornamentals. There has been some on cereal crops and fiber crops and grass crops.

MR. PETER VERMEULEN: Jack, I believe you fertilize right up to the approach of winter. Bob, you said that you cut your fertilizer applications off at the end of the active growing season. I have a question on this, which perhaps can explain the difference in your response by the difference in temperatures or your seasons. Do you, Jack, in Dundee, have a gradual approach in the winter or do you experience, as we do here on the east coast, sudden drops of temperature and then warm periods and then another drop, where we would have soft growth resulting from continued application of fertilizer damaged by these cold snaps?

MR. HILL: I do not think our climate in Dundee has the same temperatures or the same humidities, but I think it is about the same in that we frequently get cold spells. This year, for example, all sorts of temperature records were broken. Our whole philosophy is built around the theory that plant growth is controlled by the available nutrients in the mix at the onset of winter, provided the plant has had sufficient throughout summer. They stop growing whether you feed or not. In fact, our tests have indicated clearly that if the plant is fed up to the onset of winter it will be better than one that is deliberately checked and starved before winter sets in.

MR. DE WILDE: Actually, when we have completed our last fertilization, the level is quite high. It is not toxicity high, but let's say the plant has plenty to feast on throughout the winter. Since it is not growing, we feel it doesn't need any nutrients any more. That is the primary reason we stop feeding. Definitely the nutrient level will drop off during the month of September, but it will still leave the plant with an optimum amount of plant food to last throughout the winter and give it that initial start during the spring, particularly with an added teaspoonful of uramite in each can.

Actually, we feel additional applications of fertilizer after this month would be useless.

MR PETER VERMEULEN: Bob, do you feel that an additional application would not only be useless but might be detrimental?

MR. DE WILDE: Yes. I am afraid to take that chance and push them too much. I think our level is high enough so there isn't any detrimental effect.

MODERATOR CHADWICK: I would certainly back Jack Hill 100 per cent on this matter of fertilization as he is practicing it. While this example doesn't apply to canned production, we have modified our whole outdoor plant fertilization program in the last several years on the basis of results that we have obtained For instance, in our rose garden at the University, we continue fertilizing our roses right on up through the middle of October or even to the first of November. The results over the past years have certainly indicated that those plants come through just as good or even better as where the fertilization is stopped in August or the first of September.

MR. HILL: We have come a long way since those days when it was felt necessary to put a fish in each hill of corn.

DR. KAMP: I would like to make a comment here because I think there may be a difference in what you are getting due to the treatment that you are giving prior to this fall feeding.

I think if you run one of these up and down, kind of fertilizer programs and the fertility level is down, when you put fertilizer on in the fall, you are apt to encourage a flush of growth which will suffer winter injury. On the other hand, if you have been giving these plants a good solid fertilizer supply all during the season and you continue that into the fall, then you are not encouraging a fall flush of growth, you are merely giving the plant sufficient fertilizer to continue its maturation processes. I think the important thing is not whether you put on this fertilizer in October or November, but what you did prior to that date.

MODERATOR CHADWICK: What period are you referring to as a fall application that will cause late growth?

DR. KAMP: I was thinking of the application of fertilizer, say in October. If we allow nutrients to become low and then apply a good fertilizer application in October with the Indian summer weather that we get and rains at that time, we would get a flush of new growth which is easily injured.

MODERATOR CHADWICK: On what types of plants?

DR. KAMP. Outdoor roses and a lot of our shrubs, are included. In our outdoor roses if we have not let the fertility level go down and then we put on an application of fertilizer in October there is no noticeable change in growth rate of the plant. It is just keeping on at a reasonable rate of development. But, as I say, if we let it go down and then put on an application you will see a lot of new growth coming out. When you have a sudden drop in temperature to zero there isn't much of this new growth that is going to survive very long. I think the reason that Jack is able to carry on his fertilizer program that late with good results is that this is just a smooth continuation of what he has been doing all the time.

MR. FLEMER: We see in our nursery quite frequently and Dr. Chadwick, you have probably seen it a lot in other nurseries growing forsythia, California privet and weigela, where we have an extremely wet September and an extremely severe winter. Young yearling plants in the field that had been heavily fertilized and pushed along in the summer would freeze right to the ground where the old stock would bud out in the spring right up to the tip of the plant.

MODERATOR CHADWICK: I don't know as I can answer that but I have seen just the opposite happen. Not so many years ago when we had a very severe winter in Ohio it was all of the old underfed *Kolkwitzia* that froze to the ground where the good growing plants that were fertilized in the fall came back.

I think it comes back to the carbohydrate-nitrogen relationship in the plant at the time you get that drop in temperature.

MR. FLEMER: The more you fertilize the more nitrogen you get and the less carbohydrates.

MODERATOR CHADWICK. Not necessarily. By the addition of the nitrogen you have also built up the carbohydrate content in that plant.

We now come to the unscheduled part of this program. I don't know whether the Secretary of the Plant Propagators Society is just modest but when it came to his part of this discussion he left it off. This doesn't let him out of a job, however. So we want to turn now to the final phase of this discussion of container production of nursery stock and consider the point of hardiness and winter protection.

Dr. Reisch of Ohio State is going to lead off the discussion and then we will come back with the panel members. Ken!

DR. REISCH: I tried hard to get out of the job, as Chad said, but it didn't work, so I am here.

Dr. Reisch discussed the subject of winter protection as it is related to the successful overwintering of container grown plants. (Applause)

WINTER PROTECTION OF CONTAINER GROWN NURSERY STOCK

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Damage from cold temperatures is probably the most important limiting factor in the culture of container grown nursery stock in the Northern parts of the country. To profitably produce plants in containers some form of winter protection must be included in the production program. In order to more clearly understand the reasons for using protective measures, some background on the causes of winter injury will be given.

Excepting unusual winter conditions such as floods or ice storms, winter injury may be directly attributed to either desiccation of above ground portions of plants, formation of ice within the tissues, or both.

Desiccation due to water loss from stems of deciduous plants and leaves and stems of evergreens without replacement from the soil, may be particularly serious in container plants Soil volume and root extension is limited, the medium may dry out relatively rapidly, and the soil ball may remain frozen for long periods of time. This type of damage is most common on evergreens such as yew, hemlock, and some of the broadleaf types, and is especially severe when plants are exposed to high winds or intense sun during the winter.

Winter injury due to cold temperature results primarily from ice crystal formation between or within plant cells It is not unusual for ice to form in plants when temperatures are low; however, death or damage, may or may not take place depending upon the degree of hardiness of the plant or tissue involved.

Ice forms between plant cells when the temperature drop is gradual over a period of time. If plant tissues are sufficiently hardened, damage from this type of ice formation may be negligible or non existent. Any injury that does occur is due to the removal of water from the cell resulting in disruption of the protoplasm.

Rapid temperature drop may result in ice formation within the cells with death usually the result. This is believed to have been one of the major causes of death and injury to nursery stock in the Ohio, Indiana, and Illinois area during the winter of 1958-59 In Central Ohio growing conditions were favorable late in the season and woody plants, particularly those under cultivation, had not 'hardened-off' sufficiently. During the period of November 24 to 28 high temperatures ranged from 54 to 26 degrees and low temperatures from 34 to 17. On November 29th the low temperature was 5 and on the 30th, 5 below zero. This was followed by a week or sub zero temperatures in early December. Evidence for the assumption that this was the cause of much of the severe damage was found in a group of container grown *Pyracantha* plants. Plants which were protected in mid November were undamaged, whereas plants in the same condition, which were protected the first week in December, were found to be dead when examined in the spring.

Frost resistance or hardiness is based on the survival of plants or tissues under freezing or low temperature conditions. The degree hardiness can be altered by many natural and man made conditions such as pruning, transplanting, watering, and fertilizing practices. Increase in frost resistance is spoken of as hardening and is associated with certain changes in the properties of plant cells which include lower water content, higher sugar content, and higher osmotic pressure. An attribute of container culture is that the grower has better control over factors which may speed the hardening off process, such as reduced watering and fertilization

Other variable factors which must be considered in discussing winter protection is the severity of winter temperatures, precipitation, amount, extent, and height of snow cover, and the exposure of the plant area.

As indicated earlier, winter protection is necessary on most woody plant varieties grown in containers in the colder regions of the country. Many methods have been tried and are being used. Types of protection can be divided into five types (1) mulch cover over top of the containers, (2) screen protection over or around plants, (3) temporary or permanent structure over plants, (4) plunging containers below ground level , (5) placing containers can-to-can. A discussion of some of the specific methods follows.

MULCHING CONTAINERS

Mulches insulate the soil medium against rapid temperature change, maintain higher temperatures within the container, are relatively low in cost, retain moisture in the medium, and are relatively easy to apply. A major fault is the problem and cost involved in removing the material in the spring.

Ground corncob mulch has proven to be a successful means of protecting the root systems of a wide variety of plant types in containers. It is inexpensive and easy to apply but disagreeable and difficult to remove in the spring. A layer of crushed stone in the top of the container simplifies removal of this material which often sticks to the soil surface. A polyethylene layer under the bed facilitates easier clean up of the area after mulch and containers are removed.

Crushed limestone mulch is somewhat more expensive but equally as effective as ground corncobs and is also much easier to handle. It also serves to maintain the bed area when it is left after removal from the top of the containers. On hardier plant types, a mulch of this type along the South and West sides of the bed may be sufficient.

Straw or hay mulch has been used successfully by a number of commercial producers. In addition to providing some insulation for the roots in the container it also serves as some protection for tops of the plants The cost of material and application is low, however, it makes an ideal rodent nesting area and may be a source of weed seeds.

Mulching is a very effective method for protecting the root system from damage, however, on 'top-sensitive' plants, value is limited because of damage to the exposed portions. An interesting situation occurred where death resulted because a ground corncob mulch was used. Groups of plants of Berckman's Golden arborvitae were mulched with ground corncobs, crushed limestone, and placed under a polyethylene tent. Those in the latter two plots were undamaged whereas those in the corncob mulch plot had a split stem at mulch level and were dead. This may have possibly been caused by ice formation in this mulch material.

SCREEN PROTECTION FOR CONTAINERS

Snowfence was used in tee-pee fashion over beds of container stock. This method gives some protection from wind and winter sun and is easy to apply and remove; however, little, if any insulating effect is provided and exposed foliage of evergreens is often burned.

This method was not effective in protecting plants that are 'top-sensitive' such as firethorn and abelia and even when snowfence was used in conjunction with a crushed limestone mulch, extensive damage and loss occurred with these plants Asphalt paper and aluminum foil shields were added on the west side of the snowfence tee-pee to protect the plants from the sun; however, damage under these shields resulted both from contact of foliage with the mineral and from drying out because of the waterproof cover.

This method alone does not appear to have merit except in mild winters and should be used in conjunction with a mulch to assure protection of the root system. Foliage burn of evergreens is reduced; however, because of the closeness of the lath to the plants, spotty burning usually occurs resulting in a reduction in plant quality in the block.

Another screen protection technique included the use of baled straw placed two bales high on the west side of some beds and completely around others This was used during the winters of 1954-55 and 55-56 and, with the majority of deciduous plants types damage was negligible; however, losses were great in blocks of *Pyracantha* and *Abelia*. In the winter of 1958-59, losses of *Pyracantha* and *Cotoneaster* plants were high in a commercial nursery using this technique.

On the basis of observations and research results it is difficult to recommend this technique as an excellent means of protection except during mild winter, with hardier plant types, or in areas where normal winters are less severe.

TEMPORARY OR PERMANENT STRUCTURES OVER THE PLANTS

It is obvious that maximum protection for container grown stock can be obtained with permanent structures such as greenhouses, hotbeds, or coldframes, however, structural and maintenance costs would be high. One gallon size plants of *Abelia grandiflora* were overwintered with no foliage or root damage in an unheated coldframe during the winter of 1958-59; however, a large scale operation of this type would probably be cost prohibitive.

One of the most effective temporary means of protection yet developed is a polyethylene tent cover placed over beds of container grown stock. Maximum protection is provided, cost is relatively low, plants do not dry out, and application and removal is easy No maintenance is required except regulating internal temperatures by venting the cover during warm days in the spring. Some means of support is necessary and this may be a simple pipe and wire framework or a more permanent heavy wire mesh used in 'Quonset Hut' fashion over the beds. A possible problem may exist in areas of high winds; and a sturdy means of support would be an absolute necessity.

At the Ohio Agricultural Experiment Station, 4 mil. translucent polyethylene was placed on a pipe and wire framework over beds of container stock in mid November of 1957, 1958, and 1959. The poly was held down at the ends and sides by covering with crushed limestone chips. These beds were left sealed until warm days in the spring when it was necessary to open the ends and sides during the day

A wide variety of plants, including *Abelia* and *Pyracantha*, protected by this method during these winters were undamaged This was rather significant during the severe winter of 1958-59 when plants of this type were killed in field and landscape plantings. Plants under this means of protection also flowered or began growth one to two weeks earlier in the spring.

A more elaborate semi-permanent framework has been used by the Berryhill Nursery Company of Springfield, Ohio, where wire fencing was shaped into quonset-hut shaped units and placed over the beds. Although the cost of this is somewhat greater, the structure is more stable and reusable for a number of years.

To economize on space, it is possible to stack plants under the polyethylene This has worked effectively with two layers of plants and studies are underway using this technique.

Another means of protection involving a structure is the use of barns or similar buildings for storage. A nursery in Ohio is stacking containers 10 and 12 high in a barn this year

PLUNGING CONTAINERS

The practice of plunging containers in the ground is laborious and impractical although it does provide an excellent means of protection for the root system. In studies at the Ohio Agricultural Experiment Station it was found to be effective with some plant types but less advantageous with others In heavy soils, drainage and heaving may be problems. John Mahlstede has used previously plunged tile as a means of plunging container stock with the plants simply dropped into the tile.

CAN - TO - CAN PROTECTION

This method of protection, although minimum, is superior to spaced plants and affords good protection to plants in the interior rows of the beds. Drying out is a problem and some watering may be necessary during the winter. During mild winters this technique is adequate with plants such as forsythia, juniper, and deutzia, however, during the severe winter of 1958-59, these plants were severely damaged when handled in this manner. This technique will be difficult with large spreading plants.

TEMPERATURE STUDIES

In November, 1958 a detailed study was begun at the Ohio Agricultural Experiment Station to observe the effects of three protection practices on overwintering of *Pyracantha coccinea 'Lalandi,'* to determine the effects of sand-soil-peat and peat-perlite mediums on the temperature in the medium, and to determine variations in medium temperatures under the three means of protection and in unprotected containers.

Twelve to fifteen inch plants were planted in one gallon containers in September along with copper-constantan thermocouples placed in the center and edge of the containers. The containers were placed in the center and at the west side of four plots with ground corncob mulch, crushed limestone chip mulch, polyethylene cover, and unprotected plants placed can-to-can. Temperature readings were taken with a potentiometer at 8 A.M., 12 noon and 5 P.M, from December 8, 1958 to March 30, 1959.

The results on winter injury were rather striking where all plants were killed under no protection and those under the polyethylene cover were undamaged. In the mulch treatments root damage was negligible and shoot damage ranged from 50 per cent dieback in the center to 70 per cent dieback on the west side of the bed.

Temperatures in the containers under the different treatments varied as follows Temperatures under the two mulch treatments were uniform with little fluctuation and remained at the highest level of all treatments. Temperatures in containers under the polyethylene cover were slightly lower but higher than those in the unprotected plot Medium temperatures under the poly fluctuated to a greater extent than did those under mulch protection. The temperature in the unprotected containers fluctuated directly as the air temperature and reached lower levels than in any treatment.

The type of medium did not have a marked effect on temperature over the period of the study, however, temperatures were higher in the sand-soil-peat medium in most of the treatments on the 6 coldest days of the winter.

In general, the results of the study indicated the value of mulch and polyethylene cover treatments in maintaining higher medium temperatures and also the value of and need for top protection on plants such as *Pyracantha.*

SUMMARY

Winter damage is the greatest limiting factor in the culture of plants in containers in colder regions, and, regardless of the protection method employed, partial success is not acceptable. Undamaged, plants of healthy appearance and condition should be the goal of a program of winter protection.

Great variations in hardiness exist among plants and therefore, varying degrees of protection are necessary. Unfortunately, plants such as firethorn and low cotoneasters which are ideal types for containers, are rather tender and maximum protection is required. If the cost of winter protection is too great for the production program involved, then it is not practical to grow plants requiring this potection in containers. The problem is not complex but simply means providing some form of artificial protection where natural means such as snow cover are not dependable, or adequate. This protection may range from placing plants can-to-can to using permanent or temporary structures to cover the entire plant. Regardless of the method used, a plant in the healthiest possible condition is the first step to assure successful overwintering.

Variation in winter temperatures and weather from year to year indicate that methods which are effective one year may not be the next; therefore, to assure plants of consistent high value and quality, a standard maximum protection program should be set up for each area and for the type of plants that are being produced.

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MODERATOR CHADWICK. I think we will change the procedure a little bit and not give you a stretch right now. If John Mahlstede, Bob De Wilde and Jack Hill will come up, I think we will go directly to the panel and have their discussion

Bob has a lot of notes in front of him. We will ask him to give us his method of winter protection first.

MR. ROBERT DE WILDE: Winter protection of container stock is, of course, a very critical factor in the production of container material. As Dr. Reisch brought out, one of the most important things is the fact that what works one year doesn't work the next, unfortunately.

Until this afternoon I thought one of the best methods of overwintering was to first start to harden the plants off around the end of August by decreasing our fertilizer application and by limiting our irrigation. Natural irrigation is allowed to provide our water supply except in the case of drought

The first step that we take is to group the cans together. We close them up in the bed, can-to-can, where the tops will permit. The next thing we do is to mulch with salt hay This is a marsh hay that is readily available in our area and it serves the same function as a corncob mulch. As the plants are mulched they all receive a teaspoon of Uramite, which has been proven to aid in the overwintering of our plants. This provides the nitrogen factor which DuPont has claimed will aid in overwintering.

After mulching the sides of the containers are all heavily mulched with unchopped hay, about two foot long usually, which is piled up along the sides. Over the top of each bed, that is, in the open area, a snow fence shade is placed. Now our location permits us to eliminate any further snow fencing over top because we are located in a woods area, which provides us with natural shade.

Around the sides of our container division we are placing for the first time this year, reed mats to cut down on the wind velocity. Some of the plants, such as junipers, do not require this much elaborate protection in our area We can just group these plants, bank them with salt hay and leave the mulch over.

We also spray every plant with Wiltprul We are going to try polyethylene this year with our young material that we pot during the winter. We feel this has probably shown the most promise of any method. We have a number of beds set up now to receive the polyethylene cover and we hope this will give us as good results as it has given Ken.

Our damage consists of the same thing that you saw in the slides, particularly a dying of the outer edges of the canned stock, as well as some burn on the top. We have eliminated a lot of the burn by using shade in our area but we still do get a certain amount of wind burn which we hope we can eliminate by the use of the reed mats.

I would say that in general a lot of times the plants that look killed in the outer ring aren't killed, but rather are slowed down considerably and aren't saleable when we would like them to be

That is about all I have, Dr Chadwick.

MODERATOR CHADWICK. Jack, we saw a little of the winter protection you practice, but will you tell us more about it?

MR. HILL: The picture that Dr. Reisch had, was made three years ago. Our thoughts along the line of protection has been to perhaps over-protect. We were still seeking that very minimum degree of protection that would just do the job for us.

With this in mind we have each year for the past eight years, reduced the degree of protection that we have provided. Last year, being this winter of 1958-59, an extremely tough one, we found that there was no difference between the plants which had been mulched and those just provided with a vertical snow fence with snow paper stapled to the bottom. With that we have come up with a reasonably economical means of protection. Snow fence paper is readily available. We have the snow fence on hand.

The cans are first placed can-to-can wherever it is possible. However, in the case of large spreading plants, such as Pfitzer juniper in the egg can, we have not put those cans close together. The reason we have not grouped them closely this year is that in the past we got very serious disfiguration. After you spread them out you have essential branches broken and it just didn't look like it was worth it. This year, wherever the foliage cover was adequate we have left the cans on the growing spacing, which in the case of junipers I would guess was every 30 inches. All our one-gallon cans are placed right can-to-can. As I say, whole beds of them are surrounded by vertical snow fence and 20 inches of snow fence paper stapled to the bottom of the snow fence. The purpose there is to keep the wind off them.

Our whole purpose of protection is to reduce the temperature fluctuation. We do not feel that with the plants in the category we grow at Dundee, literally where the water mains are seven feet in the ground and freeze occasionally that the temperature itself is really the factor that produces the damage, it is the rate of fluctuation.

I would like to bring up something here just hypothetically and see if anyone in the audience or perhaps on the panel can answer. There has been expressed the thought that perhaps some of this injury which we have seen in the past on container plants and not infrequently manifested as a typical little slit in the outside of the corky bark of the plant, right at the soil line can be traced to ice formation.

In the spring of the year, on a thawing day the can itself remains frozen but the top of it actually thaws so you get free water, perhaps a half inch, actually standing. It cannot go through because the bottom of it is solid ice. This subsequently freezes up solid, so that when you look at it again the plant is growing right out of a disc of ice which sits on the top of this metal can.

It has been wondered many times in Dundee whether or not the freezing action of that ice actually applied sufficient physical pressure to the outside of that bark to at least initiate the tissue damage in the form of splits If anybody has any information on that, I would certainly like to hear from him.

In the end, plant economics alone will determine how far you can go in the range of protection of a greenhouse to give the plant complete protection or no protection Some place between those two extremes will be found protection which should be adequate.

Those of you who have watched field nurseries operate for many years know it is not infrequent that a severe winter will occur that will render many plants entirely unsaleable. We saw it at Dundee last winter So I think a lot of this concern over the protection of container stock is in the category of looking for an excuse.

Relative to the cost, Frank Turner quoted of 4.4 cents, we have gone, for example, to half of that figure last year. I don't know what our figures are this year, since we have eliminated all the straw. I think this year our cost for winter protection will be something just under two-tenths of a cent, perhaps even as low as 1.8 cents.

MODERATOR CHADWICK: I think we might throw this comment in here that Bob and Jack are growing somewhat different types of plant materials. Jack, your procedure is primarily on junipers, yews and a few arborvitae. Bob, I believe, you have some broadleaf evergreens and some shrubs, which does bring in a difference as far as the need and extent of winter protection.

John, may we have your comments?

