AVOCADO TIP-GRAFTING

C. P. TEAGUE
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There are many methods of budding and grafting in use today and tip-grafting is just one method that adapts itself quite well to avocado propagation. Tip-grafting is nothing new to most propagators so I will not get involved in minute details unless someone wishes to know something specific.

We grow avocado seed in clean soil, in pots on benches. By doing this we avoid most of the fungi problems and have a minimum of trouble. Cleanliness is very important as the seed are forced under high heat and humidity. We prefer to harvest the fruit before it drops so the seed does not become contaminated on the ground.

Tip-grafting of avocados was first done commercially by Walter Beck of Fallbrook, Calif. around 1946-48. Shortly thereafter, many growers and nurserymen, including myself, adopted the method. It is a guess that 75% or more of all commercial avocado trees grown today are tip-grafted by the method I will describe.

In our own nursery in Corona, Calif. we generally use the same methods as other nurserymen except that we grow the first stage of the seedling in a very small pot to save cost. The older method was to grow them in a large container (mainly heavy tarpaper) from the beginning. This was very expensive particularly when the percentage of graft takes was very poor.

Most of the seed used is of the Mexican strain. The most used varieties are TopaTopa, Duke and some selected seedlings. Seed is harvested in mid-October thru November and immediately planted. It is forced in a hothouse at around 80° F. with very high humidity. When the seedling is from 15 to 18 inches in height it is ready to tip-graft. This is usually done around February to March, approximately 4 months after planting the seed. After the scion bud grows 6 to 8 inches in height, the tree is repotted into a larger container, grown through the rest of the year and planted out the following spring (around March). This means that a tree is planted in the field approximately 16 months from seed. Some growers plant the trees in the field 8 months after seed planting (in July and August) but the tree is rather small and more difficult to care for.

As to some specifics of our method of avocado tip-grafting, our planting medium is a blow sand which is prevalent in the western end of San Bernardino County. It is light but has about 25% clay in it which gives it an ability to retain moisture. We are using it straight as this is cheaper, but we are also trying it combined with peat moss. The soil is fumigated with methyl bromide well ahead of its use then placed in small, lightweight, tarpaper containers 2¼″ x 2¼″ x 8″. These are placed side by side in old lemon storage boxes. The seed is planted in the soil and then covered with peat moss to keep them moist for sprouting.

When the seedlings are 15″ to 18″ high they are separated, tip-grafted and then placed back into boxes. The tarpaper pots give us some trouble as they break down readily and the roots grow through them; we are now experimenting with some plastic pots that could be stapled together and then re-used.

The trees are tip-grafted from 6″ to 10″ above the seed by making a long sloping cut on the seedling with a sharp knife and then selecting scion wood of approximately the same size and making a corresponding cut on it, leaving 1 to 2 buds. This scion piece is usually from 1½″ to 2″ in length. The cut surfaces are bound together firmly with budding tape or budding rubber. The top of the scion is treated with Tre-Seal to prevent loss of moisture.

The grafted trees are kept under high humidity and subdued light until the buds break and start growing. The tape is removed when the graft is healed; this is approximately 3 to 4 weeks after growth has started and is 6 inches long, or longer. Constant suckering of the seedling and scion is necessary.

Up to this point, very little cost has gone into the care and growing as little space has been taken and little material used. Now repotting is done and the trees are shifted into larger containers. For the larger container we are using pressed paper pots that can be buried when planting so that there is no disturbance to the roots. We are still experimenting with other containers. The paper containers are good but they tend to rot out on the bottom before they are ready for planting; however, they are still quite satisfactory.

MODERATOR TEAGUE: I would now like to introduce Mr. E. F. Frolich, who is well known to all plant propagators in southern California. He is with the Department of Agricultural Sciences — Plant Nutrition — University of California, Los Angeles. He will discuss both citrus and avocado propagation. Ted —

ROOTING CITRUS AND AVOCADO CUTTINGS

EDWARD F. FROLICH
University of California
Los Angeles, California

Many varieties of citrus will make satisfactory trees on their own roots (1). Nurserymen have grown Meyer lemon and Rangpur lime as rooted cuttings for many years. There are own-rooted trees of Navel and Valencia orange, Eureka and Lisbon lemon, Dancy tangerine, Bearss lime, and Marsh lightweight, tarpaper containers 2¼″ x 2¼″ x 8″. These are placed side by side in old lemon storage boxes. The seed is planted in the soil and then covered with peat moss to keep them moist for sprouting.

