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

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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

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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

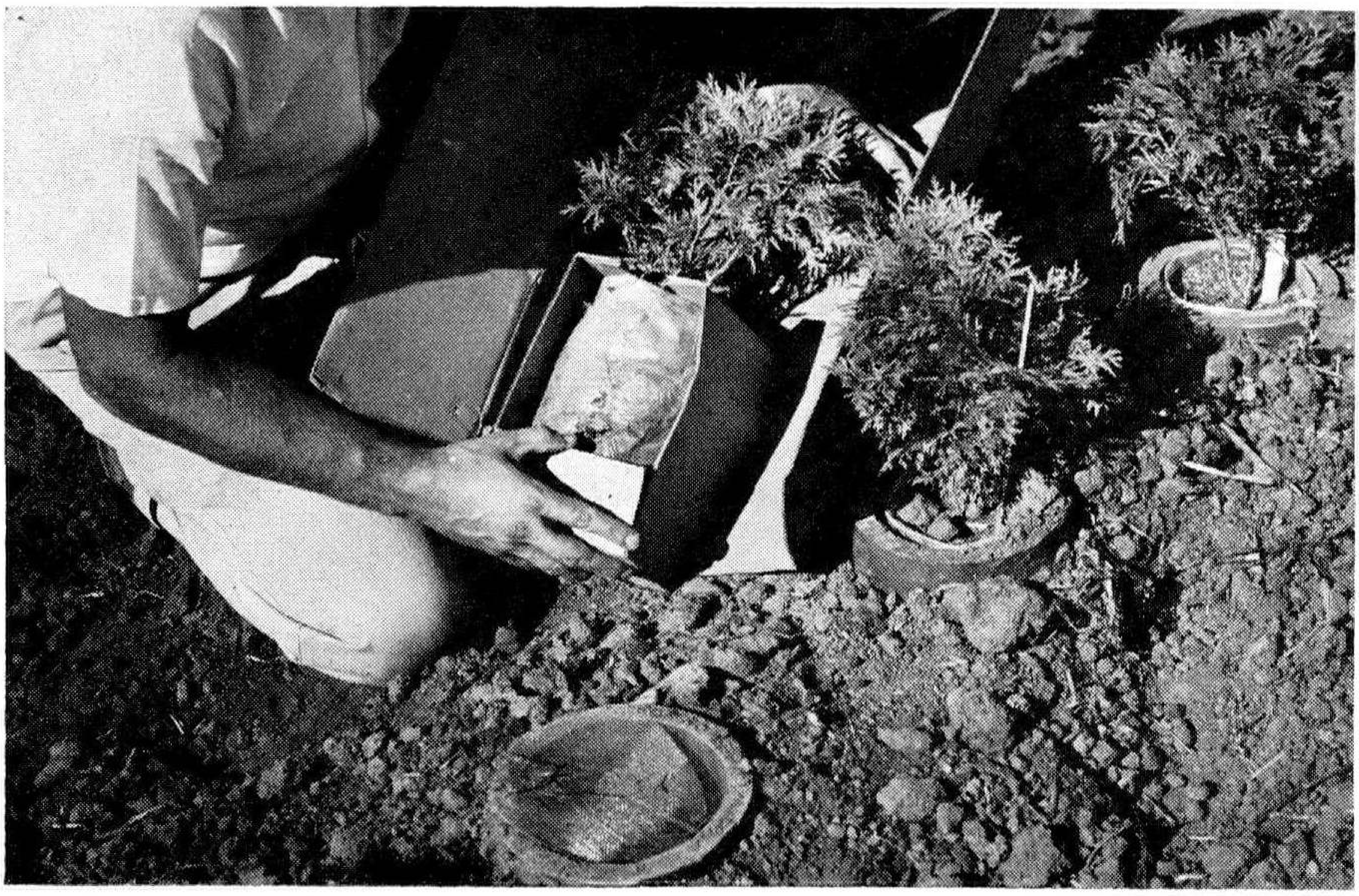

Figure 1. Details of tile growing showing vertically set tile, fly screen base and the packaging technique.