DR. MAHLSTEDE: I think we will all admit that if we could have a good heavy snow cover during the entire winter period, as they have in certain parts of Canada, this would probably be an adequate mulch for most of our conifers. If we could keep it on there for the entire winter and if the evergreens were normally hardy, I think you could safely say we could get most of our stock over-wintered on the top of the ground.

Over-wintering container grown nursery stock is probably the one limiting factor to the production of some of the so-called tender ornamentals in the North The expense involved in the erection of lath and polyethylene tents and in the consolidation and mulching of containers in convenient sized beds can be a major cost item limiting large scale container production in many areas of the United States.

In Iowa, we have successfully carried arborvitae, yews, junipers and phlox over winter the first year by consolidating the containers and literally plunging the units in redwood sawdust In the middle of December the entire area was covered with soybean straw which was removed on April 1, the following spring. This was an expensive operation. Three-year-old arborvitae growing in a variety of soil mixes were also successfully held under an overhead story of pines by simply plunging the containers in sawdust, and erecting a 3 inch high, reinforced polyflex enclosure around the area This again was a costly operation.

Arborvitae, junipers and Norway spruce either plunged in containers in the field or growing in tile overwintered without protection successfully, i e., over 90 per cent stands. *Taxus,* however, because of the particular winter and the exposure gave only a 45 per cent stand. This plant, under our conditions needs to be carefully handled to prevent undue losses.

MODERATOR CHADWICK: We will now ask for questions again and I would say let's confine our remarks first to this matter of winter protection. If we run out of questions on that phase we will come back and pick-up any others you may have

MR. A. JAN RADDER: I would like to ask Mr. Hill what he uses for protection on banded liners

MR. HILL: Our protection on the banded liners which you put in beds is a simple shade over the top We actually double it Last year for the first time we encountered a strange response from this, we got smothering The snow sifted through and partially melted. This was followed by more snow and finally we just got a layer of solid ice under those shades. Because it was double, it didn't melt off, and we didn't notice it until too late. We got considerable smothering. We had never, up until last winter, had any difficulty.

MR. C. DE GROOT (Oakville, Ont): I would like to make one comment on overwintering. Lots of methods were shown for protection but I didn't see any hedges mentioned for protection. We have our containers placed on the east side of a hedge We get that good eastern snowfall and that snow stays there three to four weeks after the other snow is all gone. That is the best protection you can get

The first year we used sawdust, corncobs and straw. It didn't make any difference whether we used them or not because they were covered up with snow which we got from the east. We soon discovered that we did not need to cover them at all.

QUESTION: I wonder if Frank Turner would comment on the cost and the results he has had with the polyethylene tent?

MR. FRANK TURNER (Springfield, Ohio): I would presume that you might not be able to stand the 4.4 cents cost per can for overwintering red barberry, whereas, you might find plenty of good plant materials that would stand that application of the cost of overwintering.

We are quite well convinced on the structure. It is not a new thing. It is simply the Templeton structure on a new dimension. Our original tryout was with two of them seven feet wide, 60 feet long. In these two units we tested the possibility of using the second layer and occasionally a third layer. This worked so successfully in what appeared to be about as much of a test winter as we would receive for a long time that we said to ourselves that if we don't have a dozen or fifteen of these structures next year we are missing a good bet.

The only thing that I can think of is a little matter of principle in the handling of this material that has not been quite clearly explained thus far We are quite discriminating about the category of plants that go on each layer We will say, for simplicity, that the bottom layer are usually young plants and in a variety that has to be there to survive. Now we would like our second layer to be a plant that would come off and sell first. It should be the first size we are going to use, as we open up in the spring We don't say that the second layer of plants in the structure has to be a plant that positively has to have that kind of protection. As an example only, we would like it to be of plants like *Euonymus vegetus,* etc where the employment of a shelter adds to the eye appeal of the plant and gives it an earlier start. These are the sort of factors that pay for the care that has been given to them.

I think that is all unless you have some questions.

DR F J. NESBIT: (Asheville, N C): I would like to ask Bob De Wilde about his use of Wiltpruf Did this come just as an added lick in hopes that the whole thing is better or is it based on the results of experimental work that proved you did get any protection from it.

MR. DE WILDE: It seems to be one of those variable type things that is, the use of Wiltpruf. Sometimes you think you get great benefits from it and it really works and then other times you are not so sure and you get down to the point where you are afraid not to use it. That seems to be the case right now. We have tried it experimentally, and yes, we thought definitely we got better results, but of course it might have been a function of the winter, too

MR. LESLIE HANCOCK: This is not exactly a question, but rather is a comment.

Jack Hill raised the question of splitting in his rather large Pfitzer cans. There is no question in my mind that the splitting of stems, whether small or large is due to the upward thrust of the soil against the cambium and an immediate freeze. I would think this is one of the prices he has to pay for fast growth where you have a very lush cambium in a large Pfitzer. It occurred to me when you were speaking about that very subject, apparently no one is trying the old-world method of laying the pot on its side, in which you won't have ice form in there after the severe freeze-up starts.

I was wondering whether the pot on the side in winter might not possibly save space also.

MR. HILL: I have never thought about laying the pot on its side. That might possibly be the answer. Our splitting did not take place on the junipers as much as on both yews and arborvitae.

MODERATOR CHADWICK: We have tried, the matter of laying the pots on their side in all our tests. The plants have not come through as well laid on the side as when they were upright. I can't tell you the reason why.

MR LOWENFELS. We are using oak leaves for mulching since they are available and don't break down all winter The first question I would like to ask is, if anybody is using an oak leaf mulch? Second, everybody is talking about the Templeton method and I think Harvey puts straw around his. If he doen't use straw in the winter, maybe a word from Mr. Templeton might be good at this time.

MR HILL: I think what we are talking about is the Templeton structure. As an actual fact, maybe I can add something here. We are, of course, testing the polyethylene igloo. We are also testing the use of saran on the top. We are planning to use that structure in more than one way We are using it for the winter protection of our container material by placing the saran shade on top of the polyethylene. That is, first the wire reinforcing mesh, then the polyethylene, and then the saran cloth on top of that, tied down with "S" hooks and springs on the bottom.

In that part of the spring of the year when we are moving rooted cuttings from the bench into the one-gallon cans we will use this same igloo structure, and eliminate the poly. We will pull the saran cloth over the wire until the plants are established Later in the season when we wish to propagate perhaps softwood cuttings directly into those containers, the first season we will just reverse the poly and the saran, putting the saran cloth next to the wire mesh and the poly over that, thereby coverting all the heat we can under the sheet and getting more use out of the structures than just a 100-day winter per year

MODERATOR CHADWICK: One question on the use of oak leaves as a mulch Any comment on that from the panel?

MR DE WILDE: In our woods area our trees happen to be oak and hickory and we definitely make use of all the leaves which fall and supplement it with chopped hay. It works very fine.

MR VERKADE: When you laid those cans down, did you put salt hay over the can or did you just lay them down?

MODERATOR CHADWICK: They were not protected with salt hay; they were laid over on their side; sort of shingled so they were at an angle of roughly a little less than 45 degrees. There was also protection from corncobs around the sides of the cans.

MODERATOR CHADWICK: Where is the next question?

MR. ROLAND DE WILDE: I was going to ask the gentleman who used the polyethylene tent whether he used black polyethylene to take care of his heat problem Would that help?

MR FRANK TURNER: We used the clear polyethylene. We depend upon the ventilation to take care of the heat and we think that we have as good a control over our structure as you would normally have over an ordinary cold frame covered with hot-bed sash.

MR. DE WILDE: That doesn't quite answer the question, but I think I can see how it works.

We in the past have had quite a lot of trouble with splitting and we found that this was aggravated in the days when we used mulch, especially during the summer months. You will get a lot of good out of the summer mulch because the plants will grow better when you keep the soil cool. We found when it came time for the first frost, that your interchange of heat between the soil and the air was, of course, shut off by the insulation from your mulch As a result the least little bit of frost would kill your flower buds and also would cause splitting, sometimes all the way down to the stem. So what we have found is best now is to either use no mulch or just use it very little during the summer. Where we use it for winter protection we don't put it on now until after we have had a fairly heavy frost at a time when we feel the plants are dormant and we don't have to worry about splitting. I do not know whether that applies to the canned stock.

MR. HILL: I have heard that explanation. It is a very interesting effect It is that the winter air above a mulch gets appreciably colder than the same air over an area that is not mulched. I think there was a paper on that by John Creech, who had that same trouble with azaleas.

MODERATOR CHADWICK: Are there other questions?

MR. RICHARD BOSLEY (Mentor, Ohio): Ken, would you care to comment on Dave Dugan's idea of putting canned material in the darkness? Sometimes you have structures available but you wonder wonder what effect you might get from keeping an evergreen or broadleaf in an environment such as this.

DR. REISCH: I have asked the same question.

MR. DAVE DUGAN (Perry, Ohio): We have not been able to obtain a definite answer to this question but we are going to shoot the works. We are putting some in complete darkness and some in a cellar which has some light coming in from a north light high in the roof. We are stacking everything from one can high to around 8 or 10 cans high.

I guess you will have to come to Cleveland next year and we will tell you what happened. I have good evidence from growers that you can put evergreens in complete darkness and also excellent evidence that you can't.

MR. RALPH M. FISHER (Morrisville, Pa.): When storing broadleaves in complete darkness I will predict that they will be pretty yellow toward spring We used to store as high as 30.000 *Daphne cneorum* a year and unless you gave them some light they weren't very saleable in the spring. That has been my experience year after year. I think you will get some chlorosis.

MR. DUGAN. Up to this year we have stored our cans by plunging them up to the surface of the can. Sometimes the fellows doing the mulching get a little excited about it and the sawdust got piled up and over the top of the plants in both the holly and firethorn groups. Those which were completely buried with sawdust came through the best. There was no windburn, and I am sure there was no light.

As I say, we are shooting the works. I was asked back here whether this storage was going to freeze The one is a bank barn. We get a little bit of frost in that one. The other one is an old nursery storage, and that one gets cold to the point where maybe the water hydrant will thaw out if you burn a newspaper under it. They have been in these conditions about a month now and are still green.

MODERATOR CHADWICK. Before we take these next two questions, is Vince Bailey in the room? Vince, I think you have had some experience on packaging of evergreens in the fall and putting them into storage where they have been in complete darkness. What has been your experience there?

MR VINCENT BAILEY (St Paul, Minn.): Our experience in storing transplanted evergreens and liners has been very good. We have had no discoloration whatsoever. They have come out in the spring in very good color. You would never know they had been stored in complete darkness These have been stored under a temperature of 32 degrees until about the middle of December when the room went below freezing. In the middle of March it thawed out and was kept at 32 or 33 degrees until planting time.

I just wanted to comment on the stacking of these canned goods, also. We have done that for three or four years but not with coniferous or that type of material. We have piled them up about 12 or 14 high, and have had very good results.

MODERATOR CHADWICK: Vince, before you leave, what kind of evergreens do you store?

MR BAILEY: Colorado spruce, Blue spruce, Ponderosa pine, Pfitzer juniper, Andorra juniper, and arborvitae.

MODERATOR CHADWICK: No broadleaves?

MR. BAILEY: No.

MR. HUGH STEAVENSON: We have a very large and dark cave, which is available to us and we stored broadleaves in variety last winter, and they seemed to come through all right. In fact, they looked pretty good.

I would like to take this opportunity to comment on one point while I am up here. I think there is misconception that has crept into the discussion on this matter of liquid feeding versus dry feeding of the organics.

I know that all the panel members are well aware that for many years many growers in the parts of the country where they have been growing a long time have been dry feeding, with results equal to the best of the liquid feeding techniques. And, of course, when you dry feed, it does bring the slow pay-out organics into the picture. The cost consideration is irrelevant as far as the materials are concerned, of which we are all aware, because you are talking about a small fraction of a cent for a container at best. As a matter of fact, when you sprinkle on the inorganics you are using a lot more fertilizer and feed than the dry application.

I would like to say something, too, on handwatering versus sprinkler watering. A lot of us feel the best possible way to water is by hand.

Therefore, it is a matter of cost. Now this year we have 100,000 cans. Two men did the watering, spacing and pruning. The cost of actual salary was $2,000 which came down to two cents per can per season. Now we couldn't cut it more than a cent, so it is a case of whether a cent extra cost isn't worth the difference in quality and insurance of a good job. I don't think as growers we have to throw out the idea that we have to have sprinklers and we can't hand-water and/or that we can't use a liquid feed. There is plenty of opportunity for the smaller operator who is not dry feeding and is hand-watering.

DR. WAXMAN: Just to get back to the overwintering of evergreens and storage of evergreens in darkness, I think it is really a matter of temperature. If they are brought in too early in the season and we have a warm fall and the temperature gets rather hot, then you might get a fairly high rate of respiration and you get yellowing. This might occur if you have a warm spring. You are taking a chance. If you are lucky enough to have a cool fall, then you are safe. I think it is mainly the rate of respiration, if you are concerned whether an evergreen gets yellow or not.

MODERATOR CHADWICK: Hans Hess has a question.

MR. HANS HESS: I would just like to offer this as far as the storage of evergreens is concerned. We have been concerned with the storage of seedlings for a long time and last fall, about November, I put in plastic bags a number of different varieties of bare root seedlings. The bags were tied and put in a refrigerator maintained at 34 degrees F. I took them out in the spring, planted them and got normal growth without yellowing. Now among these were hemlock, various pine varieties, Norway spruce, arborvitae, and many other conifer varieties. We also tried certain deciduous material such as Mountain ash which were 50 per cent successful Oaks were a complete failure. *Viburnum* varieties came through well, although dogwoods and magnolias did not survive.

MODERATOR CHADWICK: Ladies and gentlemen. we have been going just about six and a half hours on this question of container production of nursery stock. I am sure that we have not answered all of your questions, but I hope we have answered a few.

Before we break up the session I think first of all you should give these panel members, a good hand. They have put in a lot of time on it. (Applause)

The session recessed at 5:00 o'clock.

PLANT PROPAGATION QUESTION BOX

FRIDAY EVENING SESSION

December 11, 1959

The Plant Propagation Question Box Session of the Eighth Annual Meeting convened at 8.00 P.M in the Constitution and Independence Rooms of the Sheraton Hotel. Mr. James S. Wells, the Societies first president, presided over the lively session.

This portion of the meeting was not transcribed.

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SATURDAY MORNING SESSION

December 12, 1959

The fifth session convened at 9:00 o'clock, President Nordine calling the meeting to order. Dr. Wm. E. Snyder, Department of Horticulture, Rutgers University, New Brunswick, New Jersey, Moderator.

PRESIDENT NORDINE: Good morning, gentlemen. A great many of you have expressed your pleasure with the program this year. There is no question but what it has been conducted very, very well, with this panel type of program. If anybody has to ask any more questions about canned nursery materials or how to grow them, it is probably your fault rather than the way the program has been constructed.

We have the same type of panel this morning, although a different subject. There is always that controversial question, ie, how am I going to propagate it? This morning should answer that question once and for all. If you go away confused it is your own fault.

We certainly are greatly indebted to Harvey Templeton for the content of this program and the way it is put together.

Our moderator this morning is Dr. William E. Snyder, Department of Horticulture, Rutgers University. I am going to ask him to come forward now. Dr. Snyder!

MODERATOR SNYDER: Mr President, members of the Plant Propagators Society.

Looking back over the Proceedings we find that there are a number of different methods of propagation ranging from the traditional cold frame, through the greenhouse, mist propagation, polyethylene tent, and so on It is no wonder that many of us who have been propagating plants for quite a while as well as those of us who have not been concerned with propagation too long might be a bit confused about what is the best method for propagating plants.

In the first place I don't believe, and I think you will agree, that there is any one best method. There are many methods which are very satisfactory as you will learn this morning from our panel of successful propagators.

Actually, in our propagation techniques with cuttings, we are attempting to establish environmental conditions which are optimum or as near optimum as we can get them for the rooting processes. Paramount among the environmental factors are the control of light, temperature and humidity. Of course temperature would include both air temperature and medium temperatures, water relations would include that of the atmosphere as well as the medium.

We are going to divide the discussion this morning into two phases. The first aspect will be a discussion of the methods that are actually employed by these various nurseries and individuals Following that, there will be a discussion period, which will give you a chance to ask questions specifically concerning the details of the methods We will then take our break and come back and give the members of the panel an opportunity to brag about their results and about their methods.

I am prepared, if necessary, to ask a few baited questions for some of these people. I hope we can get an argument started. However, I doubt seriously if it is necessary for the panel moderator to precipitate any discussion or questions. We are going to try to make this as informal as we can by having the panel all up here at the same time.

I would like the following panel members to come forward: Bill Flemer, Roger Coggeshall, Leslie Hancock, Merton Congdon, and Henry Weller.

These gentlemen will take some five to seven minutes first to discuss the methods of propagation which they are following and then we will have a question and answer discussion We will call first on William Flemer of Princeton Nurseries, Princeton, New Jersey, to discuss their methods of propagation by cuttings in the greenhouse. Mr. Flemer. (Applause)

MR. WILLIAM FLEMER: Thank you, Dr. Snyder.

We use greenhouses with bottom heat in the winter and without it in the summertime for our softwood and firmwood cutting propagation at the Princeton Nurseries. We think that this is an economical method to use because the maintenance costs are so little.

Our houses, for those of you who have not seen them, are the old-fashioned kind of Dutch greenhouse They are low double span houses, joined side by side. They are 100 feet long and 16 feet wide, I believe. We have two, 3½ foot benches on either side of a 2½ foot central walk. The glass begins at the rear of the bench, at a point about 15 inches above the bench and then goes up to a gable overhead. By this you can see that the glass is rather close to the bench, which is great aid in maintaining uniformity of temperature and moisture.

We have eight of these houses, four on each side. Beyond these, we have eight sash houses which are wider. They have six foot beds and they are covered with sash which can be taken out during the summertime. When we are pressed for propagation room we can put two or more of those sash houses into use, either in the winter or summer, because three of them have bottom heat. We use these to help us over the hump during the rush seasons.

Our system of greenhouse cooling is a rather unusual one which you don't often see in the nursery business. We run pipes down the ridge poles of each house and they have Skinner fine spray nozzles alternately placed two feet apart down these pipes spraying out in opposite directions. During the hot periods in the summer we turn the lines on. They are full of cold well water, which is sprayed out on the glass. This cools the glass which in turn cools the air inside the houses. It is a very effective and inexpensive method of greenhouse cooling. You have to have cold well water to do it with, since warm pond water is ineffective. This water runs down to the gutters and away to a little pond which we use for irrigation

We work these greenhouses very hard We take four and a half crops of cuttings per year out of each house. The reason I say four and a half is that it depends on the speed of rooting. In some houses we take five crops and in other only four, so it averages out at four and a half crops of cuttings. I will run through the cycle just briefly with you.

Starting in mid-May, which is the only time that these houses ever become empty, just after we plant out the last of our potting stock, we have a little breathing spell. At this time we check over the houses, do any painting that might need attention, replace cracked glass and tidy them up in preparation for the next year's crops.

At that time we take out all the sand and replace it with fresh sand. We are sterilizing with steam and electricity. We are convinced that after you have grown a few crops of cuttings in the same medium you get a build up of fungi, bits of roots, bits of leaves, even though you sterilize the sand. There will soon be reinfection from aerial-borne spores and a medium full of organic matter like that is just a breeding place for fungi of all kinds.

During this May period we replace with sand completely. We take the old sand out and stockpile that and use it for covering seeds in the seed beds. After replacing the sand and touching up the greenhouses, we are ready for our first crop of softwood cuttings These are usually those varieties which start growth early and harden, like lilac, followed by *Spiraea bumalda A. W., Prunus spp., Berberis thunbergi,* and *Deutzia gracilis.* These are the first crops we put in. These root very quickly at the end of two weeks or two and a half weeks, depending on the plot.

We pot those off in jiffy pots and put them directly in cold frames where they are not taken out again until they are ready for planting in the spring.

We get the second crop of softwood things ripening in the middle of the summer which includes: *Weigela, Hydrangea P. G.* and *A. G., Viburnum tomentosum,* and as we go further into the summer *Viburnum tomentosum plicatum* and various other varieties which we grow from cuttings.

Those houses which have had two early crops of softwoods are empty in time to take what we call firmwood cuttings, which would include the evergreen barberry, hollies of various kinds, and other broadleaf evergreens. Those greenhouses which have a second crop of rather late cuttings, like the viburnums, are not available for that broadleaf crop but are emptied out in time to be available for the first of the conifer cuttings. Eventually all of the houses are filled with conifer cuttings.

We start with arborvitae. We follow those with yews and we end up last of all with junipers. Our experience has been, within reason, the later you take your junipers the more quickly and the more abundantly they root.

Since we propagate in the greenhouse the material does not get below 48 or 50 degrees in even the coldest weather. We therefore like our yews and all our conifers, in fact, to go through some cold weather before we take them. Experiments in taking conifer cuttings early in the season in August or September have been uniformly disappointing. They callus but they don't root properly and those that do root don't break bud dormancy properly.

After the first of the conifer cuttings which were stuck have rooted and have been potted up, those houses are made available and used for grafting. We practice both open bench and some case grafting, depending upon the case of the subject. Those houses which are not used for grafting are used for a very early spring crop of small hardwood cuttings of the type Louis Vanderbrook described to you in detail several years ago.

After the grafts have set up and the hardwood cuttings potted off, open spaces in the benches are filled with conifers which have been potted up in the Jiffy pots We then go into the spring season, in late April or early May, with all the greenhouses full of pot plants of cuttings which were made last winter. All the sash houses are full of potted plants and all our cold frames are full of potted plants. From that time on we are planting. We then clean out the greenhouses and repeat this cycle which I have described to you.

Costs sound bad to begin with, but when you consider the small amount of upkeep that you have to do on a well-built greenhouse versus the continual upkeep that you have on a polyethylene plastic house, you can amortize this initial cost over a number of years and it will compare very favorably with the plastic house.

Costs in New Jersey run about 50 cents per square foot of inside area for constructing a decent plastic house compared to $1.50 a foot for constructing this Dutch type of greenhouse. This is just for the house, and does not include the heating. Heating will add another dollar a square foot to the cost When you consider that those houses were built 40 years ago, and have never had major repairs of any sort, then that $2.50 a foot initial cost figures out to be a pretty low yearly cost.

I think that is all I have to say for the present. I will be glad to answer any questions which occur.