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The speed with which citrus cuttings form roots varies both with the different species and the age of the clone. Cuttings from seedlings, as in nearly all other plants, root more readily than cuttings from old cultivars. They tend also to send roots down in a more nearly vertical direction as opposed to the more horizontal-growth produced by the latter. The acid citrus, such as limes, lemons, and citron root most readily. Mandarins and kumquats are slowest to root, grapefruit and sweet oranges lie in between.

The most satisfactory cutting material is the last flush of growth that has hardened but not yet started a new flush. The greatest number of cuttings of this type would be available in early summer following the spring flush. Cuttings are generally made 3 to 6 inches long and of a single flush. The size is not critical; cuttings 2 feet long can be rooted. The important thing is that some leaf area be maintained. In general the more leaves functioning the heavier will be the rooting. Cuttings should be kept moist at all times during handling to keep the leaves turgid.

Some citrus species benefit from treatment with a rooting hormone. Indolebutyric acid at 8,000 ppm in talc is most generally used. Equally good results can be had with IBA as a quick-dip at around 3,000 ppm. The acid citrus gives a much greater response to the hormone treatments than do oranges, grapefruit, or mandarins.

Cuttings can be rooted in any equipment that will maintain a high humidity and a fairly good light intensity, either a closed case or a mist system. Mist systems are less satisfactory with the slower rooting varieties because of excessive leaching which will occur over a period of time. Bottom heat at a minimum of 75° F. is beneficial; on some citrus, such as calamondin, temperatures around 85° F. minimum may be desirable.

Twig-grafting (1), a method sometimes used, employs two or more cuttings grafted together. Two cuttings will give a desired rootstock-scion combination, three cuttings a combination of rootstock, scion, and interstem. Select material that is nearly the same diameter at the graft. At least one leaf on each piece is essential. A splice graft is generally used, making diagonal cuts ½" to ¾" inches long. Tying is done with raffia, plastic, or rubber. We have found a regular #16 stationer's rubber band to be satisfactory. It is not necessary to seal the cuts because the humid conditions used will keep them from drying out. Unions at the graft should heal in 3 to 4 weeks. Healing of the unions, unlike rooting, is nearly the same for all species. Rooting time depends on the piece at the base and is little affected by the scion (2). Citron may root in less than two weeks, some mandarins may take as long as 6 months. We have grafted 10 pieces end to end to demonstrate how readily the grafts heal even though no roots are present.

Avocados are rarely grown as rooted cuttings. Avocados grown from cuttings are more difficult to handle for the first few years than those on seedling rootstocks. Since most varieties are difficult and expensive to produce as cuttings, the method is limited to growing trees for certain experimental uses. Young seedlings (3) and a few old cultivars such as Ganter, Scott, and Zutano can be rooted by ordinary methods in either a closed case or under mist. Cuttings of the Fuerte variety have been rooted in small numbers the same way but not consistently (4). Most commercial varieties, however, require a special etiolation process in order to produce roots (5). For the varieties that are difficult to root, it is necessary to produce a shoot with a base that has developed in the dark and a top that has grown in the light. We generally graft the desired variety onto a seedling growing in a small container. We generally use a one-quart can, because experience has shown that shoots from plants in large containers do not root well. After the graft is well established and has made some growth, we cut back to buds near the base of the shoots. When these buds show signs of growth. we put the whole plant into a dark room at about 75° F. and let new shoots grow about 3 inches. The plant is then brought into the light and the bases of the shoots are covered with some material such as vermiculite to keep them dark. The tips are allowed to grow in the light. When 3 or more leaves have reached maturity, the shoots can be detached near the base and rooted in conventional propagating equipment. The shoots can also be rooted by removing a ring of bark near the base and covering the area with some moist material as in air layering. We prefer detaching the cuttings because in our experience we can use the stock plants more times than when we girdle. Girdling seems to weaken the root system much more than does detaching shoots.

Treatment of avocado cuttings, either etiolated or green, with normal concentrations of rooting hormones does not seem to help. At higher concentrations we get tissue damage but again with no improvement in rooting.

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(5) Frolich, F F, 1951 Rooting Guatemalan avocado cuttings *Calif Avocado Association Yearbook* 1951:136-138

MODERATOR TEAGUE: Thank you. Ted. Next we will hear from Mr. Paul Moore, University of California, Riverside, who will continue the discussion on citrus propagation. Paul:

PROPAGATION AND GROWING CITRUS NURSERY TREES IN CONTAINERS

PAUL W. MOORE
University of California
Riverside, California

The field propagation of citrus nursery trees is an old practice. Successful nursery techniques are well established and reasonably standardized throughout the citrus producing areas of the world. Until recent years, citrus nurserymen have shown but little interest in growing their trees in containers. Orchardists have been equally hesitant about planting container-grown stock. However, within the last decade, certain developments related to nursery tree certification, land and labor availability, automation, and transportation costs have generated a new interest in container-growing systems for citrus.

