Another way to overcome the problem of overwintering these difficult species is to keep them under long photoperiods throughout the entire winter. The plants receiving this treatment will continue to produce new growth, until spring, at which time they should be placed outdoors. This last treatment is expensive because of the greenhouse space required and should of course be done only if there is no other sure way of carrying the plant through the winter.

Summary

Long photoperiods:

1. Keep cuttings in an active state of growth.
2. Can, in some instances, increase the percent rooting.
3. Can, in some instances, increase the size and number of roots developed.
4. Extend the season during which cuttings of deciduous azaleas may be taken.
5. Retain foliage and extend the time during which additional roots may develop and carbohydrates are produced.
6. Can induce a short spurt of vegetative growth with the development of additional buds often necessary for survival the following spring.
7. Can keep plants in active growth throughout the winter after which they may be planted out in the spring; a guarantee of survival.

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MODERATOR HESS: Mist propagation can be looked up as a form of automated syringing. Carrying the concept of automation to an even greater level is Peter Vermeulen who will tell us about his experiences with rooting-growing media.

ROOTING-GROWING MEDIA

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By no stretch of the imagination should I be considered an authority on rooting - growing media. At our nursery we are keenly interested and rather heavily engaged in the commercial aspect of the propagation technique of rooting cuttings in a rooting - growing medium in containers. My comments therefore may be useful to others. This is perhaps what Dr. Hess had in mind when he asked me to participate. Having asked him

to arrange and moderate this wonderful symposium, how could I refuse.

I imagine it safe to say that from the time he stuck his first cutting, man has been concerned with the medium. Through the ensuing years, as he gradually became more sophisticated in his knowledge of the art and craft of plant propagation, there developed a long list of media that have been tried and tested, accepted and rejected and sometimes tried again. Most often mentioned in recent literature are: soil, sand (variously referred to as brick, concrete, plaster, bank, pit, silica, torpedo, etc.), peat-moss (German, Canadian and Michigan), sphagnum moss, sifted ashes, flu ash, fly ash, pumice, sawdust (several kinds), wood shavings, rice hulls, bark dust, water, cinders and more recently the manufactured media, vermiculite, perlite, calcined clay particles and shredded styrofoam. I do not recall where or when but Hans Hess mentioned stored cuttings of *Ilex crenata* 'Helleri' I believe, untreated and with nothing around the basal ends, rooting in sealed polyethylene bags. The literature is replete with various combinations of the mentioned media, either unadulterated, mixed in varying proportions or in alternate layers or both.

I am not familiar with information relating to the first use of a rooting medium as a growing medium but certainly soil must have been. Possibly it was in using the technique or layering, later that of sticking hardwood cuttings and still later softwood cuttings. A look through our own proceeding shows papers on rooting in soil by George P. Blythe (1), Henry Homer Chase (2), Merton Congdon (3), Roger Coggeshall (4), Robert J. Eshelman (5), Leslie Hancock (6), Donald J. Moore (7), F. L. O'Rourke (8) John B. Roller (9), Hugh Steavenson (10), Harvey Templeton (11), Martin Van Hof (12), Phillip W. Worth (13) and Pieter G. Zorg (14).

As the practicality and economic benefits gradually encouraged growing plants in containers it would seem natural that nurserymen would 'discover' the technique of rooting and growing plants in the same medium in a saleable container. In our own society the technique has been discussed by Charles Hess, Sr. in 1955 (15), J. B. Hill (16), Kenneth W. Reisch (17) and Henry Weller (18) in 1957, my self in 1959 and again in 1963 (19) and J. H. Tinga and Charles Hayes, Jr. in 1963 (20).