MODERATOR SNYDER: Thank you very much, Bill . We will go on now to the Use of the Polyethylene Enclosure, the procedure originally described by Harvey Templeton a number of years ago and which has since been described a number of times by others. Roger Coggeshall of Cherry Hill Nurseries, West Newbury, Mass.

MR. ROGER COGGESHALL: The use of polyethylene plastic by the plant propagator has certainly been discussed to a great extent here already. As you might imagine the use of plastic under our conditions is a little different. Our operation is relatively small and therefore the figures I will give pertain to a small operation

Now we have two sash houses 25 feet long and they are 12 feet across. In addition to that, we have a lean-to house which is 178 feet square plus a pit type of house which also is 45 feet long.

Now in these houses we have a total propagating area underneath polyethylene plastic of 716 square feet.

In setting up this type of plant propagation unit I have attempted to keep costs to ascertain actually how much it cost us.

To cover this 716 square feet we have needed four rolls of the so-called Turkey wire, which is a three-foot roll of wire with the individual squares measuring 2 x 4 inches. The original roll we had was 82 feet long and cost us $17.95. Shortly after that we purchased three additional rolls of 100 foot length each and they cost $16.50 apiece. So in the wire alone we had a cost of $67.45. I wish to give credit at this time to Harvey Gray since it was at his greenhouses that I first saw this wire being used

As far as the polyethylene is concerned, we use the two mil thickness which is bought in a roll which measures eight and one-third feet across, and 200 feet in length. A roll of this size is sufficient to cover all the plastic cases we require. A roll of this size is $14.50.

Now as Bill Flemer has already mentioned, our houses are equipped, as were his, with the hot water type of heat, which we use, of course, in propagating evergreens in the winter. However, during the spring and summer months when it comes to propagation by softwood cuttings we employ lead cables. These are 60 foot lead cables, thermostatically controlled. These cost a total of $17.50 and the 60-foot cables are around $11.40. We have six thermostats in use, plus 12 cables. Of course, each thermostat handles 2 cables The total cost of this equipment is about $241.80.

Now I look at it from the standpoint that the only part of this entire facility that is perishable is the plastic. I don't wish to imply that we don't have trouble with the cables, but if they are handled properly you should not have too much trouble from year to year. Consequently, if we look at this $14.50 for the cost of the plastic as an annual expense you have as an initial cost a total of $323.75. As I mentioned, this is just for our own setup, and, of course, it would vary according to your own operation.

I frankly like the polyethylene plastic as many of you know. I think it works very well.

(*Editor's note*. Mr. Coggeshall continued his discussion using colored slides. Some of the comments follow.)

As Harvey Gray has pointed out, we are actually growing these cuttings in a contained area with a very high humidity condition. When the weather is cloudy or when we have a rain, we actually turn back the plastic. We have run into trouble both at the Arnold Arboretum and at my present place of employment if the cases are filled, and left closed for a period of a month or two. Now in spite of the spraying which we do, which is a must with the softwood cuttings in the months of May, June and July, we have too much of a mold buildup, if you do not open it up in this manner. I grant you that with the softwood cuttings the cases may be open only an hour or two at the most. In the propagation of rhododendrons the case would be open all day. We start making our rhododendron cuttings in the middle of July right on through the month of November just as long as the space is available.

These wire frames covered with polyethylene plastic are a foot high and they will vary in width according to the width of the bench. The burlap shading is placed only on the southern side of the house It is very necessary during the hotter parts of the year as you no doubt know, as the buildup of heat under the polyethylene in exposed areas is just tremendous. You must shade them at least partially. The shading is very critical and is difficult to explain. It is your location that will determine the amount and time of shading. It is only through trial and error that the actual procedure can be modified to fit your particular needs. In our case there is very little shade on the glass of the greenhouse itself. This is done because we certainly want to root more than one crop of cuttings per year.

MODERATOR SNYDER: Thank you, Roger Several years ago at a Plant Propagators' meeting we were very fortunate indeed to have a speaker from North of the border. Mr. Hancock discussed his Burlap Cloud method. Prior to this time I doubt if there were many of us using it, although since this time many have visited his nursery. I think it was one of the most inspiring visits I have ever made. The morning would certainly be incomplete if this procedure were not included in this discussion. Therefore, I call on Mr Leslie Hancock of the Woodland Nurseries, Cooksville, Ontario, to discuss the "Burlap Cloud Method."

MR. LESLIE HANCOCK: Thank you very much, Dr. Snyder.

Those of you who are old members of our Society will probably remember that occasion. There may be some here who are new, but I would feel it would be an imposition on the records of our Society if I went to any great length to describe this system again, which has already been fully described in the Third Proceedings.

You have heard or will hear about four different methods which we are using for rooting cuttings of plants. I think it will be a long, long time before the conventional greenhouses will be put out of business. I think next will probably come the polyethylene tenters, and then a poor third and fourth, the other two.

However, let me say that I am very pleased to see that Hugh Steavenson finds burlap very useful to put over the holes he pokes into the polyethylene tent. I am very pleased to see that Roger has picked up two or three pointers which I suggested several years ago. He finds it necessary to use burlap to shade his cuttings. Also, I notice he knows the value of fresh air for the cuttings once in a while. Also, I have noticed he has learned it is a good procedure not to take off any leaves from a cutting.

Mr Hancock presented his prepared discussion, on the Burlap Cloud method of rooting softwood cuttings during the summer. (Applause)

THE BURLAP CLOUD METHOD OF ROOTING SOFTWOOD SUMMER CUTTINGS

LESLIE HANCOCK
Woodland Nurseries
Cooksville, Ontario, Canada

This method has been described in two previous issues of the Proceedings of our Society, and in the short time at my disposal it would hardly be possible for me to fully describe it again. For those, however, to whom the idea may be new, it will be necessary to give at least a brief review of the principles involved.

It is a method of rooting summer cuttings in ordinary sandy nursery soil by using light portable wooden frames with burlap covers. From experience it has been found that the best practicable length for these frames is twelve feet, and the width three feet nine inches outside measure. Because burlap comes in forty inches standard width, it has not been practicable to have the frames any wider. The lumber used is 1″ x 10″ x 12 feet Pacific Coast cedar for both sides and ends. To give the frame rigidity, a cross bar of 1″ x 3″ lumber of the same material connects the two sides of the frame exactly at the point of balance ,which also enables one man to carry a frame easily. Similar strips of lumber 1″ x 3″ x 12′ are nailed along the upper edges at either side of the frame for rigidity and for the purpose of securing the burlap. The Burlap used, which is nine ounce weight, is cut 12½ feet long to offset shrinkage and is stapled firmly along one side of the frame.

The cutting beds which can be any length or number desired, are raised beds on which the frames can be set tighty end to end, and then sunk into the ground slightly. The soil within the frame which is now two or three inches higher than the outside path, is rubbed through a large 3′ x 6′ sieve of ¾ inch mesh which fits half of the frame. The amount of soil sifted should be finger depth and the earth floor below the sifted soil should be level and compact to ensure capillary action. This sifted soil within the frame is usually left in heaps, and only made uniformly level as required.

The cuttings which are gathered in pails with an inch or so of water in the bottom, are usually about five or six inches long. No leaves are removed from the cuttings unless they are too large and would impede sticking. The only preparation the cuttings receive is a dusting of the cut surfaces with Tersan 75 powder as a fungicide. Before sticking, water is poured on the required area until the sifted soil is completely saturated and some free water remains on the surface. The cuttings are then stuck into this soft mud at the required spacing. Since the value of fresh air for the cuttings once in a while. Also, I have noticed he has learned it is a good procedure not to take off any leaves from a cutting.

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The burlap takes the place of glass or polyethylene and must be kept moist throughout the hot part of the day. It allows entry of filtered sunlight and humidified air and no other supplementary shade is used as in glass sash frame production. The burlap is thrown off an hour or two before sunset and the cuttings completely exposed to the air until the dew starts to disappear the following morning. On wet days, the frames are left uncovered as long as the sky remains cloudy.

Let me state here that I hold no brief for this method as a cure-all for propagation problems. It has worked well for us for a large number of items. In the final analysis the given method used must be that which best suits the operator's conditions and which roots the largest number of plants with the least expenditure of time and energy. I have found this burlap method exceptionally well suited for the production of varieties of *Buxus, Cornus. Cotoneaster, Daphne, Euonymus, Philadelphus, Potentilla, Spiraea, Viburnum* and *Weigela,* and, of course, the commoner easy rooting sorts such as *Forsythia, Ligustrum, Lonicera,* etc. I have not found it satisfactory for French lilacs, *Magnolia, Cotinus, Azalea* or *Prunus.* Fast rooting evergreens such as Andorra or Swedish juniper, *Thuja pyramidalis,* etc., will root well if stuck just as spring growth is about to start. The method is a natural for herbaceous cuttings of phlox, asters, etc.

The biggest disadvantage of the system is the hand spraying of the burlap curtains, and this has to be continued for several weeks after the last cutting operations. This can be eliminated somewhat by installing overhead sprinklers operated by a time clock, and turned on after a given area is filled with cuttings, but as anyone knows, this does not work so well when a high wind is blowing.

The advantages of our system appear to us to considerably offset the disadvantages. They are as follows:

1. Materials used for the frames are one inch lumber and burlap and these are very inexpensive.
2. Soil or sand does not have to be hauled from place to place.
3. Electrical installations are unnecessary.
4. Maximum use of natural agencies, e.g., filtered sunlight, free aeration of moist air, open air for fourteen hours evening, night and morning, ensure healthy plant reaction and rapid growth after rooting.

This brief outline can only give a general idea of the operation. It would not be profitable for a very few frames and requires mass production of a few paying items to properly put it over.

May I say again that in my opinion no propagator should plump for any one system. Our summer production in the greenhouses is continuing at the same time as this outdoor operation and I believe that the misted polyethylene tent system has great possibilities for certain difficult items. We have abandoned open air misting as too expensive and uncertain for ordinary production.

I shall be glad to answer any questions regarding the burlap cloud method I have just briefly described.

MODERATOR SNYDER. Thank you very much, Leslie I certainly would recommend that those of you that have not read the details of his physical setup refer to the Proceedings of the Third Annual Meeting, in which they are described in considerable detail. We will call on you later on for some additional information, I am sure.

We go now to the cold frame method of propagation, which will be discussed by Merton Congdon, Congdon's Wholesale Nursery, North Collins, New York. Congdon's originally were producers of fruit material almost exclusively. Several years ago they decided to get into the competitive ornamentals market, although having had almost all their experience with just the fruit, Mert and his brother were a little bit reluctant to start on the shrub venture. He actually did start with cold frames and I think has progressed through some other aspects.

When he was asked to participate on this program, he said he would probably not be the most experienced man to describe the cold frame method However, as you all know, he has had considerable experience and I am sure will do justice to the subject. Mert Congdon!

MR. MERTON CONGDON (North Collins, N Y.): I find it a little bit difficult to talk on the cold frame method because it is a rather old and established method. I know there are propagators here that know much more about it than I do However, perhaps we have discovered some cost-cutting short cuts that have helped in the experience of propagating in this way, and I will try to explain them to you.

In the first place, our propagation is limited to the fairly common shrubs that are probably called a class that is easy to root by the experienced propagator. The quantity that we grow is fairly extensive, running to several hundred thousand a year.

Our production by all methods is divided about as follows: About 29 per cent by this outdoor frame method that I am going to describe, about 23 per cent by division, about 19 per cent by outdoor mist, 16 per cent by hardwood cuttings, and 13 per cent by layers

(*Editor's note*: Mr Congdon discussed his general procedures from a set of colored slides. Some of the comments he made follow.)

The frame covers are quite light and are covered with celloglas wire mesh. We have long ago discarded muslin shading material because of its short life; we have converted completely to saran which we have found just as satisfactory from the propagating standpoint but with a much more longer life These frames are very light, probably weighing somewhere in the neighborhood of 30 to 40 pounds, which is easy for one man to handle.

One of the recurring expenses on this type of propagation is the wood frame. A couple of years ago we started experimenting with transite for the frames which of course, is a very permanent material and it has proven to be quite satisfactory

The top layer of our rooting medium is sand, then a very thin layer of peat and finally the soil, which is a Shenango loam.

Softwoods are taken in our Western New York area from about May 25 to July 10 on the subjects with which we are working, depending some, of course, on the season and the material.

We do treat the exposed wooden parts of our frames with Penta so the life expectancy on those woods would be 20 years to perhaps life, depending some on the material The saran is used only one month out of the year, so therefore that is a lifetime investment. Our own recurring expense, then, of any consequence is the replacement of the medium. We do this with power equipment and the cost is very low.

A few words about watering. We have overhead irrigation over the entire area. With this we can keep the entire area in a moist condition, and this is only done as needed Then, of course, sometimes it is necessary to do a certain amount of syringing of the foliage. We try to avoid this as much as possible. We are more apt to direct the syringing toward the under part of the sash or the outside of the frame. Of course, in hot, dry times it might be necessary to make this application of water, daily. As you can see, our frames are practically vaporproof, and I think much more efficient than those we used, say 20 years ago.

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MODERATOR SNYDER: Thank you very much, Mert.

Now we will go on to our last method, which is propagation under 'Outdoor Mist" Henry Weller is really in a fortunate position coming on like this He can probably strike a few of the comments made by the others Of course, they will have their chance for rebuttal. The use of 'Outdoor Mist" will be discussed by Henry A. Weller of C. W. Stuart & Co., Newark, New York. Henry!

Mr. Weller presented the first section of his prepared discussion.

OUTDOOR MIST PROPAGATION

HENRY A. WELLER
Director of Perennial Production
C W. Stuart and Company
Newark, New York

At the present time our propagation program includes three methods, ie, greenhouse propagation, seedbed propagation, and outdoor mist propagation. These three methods are utilized for their specific primacy. The selection of one of these methods, in preference to the other, is determined by the quality of rooted material, that which is more suitable for transplanting.

During the past few years outdoor misting has taken a definite step in producing quality stock and is now our main method of propagation.

The propagation of perennial stock is done primarily within the greenhouse and seedbeds as it involves divisions, stolon cuttings, hardwood and semi-hardwood cuttings, hardwood, because of lack of material during the summer months and those varieties that do well from

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The propagation of perennial stock is done primarily within the greenhouse and seedbeds as it involves divisions, stolon cuttings, hardwood and semi-hardwood cuttings, hardwood, because of lack of material during the summer months and those varieties that do well from seed Most of the evergreens, deciduous and broadleafs are taken care of under mist.

A schedule, dealing with a specific group of plant materials in production, is taken care of through a set pattern. For instance, the greenhouse procedure begins with *Teucrium chamaedrys* cuttings taken in October and after they are completed, *Taxus* cuttings are taken. Geranium cuttings will be continued to be taken to the middle of March, followed by *Phlox paniculata* varieties *Lavandula vera* seed is sown in flats the first of February after receiving a pre-chilling period. Incidentally pre-chilling and a germination test of seed has given concrete assurance of production. *Lavandula* is followed by chrysanthemum cuttings and then by *Plumbago larpentae* cuttings. In the meantime, test varieties are run through on their own schedule

Seedlings, other than *Lavandula vera,* are sown the middle of July and the latter part of September. The varieties sown in July, such as *Aquilegia, Asclepias tuberosa, Platycodon grandiflorum, Chrysanthemum, Iberis sempervirens, Delphinium* and *Pyrethrum,* to name a few, require no cold treatment to aid in bringing about germination Those sown in September, which require a cold period or stratification to break dormancy are, *Sorbus aucuparia, Mahonia aquifolium* and *Taxus cuspidata capitata.*

Outdoor mist propagation also has a schedule all of its own and it begins the first week in June and continues on through the last week in August. Some of the early varieties propagated are transplanted the fore part of August with excellent results

The varieties we propagate under mist in full scale production are. *Euonymus fortunei,* Winter Glory and Winter King which are two new euonymus hybrids, *Buxus sempervirens, Mahonia aquifolium, Pachysandra terminalis, Vinca minor,* Chrysanthemums, *Plumbago larpentae, Salix purpurea nana, Ligustrum vicaryi* and *Philadelphus virginalis* Some varieties we have had under test which have shown good results are; *Cytisus scoparius, Cotoneaster adpressa* and *horizontalis, Viburnum carlesi, Taxus cuspidata, T. media hicksi, T. brevifolia, Juniperus hetzi, Rhus cotinus atropurpurea, Berberis atropurpurea nana, Pachistima canbyi* and *Philadelphus aurea*

Misting has advanced very rapidly considering the fact that six years ago it was still in the talking stage. Our operation in this period of time has increased in area from 500 square feet to 25,000 square feet. This area involves 1000 mist nozzles spaced every 5 feet. The overall area is covered with 2 inches of ½ inch gravel for drainage. The beds are five feet in width and are edged with discarded railroad ties The ties are weatherproof with creosote and are heavy enough so that they stay in place without having to be staked We are using Florida type nozzles, the orifice of which has been drilled to 1/16 of an inch to acquire better water coverage and less clogging of the nozzles The water pressure is maintained at 80 pounds. The beds are controlled with individual timers and solenoids. The timers have a range from two minutes through one hour, and in addition to this have a switch which can either turn the individual line off, hold it on constant or set the timers in control. The beds are protected from the northwest with a polyethylene wind baffle to prevent drying along the edges

Of all the rooting mediums available, we have found that vermiculite works the best for our mist propagation The vermiculite provides good aeration and good drainage, even though we are applying great quantities of water. The vermiculite also has a tendency to cling to the roots during transplanting, keeping the roots moist.

The cost of setting up a good substantial mist system is reasonable, particularly when considering the return Approximately 33 cents per square foot will grade, provide drainage, wind baffles, pipe, nozzles, solenoids and timers. Labor in addition to this will vary as to source. The recurring cost has been negligible over a five year period. The timers, solenoids and nozzles are checked each year to insure trouble free conditions the following year The equipment available continues to be improved and thereby adds to this already superlative advance in propagation.

I have some slides that will illustrate the area and also some of the materials we have been working on

(*Editor's note.* Mr. Weller completed his discussion by illustrating the salient features of his talk with slides. Some of the comments and questions follow.)

QUESTION· Do you have a wire mesh in the bottom of the box in which you root your cuttings?

MR. WELLER: No, these boxes have wooden bottoms. We have no problem with drainage. In fact, I have seen water standing right up in the box and it doesn't seem to bother them too much

We do feed these cuttings with the mist line with a water soluble plant food containing the three basic nutrients and the trace elements. This does help overcome some of the leaching. With *Taxus cuspidata* it is almost impossible to prevent chlorosis

MR. HOOGENDOORN· Where do you store these rooted cuttings?

MR. WELLER: I think it was Leslie who mentioned that these cuttings having to be brought inside These cuttings, however, are left in the area where they are rooted. We don't worry about overwintering. The cuttings are fed much like Jack Hill has set up his schedule. These are set up along the same method of fertilization, and to this point we have not run into any overwintering problems.

QUESTION: How many plants do the boxes contain?

MR. WELLER: These boxes contain approximately 160 to 200 cuttings.

QUESTION: What is the depth of the box?

MR. WELLER: It depends on the type of material. For *Pachysandra* we use a large box.

MODERATOR SNYDER: Are there any panel members that have questions, comments, criticisms or anything else to add about other methods?

MR. HANCOCK: I was very pleased to hear the exact figure for cost per square foot of misting, that is 33 cents. Does that include your boxes?

MR WELLER: No, it does not.

MR HANCOCK Does it include the cost of mixing up your fertilizer and peat?

MR. WELLER: No, it does not That is an additional cost. The boxes are normally used during storage so we disregard that cost. The Terralite is necessary and we don't use peat moss

MR. HANCOCK: What do you use with this Terralite?

MR. WELLER: Nothing. Straight Terralite is a trade name for *vermiculite*. *Leslie, you mentioned soft mud for rooting cuttings* I was wondering what the possible aeration is?

MR. HANCOCK: The soft mud is called a slurry. Now the aeration theory is not upset. Let me tell you by removing no leaves from cuttings and keeping your fingers above the mud, you can stick them fast. It makes an open hole and the cutting goes in. What we see on the sides of the cuttings, where the leaf folds around there is a bunch of roots coming out because of the aeration by leaving the leaves on.

MR. FLEMER: There is one other thing which I see I neglected to state about our greenhouse system which I would like to mention now. We have erected over our greenhouses a permanent frame made of pipe, put together with pipe joints and on this framework are laid parallel strips of one-inch pipe running out at right angles from the head house. On these parallel strips of one-inch pipe we have four-foot snow fencing permanently fixed with copper wire. It is good for a number of years and it is never taken off. It is on there both winter and summer. During the summer softwood period when the temperature is high, the men get up on this snow fence and stretch shrimp nets. As soon as we get into the firmwood cuttings in the late summer and early fall, we roll up the shrimp net and put it away. We usually get three seasons' use out of the shrimp netting, which gives us extra shade during that hot summer period. We leave the snow fencing on at all times, both as a protection against hail and also to prevent the greenhouse from shooting upward in temperature during some bright spells during the winter weather

I think it cuts down on a certain amount of heat radiation during winter nights, too, and it is just an added protection and moderating factor for the greenhouse itself.

MR. HOOGENDOORN: What happens during heavy snowstorms?

MR. FLEMER: The snow seems to sift through We have only once had trouble. That was a year ago when we had 12 inches of wet snow and part of the frame collapsed. That was the first time in all the years that the snow bridged over the snow fencing and built up very rapidly. The normal snow sifts through the rather wide spacing between the lath, falls on the glass, is melted and runs away.

MODERATOR SNYDER: Any other questions?

MR. HILL: Do you change the medium in the greenhouses?

MR. FLEMER: We have tried sterilizing by chemicals and by steam. We have come to the conclusion that after you have run through four and a half crops per greenhouse you have built up your organic matter considerably. You can't sift out old roots and bits of leaves satisfactorily. Even if you do get it completely sterilized, you will get reinfection from aerial-borne spores. It doesn't pay to keep it more than one season. You will notice our protection is through the medium, beginning with very soft to medium soft cuttings, to firmwood and then to hardwood cuttings each year. As you go down this process the cuttings become successively more hard and, therefore, more resistant to basal rot So we can get through one full season's work without having to change it. We don't dare go back again into the first cycle with extremely tender cuttings because they damp off. It is poor economy not to change the medium.

MODERATOR SNYDER: The floor is now open for questions.

MR. MARTIN VAN HOF: This is for Bill Flemer. He mentioned the overwintering of the cutting in a frostproof frame. I would like to know what kind of a frame it is, how it is constructed, and if it is a deep frame how he keeps the water out, and so forth.