For many years, the University of California, Citrus Research Center, has been growing trees in containers for research purposes. Thousands of such trees have been planted in our orchards and have performed as well as field-grown nursery trees. The consequence of our favorable experiences was a decision to discontinue our field nurseries in favor of container growing. Some of the advantages which led us to this decision are listed below:

Advantages:

1. *Standardized soils*
   Soil mixes can be standardized for physical and nutrient characteristics. Flexibility in selecting mixes tailored for specific needs is also possible.
2. *Pest-free soils*
   Steam sterilization or pasturization guarantees freedom from soil-borne diseases, pests and weeds.

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2. *Pest-free soils*

   Steam sterilization or pasturization guarantees freedom from soil-borne diseases, pests and weeds.

3. *Fertility control*

   Frequent applications of dilute fertilizer solutions through the irrigation system and ease of manipulating fertilizer amounts and ratios bring about optimum growth.

4. *Lower space (land) requirements*

   A space requirement of one square foot per tree, including working aisles between beds, is satisfactory compared to three or four square feet per tree in field growing.

5. *Shorter growing cycles*

   By using plastic greenhouses, growth rates are increased and the effective annual growing season is prolonged. Budded trees ready for planting to orchard locations can be grown in 14 to 18 months from seed planting. Two to three years are required for field growing.

6. *Lower frost protection costs*

   The high concentration of trees under plastic permits automated temperature control at lower labor and fuel costs per unit area than are required under field conditions.

7. *Permanent growing site*

   Container-growing permits the use of a permanent location and eliminates the usual practice of moving to new ground for each successive nursery.

8. *Potential automation*

   Proper system design can automate irrigation and temperature control.

9. *Salinity control*

   Under a combination of field conditions, including the use of irrigation waters containing from 250 ppm or more of dissolved salts applied in furrows between the nursery rows, injurious saline conditions may develop. The use of well-drained soil mixes and irrigation practices, which include adequate leaching, eliminate this hazard in container-growing systems.

10. *No setback when transplanting to field.*

    Balled trees experience a temporary setback when moved from the nursery to the orchard. The growth of container trees is uninterrupted by transplanting. Although the younger container grown nursery trees are usually of smaller caliper when planted in the orchard, after one season in the field, they frequently make up the size difference because no recovery period is required.

Special precautions

Container-growing is not free of problems and certain hazards must be recognized, anticipated, and preventive measures taken to avoid them. Some of the problems which have been experienced are (1) correct pH control, (2) micronutrient deficiencies, (3) rootbinding, (4) salinity, and (5) root diseases.

The first three problems are associated with the limited volume of soil used in conveniently sized containers. Salinity is associated with poor irrigation or fertilization practices, and root diseases with inadequate sanitation control.

1. *pH control*

   The optimum pH range for citrus lies between 5.5 6.5. pH values above 7.0 adversely affect micronutrient uptake. Poor growth occurs in soil with values below 4.5. Approximate pH of the soil solution can be determined by periodically collecting and testing the leachate that runs out of the drainage holes of the container. Soil pH can be regulated by varying the ratio of calcium nitrate and ammonium nitrate in the liquid feed program. Calcium nitrate will increase pH and ammonium nitrate will lower it. A liquid feed program will be discussed later under the caption "Liquid Feeding".

2. *Micronutrient deficiencies*

   Micronutrient deficiencies can be prevented by additions of appropriate amounts of micronutrients to the soil mix and by controlling pH within the desirable range discussed above. Amounts used in our mixes will be discussed under "Soil Mixes".

3. *Rootbinding*

   Rootbinding resulting from holding trees in containers too long is a distinct hazard. We have experimented with several can sizes and have standardized on a nominal "2 gallon" (actual capacity about 1.4 gallons) container, 8½" in diameter and 8½" deep. Citrus can be grown in these for as long as one year without root binding. After one year, the trees should be planted into the field or re-potted into larger containers.

4. *Salinity control*

   Dissolved salts from fertilizer or saline irrigation water sources must be kept within the tolerance range for citrus. One way to achieve this is to pursue a liquid feed program which applies dilute fertilizer solutions frequently in sufficient amounts of irrigation water to cause some leaching with every watering. We periodically run conductivity tests on the leachate collected for pH determinations and aim to maintain the soil solution below 3 millimoles/cm.

5. *Disease prevention*

   Steam sterilization is the first line of defense against soil-borne diseases and pests but carelessness in sanitation control may allow the reintroduction of disease organisms. Frequently, introduced pathogens will cause more extensive damage in sterilized soils than they would in non-sterilized soils. Strict measures should be followed to prevent contamination of tools, hoses, soil, and growing premises.