It is interesting to note the media mentioned in these papers. Hess used equal parts of vermiculite, perlite and styrofoam (15). Hill used "the standard sand-peat mixture", no proportions given (16), Reisch used equal parts soil, peat and sand (17), Weller's comments concerned growing perennials from cuttings to maturity under mist in plastic bags but he did not name the medium used (18), Tinga and Hayes reported a project to test the rooting for very large cuttings in containers and listed 4 mixes consisting of equal parts of: 1. bank sand and German peat, 2. bank sand and Canadian peat, 3. coarse perlite and German peat, and 4. coarse perlite and Canadian

peat. They further reported no significant difference in rooting with any of the four. (20). Robert Ticknor in 1960 reported successfully rooting *Rhododendron catawbiense grandiflorum* in plant band and peat pots using a mix of equal parts of sand and sphagnum peat, (21). My paper in 1959 reported using 1 part soil, 1 part peat (German) and 20% by volume of shredded styrofoam; and in 1963 a medium consisting of 53% German peat, 17½% #1 Horticultural perlite, 17½% finely shredded styrofoam, 9% clean fine sharp deep pit sand and 3% soil (19). The latter is now our "standard mix" for all "in container" propagation.

I must comment here on an area of confusion. The perlite we use is purchased from PerAlex of New Jersey, Inc., Paterson, N.J. It is offered in two grades, Horticultural #1 which is coarse and Horticultural #2 which is fine. Technical data in our files on Sponge Rock from Paramount Perlite Co., Paramount, California, indicate seven grades available, No. 000, No. 00, No. 0, No. 1, No. 2, No. 3, and No. 4. Their graduations, however, run opposite to that of PerAlex with #000 grade being the finest or smallest particled and #4 being the largest or most coarse. Particular danger exists here in that reports on propagation and/or growing media using perlite generally mention only the grade number and not the particle diameter. An initial attempt this week to relate the difference in particle size to the grade numbers used, by comparison of furnished typical screen analysis, proved inconclusive since the screen sizes used did not correlate properly. This will be pursued in an attempt to eliminate the confusion and I bring it in here only so that there may be awareness of it.

This past summer we tested two other mixes. One of equal parts of German peat and #2 Horticultural perlite (PerAlex) and one of 2 parts German peat, 1 part sand and 1 part finely shredded styrofoam. The reason for the testing of new mixes is in part because of my belief that soil, even though in small percentage, by reason of its introduction of micro-organisms, contributes to the eventual development of a more effective root system and consequently a better plant. Others in our organization do not particularly hold to this belief and are attempting to prove their point. I must say that the results initially seem to be in their favor. It remains to be seen however how the roots and the plants will develop and we certainly will continue our tests.

Looking through the literature published on rooting media it appears there are sundry media used but that throughout there is a consensus on the particular physical properties a medium must possess. These can be summarized as: 1. that it must hold the cutting in position rather firmly without excessive compaction, 2. it must provide at the same time both sufficient drainage and adequate water retention, and 3. it must provide for a proper oxygen-water relationship. Dr. O. A. Matkin in his recent article in the Plant Propagator presents some very

interesting and useful information on the physical properties of propagating media (22).

A prime requisite in the rooting process is the prevention of moisture loss from the cutting until such time as roots are formed and the cutting can provide its own water supply. The water in a medium is of only little value to the cutting since there is insufficient uptake through the stem. In mist propagation this water loss is prevented by artifically supplying a film of water on the leaf surface to prevent water loss from the cells. Surplus water falls down into the medium which dictates that the medium must be well drained. It it were not, the water would displace the oxygen which is necessary to prevent cellular breakdown or rotting. Oxygen is also necessary in the chemical and physiological processes involved in root initiation. Dr. Matkin refers to this drainage requirement of a medium in terms of free porosity, water retention and wet density. He suggests that, in mist propagation, free porosity should not be less than 20%, explaining that free porosity is the air space within the medium after drainage. He further advises that the medium be as deep as possible in order to provide a place for the excess water to settle, thereby permitting the zone of the medium surrounding the cutting an oxygen-water relationship conducive to root initiation. The type of medium used will dictate the depth of the medium according to its free porosity and water retention properties.

Because we are concerned after rooting with growing, attention must be given those physical properties considered ideal in a growing medium. An excellent reference on growing media is "The U. C. System for Producing Healthy Container - Grown Plants" (23). The properties required in a good rooting medium are likewise required in a growing medium. Additionally a growing medium must be capable of receiving added nutrients, retaining them for a sufficient length of time, meanwhile releasing a balanced supply to the plant. Since adding nutrients brings with it a salinity problem the drainage or leaching properties of the medium become doubly important. We have found that an application of Aqua-Gro, a non-ionic organic wetting agent, at the rate of 1 teaspoon to 4 gallons of water, in the initial watering appreciably aids drainage. Another property is that the medium must permit maintenance of a proper pH for optimum rooting and subsequent plant growth.