MR. FLEMER: We used to have the conventional six-foot wooden cold frames which took a sash just nicely During the long war period when wood was not available, these were pretty well dilapidated so we decided to replace them with four-inch cement block frames. We would put two frames together back to back in order to save two walls. They are dug down in the ground about 18 inches. We have a high piece of ground, Martin, so that there is drainage. The frames, although dug down into the ground, are still higher than the roadways which run alongside, so we can get drainage through the pipes at the end of the frames

Down the center of the frame is a row of pipes with a 2 by 6 laid flat, and screwed to the pipes On top of this is a 2 inch by 3 inch laid to form an inverted "T" This is higher than the sides of the frame and they slope off to the sides of the frame to give you a miniature greenhouse effect. It is actually a double slanted roof.

MR. VAN HOF· What is the pitch?

MR FLEMER: The pitch is one inch from the high to the low side We have in the bottom of the frame four inches of pea size gravel for drainage. With these pots it is important to have gravel underneath or polyethylene. If you put them on sand ,they root through and you tear the pots to pieces when you remove them. They do not root badly in the gravel. During the wintertime at about this time of year, we can pick up leaves very cheaply from our town, and these are hauled in and we bank those frames with leaves The leaves extend about 18 inches out, and they go up over the edge of the sash. We put board covers on top of the sash after the material has hardened up, and the leaves have dropped.

These frames will freeze on occasion but they do so very, very gradually and once they become frozen they stay frozen. We think one freeze is beneficial. We think what is detrimental is what Jack Hill was talking about yesterday, alternating freezing and thawing. The slow, gentle freeze and then a long sleep seems to make them break much more vigorously in the springtime.

MR. CONGDON: Bill, I will get around to directing a question to you but momentarily I was going to say I believe from what I have learned here that Mr. Hancock and I are the only ones that are rooting down into the soil. You remember that I mentioned the stratified areas that we were rooting down through. Now I feel that the performance of this stock after you get it out into the field is of prime importance and with the method that we use we are carrying along a small amount of earth in our peat with this plant when we take it to the field. Bill, you are familiar with our operation. Do you feel you are taking to the field a plant in the line I am working, with as good a root system as the one produced by my method?

MR. FLEMER: I think that your method is less expensive, but the key to the success of your method is that you are a better nurseryman than we are. You dig all your shrubs at one time of the year. You are handling bare root shrubs which are all brought in for storage. You have a distinct harvest time. When it opens up in the spring you have no harvest, no plants to dig and trees to get out of the ground, and the first thing in the spring you go right to work with those bareroot cuttings with a little earth adhering, and they go right to the field and you get wonderful stands.

We, unfortunately, or foolishly perhaps, growing a general line of evergreens, broadleafs and shrubs, are so darn busy in the spring that we just can't take the time, at the proper time, to put out bare root shrubs. So our solution on this thing is to pot them up.

MR CONGDON: I would like to point out that these are not bareroot cuttings that are going to the field: they can stand in the frame for whatever length of time is necessary. Sometimes as late in our areas as the first of June. I feel we can hold them there as long as you can in the pots.

MR. FLEMER: If you can make the soil stick to them, there is no question it is just as good, and obviously, I have seen your stands many times and they are as close to this mythical 100 per cent we all bandy around as it is possible to get Our operation, I should say, is geared to precision. We are in a high labor area. We grow a great number of plants. Our cost compared to our Tennessee brothers are fabulous. The only way we can keep going is precision — precision in production We plan ahead year after year, sometimes many years in advance what we are going to produce. We grow many of these shrubs in rather small quantities, surprisingly small, some only 250 of a kind, some only 500 of a kind, some only 1,500 We grow a lot of odd shrubs other nurserymen don't grow. In these oddities we can guess fairly well what we are going to sell. If we have scheduled 500, we don't want 1,500 and we don't want 100, because then we would be listing in our catalog something that was unobtainable somewhere else.

We can justify this higher cost of potting these plants and then going to the field and chalking it up to precision After all, what really costs you money is not in the few cents you save on your liner; it is that stand in the field. If you have a good steady, even stand across the field, it enormously reduces your fertilizing cost, cultivation cost per plant and most especially your weeding cost. Any other questions?

MR. RALPH SYNNESTVEDT (Glenview, Ill.): Bill, back on this cost again — in the days before you potted off into Jifty pots coming out with your first crop of softwoods, what additional charge do you now feel that this potting operation is costing you over that? I assume in the days before the potting you went to the frame outside with the rooted cuttings from the house. Is that correct?

MR. FLEMER. No, that is not correct. We used to do it in clay pots and that really got to be expensive. We were so relieved when the peat pot came along. Just to give you some figures of what we grow, we run through this range of evergreen houses just short of a million plants a year and taking all our costs, including overhead which most nurserymen and especially most propagators don't figure when they are figuring production cost, we figure it costs us six and three-quarters cents per pot plant, that is a two and a quarter inch pot plant, before it goes to the field. That is high, but it is worth it.

MODERATOR SNYDER: We will throw it open to all members of the panel.

MR. MILTON SPANGLER (Boston Park, N.J): I would like to ask Mr. Flemer about the yew cuttings he takes out of the greenhouse and pots up in peat pots.

MR. FLEMER: Our yew cuttings are rooted usually by early March. They are potted in two and a quarter inch peat pots and either set up in sash houses or in the greenhouses, depending where we have the room. They root very rapidly through the walls of the peat pot. They are planted out in May, in the open field in narrow rows, three, 18-inch rows are opened simultaneously by a three row opener. We plant them out in the open rows and cultivate with a cultivator rigged with these little, tiny vegetable cultivators.

MR. SPANGLER: The reason I asked this is that I put out 40,000 yews last spring. I had the Puerto Ricans do the planting. It costs $1.00 an hour. I planted them in beds about six inches on the square. When they got through weeding them, and in about three weeks I had a beautiful hay field. I am afraid somebody is going to come along with a match. I don't know what to do.

I have planned for this coming year that whatever I take out of the greenhouse I am going to pot up in peat pots and put in a frame. I wondered whether you waited for fall.

MR. FLEMER: As early as they are hardened off sufficiently to stand outside temperatures they are planted in the field. The earlier you get them in the field the better.

We find bedding and weeding costs extremely high. That is the reason we have gone to the three-row modification, much like Hugh Steavenson has described.

MR. SPANGLER. While I am here I would like to ask Mr. Weller if he takes his yew cuttings in the spring and puts them out under mist?

MR. WELLER: The yew cuttings under mist are taken in July. For the greenhouse procedure the cuttings are taken in November. We do bed our cuttings out in beds in early spring, but we have no weed problem to speak of.

MR. MARTIN VAN HOF. I saw some beautiful stands in the pictures of all your shrubs. I have had a miserable failure with *Philadelphus coronarias aureus* under mist. They start to root and then their leaves drop. What am I doing wrong?

MR. WELLER: I have run into the dropping of foliage to some extent, but not to the extent of decreasing the amount of rooting. I don't consider that a problem. The root structure is the thing I am after. If they drop a few bottom leaves, I don't feel that actually enters into the picture.

MR. VAN HOF: I wasn't worried about a few bottom leaves but rather any leaves.

MR. WELLER: I think, Martin, possibly the timing might have a little to do with that.

MR. CONGDON: I showed you a block of 30,000 *Philadelphus coronarius aureus* that were grown under sash. I could have also shown you an equal block grown under mist The secret of *Philadelphus c. aureus* under mist is to put them on an extremely dry cycle. On dry, hot days, they flag terribly. We would much rather see them flag than have them too wet, since they will come up during the evening and night. As long as you keep them on a dry cycle you will have no trouble with *Philadelphus c. aureus.*

MR. HANCOCK: I can confirm Mert Congdon's statement absolutely. The leaves would drop off, I would think, because it does not stand wet conditions. That is one item we can grow perfectly under our method and if we get a very wet period that is exactly what happens to them. When we see that coming, first of all we have to avoid watering. We don't have nearly the same amount of water going on the *Philadelphus c. aureus* that they do in misting. We merely have humid air. The *Philadelphus* species cannot stand a lot of water. As soon as we see that rot is starting, we dust them with a fungicide to stop it.

MR. HOOGENDOORN: How can you stop it if you are going to put water on it again right after?

MR. HANCOCK: We don't actually. I just make sure that it gets very little water. That is one thing I have against this mass misting. For some things it might be beautiful; for other things it might be a flop. When people say you shouldn't do all this hand work, we can actually avoid putting water on the *Philadelphus c. aureus* with the use of burlap, just enough to keep them from wilting.

DR. PRIDHAM: I was interested in having Mr. Weller tell us again how he handles the cutting down of the frequency of the mist. I think you said, Hank, each bed was run individually and you had pretty complete control over the material in one bed. You said something about cutting down on the original number of misting applications to, I think, about one-tenth of what you started with, but I am not sure. Would you tell us again?

MR. WELLER: We are using a timer that has a particular cycle of two minutes to one hour, and a solenoid that has a period of approximately 25 seconds. When we first take the cuttings the period is 25 seconds out of every five minutes. Generally, within a week or possibly two weeks, the cycle is dropped to ten minutes. Then as rooting is taking place, the cycle is dropped off as fast as possible and cut down completely to 25 seconds every hour, and it is absolutely foolproof. Each bed is controlled individually and each bed contains one variety. We do have control over that particular material.

MODERATOR SNYDER: You see, when you begin to ask questions you get a lot more information coming up from these people.

MR. MARTIN VAN HOF: I saw some lilac propagation over at Roger's with the plastic inside the greenhouse Now I would like to know from Henry and Roger how they are doing it, under mist, especially with the white variety cuttings?

MR. WELLER: Lilacs under mist is still in the testing stage and it will probably continue to be there for some time.

MR. COGGESHALL: I think Gerald Pfundstein could answer that question concerning lilacs under mist.

MR. GERALD PFUNDSTEIN (Dundee, Ill.): We have not done so many after the first couple of experiences under outdoor mist. We are doing it in the greenhouse. The first season we tried them in the house with the mist we did not have very good luck. The second year we tried many more in the house and with a comparable lot got not nearly as many as in a frame outside We had very poor luck with it. We did it in a plastic-lined house this past year and had very good luck, mostly with hand misting and without automatic units.

MR. AART VUYK (Indiana, Pa.): I would like to come back to the question of the deep tray. We built a couple of deep trays and we made them approximately three and a half feet deep. We have drain tile underneath on account of our terrible clay conditions, and we run our drain tile towards the dam we have there. But we also have heat pipes in there and the thermostat set at 40 degrees, and I think it is quite an advantage to have heat in the tray.

We put cuttings in there like American holly, Japanese holly, and all that kind of material and we feel that we get a rather heavy plant by June to line out. We believe this happens because we get the first flush of growth right in the deep tray, and I think it is quite an advantage.

MR. WELLER: I would like to ask Bill Flemer about this Jiffy pot, because our experience with them has been somewhat disastrous, and I gather other people have had trouble with them, too. The difficulty seems to be in, first, the material that you put into the pot. A very fine-rooted plant such as azalea or rhododendron seems to have no ability to drive through the peat pot and really submerge when it is planted. And the second thing is that the Jiffy pot itself acts as an evaporative surface, so unless you are very careful as, of course, you should be, the material will dry out in storage or through the winter.

We ran comparable tests on two plants, ie, *Prunus* 'Hally Jolivette' and *Clematis montana rubens,* putting half of each lot of plants in Jiffy pots and the other half in soil. The straight soil was greatly superior.

I woud like Bill to comment on that in relation to his material.

MR FLEMER: Jim, you have had the same experience that we have had on *Prunus*. We have tried *Prunus* in Jiffy pots and for some reason which I can't explain they don't do as well as in the clay pots. They are one of the few plants that we still go to the added trouble and expense of potting in clay pots.

About this drying business, we do not have trouble with that because we are used to peat pots It is difficult if you are using several different kinds of pots to get the greenhouse crew accustomed to watering them properly. If you have some plastic pots, some clay pots and some peat pots you will find the clay has to be watered frequently, the peat pots less frequently, and the plastic pots still less frequently. Once you shift over entirely to one kind, be it clay or peat, you can soon work out a watering schedule that gives you good success.

We have not had trouble with azalea and rhododendron in peat pots. They are one of the few that we water in the flat before we set them up The others, after potting we set them up in the cold frame dry so the pot is rigid and water them in the cold frame where they are going to stand for the rest of the winter. This gives us air spaces between the pots. In the case of the azaleas and rhododendrons, we water them and then set them up. That means the walls become soft and rather spongy since the pots are set closer together. We have no trouble getting roots to come out all over the surface of the pot as it fills up with roots. If you are not familiar with using it, you do have to pay more attention to watering, definitely, and just make sure that you don't allow them to dry out.

MR. WELLS: About the planting of this material in the field after it is established in the pot will the edge of the pot serve as a wick? If you run into a dry period it seems that you can rapidly deplete the water reserves just in the small pot ball, and as these pots are fertilized also you run into a layer of highly soluble salts which can be lethal for touchy plants, particularly the ericaceous material.

MR. FLEMER· You have to be careful in fertilizing, because there is fertilizer in the wall of the pot itself, and you can over-fertilize rather easily. Now our pots go to the field out in nursery rows, Jim. That means the trench is opened mechanically and we set the pot deeper than you would probably in bedding a shallow-rooted subject like a rhododendron. The pot is down a couple of inches below the soil surface by the time we follow up our planting with cultivation, and we do cultivate almost immediately. As soon as the planting crew is out of a row, the cultivators are following and throwing up loose soil over the pots. Furthermore, these pots are flat enough and go on a truck to the field, and the driver goes around to the hydrant and soaks them. The pots are literally mushy wet and they usually have enough reserve supply of water to reestablish themselves before they get into the wick-like drying which you mentioned.

MR. HANCOCK. Again, I can collaborate that Jim, this might answer your question, too. We brought up some one thousand *Pachystima canbyi* cuttings and potted them in Jiffy pots I wasn't there when they did some of the planting and some of the pots went into the ground two inches and some of you could see the rim on the surface I might say those in the ground two inches, the plants grew magnificently and the others, where you could see the edge of the Jiffy pot on the surface, not as good. I quite agree that you must get that Jiffy pot at least an inch and a half below the surface.

MODERATOR SNYDER: Thank you, Leslie I think we had better take a break so you gentleman can catch your breath and then come right back (The group recessed briefly)

Take your seats, please. The panel will come back to the platform and we will get underway. We are going to give the members of the panel now an opportunity to brag, I hope, about some of the plant materials that we have been particularly successful with and also an opportunity to possibly express reasons why they prefer their method to other methods. We will follow in the same sequence in which they appeared originally, which I believe started with you, Bill.

MR. FLEMER: It is pretty hard for me to say what special plants we can propagate that other people can't because I can't just offhand think of a thing that we are rooting successfully in quantity that someone of you fellows isn't doing at the same time I will say that in our trials, we have a misting unit, too, which we have found more successful for rooting magnolias than our conventional mist house. This is one of those sash houses with a raised bench which I described earlier, with bottom heat. It has Florida nozzles, three feet apart down the bench from the overhead pipe and in it we find we can take magnolias softer than we could under our conventional greenhouse method and root *Magnolia soulangeana* and *M. s alexandrina* very successfully. We have not been successful with *M. speciosa* or *lennei*, which are other varieties we grow.

I would like to bring up this matter of peat pots again, because we have tried many different kinds. The one that is sold under the commercial name of the Jiffy pot, has proven to be far away and above the best of the lot The Bird pot is made with a great deal of paper in it. If that is the one you are using, Jim, that would be the cause of your trouble I see you are shaking your head. You are probably using the Ball pot. The Ball pot is made only of peat and spruce fiber, and it is both tough and porous. You get good aeration through the sides of the pot and good root penetration The roots just shoot right through the pot and slow down and grow now more. Additional roots come out from within the root mass, so by the time the plant is ready to go to the field you have just the pot entirely filled with roots, and the plant is ready to go right on out. None of the other brands which we have tried have been as successful.

I want to emphasize once again the terrific importance of putting all your peat pots in one area if you are using different types to begin with and of getting your hose man accustomed to watering this particular type of container. Its requirements are different from the other two classes which are commonly used in the nursery business today.

I might also say that we syringe our cuttings during hot weather if they are flagging a little, as much as four times a day. People have asked, why don't you just substitute a mist line for all that labor. To me, any technique, even though it increases the cost of operations that makes the propagator and his staff get down in those greenhouses, go through and have a look at the material is a device which increases your overall success. The trouble with these automatic things and failures with them are almost always traced to just turning it on and letting the clock do it or the electronic leaf do it, and think no more about it. In our opinion, the secret of successful propagation is no more nor less than every day attention. Hand-watering does enforce this at least it makes the men get in there and see what is going on, even though they might not do so otherwise.

Well, that is all I have to say at the present time. Thank you.

MODERATOR SNYDER: Now we will go to Roger again for a few comments on the polyethylene system. Roger, can you really propagate plants under polyethylene?

MR. COGGESHALL: Thank you very much, Bill. I will try to answer your question. I believe we can propagate plants under polyethylene, at least I have been told so for a good many years.

We start off, as far as our propagation schedule is concerned, with the spring and go right on through the summer, fall and winter.

We start off first with the propagation of lilacs. Then comes the *Prunus*, 'Hally Jolivette.' It is a bush type of cherry, very easy to root. I believe in getting it to live is in reality getting it to overwinter. Jim Wells mentioned that he had trouble with it in Jiffy pots, is that not right?

MR. WELLS: Eighty per cent of them died in Jiffy pots but 100 per cent came through in flats of soil.

MR. COGGESHALL: We propagate this kind of cherry in exactly the same manner as we do the lilacs ,the magnolias, and the shrub *Kolkwitzia*. All these types of plants are made when the top growth is just about long enough to make a cutting. In respect to the cherry, when we make the cuttings we root them, pot in Jiffy pots, and then they are immediately put out. Next spring they will be 15 inches high. We have no trouble overwintering the plants with Jiffy pots in that manner.

(*Editor's note*: Mr. Coggeshall continued his discussion from slides.)

We collect the lilac and cherries when the growth is long enough to make a cutting. By that I mean with the lilacs we have two sets of leaves with a three double-lobed cutting. The cuttings are treated with Hormodin No. 2 and Hormodin No. 3. We have had considerable difficulty propagating the white varieties. Mme. Antoine Buchner and

Vestale and Ellen Willmott, these three in particular were practically nonexistant percentagewise. This past year for the sake of comment we held off until the growth was a little harder and we decreased the hormone Instead of Hormodin No 3, we used the No. 2 product. The idea was that the cuttings would take a little longer to root but the results were quite a bit better. Maybe that sounds a little odd that with the decreased hormone concentration you get better rooting. That was certainly the case in these particular varieties.

With the dark-colored varieties such as Lucie Baltet and Katherine Havemeyer, rooting was very good Once they are rooted, we pot them in two and a quarter inch Jiffy pots. They are carried in a tenthouse until the roots come through the sides, which will take place in a week to ten days. Following that, we bed them out seven inches apart, across in a bed 42 inches wide.

The advantage, in bedding them out, at this time of year, which I mentioned was around the first of August is that most of the varieties will go on to make from an inch to six inches of growth, depending on the variety

The propagation of lilacs under polyethylene plastic is very successful. I ran an experiment in connection with rooting the cuttings directly in the ground. The results there were far superior to growing them in the greenhouse benches and the greenhouse space being at a premium, next winter we will throw most of the lilac propagation into the ground with a polyethylene cover, the idea being there is no necessity to pot them the following year.

This picture is an illustration, at least in part, of the difficulty we have had with the Jiffy pots in a way that has not yet been mentioned. Now we had tremendous heaving through this past winter. These plants, which I did not mention are mulched with sawdust following the bedding-out operation, and I can certainly back up Mr. Hancock's comment that if you plant them too shallow you are going to have problems. They are planted at least two inches deep. We had a tremendous heaving loss. We reset the plants as early as we noticed it in the spring.

Once the lilacs have been made, we switch on the azaleas and select the color in the Ghent and Flame azaleas. As I have already mentioned, we cannot grow many of the things that you can grow here in Pennsylvania and New Jersey. These azaleas for the most part have proven quite hardy, although last year we changed our minds in respect to certain varieties which were killed right to the ground.

These cuttings are also made before Memorial Day As I mentioned previously, we have a lot going on during this, the busiest part of the season. However, I certainly believe that if you are going to bother with this type of plant material you have to do it now or forget it. If you make these cuttings in June or July, you won't get one-tenth of the material you should have. These are treated with Hormodin No. 3 without wounding. They were then put into a medium of sand, peat and styrofoam. The styrofoam is ground, and the medium mixed in equal parts by volume. These cuttings we leave in the medium for approximately three months. Then there is the matter of potting them off again into Jiffy pots. In many instances the varieties we root are: "Josephine Klinger," and "Daviesi" which we grow very little of; the "Coccinea Speciosa," "Pallas," and "Raphael de Smet," which are much slower to root. These cuttings also go into Jiffy pots and this winter we are handling them a little diffferently

Along the lines of Charlie Hess' comments in connection with the dogwoods, we have them in a storage condition where the temperature will fluctuate very little. In that way, we hope to overwinter them. We ran them under light about the second of November. That is a continuation of the normal daylight plus artificial to supplement the continuous daylight. The varieties grew anywhere from two to 15 inches, depending on the variety. The difficulty came into play when we attempted to overwinter them. The temperature dropped the second of January and the house froze up solid and I can say that we won't try that again

We do not place these azaleas too close together. The terminal buds were removed. We believe they have an inhibiting effect on the regrowth of the cutting in the spring, but next year we will know more about it.

This polyethylene plastic unit roots the cuttings in extreme heat and extreme humidity. I honestly believe the results we have propagating these hard-to-root materials is due to the fact that the temperature under the polyethylene is certainly much higher than under your mist system or conventional hand-syringing operation.

We begin our rhododendron propagation approximately in the middle of July with cutting material such as *Rhododendron fortunei* or Dexter hybrids and *R. catawbiense.* These are rooted by, say the middle of November at the latest. We try to turn over the benches as fast as we can but can get only three crops in one single year.

With these *Rhododendron fortunei* hybrids we have quite a few seedlings which have been collected locally These plants have proven to be hardy over a great many years and the stock plants are up to 12 to 15 feet in height. As far as hardiness is concerned, we had very good success in overwintering them last winter

There were varieties such as Caractacus, Dr. Dresselhuys, E. S Rand, and Mrs Peter den Ouden which were killed.