One system of container growing

It is recognized that there are many successful variations that can be used to grow quality citrus nursery stock. The system described herein is one that has been used with satisfactory results by our nursery for the past two years. The soil mix selected is one used successfully for several years by a group performing virus indexing, a program demanding vigorous plant growth free from micronutrient or other leaf patterns that would interfere with the reading of virus symptoms. The liquid feed program was also proven by the virus indexing group.

Soil Mix

The soil mix described below combines good physical characteristics, with good internal drainage, good soil moisture retention and moisture release characteristics, and adequate starting levels of nutrients.

The initial addition of phosphorous as single super-phosphate, calcium as calcium carbonate lime, and magnesium as dolomite lime appears to provide satisfactory amounts of these elements for at least one year. Nitrogen and potassium are provided in the original mix and supplemented by the liquid feed. Micronutrients are provided in the original mix.

Dry Mix

The following materials are mixed dry in a cement mixer for two or three minutes.

Materials	*Amount per cubic yard*
Canadian peat moss	10 cu. ft.
Fine sand	10 cu. ft.
Redwood shavings	7 cu. ft.
Single super-phosphate	2½ lbs.
Calcium carbonate lime	1¼ lbs.

To the dry mix, add the following ingredients in sufficient water (15 - 25 gal.) to insure good distribution of the nutrients through the soil but not enough to cause drainage of free water from the mix. Agitate the mixture sufficiently to keep the dolomite in uniform suspension.

Materials	*Amount per cubic yard*
Potassium nitrate	4 oz.
Potassium sulfate	4 oz.
Dolomite lime	3¾ lbs.
Micronutrients (see below)	1 gal. stock solution

Micronutrient stock solution

Materials	Amount/gal distilled water	Appx. ppm in soil (dry basis)
Copper sulfate	1.9 oz.	25 Cu
Zinc sulfate	0.8 oz.	10 Zn
Manganese sulfate	0.6 oz.	10 Mn
Ferrous sulfate	2.2 oz.	25 Fe

Liquid feed

Several variations of liquid feed formulas could give satisfactory results. Only two are suggested below:

Liquid feed A

Material	Amounts per 100 gal. water *applied*
Calcium nitrate	4 oz.
Ammonium nitrate	4 oz.
Magnesium sulfate	4 oz.
Potassium nitrate	1⅓ oz.

Liquid feed B

Material	Amounts per 100 gal. water *applied*
Ammonium nitrate	8 oz.
Potassium chloride	3¼ oz.

Calcium nitrate may be substituted for part or all of the ammonium nitrate for pH control purposes. Since calcium nitrate contains approximately 16% nitrogen and ammonium nitrate 33%, twice as much calcium nitrate should be substituted for each unit of ammonium nitrate.

Note that the amounts are per 100 gallons *applied.* If proportioners are used, proper ratios of concentrate to applied amounts should be calculated.

pH control can be obtained by varying the ratio of calcium nitrate to ammonium nitrate. Calcium nitrate will tend to raise and ammonium nitrate to lower pH values.

Typical propagation sequence

Compared to field growing, one advantage of the container system which also utilizes plastic growing structures is the great flexibility one has in performing the sequential operations such as seed planting, budding and forcing. One can perform any of these at almost any time of the year. The preferred cycle in areas climatically similar to Riverside, California is:

1. Sow seed in seedbeds containing the soil mix described above in March or April. Seed should be spaced to allow about three to four square inches per seed.

2. Transplant seedlings into 2-gallon containers from July to September. We have standardized on a tapered, flexible pot. These pots nest and require relatively little storage space. They also have a smooth, non-corrosive wall and the plants can easily be removed at planting time by inverting the pot and tapping the rim. They can be steam sterilized and appear to be reusable for at least three growing cycles, thereby reducing the container costs per tree.

3. The more vigorous, commonly used rootstock varieties such as Troyer citrange, Carrizo citrange, Rough lemon, *Citrus macrophylla,* and sweet orange are ready for potting first. They will be ready to bud as early as September but can be held until the following March when it is easier to force buds. In a warm plastic house, September buds can be forced to produce plantable trees by June or July of the second growing season. March budding will give plantable lemons, grapefruit, or oranges by July or August but normal planting schedules dictate orchard planting the following spring.

The cycle is longer when the dwarfing stock, *Poncirus trifoliata,* the trifoliate orange, is used. The above sequence is followed through transplanting but budding is best performed in the spring after the seedlings start their spring growth. Scions grow more slowly on trifoliate stocks and will require a full year to 15 months after budding to attain planting size.