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.

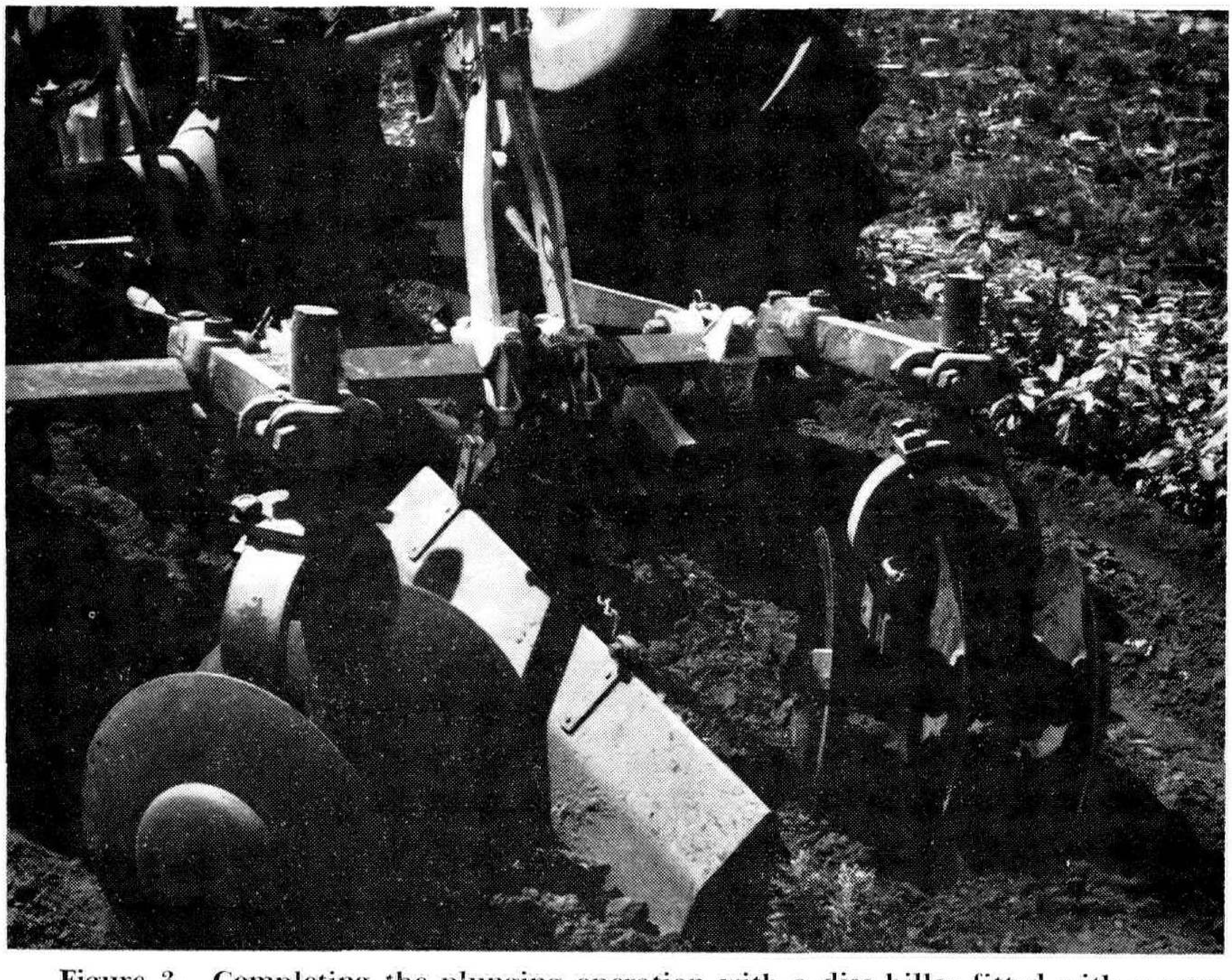

Figure 3. Completing the plunging operation with a disc hiller fitted with a corn cultivator guard.

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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

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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.