We do not get the rhododendron in the State of Massachusetts that you get in New Jersey. We usually get two flushes of growth in a year. We had a third one this year and we pruned it all off. By that, I mean it wasn't longer than an inch and a half to two inches. It has all been killed by the frost now, the plants grew so late. These plants are what we would consider one year old.

Now we pinch the two-year old rhododendrons heavily so as to shape them up prior to the lining out operation When the cutting is potted it is benched. Then when it is at the end of the first flush, the first year in the bed, it is pinched and pinched again at the end of the second year. If it stays in the bed two years the pinching operation is continued and the spring of the third year they are lined out.

As far as the *Taxus* are concerned a question came up a while ago as to what we do with them once they are rooted We pot all ours. This operation is done in the way Bill Flemer described. We eventually hope to have all our cuttings potted by the time spring rolls around. They are placed in a concrete frame in Jiffy pots with a light layer of sawdust over them.

In the Jiffy pots that you see, they are bedded out the next spring. In other words, we pot up material you saw in the frame in the spring and it remains in that frame all that summer and all the next winter, and the bedding out operation takes place the next summer. This material here is again planted out on the same spacing I have already mentioned, and the mulch is soft. A good many of you I know do not like sawdust. We pay pretty close attention to fertility and in my short experience of time in a nursery, I have not seen any damage due to the use of sawdust.

I might comment that once these plants are dug, the lining out operation begins. The space they come from is cover cropped for two years before it is put back into plants again

This is a field of six year old plants which range in kind and age. However, one application of Simazin was applied in the month of May, the first year, and again in the month of May the second year. There was no necessity to hoe that piece following application.

The only further thing I have to comment is that with the propagation of the evergreens we do not use any polyethylene plastic at all. They are bedded out in open benches under standard greenhouse operation procedures.

MODERATOR SNYDER: Thank you, Roger. I know you can propagate plants and I know the polyethylene frame is a very effective method for doing this.

We will call on Leslie Hancock to comment on some plants that he has been especially successful with.

MR. HANCOCK: I will say that there are very few plants in my honest opinion that we can produce any better. After all these wonderful pictures it really makes you wonder whether you have ever learned anything

We find that because we take the plant up with just a little ball of roots it is as good as if we had it in a Jiffy pot. We take them right over to the bed and pull them apart and put that chunk of earth into the soil, and it goes right on growing.

As far as two other items, Silver dogwood and *Viburnum tomentosum plicatum,* I know that these are not expensive plants. This method gave us 100 per cent rooting of Silver dogwood As you know, the Holland propagators had to rely on layering as a method for propagating this plant. Of course, I might also say that we have always been able to grow *Philadelphus coronarius aureus* particularly well.

The only other item which I would comment on are the cotoneasters. I don't know that Harvey Templeton asked me what experience we had with propagating cotoneasters. I think this is one thing that we will be able to do better than anyone else I have two plants in the back of the room of *Cotoneaster adpressa praecox,* which I bet you never saw. Also, I brought a *Cotoneaster dammeri* which is 18 months old, and which you can inspect

MODERATOR SNYDER We will go to Mert Congdon for any rebuttal or comments he would like to make

MR CONGDON. Bill, when I first went over the list of material that we are working on in these outdoor frames I explained to you that it was all fairly easy material to propagate I am not really familiar with some of the difficult subjects that might possibly be done in this way, since I am solely interested in producing a volume of the easier to propagate deciduous subjects.

As was brought out earlier, we do particularly well with the *Philadelphus coronarius aurea, Potentilla, Philadelphus virginalis,* the viburnums, and hydrangeas, *Deutzia, Kolkwitzia,* and *Ligustrum ibota vicari,* which do better under mist, at least for us

Now the reason that I prefer the cold frame and mist method is because we feel that the frames and the mist are the methods of lowest cost for the subjects in which we are interested. If we are to produce a two-year, two to three foot, field grown weigela, for example, at 35 or 40 cents, and believe me, the trade expects us to produce them for that price, we must watch these costs all the way.

Henry Weller gave a good talk on this subject last year in Cleveland. The nurseryman that is producing liners had better not go over about five cents on this class of plant material. We feel that we are doing it for less than half of this cost. If we are to watch costs, then we certainly cannot transplant but once directly from that propagation to the field, and this generally eliminates the greenhouse. We must root directly in the soil or have a satisfactory growing medium.

Secondly, we stick to this method in order to balance our propagation As previously mentioned, I don't like to go over 25 or 30 per cent on any method. Rarely a year goes by that we don't have trouble with one of these procedures. By attacking it in five ways, as I pointed out, we spread the risk. In cold frames with us, our controlled conditions produces uniform results. Of course, we stick to the method because of the successful results in the past. We have had no experience with conifers and ericaceous materials.

Another advantage of this technique is the little need for attention. Outside of the 7:00 a m. inspection each day, the frames can be left to themselves and the attendant can devote his time to other matters. I must admit this is not true on hot. windy days when drying conditions are severe. I must also admit that we are in a very favorable location up in Western New York on the shores of Lake Erie. We have a comparatively cool, humid climate all through the summer and some of the problems that people would have, say, in the Midwest, with frames, are not a problem with us.

We are without any question propagating these plants under frame and mist procedures equally at about, I would say 1.5 cents per plant

Divisions cost us that much since there is the labor in making divisions When we get into hardwood cuttings and layering then we are going to get up to about 2.5 cents per plant I might point out at this point that the plants produced from hardwood cuttings and layers are larger plants when they go to the field. As a result they perform a little better than this other material and therefore, are worth more to us.

But what I want to leave you with is the fact that we are getting that cost down pretty low, and these other fellows are going to have to scratch and cut cost if they are going to meet these figures.

MODERATOR SNYDER: Thank you, Mr. Congdon. Since we are pushing for time, we will go right on to Henry Weller for rebuttal or additional comments on mist.

MR. WELLER: I must say I am quite fortunate in following rather than preceding some of these fellows.

The essence of outdoor mist propagation is outstanding in many ways. In analyzing any feature of misting with those of some of the more basic methods of propagation, there is no point of comparison. Mention the factors involved and mist will show a definite advantage; whether in the selection of materials, flexibility of timing (the period of time when a cutting can be taken, and also the period of time after rooting), the type of cut made and location as to either above or below a node, control during and after the rooting period brought about by automation, the absence of having to use root stimulants, root structure, percentage of rooting, percentage in transplanting, the use of containers in conjunction with the operation, insect and fungus free conditions, foliar and root feeding, the methods of hardening-off various materials and the over-wintering problems indicate one factor, or all factors, if taken into consideration will definitely point towards outdoor mist propagation as approaching the ideal method.

Outdoor mist propagation, of course, is only practical when dealing with softwood materials and therefore should be utilized during the months of greater light and heat intensities.

The main objective in propagation, is to produce the very best rooted material possible. The secondary objective is cost. The two objectives, quality and cost, can be checked through cost analysis and by taking into full consideration all the factors involved, quality very definitely should prevail if the material is checked not only in the propagation stage, but through the process of becoming a salable plant.

Outdoor mist propagation has been most influential in reducing our cost, simply because all factors from the beginning of propagation through the eventual salability have resulted in quality as the primary asset and cost as the secondary result.

The main factors that make outdoor mist propagation ideal are; (1) the flexibility of timing In our experience cuttings can be taken over a longer period of time with excellent results. We can take cuttings earlier in the year; also the after rooting period is lengthened because the cuttings are fertilized through the mist line to insure active growth which continues until transplanting. The cuttings can also remain an indefinite length of time within the rooting medium. (2) Using flats and storage boxes that are normally put away for the summer, again is an advantage in that the cuttings can be moved directly to the field in their growing boxes This means the cuttings do not have to be pulled until the last minute before they are to be planted into the ground. (3) The rooted cuttings are fed through the mist line, saving us the time and labor of hand feeding. We use a water soluble fertilizer containing the three basic nutrients and trace elements and by doing this, we increase the growth and vitality of the cuttings so that they can be transplanted the same season that they are taken rather than waiting until the following spring This allows us to plant at a time when we are not as busy as during the spring rush. It gives us a better and larger plant at the end of the normal two or three year period of growth. In many cases we are able to grow a salable plant in one year less growing time Some of the other advantages, although not as significant, include the cut used. With the plants we have tried, we have found that in most cases it doesn't make any difference whether the cut is made above or below the node This enables us to cut a handful at one time with a pair of pruning shears. No hormones need be used. In our testing we have not found any advantage in using hormones under mist. Less attention required. There is no need for constant vigilance necessary with any other method of propagation. Watering is taken care of automatically and the distribution of moisture is equal in a given area. I'm sure you have all experienced the misfortune of poor water distribution, the lack of moisture in one area and excessive moisture in another

The cost of propagating by misting, as I mentioned previously, is greatly reduced because of the quality of the rooted material The quality is brought about by the combination of two or more factors associated with propagation. Cost of materials originally propagated within a greenhouse has been reduced as much as 40 per cent, while those propagated in cold frames were reduced by approximately 25 per cent. However, there are varieties that will not fit into your outdoor mist program because of the time element and availability of cutting wood. There are those varieties which require certain particular care, such as grafting, layering or air-rooting and which therefore have to be given special attention. This generally involves the use of either coldframe or greenhouse facilities. The greenhouse will always have a place in propagation to be sure, but if it can be avoided the profits will generally show a substantial increase. Again I mention quality as the prime essential The material involved should be checked through cost analysis. Whichever method of propagation shows the better quality, that method should be used. Decreased cost will be the eventual end.

Try misting and run a comparison with your basic routine. Set up a cost analysis program, it's comparatively simple, there are only four steps to be considered, namely; (1) The planting stock. (We at Stuart's set .003 per cutting as the credit to the stock block. It provides care and maintenance for the area.) (2) Materials. Items such as the mediums in use, and any other material used must be allocated. (3) Labor — men and women. The hours spent in propagation and those in the field, during and after transplanting, are necessary to acquire a true and accurate picture of the complete operation, step by step. (4) Overhead. This includes benefits, indirect labor, supervision, rent, water, heat and light, equipment and repairs. It can be allocated as a percentage of the labor dollar, or while in the process of propagation it can be broken down on a square foot basis and while in the field it can be absorbed by blocks or by the square foot within the area containing the particular material under analysis.

A percentage figure on rooting, transplanting and salability losses, will give you a complete and accurate picture and will guide you to the ideal method of not only propagation, but growing within the field.

Propagation brings about reduced or increased loss The condition and type of root structure at the time of transplanting brings about the eventual profit or loss. The root structure is the anchor, the foundation, and certainly the top growth depends on it's initial start brought about by a good healthy vigorous root system

Concern over percentage of rooting becomes a thing of the past when dealing with mist. With the varieties with which we have worked, consistent percentage figures of 90 per cent or higher rooting, eliminate this age old problem

The potential of mist can only be fully realized if we all develop this vast field of true opportunity.

MODERATOR SNYDER· Thank you, Henry.

I would like for the panel to come back up on the platform. I am going to ask the panel to make their answers short so we can cover more in the time allotted.

MR. VERKADE· I notice that a lot of nurseries are planting *Taxus* cuttings in Jiffy pots or in other containers. I would like to know if someone coud give me an idea what that costs compared to planting in beds Is it possible?

MR. FLEMER. Those figures are extremely difficult to arrive at because of the difficulty in getting a cost for keeping those beds clean. It depends on the year. If it is a wet year you have to weed a lot. If it is a dry year you don't have to do so much and the men are in and out Unless you have somebody right there watching all the time and clocking them in weeding that particular bed it is a very difficult thing to change.

Our potting costs, producing potted *Taxus* ready to go to the field average about six and three-quarters to seven cents apiece. I can't give you bedding costs because we have never been able to keep up with it accurately enough to find out just exactly what it did cost us

MODERATOR SNYDER: I saw Mr. Congdon shake his head. Have you a comment?

MR. CONGDON I was shaking my head on the weeding of these beds It is so minor with us it is practically nonexistent.

MODERATOR SNYDER: Do you mulch?

MR. CONGDON: No, but with your two inches of sand or whatever sterile medium you might be putting over the peat and the Shenango loam up we just don't have any weeding costs at all.

MR. FLEMER: Mert you are not spacing out *Taxus* in soil to stand for two years, you are talking about leaving the cuttings where they are. When you space them six by six or six by eight and have to keep the beds free of weeds for two years, that is quite another matter.

MODERATOR SNYDER: Any other questions?

DR. FRED NESBIT: I would like to ask Roger Coggeshall if he thinks I would have any luck with *Magnolia ashei* under the poly tent, and if so, how hard should I take the cuttings? I take things pretty soft for my mist bed. With *Magnolia ashei* I haven't been able to hit the exact time.

MR. COGGESHALL: I am sorry I can't answer your question. We attempted to propagate *Magnolia ashei* on material sent in to the Arnold Arboretum. This was attempted under polyethylene and was a complete failure. It is very difficult. I don't believe, frankly, it would root any better under plastic than under open mist.

DR. NESBIT. Would you think if I took a fairly hard rather than soft?

MR. COGGESHALL: I would stick to the softest possible material you could keep from flagging.

DR. NESBIT: There is one other thing that nobody here seems to be able to grow, ie, *Elliottia racemosa*. I don't know whether I should try that under open mist in the summer or under mist in the greenhouse in the fall or under polyethylene?

MODERATOR SNYDER: What is the plant?

DR. NESBIT: *Elliottia racemosa*. Mr Beetle found it down in Georgia and we are one of the few sources, and Kew wants it now, and I can't send them.

MR FRED GALLE: Try taking root cuttings.

MR. WALTER PEFFER (Trafford, Pa.): My question is directed to Roger Coggeshall. Do I understand that on your *Taxus* this spring that you used Simazin after they were planted?

MR COGGESHALL: No, I mirespresented that. The only time we have Simazin for weed control is on established plants in the field after they have grown at least a year prior to the application. We have not attempted it at all on the young beds of *Taxus* cuttings.

MR. PEFFER: What is the rate of application and the length of control?

MR COGGESHALL: The rate of application I believe was two pounds to the acre and the length of control, as I mentioned, one application in May was sufficient for that summer.

MR. MARTIN VAN HOF: I would like to ask Roger, if he is going to change from inside propagation of lilacs to outside?

MR COGGESHALL: That is right.

MR. VAN HOF. Is that going to be in the soil?

MR. COGGESHALL: In the soil, that is correct. In addition to the soil we will add sand to make it lighter.

MR. JIM WELLS: I would like to ask Roger Coggeshall if he has used sawdust as a mulch for rhododendrons, and if so, with what results.

MR. COGGESHALL: Yes, Jim, we have. On the newly bedded out ones that sawdust had not been applied. On the one or two year old plants, as soon as they are bedded out we apply the sawdust. That stays on for the life of the plant in the bed, a period of two years.

MR. WELLS: Do you find any greater incidence of *Phytophthora* in the beds with it?

MR COGGESHALL: No, we don't, or at least not to my knowledge.

MR. WELLS: What kind of sawdust do you use?

MR. COGGESHALL: We use any kind we can get.

MR. WELLS: How thick?

MR. COGGESHALL. Perhaps an inch or inch and a half; two inches at the very most.

MR. WELLS. I just want to make a comment before I leave the microphone about this cost accounting. I think there is a confusion between cost accounting and time study. If you set up a cost accounting system it is usually very simple to extract from that a time and motion study of how much direct labor you are expending to produce a given number of cuttings or to do any clearcut operation. Over a five-year period at Koster Nursery we proved very clearly that the direct labor cost which you could allocate any day to any given operation could be multiplied by four in order to weigh it with all other costs, ie, indirect labor, overhead, and anything else that keeps the doors of the nursery open. That formula worked consistently, and the cost was so clearcut that is what we used

We then dropped back to a time study and multiplied by four to achieve a known cost. It is very simple.

The second thing that came out of those cost accounting figures was that by far the most serious question in any nursery is the plants we try to grow and do not. Every time that we took inventory and there was a loss, we showed this loss in dollars, in red. When you see how much money you have spent for plants that aren't there you really sit up and take notice.

MODERATOR SNYDER: That is a point Jack Hill emphasized a couple of years ago.

We will have time for one quick question and answer.

MR. HOOGENDOORN: I would like to address my question to Henry Weller. Do I understand you to say you don't use any hormones of any kind under your mist?

MR. WELLER: Under the mist we do not use any hormones.

MR. HOOGENDOORN: You said it didn't make any difference whether you used hormones or not. We have a mist system and we use hormones. Why do I get a difference in certain items. Sometimes using a No. 3 will give better rooting and sometimes a No. 2 will be the best.

MR. WELLER. As I mentioned previously, we do not use any hormones under mist, and I attribute this mostly to the problem of excessive leaching The amount of water that passes through evidently subdues any beneficial aid from rooting powders. I have not seen any significant difference.

MODERATOR SNYDER. Case, it may be the condition of the cutting in the bottom two inches. The hormones may be effective with the harder cuttings and not the softer.

I would like to take this opportunity to thank the panel members for their participation. I think that if you were confused when you came into the room you are probably equally confused now.

We could say there are many ways to propagate plants and probably one thing which is very elementary but we sometimes lose sight of is that if we change one procedure or part of one procedure we are going to have to watch all other operations. We can't go from the greenhouse to the mist to the cold frame and expect to water the same, to take the same type of wood and carry on all other procedures as we have formerly done.

I will now turn the meeting back to President Roy Nordine.

PRESIDENT NORDINE. Just a couple of brief announcements, and one is that both the Executive Committee and Membership Committee will meet for lunch during the lunch hour.

All those who will be speakers or who will be appearing on the program this afternoon are to meet immediately in this corner.

The meeting is dismissed until this afternoon, which will begin promptly at 1:30.

The session recessed at 12:00 noon.

SATURDAY AFTERNOON SESSION

December 12, 1959

The final session convened at 1:35 o'clock, President Nordine calling the meeting to order.

PRESIDENT NORDINE: This Saturday afternoon program has become a tradition with this Society. The papers given by our members are very short. There will be time at the end of the session to answer some of the questions.

Our Moderator this afternoon will be Jack Blauw.

MODERATOR BLAUW: Ladies and gentlemen. Because we have very little time this afternoon and because we have a great number of speakers, I will now present Mr. Walter Grampp to speak on "Propagation Records."

Mr. Grampp presented his paper on the essential aspects of keeping accurate propagation records. (Applause)

PROPAGATION RECORDS SYSTEMS

W. F. Grampp
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Red Bank, New Jersey

Some time ago there appeared in the American Nurseryman a list of comic definitions, in which a propagator was described as "the fellow who runs through the greenhouses pulling out the dead cuttings before the boss comes around. In the event the boss is the propagator then he does the same before his friends come around."

Now later in the season, at a winter meeting in Cleveland or Philadelphia perhaps, when this fellow is questioned on the results of a particular strike, he will calmly reply, "Oh, 85-90 per cent." What he really means, of course, is that he stuck 12 or 13 hundred, guessed it was a 1000, rooted 700 and figures he was doing pretty well. I am sure that any of you in this audience, who have had the experience of keeping an accurate record for one season, of an operation that was deemed highly successful in years past, can testify to the shock that is in store for the grower who has been guessing at his very comfortable percentages.

I feel that the main reason more records, particularly propagator records, are not kept by nurserymen, both large and small, is that many people think that to keep these records is too time consuming and really not worth the effort. This type of thinking could not be further from the truth.

A *good* system of propagation records entails three considerations, simplicity first and foremost; continuity and accuracy. I put simplicity first because I feel that it is the essence of a *good* system. A great many people who endeavor to keep propagation records start out all fired with enthusiasm and lay out an elaborate scheme only to find that they have created a rod for their own back They quickly give it up for it is too troublesome and more important, too time consuming. This is probably the greatest pitfall in the whole concept of keeping propagation records.

The second consideration in keeping good records is continuity. To keep a really comprehensive record all elements of the propagating process must be recorded. Anytime the particular crop is worked on, an entry should be made; such as a spraying or drenching, etc. To simply enter the number stuck and then the number rooted is not enough. Entries made along the way will tell the story of the final figure, be it good or bad. If the strike is a good one, then conditions can be duplicated next time. If it is a poor one then the reasons why should show up in the entries made during the propagation process. In order for the necesary entries to be made, the records must be readily available, which means they must be kept as close to the bench as possible. We keep ours right in the shed.

The last consideration is accuracy. All is for naught if the figures are not true Anyone who goes to the trouble of keeping records and then makes mistakes or forgets an entry is simply wasting his valuable time and would be better off to make a few extra cuttings. We have found that the greatest source of errors comes from neglecting to record an entry, or arrive at a final total when the particular operation is over and past. This is most easily corrected by making one person responsible for the records and having him make all entries. With this scheme there is no doubt as to who is to make a particular entry

I am sure that there can be as many good systems as there are individuals in this room. Everyone should decide for themselves what type of record will best fulfill this particular need. I am going to explain our system in detail; not that any one should emulate our methods, but simply as an example of a propagation record system.

Our system, like all things created by man; had very humble beginnings, but none the less was a start

The next year we made entries into an extension pad, which is now the basis of our system. Each group of plants to be propagated, whether by cuttings, grafting or seed, is assigned a number which stays with the group throughout the propagation process. If the same group is going to be treated in two or more different ways, i.e., with different hormones or in different mediums, then a dash number is added. This number, along with the varietal name, the date, the number propagated and the treatment is entered into the extension pad. The same information is also written on a 12 inch white plastic label.

This label stays with the group until they are either sold or set out into the field All comments, notations, etc. are put into this extension pad during the propagation process One of the things we have found is that we did not allow enough space for remarks and were writing all over the pad, which leads to confusion About two entries per page of this size is maximum. At the end of the season we go through these pads, add up the totals, figure the final percentages, analyze any tests made and generally finalize the day to day comments. All this information is then condensed and entered into a master record book.

Each plant we propagated has a page and a year to year account of our results with it. We try to keep the entry to a maximum of one sentence since the extension pads are kept and we can always refer back if the need arises. These books are preserved a little more carefully than the shed books, for here is the essence of all our findings. The extension pads are simply bolted together along with an index and kept handy.

This then is our propagation record system We think that it meets the requirements, or being simple, continuous, and reasonably accurate. It has worked well for us in the past and is presently working well. I hope that it may serve to help some of you to start and maintain your own propagation record system.

MODERATOR BLAUW: Thank you.