Budding and grafting techniques

Our budding techniques are similar to those used in field propagation but some modifications have been made to accommodate smaller stock seedlings. Field grown rootstock seedlings may be 18 to 24 months old at budding time and will have attained a caliper of ¼″ to ⅜″.

Under our container-growing sequence, rootstocks are transplanted when they are four to five months old. The vigorous growing varieties may be budded as young as six months. In nearly all cases, they will have been budded before they are one year old. Caliper will range from ⅛″ to ¼″. For these smaller stocks, we prefer a veneer or chip bud over the conventional shield bud.

We have also used the "microbud" technique which was probably first used by Ian Tolley of Renmark, South Australia. Microbudding uses only the small bud, seldom more than 3/16″ long, without any surrounding wood or bark tissue. It is inserted beneath the stock bark into an inverted "T" cut. The advantage of microbudding is that very small stocks or very small budwood can be utilized when either situation must be met. Polyethylene tape is used to wrap the buds and is removed after they have healed in.

Tip grafting may be used under greenhouse conditions. One of the larger lemon plantings at the University's South Coast Field Station was propagated in this manner.

Buds are forced into growth by either of two methods of lopping. (1) cutting off the rootstock seedling above the bud or (2) bending the seedling back upon itself and tying into position like an inverted "U" with the upper bend a few inches above the bud. The first method is performed after the bud has healed in The second may be done immediately following budding or after the bud has healed in. In the second method, the portion of the lopped seedling which remains above the bud is left until the bud has grown to a height of 28″ to 30″ and then removed by a clean, smooth cut.

When the buds have reached a height of 30″ to 36″, they are tipped at about 28″ to induce lateral shoots or "head" development.

Orchard performance

Certain prejudices against container-grown citrus trees are held by growers. Their greatest concern is about root-binding and its effects on future root development and fruit production. Properly handled, that is held no longer than one year in 2-gallon pots or moved up to egg cans or 5's if longer holding periods become necessary, the trees will develop normally and be equivalent to those from field-grown, balled nursery stock. We have planted several thousand trees grown in No. 10 cans, full gallon cans, egg cans, and 5's. All have grown normally. Some have been dug up two, three and five years after planting and found to have root systems comparable to those grown from balled nursery trees.

Anticipated changes

We have an experiment in progress which compares the early orchard performance of nursery trees grown in three container sizes, No. 10 cans, 2-gallon pots, and 4-gallon egg cans. Three soil types, fine sand, UC soil mix "H", and a local Ramona sandy loam, were used in each of the three can sizes. Although the experiment is still in progress, three trends have been observed:

1. The larger container sizes required less frequent irrigation and thus would have lower maintenance labor costs where hand watering is performed.

2. The trees from the 4-gallon containers had more extensive root systems at planting time and have developed more extensive root systems in the orchard site during the first three months following planting. There are still no apparent size differences between tops. As yet there are no consistent differences in top growth due to container size or soil mix.

3. For the first two months after transplanting to the orchard, trees in the local Ramona soil, which is similar to the orchard soil, dried less rapidly and required less frequent ir-

rigation than trees grown in either the sand or soil mix.

These very limited results suggest that further studies should be undertaken to obtain more precise data on the interrelationships between container sizes, container soil-orchard soil interactions, and the first year's performance of trees in the orchard.

MODERATOR TEAGUE: Thanks for a very interesting discussion, Paul. Now, are there any questions?

VOICE: Paul, would you comment further about these microbuds? You say you have to force them out real fast.

PAUL MOORE: Yes, they are so small that the callus around the cut will bury them if they're not forced into growth rapidly. One way of doing this is to actually lop the seedling at the same time you bud. That is, insert the bud and lop it at that time. The bud will heal and will force a little more rapidly than if you allowed, say three weeks for it to heal, and then lop it.

BRUCE BRIGGS: Did you try to use any liquid hormones sprayed on the avocado leaves to help stimulate root formation up the stem?

CRAWFORD TEAGUE: We've never used any hormones in avocado propagation at all; they seem to be useless on avocados.

VOICE: Have you had any success in rooting kumquats and other difficult citrus?

TED FROLICH: We have worked with kumquats some; we find that, unlike other citrus, we have to cut the tree back hard to get very rank thorny, angled shoots; we can root such wood but when we get it rooted we still don't get a very good plant — not nearly as good a plant as if you bud it on another rootstock. Kumquats are rather poor on their own roots. We would recommend against it.

CRAWFORD TEAGUE: We've budded kumquats on Troyer citrange and Trifoliate orange; they make very fine trees.

GENE BACIU: What varieties of citrus seeds produces the fastest growing seedling in the nursery?