Economic Considerations

General economics can not be overlooked especially in a commercial application of this technique. It would seem that many of a long list of ingredients can be utilized in creating a practical rooting-growing medium provided the forementioned requirements are met. One of the prime considerations in economics is consistancy, both that of performance and availability. A good program can not be sustained with an ever changing medium. In this regard a sufficient and constant supply is more important in the long run than initial price. S. Challenger

(24) and G. Smith (25) in 1961 both discussed the use of locally procured sawdust in preference to expensively imported peat-moss in work they have done in New Zealand.

Weight of the medium is principally a commercial consideration. If light in weight, more containers can be handled by a given person in a given time with less effort. Also, if light in weight, shipping costs are substantially reduced. However if too light in weight, stability of the container in the growing area may be a problem in nurseries subject to much wind.

Another saving results from the more rapid and uniform growth generally achieved. This tends to reduce or may even eliminate costs of culling and grading. It also enhances the saleability of the crop.

The most appreciable saving however results from labor saved in transplanting and handling. Jack Hill referred some time ago to the phrase "down-time" coined at C. W. Stuart. I will take the liberty of refining or combining the phrase to "up and down time" or since this is the age of alphabetese — UP DOT. With only a bit of imagination one can perceive the huge savings in UPDOT using ROCISECIROGME, which means "Rooting Cuttings in Selling Containers in Rooting - Growing Medium." Seriously, however, I see the desirability of a suitable standard term for this propagation technique and suggest for the consideration of our Glossary Committee the terms ROO TICON meaning "rooted in containers", SEEDICON meaning "seeded in containers" and PROPICON to cover all phases of propagation in containers.

Next year we are going to try a system whereby we will be taking the mist to the cutting — a portable mist system so that we can bring our filled containers to the greenhouse bench or growing area, insert the cuttings, apply the mist, remove it when ready and then watch them grow. With Jack Hill's "Black Box", no UPDOT and using PROPICON we should soon catch up with PHYTOTEKTOR — and retire.

Containers

The present media available, properly used, permit rooting in almost any container, provided there is adequate drainage. About the only limiting factor I see concerns the type of roots produced by the item being rooted. Some plants tend to send the roots out of the container through any opening of appreciable size or through the walls of the peat pots to the extent that they must be later cut apart. To contain these roots and still stay with the peat pot we have successfully use the POLY-SKIN pot which is a thin walled peat pot with a skin or covering of thin polyethylene. Unfortunately they are no longer available. Plastic pots of many grades and sizes are economically available and are quite satisfactory. For lining-out stock that has to be shipped they do present a bit of a problem in packing and they do require labor to remove the pot before planting. The PULLEN Hard Pot was tried this summer with success but it too must be removed prior to planting. For lining-out stock that

must be shipped we would like to see the POLY-SKIN pot back on the market. Better yet, what we really need is a peat-moss or similar pot so treated that root penetration will be prohibited for a chosen period of time after which the pot will deteriorate to permit root penetration and development. I do not believe this to be outside the realm of possibility considering all the other technological advances we have experience in recent years. This may be considered a challenge to the pot industry.

Materials Propagated

Time does not permit a detailed list of materials propagated using PROPICON. A quick mention, however, will tend to substantiate the practicality of it. While we are not rushing pell-mell into it, we are convinced that before too long a rather large percentage of our rooting will be directly in containers. This past summer we handled a little over 29,000 in this manner with percentages ranging from 0% to 100%. The 0% was on some Flowering Crabapple that were hard when stuck. Several cultivars rooted practically 100% however. In general, percentages centered around 85% to 100%. I realize that mentioning a 100% strike in this Society raises some eyebrows but I will stand behind the claim. Successfully rooted were the following: *Acer palmatum,* 5 cultivars; Deciduous Azaleas, 31 culivars of Exbury, Ghent, Knaphill, Mollis and Slocock hybrids; Evergreen Azaleas. 5 cultivars; *Cotoneaster horizontalis* and *adpressa praecox; Cornus florida plena* and *rubra* and *kousa chinensis; Franklinia alatamaha, Ilex crenta* 'Glory' and 'Green Thumb'; *Ilex glabra compacta; Ilex opaca pyramidalis* ('Brilliantissima'); *Juniperus chin.* 'Armstrong', Nick's Compacta' and *pfitzeriana* (only 40%); *Juniperus hor. plumosa, chin. glauca* 'Hetz' and 'Kallay Compact'; *Magnolia,* 6 cultivars; *Prunus serrulata,* 3 cultivars; *Pyracantha,* 4 cultivars; *Rhododendron catawbiense* hybrids, 20 cultivars; *Cotinus cogg.* 'Royal Purple', and *Ginkgo biloba,* male selection.