The next speaker on the program was to be Dr. Waxman. He has asked me to delay his talk and our speaker will be Vincent K. Bailey of the J. V. Bailey Nursery, St. Paul Minnesota. Mr. Bailey.

MR. VINCENT K BAILEY: My subject is entitled, "Propagation of *Prunus cistena* and *Prunus triloba* and their Storage Overwinter."

We use a comparatively large greenwood cutting for this purpose. As you can see from our exhibit, the cutting is 10 to 15 inches long. We like this large cutting because we think that it stands up better in the operation of planting directly from the propagation bench to the field.

I might state here that we do not do any potting of rooted greenwood cuttings or for that matter of rooted conifer cuttings. We plant everything directly into the field.

Now the *Prunus* propagation wood is taken from a stool block of certified virus-free stock, a program which our state, along with many other states, is sponsoring. This certified stock, I presume, is a little better than the other stock. However, I am sure you could get similar results from uncertified stool blocks. The main thing is the condition of the material when you take the cutting. We like a medium green cutting, not too ripe. This is then prepared and put in an air-conditioned greenhouse.

Now I am rather partial to sunlight and contend that as much sunlight as possible should be used in the propagation of any greenwood or conifer cutting. I think sunlight is a source of all our energy and within certain limits it is beneficial in the propagation of cuttings.

We got by count in 1957, seventy-eight per cent rooted on the basis of roughly 9,000 cuttings while in 1958 we had a 75 per cent stand out of that planting. This year, I haven't had time to tabulate the results. Now this is far from the 100 per cent that we would like, of course, but we do think it is satisfactory and it pays over the other method of propagation of *Prunus,* that is by budding on *P. americana* understocks.

We feel rather proud that these cuttings are well-rooted. They are rooted up and down the stem for at least two inches. There are enough roots on them so that they will stand, as I said before, planting out directly in the field. They will go on and make salable plants in a minimum of time.

You might ask, why do we propagate *Prunus cistena* and *Prunus triloba* from greenwood cuttings? In the first place, we think it is a little better with the advent of canned or potted nursery stock. Those nurseries that are using this method for sales much prefer the own-root plant. I think the landscape men are coming to realize, too, that they are much more valuable because of the reduced trouble with various types of understocks that might be used. The customer isn't continually wondering what is coming up around his ornamental plants.

Now we store these cuttings in a polyethylene wrapping. We put about 200 per bale and roll them up. First, we take them out of the bench when they are rooted and mature which in our locality is around October 20 to 25. By this time they are well hardened and can be put in the refrigerated storage room where the temperature is kept between 32 to 34 degees F. Here, they are kept, wrapped up in this polyethylene without any packing or moisture until May, which is our season for planting out. Occasionally we do have adverse weather conditions, so we hold them until as late as the middle of May, when we find we get nearly as good a stand as by early planting.

The survival in the field is not 100 per cent. We are quite well satisfied, however, with the survival. I am sure we could get a greater survival if we would pot these plants, but the much reduced cost of handling under these conditions I think more than pays for the slightly reduced survival in field planting.

We are quite interested in costs While I do not keep records we think that this matter of going directly into the field has given us a tremendous saving in labor. We don't have to have a truckload of plants going out every hour or two to the planting machine. We can load enough in the pickup, to keep a reasonably good-sized planting crew busy planting the whole day. There we think we are saving a considerable amount just in our trucks.

This polyethylene we use is a low-cost product. In our case, we get it for carrying it away from the wholesale candy company that has it as waste material from their retail packaging operation.

In summary then, we believe that the light in the air-conditioned greenhouse is one of the main factors that is responsible for our moderate success in the rooting and planting of this plant material.

MODERATOR BLAUW: Next on the program is Leslie Hancock. I think we have heard about the Burlap Cloud Method and we would like to hear from Mr. Hancock again but he believes that he has already explained the essential details of this procedure.

We will next have a paper read by Dr Mahlstede.

DR. JOHN MAHLSTEDE: These two techniques are described or at least outlined in the demonstration exhibit displayed in this room. Some of you have had an opportunity to look at them. The papers have been prepared by Mr. Donald B. White, a graduate student in our department at Iowa State University.

Dr. Mahlstede read the paper, "Laminate Budding, A Technique for Budding Incompatible Woody Plants." (Applause)

"LAMINATE BUDDING", A TECHNIQUE FOR BUDDING INCOMPATIBLE WOODY PLANTS

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Incompatibility between stock and scion has been a basis for research in the field of plant propagation for centuries. The present techniques, for the most part, find their beginnings hundreds of years ago when ingenious plantsmen developed the double working method of propagation. John Parkinson (7) in 1629 wrote, "The green and yellow nectorin do best on plumme stocke" but that others should be worked on an "apricocke" that was previously worked on "plumme or they will die of starvation." In 1665 Austin (1) wrote, "Set graft upon graft for divers years together." Miller (5) in 1759 described double working pear and quince when the pear to be dwarfed was uncongenial with the quince.

More recently, Garner (3, 4) published a description of "Double-Shield Budding" in which a blind shield of the compatible variety is inserted into the stock so as to be an intermediate between the stock and the varietal bud. He states, "The resulting trees have developed stronger unions and grown more than single worked trees . . . Double-shield and single budded trees were sawn longitudinally through the union and this revealed that the intermediate budless shield had grown rapidly and had become the main link between the Williams' scion and the quince rootstock."

Nicolin (6) first described the "Nicolieren Bud" in 1953 This method utilizes a "T" incision in the stock, into which a varietal bud is inserted with a matching "nicolier" shield between it and the stock

In Europe, both of these methods have proven to be satisfactory for overcoming certain incompatibilities of plants propagated by grafting. However, in North America the application of these techniques has generally led to unsatisfactory stands in the field. Cummings (2) secured only a 55 per cent stand with Nicolieren budding at the Canada Experimental Farm, Morden, Manitoba, in a 1956 trial. From verbal and other communication with propagators in this country it has become apparent that results have not been satisfactory, very possibly because of the different climatic conditions found in a continental or inland climate.

Trials at Iowa State University also were rather disappointing Yet, it seems safe to assume that the trials of Garner and Nicolin have established the principle and practicability of the double shield type bud-

[1]Journal Paper No J-3781 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project No 1310

ding Indeed, the value of such a method is well recognized. Because the double shield type budding has proven so successful in Europe, studies were initiated to develop a comparable method that would consistently give stands equivalent to those realized by the ordinary single budding operation under North American conditions. This study resulted in the "laminate bud" technique for propagating incompatible woody plants by budding.

The "Laminate" method consists of two separate budding operations employing the normal "T" bud technique, spaced three or more weeks apart. The laminate bud depends upon the use of a manufactured bud stick which, to the author's knowledge, has never before been reported in a scientific publication.

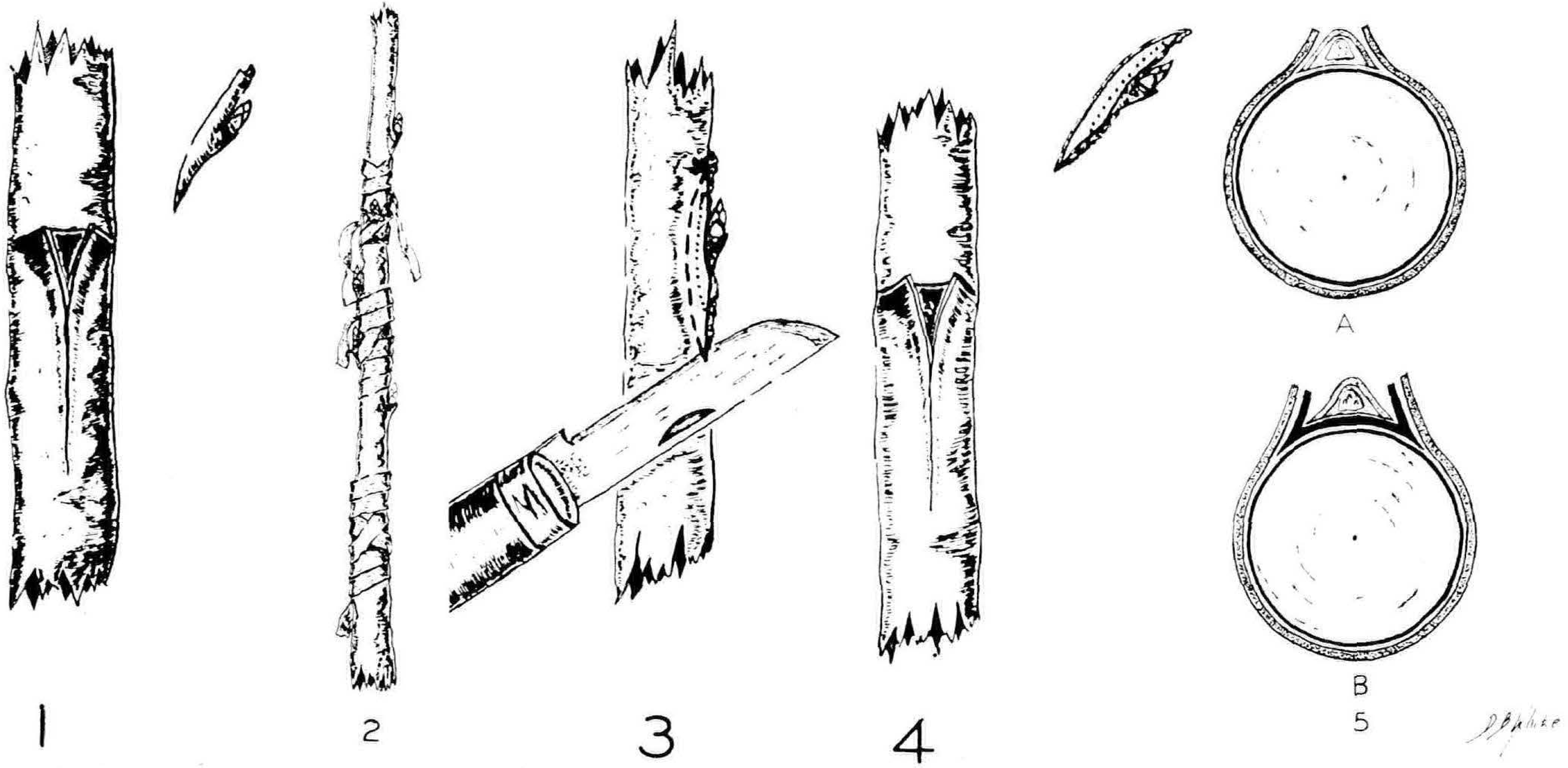
Buds of the desired variety are first budded onto compatible interstock scions at intervals of approximately three inches and staggered up and around the branch in spiral fashion. Care must be taken to ensure that only a moderate amount of bark (and wood, if desired) is taken with this bud. In effect. one makes a bud stick of the desired variety from a branch of the compatible intermediate stock. The "Speed-Easy" type bud tie greatly facilitates the preparation of the manufactured bud sticks. After the buds have united, a process which takes approximately three weeks, they are removed by slicing into the wood of the manufactured bud stick so that a small platelet of the intermediate stock is removed with the varietal bud. This unit, or "Laminate Bud," composed of a bud with a knitted shield on the back of it, is now handled in the same manner as any other bud would be in the "T" budding technique

Success of this method dictates that bud sticks be made as early as possible in the budding season, in order to allow sufficient time for the bud to knit to the compatible stock before the laminate bud is transferred to the rootstock The laminate bud is best transferred at the normal time set aside for the propagation of the variety in question.

The experiment for testing the laminate bud technique was started on July 22, 1959 On that date, Bartlett pear buds, as many as nine per stem, were inserted on Beurre De Anjou stock By mid-August these buds had knitted sufficiently for transfer. On September first, 65 laminate buds (Bartlett on De Anjou) were inserted on Malling Quince "A." Since Quince "A" is not reliably hardy at Ames, a bud-take count was made on 13 October and some buds were sacrificed to make sure that they were alive. Fifty seven or 87.7 per cent of the 65 laminate buds, had knitted to the stock and were alive.

The total time required to accomplish the two budding operations with the laminate bud is just twice the time required to place one single bud. If one considers the per cent take and the time required to make the necessary manipulations for either of the European methods, it appears that the laminate method is more economical.

This technique could be easily scheduled into the present system of budding used by most nurseries. Since the European experiments offer experimental proof of the basic principle, the laminate bud techni-



1. Single bud inserted on stock; 2. Portion of a manufactured bud stick; 3. Cutting Laminate bud + Platelet of interstock; 4. Laminate bud inserted on rootstock; 5 A, Cross section of stem with single bud; 5 B, Cross section of stem with Laminate bud.

que may be considered sufficiently developed for trial by nurserymen who might benefit by its use Furthermore, there is no reason why laminate budding should be restricted to fruits, since the principles should apply to all woody plants that are propagated by budding.

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ACKNOWLEDGEMENT

Seven Dwarfs Nursery, Medford, Oregon, for furnishing certain of the quince stock used in the experiment.

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(*Editor's Note*: Time did not permit the presentation of the second paper. However, it is included at this point as a matter of record.)

"TENANT GRAFTING", A QUICK METHOD OF PROPAGATING INTERSTEM TREES

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One of the major obstacles in producing interstem dwarf trees is the prolonged time interval between propagation and salable size. The present methods encompass a minimum of two growing seasons.

The techniques used today are essentially the same as the one described in 1665 by John Rea (1). He wrote "I have found out another expedient to help them (dwarf trees) forward, that is, by grafting the cyen of the Paradise Apple in a crab, or other apple stock, close to the ground, with one graft, and when that is grown to the bigness of a finger, graft thereon, about eight inches higher, the fruit desired . . . and will cause the trees to bear sooner, more and better fruit."

[1]Journal Paper No J-3778 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa Project No 1310

que may be considered sufficiently developed for trial by nurserymen who might benefit by its use Furthermore, there is no reason why laminate budding should be restricted to fruits, since the principles should apply to all woody plants that are propagated by budding.

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ACKNOWLEDGEMENT

Seven Dwarfs Nursery, Medford, Oregon, for furnishing certain of the quince stock used in the experiment.

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(*Editor's Note*: Time did not permit the presentation of the second paper. However, it is included at this point as a matter of record.)

"TENANT GRAFTING", A QUICK METHOD OF PROPAGATING INTERSTEM TREES

DONALD B. WHITE

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One of the major obstacles in producing interstem dwarf trees is the prolonged time interval between propagation and salable size. The present methods encompass a minimum of two growing seasons.

The techniques used today are essentially the same as the one described in 1665 by John Rea (1). He wrote "I have found out another expedient to help them (dwarf trees) forward, that is, by grafting the cyen of the Paradise Apple in a crab, or other apple stock, close to the ground, with one graft, and when that is grown to the bigness of a finger, graft thereon, about eight inches higher, the fruit desired . . . and will cause the trees to bear sooner, more and better fruit."

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[1]Journal Paper No J-3778 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa Project No 1310

Some of the schedules and methods in use today are as follows:

Method

Schedule A.

Winter 1959	bench graft interstem to root
Summer 1959	bud variety to interstem (1 growing season)
Summer 1960	varietal bud grows (1 growing season)
	Growing seasons required to produce a one year whip ---- ---- ---- ---- ---- ---- 2

Method

Schedule B.

Spring 1959	plant rootstock
Summer 1959	bud interstem to rootstock (1 growing season)
Winter 59-60	cut back rootstock
Summer 1960	interstem bud grows — bud variety to interstem (1 growing season)
Winter 1961	cut back interstem to variety
Summer 1961	varietal bud grows (1 growing season)

Growing seasons required to produce a one year whip ---- --- --- ---- ---- ---- 3

Method

Schedule C.

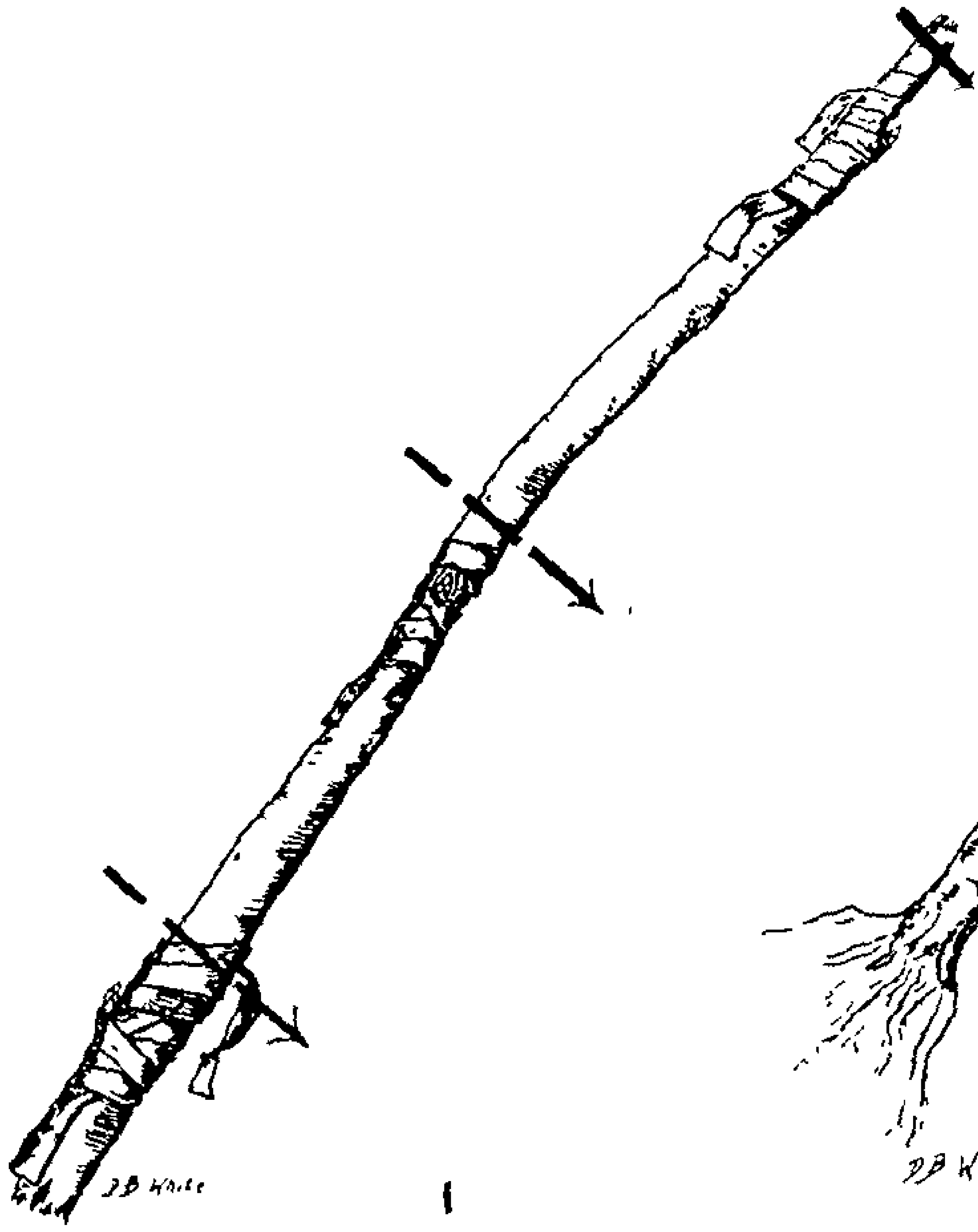
Winter 59-60	bench graft the variety to the interstem and the rootstock simultaneously in the winter and plant the double graft in the spring.

Growing seasons required to produce a one year whip ---- --- --- ---- ---- ---- 1

The shortest time lapse, as well as the highest percentage of failure are realized by employing the latter method (Schedule C).

Considerable saving in time, money, and overhead would be realized if one growing season could be eliminated from the schedules commonly employed, provided stands were not reduced. With this in mind, an experiment was conducted at Iowa State University to ascertain the practicability of producing interstem dwarfs by a method we term the "tenant graft." The "tenant graft" is so named because the interstem piece to be grafted on the rootstock has a varietal bud already healed in place as a "tenant," so to speak, at the time of grafting.