PAUL MOORE: Usually the acid types of citrus, such as Rough Lemon or *Citrus macrophylla,* grow very rapidly. Also some stocks, such as Troyer and Carrizo citrange produce very good trees in contrast to the more dwarfing stocks like Trifoliate orange. The most rapid growing would be Rough Lemon, *Citrus macrophylla,* and Rangpur lime — very vigorous rootstocks. The Rangpur lime is very subject to brown rot gummosis, so is not a preferred stock. Rough Lemon is resistant to gummosis and is commonly used in the ornamental trade because of its rapid growth. Troyer citrange is resistant to these root disorders and is also a vigorous rootstock, imparting a couple degrees of frost resistance to the tree and produces good quality fruit, too.

VOICE: Are commercial citrus growers reluctant to use nursery trees grown in containers?

PAUL MOORE: Yes, there is a reluctance; I think it stems from the feeling that anything grown in a container is apt to be pot-bound and will not give good performance. This is one reason why I spent a little time with the slides showing that normal root systems can develop from container-grown trees; when moved out properly I don't believe the commercial grower has anything to fear from this. We might design a better shaped pot. I think the ideal container would be two pots deep and one pot in diameter. This would give something that is similar to the size of a balled and burlapped commercial tree, and in fact I could have shown you some pictures of trees that were grown in a double egg can, one on top of the other, with excellent root development — no twisting roots — that would be every bit as good as from a field-grown nursery tree. Maybe before the prejudice is overcome, however, the commercial citrus nurseryman may have to go to a pot that is, conceivably, a better shaped pot in the mind of the orchardist.

CRAWFORD TEAGUE: I might point out that we're growing quite a few thousand container-grown trees, and we're also putting them out in our own groves. If we're not afraid to use them, and if we can show good trees in the field after several years, perhaps most of our customers will go along with this procedure — but they're very reluctant to change.

RON HUROV: What are the problems associated with growth of avocado cuttings once they're rooted?

TED FROLICH: They just seem to be tempermental for about a year or two. If any thing happens to defoliate them, the plants will die. On the other hand, if you have a seedling, you could pick all the leaves off it but it will just grow new leaves and every thing will be fine; an avocado cutting in its early stages — for a year or two — is a very tempermental thing. If we cut them back to graft them, we very often lose them. Once they get up to a certain point, they grow just as well as seedlings; we don't know basically what the trouble is.

THURSDAY AFTERNOON SESSION

October 13, 1966

VICE-PRESIDENT HENRY ISHIDA: Our first panel this afternoon will be on Soils and Fumigation and the Moderator is Dr. Robert Ticknor, from the Northern Willamette Valley Experiment Station, Aurora, Oregon.

MODERATOR TICKNOR: Thank you, Henry. To get started we will have Jerry Hanes of Tri-Cal speak to us on chemical fumigation. This will be for field production, I understand. Jerry:

CHEMICAL FUMIGATION

GERALD L. HANES
Tri-Cal, Inc.
Placentia, California

Soil fumigation in California has developed very rapidly during the last few years. This recent rapid development has been mainly through the utilization of the very volatile fumigant, methyl bromide. Prior to this time control of weeds, nematodes, and fungi by fumigation was accomplished with the slowly volatilizing chemicals.

There still are large acreages being treated with these less volatile fumigants. Some of the most common chemicals used are dichloropropane-dichloro-propene (D-D), carbon bisulphide, methyl isothiocyanate, chloropicrin, allyl alcohol, and dibromochloropropane (DBCP).

The individual fumigants have their own application techniques and soil requirements, and it is not possible to list a set of rules applicable to them all. Generally, however, they require the following: soil moisture in excess of 40% field capacity but less than 80% field capacity. It is best that the soil be moistened and the moisture maintained ten days before application of the fumigant. The soil should be worked to seed bed condition and rototilled if necessary. The application of fumigants is generally done through chisels mounted on a tractor. The chisel spacing varies from 4″ to 12″, dependent upon the diffusion pattern of the fumigant. Depth of application is also dependent upon the diffusion pattern and is from 4″ to 8″. After application of the fumigant, the soil is usually packed, and in some instances a light water seal is applied. With the increased use of tarp layers some of the slowly volatilizing fumigants are being sealed in with polyethylene film. After lying undisturbed for not less than ten days the soil can be worked. The soil cannot be planted until the fumigant has escaped. This aeration period may vary from 10 to 90 or more days depending upon the fumigant used, the dosage, soil temperature, and soil moisture.