Nutrient Mist

Dr. Hess asked me to include some work we had done with nutrient mist. In preparing this paper I have not had the opportunity to review that of Mr. Wott but do not feel there is any danger of repetition since our experience has been limited.

In 1964 during our summer mist propagation outdoors we introduced nutrient mist to our rooting cuttings. We used three mist beds, each 800 square feet and each with separate misting lines but we had only one proportioner. We therefore alternated the application so that each bed received nutrient mist every third day and regular mist the other two days. The nutrient used was Peter's soluble 20-20-20. Mist was controlled by clocks and the interval was adjusted according to the variables in weather. The average setting was one minute of mist every four minutes from approximately 8 a.m. to 8 p.m. Nozzles used were the Flora-Mist with .020 orifice, spaced 30 inches apart, 120 nozzles per bed. At 25 lbs psi each nozzle delivered 3 gal-

lons of water per hour, each bed receiving a total of 108 gallons per day. The average crop remained in the bed 45 days so received a total of 1,500 gallons (108 being rounded out to 100 to compensate for drift and other factors and the bed receiving mist only every third day). At 4 oz. per 100 gallons each crop of approximately 17,500 cuttings received about 4 lbs. of nutrient.

We are not just sure what we achieved. From all appearances we had real healthy rooted cuttings. Foliage was retained well into fall after hardening off. *Prunus kwanzan, Acer palmatum* cultivars and *Cotinus cogg*. 'Royal Purple' exhibited new growth that we had not experience before. An unsatisfactory result was that plants were not sufficiently hardened off and when we experienced a temperature of 18 degrees the first week of October many were split. Those that survived however came through and broke dormancy very well this spring. I should say plants were stored in a polyethylene covered deep frame, unheated. This year the frame is heated. Also this year, because of several reasons, we did not use nutrient mist. Since our results on everything were as good or better than that of 1964, we can't really say at this point that nutrient mist gave us any appreciable immediate benefit. We will, next year, run additional carefully controlled tests and will have some sort of a report at a future date.

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MIST SYMPOSIUM

DISCUSSION

DR. HESS: Jim, at what time do you start the hardening off process?

JIM WELLS: It's impossible to answer precisely; this is where common sense comes into the picture. I do believe that most cuttings are improved by a gradual reduction in misting as rooting develops. I think that you need to have a small bunch of roots on the bottom of the cuttings, 6-10 roots possibly, an inch or more in length beginning to become attached to the rooting medium. That is the cutting is beginning to establish itself again as an individual. About this time I think that a modest reduction in mist application is adopted. And this [reduction] needs to be slowly increased in amount as the plant develops over a period of 2 or 3 weeks.

Now the difficulty in doing this lies particularly with the type of control such as a timer. It requires an on the spot interpretation of conditions by someone and this is almost impossible. Here is a real value of the electronic leaf control. One of the simple, very nice things which I think the control from England has is the sensing unit which has 2 carbon electrodes imbedded in a block of plastic. The sensing unit can be placed in any position in the bed in relation to the misting head. This provides an infinite variety of positions available to you in relation to the mist coming from the jet and landing on the sensing unit. I don't think there's any hard and fast answer to your question, Charley. I think the plant has to become essentially established on its own roots and then it requires a gradual tapering off.

MERTON CONGDON: I don't think I have anything to add to what Jim Wells has said, but in our operation we go by the general appearance and condition of the cutting as we reduce the mist. We have not found under our open air mist propagation that the reduction of mist in the hardening off process has been any problem.