The process utilizes a manufactured bud stick, (2) which is made by inserting buds of the variety up and around the limbs of the interstem stock in a spiral, at intervals of approximately seven inches. These



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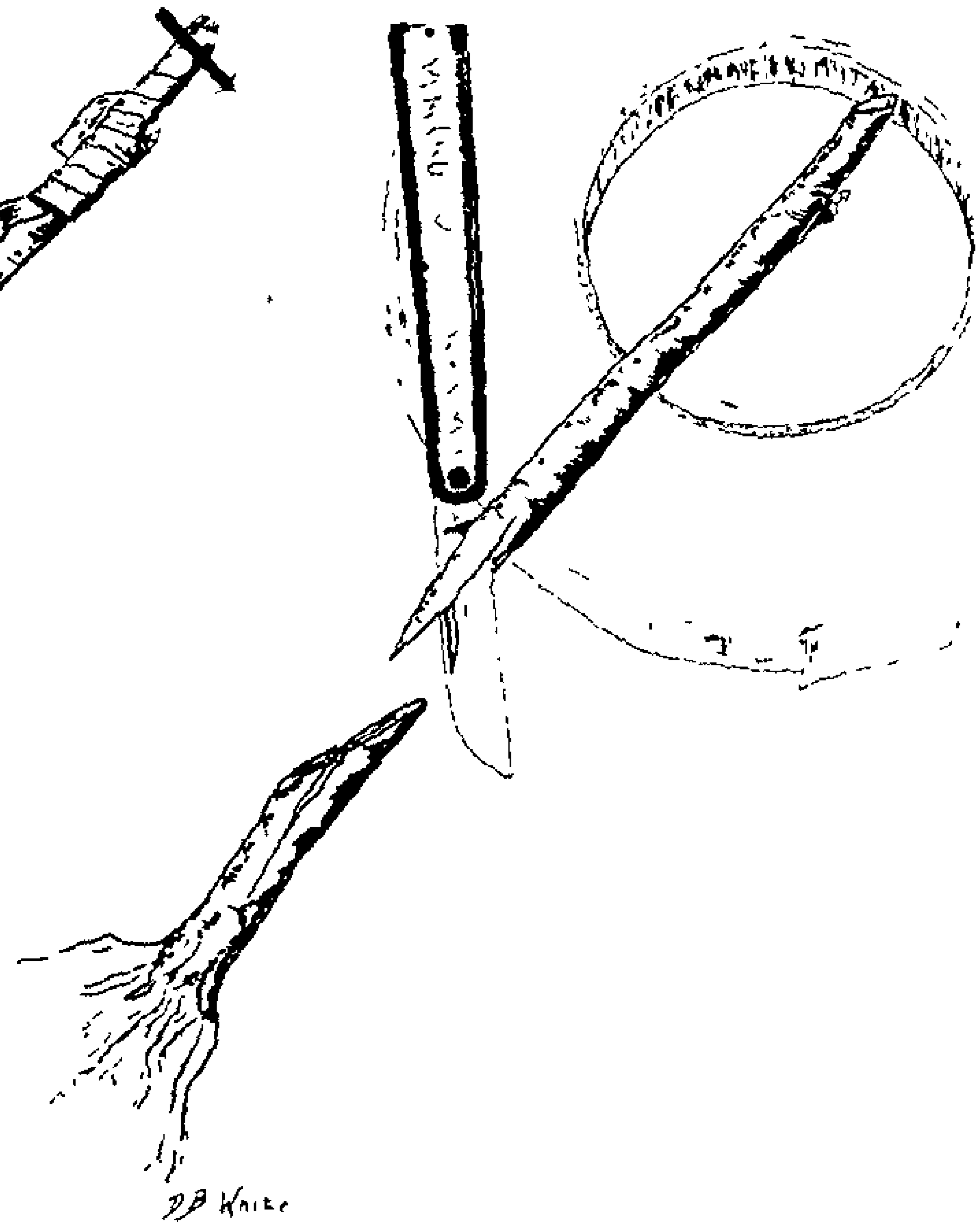

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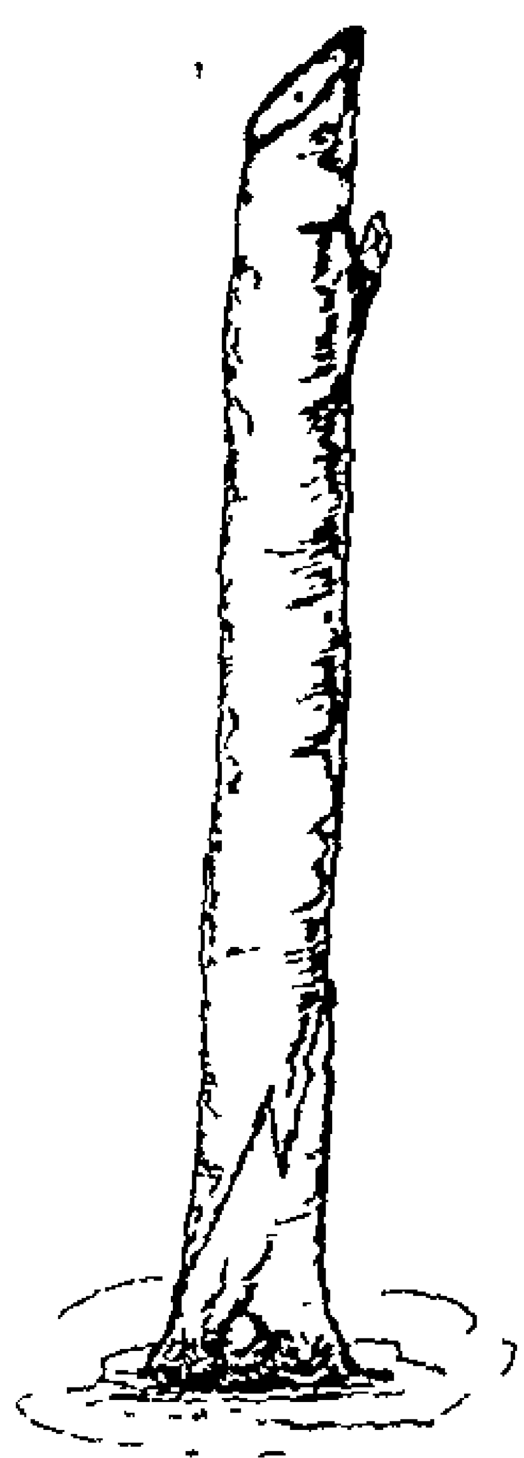

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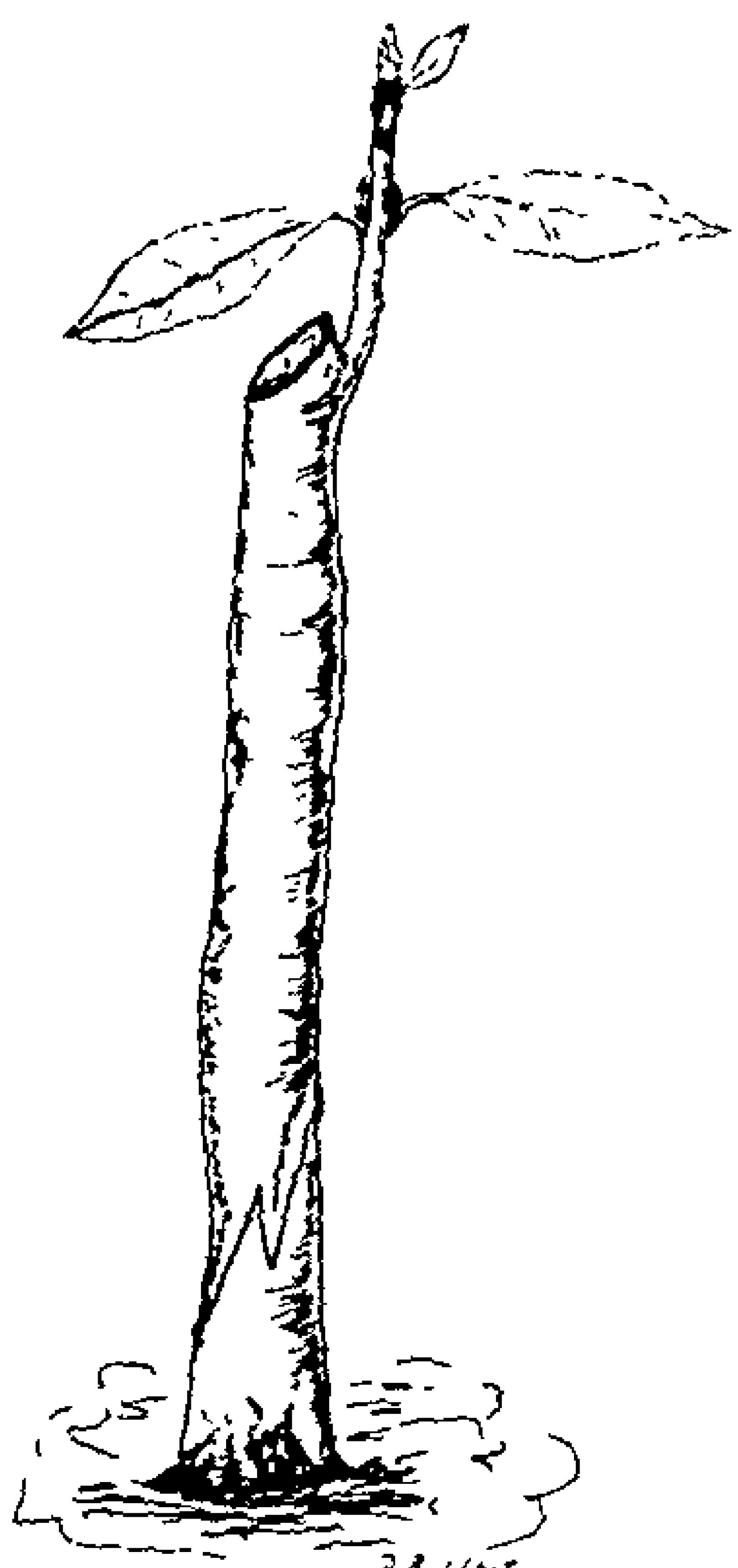

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1. **Manufactured bud stick (Variety on stock).**
2. **Whip and Tongue Tenant graft.**
3. **Tenant graft after planting.**
4. **Tenant graft after bud break.**

buds are best held in place by a "Speed Easy" type bud tie. Thus each branch of the interstem stock, growing in a scion orchard, is made into a bud stick of the desired variety.

The following winter, these manufactured bud sticks are cut into sections, each section having one bud of the variety about one inch below the apex of the section and approximately six inches of the interstem below the bud. These "tenant" scions are then bench grafted onto hardy rootstocks, callused and held in storage for spring planting.

A sample schedule is as follows:

Summer, 1959	place variety buds on branches of interstem stock in the stool block (scion orchard)
Winter, 1959	tenant graft (scion with bud tenant) to rootstock
Spring, 1960	plant grafts
Summer, 1960	variety buds grow (this is the first growing season in the field)
Fall, 1960	dig one year whips

Growing seasons required to produce a one year whip ---- ---- ---- ---- ---- ---- ---- 1

This procedure requires that a scion block of the interstem stock be maintained in a manner which ensures the production of vigorous growth onto which the buds may be placed every year. Both the space and field requirements will be much less than needed for the present methods of propagation. The "tenant" method also takes one less growing season in the field for the production of one year whips or two year cut backs.

Table 1. Influence of tenant grafting on field survival of apple trees

Number of tenant scions	%take	Final field survival % (buds and grafts)
52	90 4	80 8*

* Average height at end of one growing season was 16½ inches

The use of this method need not be restricted to the propagation of apples, for it should do well wherever interstem grafts are employed, whether to dwarf a plant or overcome an incompatibility between stock and scion.

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ACKNOWLEDGEMENT

Interstate Nurseries, Hamburg, Iowa. For furnishing the material for this experiment.

* * * * *

MODERATOR BLAUW: We next have Mr. Nordine who will discuss the budding of hawthorns.

PRESIDENT ROY M NORDINE: I happen to be one of those individuals who came to the convention with certain ideas and certain techniques and found out I wasn't quite one hundred per cent right.

I will read what I have written and then I will comment.

President Nordine read his paper on "Budding Hawthorns." (Applause)

BUDDING HAWTHORNS

Roy M. Nordine
Morton Arboretum
Lisle, Illinois

The questionnaire inviting this topic asked for the "Propagation of Hawthorns." Because of the slow growth resulting from any method of grafting and the failures of cuttings we have selected the only profitable method.

Crataegus phaenopyrum, previously called *C. cordata* or Washington Hawthorn is used for the understock. This species provides a good root system, it transplants easily, and the bark peels well over a long period of time. Seedlings are easily raised from fresh, clean fall sown seeds that have not been allowed to dry too much. Dry seeds may become dormant and require stratification for a year

Seedlings can be lined out in the early spring and budded during August or the first half of September. Hawthorns vary a great deal in the size and shape of the buds making peeled buds difficult to fit and tie. Therefore, all buds are cut out with a sliver of wood attached to the bud, some refer to this as a wood bud. Buds are tied with a rubber band and waxed with paraffin and covered with soil. In the following early spring the understock is cut off about six inches above the bud. This stub is used to provide the growing bud with its only tie during its growth. This stub can be cut off during the fall or winter.

Several native and exotic species and numerous varieties have been budded and all produce excellent results I can't recall a case of incompatability.

During the first year whips of three to four feet or more are average growth. In the second year whips and branched plants of four to six feet are produced

I wish to quote from a letter from Wayne McGill of A. McGill and Son, Fairview, Oregon.

"We note your inquiry regarding the understock used for propagation of Paul's Scarlet Thorn and are glad to advise you that we have always used the *Crataegus oxycantha* and find it very satisfactory, as of course, Paul's Scarlet Thorn is a variety of *C oxycantha*. However, one year we were unable to secure all the *Crataegus oxycantha* that we desired and substituted *Crataegus cordata* and the trees are being dug this year as two year olds. We might say that our experience was quite

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However, we have found that *Crataegus cordata* is much better for an understock for the propagation of the *C. cordata* itself as we bud ours to a selected form."

* * * * *

MODERATOR BLAUW: The next speaker on our program will be Dr. Sidney Waxman who will speak on intermittent light as it affects growth of seedlings and cuttings. (Applause)

DR SIDNEY WAXMAN (Storrs, Conn): I have two parts to cover and I will try to cover them each in five minutes.

The first device I would like to discuss is a mist control that operates according to the intensity of sunlight. In misting cuttings we all know we need a greater frequency of mist when the sun is bright. As the days get cloudier, the need for mist decreases

This mist control has inside it a photocell that is activated by the intensity of the sunlight. The idea behind this unit was suggested by Dr. Hans Peterson of Denmark while he was a visiting professor at Cornell. I wanted a unit I could depend on in Connecticut and I had the Agricultural Engineering Department working on it They improved it. They made it more adaptable for the propagation of woody plant cuttings. The feature they added to this is that you can adjust its sensitivity to light. In other words, if you have cuttings that you don't want to get too wet, just turn the sensitivity light dial down and it will be less sensitive to light and there will be less misting. Conversely, if you have a plant that tends to dry out quickly, you can turn it up and get more frequent misting.

On cloudy days the light will be down so low you may not get any mist at all This is good for some plants. However, for other plants that have a thin epidermis or cuticle you may want to keep the mist on. Therefore, we turn another dial and this changes the slope of the curve so you get a little mist, ie, just enough to keep them wet.

There is another feature. It needs no 24-hour clock to control it. As night comes the frequency of misting will get longer and longer and will eventually turn off once it gets completely dark. You may perhaps want to mist during the night. In that case, there is another switch and it will operate on a timer and you will get a slow misting all night long. You must remember this is adaptable for use within the greenhouse. It is possible that it can be arranged to work outdoors, but I won't go into that now.

I will go on to the next paper. On the table you may have noticed a box with a clicking light. The light goes on for one second and will remain off for five seconds. To review briefly, you will remember that in a paper presented several years ago, we showed that you can make a plant grow continually by giving it long days. That is giving it light during the night or stop it from growing by giving it short days.

If you take a flowering dogwood and give it 10 hours of light each day, it will just stop.. If you give it 14, 16 or more hours of light, it will tend to keep on growing. More recently, York has shown that this response occurs only when the temperatures are above 65° F. If you live in an area where the night temperatures get below 60° F., your response is very small, and it wouldn't really pay.

What, then, is the value of giving these plants light during the night? Well, we have learned that photoperiodic treatment can keep *a plant from growing, and it can also break dormancy.* The plant however, must have leaves. Whenever I refer to this effect on plants I am referring to plants that respond to daylength. There are many plants that do not respond to this phenomenon.

In earlier experiments we have found that we can obtain more roots per cutting when they are given long photoperiods instead of short photoperiods.

(*Editor's note*: Dr Waxman continued his discussion from colored slides. Some of the comments are herewith recorded.)

You really don't need to have a long photoperiod to get increased or better rooting. You can let the normal day stay a little longer by lighting at the end of the day. It really doesn't pay to light up cuttings just for the sake of getting more rootings. However, for those plants that tend to drop their leaves and even those which root first and then drop their leaves the effect of light may come in handy. A plant like this uses up its food in the manufacture of roots which cannot be replaced because it loses its leaves. It will be weak. By putting on additional leaves the plant will be invigorated and will rebuild itself which will allow it to withstand the winter better.

There is one other feature When you take a leaf bud cutting, the bud is very slow to grow. We gave this particular batch long days and when we have the long days the bud breaks out very soon ie, within three months after the start of lighting.

Now in lighting plants during the night there is quite a bit of cost involved, if you were to do this on a large scale What we tried to do was see if we could eliminate or reduce the cost. It wasn't the amount of light that was giving us our response but rather it was the amount of continuous darkness during the night. What we did was to break up the night into very narrow parts. We gave the plants light for one second out of each minute during the entire night. With *Cornus florida* on an eight hour day the plants stopped growth in 20 days. In the next treatment they were given 16 minutes of light during the night beginning at 12.00 midnight, or in other words the night was broken up into two parts. They grew taller, but even that stopped. Where they were given 16 hours they received continuous light and at night received continuous artificial light Under this treatment the growth is at a fairly rapid pace. Where the plants received only one second of light out of every one minute and in treatments where the plants received 16 hours of light, the growth curves are nearly identical. Actually, we have run it one second every two, three and four minutes, and it works almost as well up to three minutes. When it gets to four growth slows down. Thank you.

MODERATOR BLAUW: We will now have Hugh Steavenson who will talk on, "Tree and Shrub Seedlings Produced under the Mulch System." (Applause)

MR. HUGH STEAVENSON. Just a few notes on our seedlings produced at Forrest Keeling Nursery at Elsberry, Missouri.

(*Editor's note*: Mr. Steavenson used a series of colored slides to describe the system he uses at the Forrest Keeling Nursery to produce tree and shrub seedlings. His comments follow.)

Here you see our seed-cleaning operation Virtually everything that we collect or harvest themselves, is put through an old hammermill which we have been using for many years This is usually a high capacity operation for cleaning seeds in some quantity although it can also be used very well for small batches of seeds. The seed does not go through the screen at the base of the unit since it should be slightly smaller than the seed. The pulp is mashed and a heavy stream of water carries away the effluent leaving the clean seed which is then dropped into a wire-bound basket.

After cleaning, the seed may be ready for sowing. If we want to put the seed through a seed drill, of course, we have to dry it and put it through a fanning mill to clean it up. If it is going to be broadcast by hand or stratified right away, it doesn't need to be cleaned any further.

In the event that a seed has a hard seed coat and a dormant embryo, it must be scarified at this time. All our scarification is done in a sulphuric acid bath.

I might say in connection with seed that it is much better where you can harvest your own seed. However, this isn't always possible with all the various items that you may want to grow from seed. We grow or try to grow around a couple hundred different species of tree and shrub species, and of course many have to come from more distant places. We secure seed from a number of collectors throughout the various states and, of course, also foreign countries such as Italy, Germany, Austria, Japan, and elsewhere. Usually when you have a good domestic collector lined up, this works quite well. You get your seed about the time you should get it It is usually fresh seed and ready for the handling you want to give it. Of course, the difficulty with foreign importations is that so many times you will get the seed after the time when it is necessary to start the after-ripening process and as a consequence you may have to carry it over as a two-year item. We have many seedbeds that do carry over, which normally if we could harvest the seed ourselves would germinate the first year

We do treat our seed with a fungicide when we are going to stratify it, or in some cases where we seed it immediately.

Our seed beds are all made with a Lachmount seedbed former which is made in Massachusetts. They are all six foot on center or four foot beds. Regardless of what we do in the field, whether transplanting or field lining, everything, as I mentioned the other day, goes into beds of this dimension so that they fit all our various pieces of equipment that we use.

We treat our bed areas with allyl alcohol which is relatively inexpensive and easy to apply through the irrigation system. It is a pretty good herbicide. It is used in a fairly heavy dosage and at the same time it isn't too expensive It is considerably less expensive than the various proprietary items, such as Vapam, Mylone and methyl bromide, and is also much easier to apply. It is not as effective as methyl bromide. I wish we had something as effective as methyl bromide and still relatively easy and economical to apply. We need something that will take the place of allyl alcohol since it is hazardous to use and should be used with a great deal of caution.

I might say that we never have to touch up our beds by hand once they have been formed. When we finish with the Lachmount spreader and the Brillion Culti-packer, they are ready to go

Our soil preparation is the usual preparation going through a sod crop, if possible, and the development of the optimum degree of soil fertility Once we do get into seedling production we add so much organic matter in the form of sawdust that we think we maintain a fairly good humus content and so we are not reluctant to go back and seed after one crop of seedlings. I might say further in regard to soil, this happens to be in the Mississippi River bottom which has glacial aeolian deposits, called loess, where the hill soil is eroded and runs down to the bottom. It is a light, friable soil.

I don't think it makes any difference in production what kind of soil you have so long as it has characteristics of good internal and external drainage. It can be a loam or sandy loam or a silt loam; as long as it has the right physical characteristics you can certainly get along with it.

Somebody asked about sawdust in the beds. We use it in very large quantities, ie, a few hundred truckloads a year. We have used it for many, many years on the same ground We think we get a constant improvement in the physical properties of our soil Of course, it takes a good deal of nitrogen, about two pounds of actual nitrogen per hundred pounds of dry sawdust. We haven't observed any pathogenic situation arising from the use of sawdust. As Shadow Hoskins mentioned the other day, it is necessary to have a friable condition for the seed to emerge through. This could be had through the use of sawdust, or ground corncobs, although it doesn't make too much difference what you use as long as it is readily available and not too expensive.

We use a portable irrigation system which pumps out of our ponds We would prefer to have a permanent type Skinner overhead system. There are times when we would like to get water on faster than we can by moving our pipes around. With this mulch system we can get by pretty well without the need of applying water daily or anything like that, because the mulch does hold the moisture during germination and during the after-ripening period so that the constant application of water to keep the seed in a moist condition and prevent the germinating seedlings from drying is not essential.

I might say in regard to herbicides, I think we have tried everything in the book for possible pre-emergence weed control in seedlings. Aside from the Stoddard Solvent for conifers, we don't know of anything that is applicable with seedlings. In other words, the newer chemicals, such as Simazin and Chloro-IPC are not applicable to seedling production, although we certainly use them extensively for our transplant areas We do use them, too, in our paths. However, the necessary thing with seedling production is to get the bed areas free of weeds before the seed is sown.

In our harvesting operation we have used various types of diggers over the years. Last year we secured a Plumfield digger, developed by the Plumfield Nursery, Fremont, Nebraska, which is mounted on my high clearance 560 International tractor. This tractor is of the type that is used in the rice and sugar cane fields in the South and it has a pan, that gives us almost my clearance It is inter-changeable with a U-shaped blade for digging. One thing we need is a shaker on this thing for a more rapid pull. These diggers can go any depth we want although usually we don't want to go more than 10 to 12 inches for seedlings.

After pulling the seedlings are taken to the packing shed We have a nice cave that some of you people have seen, an old quarry, where we grade and store these seedlings. Many items are spring dug except those for fall shipment We try to store as close to the freezing point as possible, keeping the roots in a moist medium. In recent years we have been trying storing seedlings in polyethylene bags. This seems to work just fine. We are going into this more and more.

We cannot grow cedar a second year because of blight. We have tried all the usual fungicides and I believe, because the fungus attacks the growing tip, it is virtually impossible to keep a protective coat on the plant. We have tried sanitation, ie, growing them completely away from where any cedars have been grown before. We can get by very nicely the first year. The second year they get woody and I don't think the understock is worth a darn It is a case of getting them up there the first year. If we don't do that, we might as well forget about them Thank you very much.