Prior to about 1957, the very volatile material, methyl bromide, had limited use because of its cost and difficult application. Fumigation was accomplished by introducing methyl bromide beneath a gas tight tarpaulin that was slightly raised above the area to be treated and sealed at the edges by soil. This method is still used for fumigating flats of soil or small areas such as golf greens. More fumigant must be used with this method, so the cost of material would be about $400. The cost of labor is also very high. In 1956 work was commenced in introducing methyl bromide into the soil through tractor-mounted chisels and covering the area with a gas-tight tarpaulin by hand after the injection was made. The methyl bromide was diluted with a petroleum hydrocarbon to reduce its vapor pressure, thus slowing its escape from the soil so there was time to spread the tarps over the area.

This method was quite an advancement for several reasons. It reduced by half the amount of methyl bromide required. It was no longer necessary to raise the tarpaulin off the soil and therefore thinner and cheaper tarpaulins could be used. It enabled the utilization of larger tarpaulins. Labor was reduced from $100 per acre to less than $20. The above factors reduced the cost by more than half and thereby made its use on large-scale operations practical.

In 1961 tarp-laying machines came into use. The first models were quite crude, but their effectiveness is proven by the large number of improved machines that are being used today. The major factor in the development of this tarp-laying technique was the plastic film producers ability to produce film thin enough to use once, then throw away. By using tarpaulins that are disposable after using only once, fumigation can be accomplished in a very short period of time, and labor requirements can be drastically reduced. A machine can handle much thinner material without damage than can be handled by men. Also tarpaulins can be laid by machine under weather conditions that would render other methods of application very difficult, if not impossible. The machine application of tarps is now perfected to the extent that it is possible to lay between 10 and 20 acres of tarp per day.

Chloropicrin is used mainly for high activity against soil-borne plant disease organisms. Its weed and nematode control qualities are not satisfactory when its cost is taken into consideration. Methyl bromide, at weed and nematode control dosages, is not satisfactory for control of soil-borne diseases. Methyl bromide, however, has disease control properties, as chloropicrin has weed and nematode control properties. Experimentation was commenced to evaluate mixtures of these two materials. It was found that a mixture of 100 pounds methyl bromide and 200 pounds chloropicrin per acre controlled nematodes, most weeds and most disease organisms. Also a mixture of these fumigants in opposite proportions (100 pounds chloropicrin and 200 pounds methyl bromide) performed nearly as well. Today, if methyl bromide is to be used, chloropicrin is generally added to give disease control as a bonus. If chloropicrin is to be used, methyl bromide is added to give weed and nematode control as a bonus. The added cost by these additions is not excessive because the qualities of each fumigant are enhanced by the action of the other. Aeration of soil for two days is sufficient following methyl bromide fumigation. Ten to 14 days are required for methyl bromide-chloropicrin combinations.

Generally the end result of a fumigation is failure when the principals are not thoroughly familiar with the fumigants they are using, or if they are unaware of the susceptibility of the weed seed or pathogen to be controlled. Failure can and most likely will occur, irrespective of the fumigant used, if improper application techniques are used, or if soil condition requirements are not met, or if an incorrect dosage is applied.

MODERATOR TICKNOR: Thank you, Jerry. Our next speaker is one whom I think most of you know, Mr. O. A. Matkin. He will speak to us on recent developments in soil mixes. Mr. Matkin:

SOIL MIXES

O. A. MATKIN
Soil and Plant Laboratory, Inc.
Orange, California

The term "soil mix" is rapidly becoming a misnomer. In recent years there have been millions of plants sold which never saw "soil" as such. In the past two decades we have seen a radical departure from the old "green thumb" approach to plant production. The beginning of a new philosophy probably had its start with the John Innes approach in England. With the publication by the University of California of Manual 23, titled "The UC System For Producing Healthy Container-Grown Plants", an overall philosophy was outlined which has become an accepted approach throughout the world. In any final analysis of events which have occurred and will occur, economics must be accepted as the dominating factor.

Since the number of potential soil mix preparations is infinite, we should look first at the underlying economic factors which must influence our choice of formulation.

1. Cost of raw materials is an obvious consideration. Why pay $5 for something which can be obtained in equal quality for $2.50? The term "quality" is not always easily defined, but must inevitably show up in some phase of economic evaluation.
2. Cost of mixing can be a substantial factor. Equipment, man-power, and storage areas all have values which can be assigned. Materials which are difficult

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2. Cost of mixing can be a substantial factor. Equipment, man-power, and storage areas all have values which can be assigned. Materials which are difficult

to blend may be very costly to use for that reason. The time is coming when specialists will prepare custom mixes to save the grower and the landscaper time and money. There are already a few instances of this type of activity.