MODERATOR BLAUW. We will not have a talk on the "Propagation of Woody Ornamentals Under Mist in Peatmoss Pots," by J. Peter Vermeulen. (Applause)

MR. PETER VERMEULEN (Neshanic Station, N.J.): As commercial propagators we are continually thinking, of course, in addition to quality about costs. One of the primary costs in the nursery business is the overwintering of stock

This idea of rooting plants directly in the growing medium, contained in the selling container is not new, I am sure. Perhaps this particular phase of it is new, and we thought it would be both interesting to you and perhaps profitable.

We have thought about rooting directly in the soil in the selling container for sometime, but there have always been disadvantages imposed on us. Because of recent developments that have taken place in the field of propagation in the last several years we think now that this type of culture can be applied on a commercial and wholesale basis.

One of the problems, of course, has been the rooting or the growiteing medium. Heretofore we didn't have the aerators such as vermiculite, perlite, or styrofoam. The plain soil that we could use in New Jersey, being our red New Jersey clay, is not conducive to rooting, but rather to rotting.

We also had the time factor in propagation, which with the hormones and chemicals we have now, have cut the rooting process down considerably in the length of time it takes.

We know that we can stick a given number of cuttings in every square foot of a propagating bench If we are going to use this same space for pots and insert cuttings into these pots we are going to cut down very markedly the number of cuttings we can get in a given area of our propagating house.

As I mentioned before, these three most serious disadvantages now have more or less disappeared. We can make a growing medium using soil which is fitted to this type of culture We use a medium composed of one part soil and one part peat to which is added 20 per cent by bulk of finely shredded styrofoam We chose styrofoam in preference to some of the other aerators because it is completely inert and very light. It does not hold moisture, therefore, does not give us an added moisture headache. Also, by not absorbing moisture, it gives better soil aeration as well as a very light, growing medium which we can use very effectively.

In 1958 we thought that we would go ahead and try to propagate directly in the medium in selling containers. We did this on a very small scale, perhaps 200 or 300 cuttings. Most of these were inserted into clay pots, only a few were put in peat pots. We were still feeling our way with the peat moss pot at that time. The results were very encouraging.

I might say it was all done under mist in a greenhouse rather than in an open bed This method, I am sure, can be applied to open mist bed propagation also. I might say here that our mist system is not one of the commercial types that can be purchased or whose integral parts can be purchased and put together yourself. It is one of our own making We have always thought that the mist systems as presented to us by commercial concerns gave us more water than we wanted. This idea did not originate with us, but we are using the oil burner nozzles under extremely high pressure with a pressure regulator at the end of the line. The oil burner nozzle is one and a half gallons per minute and the pressure we use is 125 pounds This pressure we get with an inexpensive bronze gear pump that can be purchased for approximately $18 or $20. It has a lasting life of approximately one year, at which time it can be traded in for another pump, we get $6 for the old one. The pressure costs us practically nothing The oil burner nozzles are spaced on a three-quarter inch overhead line We place our pipe over the tap, because there is drip from an overhead nozzle We also placed the pipe over the path and directed the nozzles so they will disperse the fog over the growing bench. We chose the oil burner nozzles at one and a half gallons per minute because this gave us the best fog. We would rather call it fog than mist, because of the pressure that we have. For instance, in one house 130 feet long we have 40 nozzles Our mist interval is one minute on, two minutes off. For one minute application of mist with 40 nozzles we can get a very fine fog in that house with one-half gallon of water, which is highly desirable. That gives you a little background of the physical house that we are doing this work in.

As I mentioned, in 1958 we started on a small scale. We chose to start with *Franklinia alatamaha,* the Japanese maple variety *Acer palmatum oshio-beni*, *Cornus kousa chinensis, Viburnum fragrans*, *Viburnum tomentosum*, and *Prunus beni-higan*

I might add that the reason we chose these was because of the sometimes difficult nature of transplanting these plants once they were rooted. This was another thought behind this method, so that we could reduce losses in the initial transplanting from the cutting bench.

Our results were, as I said before, very encouraging. We got in the neighborhood of 60 to 100 rootings within 16 days on some items and three to four weeks on the rest depending on the variety. *Franklinia alatamaha* was practically 100 per cent. *Cornus kousa chinensis* gave 100 per cent. *Acer palmatum oshio-beni* about 100 per cent, the two viburnums, *V. fragrans* and *V. tomentosum* 100 per cent, and *Prunus beni-higan* gave about 80 per cent rooting. At the same time we also did just a few plants in 2¼ inch, Jiffy peat moss pots and the results were about the same

With this background, this past summer we expanded our experiments to approximately 4,500 plants. This time we chose mostly the three-inch pot because it afforded us more growing medium. We also planted some in two and a quarter inch pots, thinking maybe that we would watch this growth to see whether we would get better growth in the three-inch as opposed to the two and a quarter inch pot

Our results this year were approximately the same. We added some genera, species and varieties. I will name them just briefly: *Viburnum tomentosum* and *fragrans* were tried again. We also added *Viburnum sieboldi, Viburnum carlesi, burkwoodi* and *juddi*. We chose also to try the magnolias and in this group we chose *Magnolia stellata* Royal Star, and also *Magnolia soulangeana* and *M. stellata* We also tried *Wistaria rosea* and an unknown crabapple. This latter happened to be a plant growing in the greenhouse. *Cornus florida rubra, Cornus kousa chinensis, Cornus florida plena, Cornus florida xanthocarpa. Cornus florida pendula, Viburnum tomentosum plicatum, Viburnum rhytidophylum,* and *Franklinia alatamaha* were also tried.

The plants were inserted between July 15 and August first. The medium was placed directly into the peat pot, firmed fairly well, and the pots were placed in a veneer tray. This is another cost-cutting method that we are using. We ship directly in these veneer trays in which our stock is grown. You can see how much we can save if we can place the pot in the tray, insert the cutting, root it, store it over winter or grow it in the greenhouse over winter, and ship in the spring. We will pick up a unit of 25 or 36 plants as opposed to picking up individually 25 or 36 plants and preparing them for packaging.

Our cuttings were all treated with either Hormodin No. 2 or in some cases Hormodin No 3. In some cases we have used Cutstart No. 7 Our results on the *Viburnum tomentosa* were excellent since 295 rooted out of 300 That is in the three-inch pot. In the two and a quarter inch pot 36 out of 36 rooted. Of the *Viburnum sieboldi*, 275 out of 300 in the three-inch and 35 out of 36 in the two and a quarter inch pots rooted For the *Viburnum fragrans,* 200 out of 225 in three-inch pots rooted. *Viburnum carlesi* rooted only 10 out of 36 in the two and a quarter inch container. The *Viburnum burkwoodi* was not much better with only nine out of 36 in the two and a quarter rooting We had a similar results in *Viburnum juddi* which rooted only 10 out of 36. All of these later died, which we think could be attributed to too much water.

Magnolia stellata Royal Star rooted 20 out of 25 and I might add here that we had much better roots in the manufactured growing medium than we had in the sand. For the *Magnolia soulangeana,* 20 out of 25 in the three-inch pots and 15 out of 25 using Hormodin No 2 rooted. *Magnolia stellata* gave 15 out of 25, with an inferior root size Cuttings of *Wistaria rosea rooted* 10 out of 15 while none of the crapapple struck. Only 25 out of 75 of the *Cornus florida rubra* rooted *Cornus kousa chinensis* only rooted 50 out of 324, as compared to 100 per cent in 1958. Keep in mind that in 1958 we inserted the *Cornus* cuttings in clay pots rather than in peat moss pots We believe that they got too much water. For example *Cornus florida plena* gave only 6 out of 36, *Cornus florida xanthocarpa,* none out of 36, and *Cornus florida pendula* also none out of 36.

Viburnum tomentosum plicatum rooted 400 out of 500, while *Viburnum rhytidophylum* gave 25 out of 25, which was more or less a surprise *Franklinia alatamaha* rooted 750 out of 775. We were so much encouraged with that, that a week later we stuck 1625 and got approximately 1590 cuttings of this same plant

Just as a matter of comparison, at the same time we stuck in sand, as we ordinarily do, 400 *Cornus kousa chinensis,* and rooted 350. Of the *Cornus florida xanthocarpa* cuttings we stuck 200 and rooted 200 *Cornus florida pendula* gave us 47 out of 50 stuck. *Cornus florida plena* rooted 178 out of 200

If we can compare what we stuck in sand with what we stuck in peat moss, you can see that our results on the dogwood were much higher in the sand We definitely have a water condition here that we think is causing poor rooting as far as this genus is concerned

In conclusion, we definitely think that this method has distinct possibilities. We would be very willing to compare notes with anyone else who has done any work in this line or who might attempt to do so in the future.

The requirements for success are as we have seen, a very light, well-drained and well aerated rooting medium or growing medium, a very fine mist, that is, one that gives you maximum moisture without too much moisture, and root-inducing chemicals to hasten the process so that the plants are not in the very moist environment too long Thank you.

MODERATOR BLAUW: The last speaker on our list is Tom Kyle, Jr. who will speak on the "Propagation of Miniature Roses." Mr. Kyle. (Applause)

MR. TOM KYLE, JR. (Tipp City, Ohio) · Ladies and gentlemen of the Plant Propagators Society: Since I am the last speaker on the program, I will try to keep this talk within the allotted time.

While miniatures have been known for over a century, they have not become really popular until the last ten years. Until this time there were only one or two varieties Approximately 25 varieties are now either patented or have patent rights reserved.

We are growing in the neighborhood of 250,000 plants of over 50 varieties. Several of these varietiess are recent European introductions and are being grown in rather limited quantities

Miniature roses have tiny buds and blooms and dainty foliage and are just like larger garden roses except that they only grow 10 to 15 inches tall and the flowers are seldom larger than a quarter when fully open.

They are completely hardy and very easy to grow outdoors when not overcrowded in borders, beds, and rock gardens. They should be spaced a foot apart in good, well-drained soil and should be fertilized, watered and sprayed the same as large roses. Soil should be mounded over the crown for winter protection.

Miniatures are the only roses which can be grown successfully indoors Like azaleas, however, miniatures should be allowed to go dormant or have a rest period outdoors during the fall and early winter in order to force well. If a few rather simple cultural practices are followed these little roses will bloom for several weeks indoors during the winter. The biggest problem is to maintain a reasonable humidity in the relatively dry, modern home. The roses should also have a sunny location with a constant 65 degree temperature, careful watering and occasional spraying. Miniatures grow better outdoors and should be moved outside in the spring for best results.

Miniatures are very easy to grow from either hardwood or softwood stem cuttings and can be rooted in the greenhouse or outdoors in frames. We perfer softwood cuttings and propagate year-round indoors, using an 18 x 100 foot house for rooting cuttings and two, 36 x 100 foot houses for growing houses.

A constant 65 degree temperature is maintained in these houses and the cuttings are rooted in coarse sand and one-half sand and one-half perlite mediums. During the summer an intermittent mist system is used to control temperature and humidity. During the winter months roses are rooted without misting, although a high relative humidity is maintained in the house.

A stem cutting is taken from one of the mature established plants in our growing houses and all of the top leaves are removed from the cutting with the aid of small shears. Cuttings which average from two to two and a half inches long are stuck directly in the medium, using a board guide and a knife. The cuttings root in 21 to 30 days, dependent upon the season of the year and the variety involved.

The cuttings are then removed and potted off in two and a half inch clay pots, using a medium consisting of two parts good topsoil and one part German peat. The medium is treated with methyl bromide to control weeds and disease organisms. The roses are then moved into one of our growing houses and placed in concrete benches.

After the plants have matured and have developed several sturdy upright canes, they are hardened off and are moved outdoors in beds in our lathhouse. During the winter these beds are covered with sacks and the plants are held in a dormant condition in these cold frames until spring.

During the maturing period indoors the plants are watered daily, fertilized and sprayed weekly. The buds and blooms are removed in order to get more vegetative growth. Watering is done by hand, using a breaker and being selective with certain varieties which do not require excessive moisture.

During the summer months a dilute soluble fertilizer is injected into our greenhouse water lines at a 200 to 1 ratio, through a FertoJect unit. We mix our own concentrated solution, using dry constituents. Winter fertility is maintained by spraying every two weeks with Rapid Gro at recommended rates.

Disease control is the biggest problem in growing miniatures. Until recently we were unable to obtain satisfactory control of mildew and Botrytis blight without constantly spraying and shifting the roses in the bench. We were often able to root a high percentage of cuttings only to lose half of them after potting because of mildew or blight.

We seem to be getting satisfactory control now with a weekly spray schedule, using Malathion for two succeeding weeks and Systox the third week. We also use electric sulphur vaporizers in the greenhouse and ventilate during winter to change the air and cut down on the moisture in the vicinity of the foliage.

Some varieties are very susceptible to red spider; however, this is very easily controlled by our spray program, provided the underside of the leaves are well covered with the material.

SUMMARY

1. Miniatures are easy to grow and require a minimum amount of care.

2. They may be propagated using either hardwood or softwood cuttings and may be rooted in frames or in the greenhouse.

3. Rather rigid watering and fertility cycles must be adhered to in order to obtain optimum growth.

4. Disease control is the biggest problem but can be controlled by adopting a timely spraying schedule and an adequate sanitation program, both in the rooting and growing areas.

MODERATOR BLAUW: Are there any questions?

MR. F. L. S. O'ROURKE (East Lansing, Mich.): I would like to have one minute, if you please

Mr. Chairman, fellow members: I am prepared to present a paper by a graduate student at Michigan State University, one James R. Feucht, who has done a good job of air-layering of pine and spruce. However, since time is limited I will merely pass this paper around and will plan to publish it in the Proceedings. I also have a tool in my pocket which was devised by Mr. Feucht that I would like to show anyone interested in making a girdle.

(*Editor's note*: The paper by James R. Feucht and Professor F. L. S. O'Rourke follows.)

AIR-LAYERING OF PINE AND SPRUCE

JAMES R. FEUCHT AND F. L. S. O'ROURKE
Department of Horticulture
Michigan State University
East Lansing, Michigan

The widespread use of many superior selections of conifers is limited by the difficulty of propagation While established clones of pine and spruce are commonly grafted on seedling rootstocks, the method is seasonal, costly requires special facilities. Several propagators and scientific investigators have reported on trials with both cuttings and air-layers but without any marked degree of success.

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This report concerns an investigation started in the spring of 1958 to determine the influence of some factors which affect the formation of roots on marcots. Studies were also made toward developing a satisfactory technique that might possibly assure a fair degree of rooting with certain conifers.

Air layers were placed on terminal shoots of lateral branches of seven-year old Scots pine (*Pinus sylvestris*) and nine to twelve-year old White spruce (*Picea glauca*). The needles were stripped from a portion of the stem on one-year old wood about six inches back of the apical bud. In the center of the needle-free area, a ring of bark two to three mm. wide was removed with a special tool consisting of two razor blades spaced apart with small springs and two corresponding steel guide edges to prevent uneven cutting. The tool was so constructed that the width of the girdle could be adjusted simply by turning three small bolts.

After removal of the bark, a ball of moist sphagnum was wrapped tightly around the wound with polyethylene film. The polyethylene was wrapped from the top downward and overlapped in order that rain water would not penetrate through the fold. "Twistems" were used on each end of the plastic to bind the material closely against the stem.

A number of synthetic hormones at various concentrations were tested in 1958 by applying aqueous solutions of the chemicals into the sphagnum with a hypodermic syringe. While some of these treatments appeared promising, further trials in 1959 showed that there were no significant differences due to chemical application

In 1959 fifteen marcots per tree were placed on fifteen trees each of pine and spruce at the beginning of April, May, June, July, and August. The air layers were equally divided between the top, middle, and bottom branches After 100 days they were removed and examined for rooting.

No significant results were obtained in respect to the position of the marcots on the trees but a significantly greater number of White spruce stems rooted from air layers applied in May (41 out of 225 stems) than when applied at any other time. The July treatments resulted in the least rooting, perhaps due to high temperatures immediately after application.

The highest rootings from the Scots pine air layers were obtained from those applied in July but were largely confined to individual trees suggesting that some trees are more capable of producing roots on marcots than others of the same species. These experiments indicate that this method of air layering of conifers is not as yet developed sufficiently to be a practical means of propagation but may have a use in securing a small number of rooted plants from unusual trees for observational purposes.

*   *   *   *   *

MR. J. PETER VERMEULEN: I forgot to mention that we have some of the plants that were rooted at the side of the room and they can be seen there.

DR. CHARLES HESS: Pete, did you punch holes in the bottom of your peat pots for drainage?

MR. PETER VERMEULEN: No, we did not.

DR. HESS: Do you think this would help or does the pot swell?

MR. VERMEULEN. I don't think it would help unless you had a very large hole. Perhaps most of the moisture that was giving us trouble was contained in the peat pot itself.

MR. JIM WELLS: I would like to direct a question to Hugh Steavenson. Would he describe first of all the physical setup whereby he applies fertilizer through his portable irrigation system, particularly when he pumps from a pond, and secondly, what fertilizer does he use?

MR. STEAVENSON: Well, Jim, that is a very simple matter. If you have a centrifugal pump, because you can simply draw in on the suction side whatever you want to draw in, and you can proportion it very simply with the use of an ordinary garden hose valve, any simple valve.

We mix the fertilizer, and obviously, it has to be something that will go into solution and, of course, we put on whatever fertilizer we care to do, according to soil tests, and what we think the plants require.

MR. WELLS: How do you graduate or how do you calibrate it?

MR STEAVENSON: That is also very simple, Jim. We irrigate about two acres at a time, as a rule. Well, let us say we want to put on 500 pounds of 5-10-5 per acre, for example. We can mix up the ingredients, using anything we want to for nitrogen. We would probably use ammonium nitrate, potassium chloride and one of the soluble phosphoric acid constituents, and dump this stuff into a horse tank which holds a known amount of water, pump the horse tank full of water and after a very simple regulation with a valve, we know how long it takes to draw it into the suction side as the pump, which is pumping water out of our pond

Now if we are putting on from an inch to two inches of water per irrigation we start drawing the fertilizer in when the pumping starts. We usually pull it right on through the entire fertilization and usually run it off with clear water when the fertilizer is exhausted from the horse tank.

With our allyl alcohol we do the same thing except we draw the alcohol in from a 55-gallon tank. In that case, we are putting on 5,000 gallons of water per acre to 25 gallons of alcohol. Of course, we always rinse out the line with clear water, since this acts as a water seal, after the alcohol is on That amounts to about a quarter of an inch of water in the case of the alcohol. So, with irrigation, we will be putting on an inch to two inches of water with the fertilizer. The same thing as spreading with the spreader.

MR. WELLS: How long do you have to leave the land after putting the allyl alcohol on before you think it is fit to go into seed?

MR. STEAVENSON: About a week, depending on the temperature and wind condition, and so forth. You can smell the ground and when it no longer has an odor, it is all right.

MODERATOR BLAUW: Any more questions?

MR RICHARD FILLMORE: I have a question for Sidney Waxman on the first part of his presentation May this photocell for the control of mist be operated with a normally open solenoid valve, that is a solenoid valve which, if the photocell fails, will continue to deliver water? And one on the second part is, is this apparatus available commercially, and if not, may plans for it be obtained?

DR. WAXMAN: To answer the first question, I have just been told yesterday that it can be arranged with the normal solenoid valve. To answer the second question, it is not commercially available yet, and I might say to some manufacturer, here is an opportunity. Thirdly, we have blueprints and if we have enough requests we will print them up.

MR. MARTIN VAN HOF. Will we get a condition when we store our rooted cuttings and put them in bags with any kind of moss or whatever we use? I heard somebody puts those cuttings in bags without any moss or medium.

MR. VINCENT K. BAILEY: We have used moss experimentally in these polyethylene containers where we stored bareroot deciduous greenwood cuttings over winter. We also experimented without any packing of any sort. We did not find any adverse results from using the moss but we did not find any beneficial results. The stock that was stored without any packing of any sort came through just as well So in the last two years we have used nothing in the containers where we stored the rooted cuttings

MR. VAN HOF: Would it also apply to evergreens and broadleafs?

MR. BAILEY: I haven't had any experience with the storing of broadleaved evergreens in polyethylene We have stored evergreens, as I said, last year from September to April very successfully in controlled conditions of temperature and humidity without polyethylene, only moss over the roots in a dark room, of course.

MR. VAN HOF: What do you think about some light on the evergreens? Do you think it would be necessary?

MR. BAILEY: We have not found it necessary We have found no adverse results or detrimental results from storing in darkness.

MR. KARL KERN (Cincinnati, Ohio): Going back to the topic of Roy Nordine of budding *Crataegus.* I have been carrying on experiments with the idea of producing or growing cotoneasters on the stems of hawthorns. I have two-year old *Cotoneaster apiculata* on stems about three feet high *Crataegus* stems. When I carry this on I want to graft *Cotoneaster horizontalis* and *C. dammeri* on the standard stems to produce plants for accent points in landscape composition. So far, *Crataegus cordata* seems to be the largest understock I have used

MODERATOR BLAUW: I thank you, ladies and gentlemen, and especially the speakers for this afternoon.

PRESIDENT NORDINE: The next item on the program, of course, is the business meeting, and we hope we can do this as quickly as possible.

The meeting recessed to reconvene in the Annual Business Meeting (See page 12).

NINTH ANNUAL BANQUET

Our Past President, Mr. Roy M. Nordine, and the newly elected President, Mr. Harvey M. Templeton, Jr. presided at the annual banquet.

Highlighting the evening was the presentation of the Plant Propagators Award to Mr. James S. Wells of Red Bank, New Jersey. Mr. Louis Vanderbrook, in making the Award, noted Jim's prominence in the organization which took the form of his being the only man to hold the presidency for two terms. Mr. Wells was the opening "Spark Plug" which launched the organization back in 1951 at Cleveland, Ohio. In recognition for his book, Plant Propagation Practices, for his willingness to share information, and for his loyal service to the Plant Propagators Society, Mr. Jim Wells has rightfully been so honored.

For his loyal service to the organization, Mr. Roy Nordine also was honored and received an inscribed gavel to remind him of his years tenure at the helm of the Society.

Climaxing the Annual Banquet was a talk and series of slides given and shown by Dr. Cornelis Broertjes on the Experimental Station for Ornamental Trees and Shrubs at Boskoop, Holland. Dr. Broertjes, who was currently working as a research fellow at the Brookhaven National Laboratory gave the Society a most interesting and first hand account of the nursery research work being done at Boskoop. Many in the audience recalled pleasant memories as the slides were being shown as evidenced by an occasional remark.

The Ninth Annual Meeting of the Plant Propagators Society adjourned Sine die at 10:00 P.M.