3. Cost of transportation is becoming an increasingly important factor. Not only does the soil and the container have to be transported within the confines of the production area, but long-distance shipping may also be involved. It is no longer unusual for California-grown container plants to be sold in Eastern United States. Some are even shipped overseas.
4. Cost of cultural care can also be influenced by soil mixes. The more porous mixes usually require more frequent application of both water and fertilizer. Usually the cost of these items is not considered a major investment, but cost of application of fertilizer and water can be very important. With the modern mixes and the need for more precisely controlled cultural conditions, it is not surprising to find automatic irrigation and constant liquid-feed injection becoming common place.
5. Cost due to overhead during the period of growth is commonly figured in terms of cents per square foot per month. Since this type of overhead is inescapable, it follows that the more rapid the growth and development of plant material to point of sale, the lower the overhead investment in the product. Both uniformity of growth and speed of growth become important, since growing areas involved often can not be replanted until the last plant has been removed. Numerous growers have reported as much as a 50% reduction in growing time by converting to more modern methods.
6. Cost of producing "quality" plants might well be considered as an additional factor. Although growing media are frequently held responsible for this vague property, it is more often the result of cultural care and environment. Such simple tasks as trimming and and spacing at appropriate stages of growth often make the difference between a saleable and an unsaleable product. Fast production methods require alert growers and constant attention.

With full appreciation of the foregoing underlying influences, one should be prepared to attack the task of soil mix formulation from available materials and get the desired results.

DESIRABLE CHEMICAL PROPERTIES

1. Low salinity is normally required and desirable, though in some instances slightly elevated salinity may produce a better quality product at the expense of speed of growth. This

has been evident in such crops as pot mums where height control is important and in the production of certain vegetable plants such as celery and tomato seedlings for transplant into the field.

2. "Optimum" fertility is another desirable feature under most circumstances, but again, there are some conditions where this may not be the case. For instance, there is the bedding plant grower who wishes to hold back an early planting of petunias so that it will be in saleable state at the peak of the season. He may omit nitrogen and allow the plants to become quite yellow and stunted, knowing they can be quickly greened up when the time is ripe. Excessive fertilizer may be employed to provide the semi-stunting effect of slightly high salinity.

3. Freedom from toxic minerals or compounds which may accidentally be present or may be evolved through such treatment as steaming or fumigation is of primary importance.

4. Maximum practical nutrient retention is desirable. Although clays impart this property in the form of high cation exchange capacity, the many shortcomings of clay usually prevent its use. Few artificial or specialty products provide this property in appreciable degree. Peat moss is among the best.

PHYSICAL PROPERTIES

1. High water infiltration rates virtually assure high porosity and adequate air space after drainage. For very shallow soil columns, it may be necessary and desirable to obtain *unusually* high rates for assured aeration.

2. Maximum practical water retention commensurate with aeration is desirable under most circumstances. Certain exceptions are noted, as for instance, in propagating media where mist is to be applied, or, in container glasshouse growing in the northern states during winter months when rate of drying is extremely slow.

3. Resistance to loss by decomposition might be considered important in many uses such as landscape installations or permanent beds for cut flowers growing. Decomposed organic materials can attain some of the undesirable features of clay.

4. Low density is often desirable in containers and in modern landscape on rooftops or similar locations. Usually the low density products impart unusually high porosity. However, mixing of unlike materials can frequently defeat the purpose. For instance, consider mixing equal volumes of course perlite with sand. The resulting mixture tends to have properties more like sand than like perlite, since the fine particles infiltrate the voids between the larger perlite particles. To the extent possible, uniform particle sizes should be employed for all additives.

CURRENT TRENDS

1. Peat moss has long been a basic standard amendment and is commonly used as part or even 100% of the growing medium. Besides cost, a major shortcoming has been lack of standardization of grades. As a result, many growers have been anxious to obtain reliable *substitutes.*

2. Wood residuals such as sawdust and bark, have come into widespread use, particularly on the West Coast. This approach has become feasible and economic, as we have learned how to provide necessary nitrogen additives to compensate for their primary limiting factor. Emphasis in use has been placed primarily on those materials resistant to decomposition. The demand often exceeds the supply in California. A new approach is the preparation of the amendment in such a manner that only a little sand, soil, or other mineral need be added to provide a complete planter or growing mix. All fertilizers have been incorporated in the amendment.

3. Minerals of various types have been successfully employed including the original fine sand recommendation of the UC System. Currently many container mixes include, as a substitute for all or part of the sand, such materials as pumice, haydite, calcined clay, perlite, and vermiculite. Except for vermiculite, these materials provide little except physical stability and low density. They actually reduce the water holding capacity of the medium in which they are mixed. Vermiculite is less stable physically, but does have a unique property of providing substantial potassium in an exchangeable form. As a result, where it is used in high proportion (20% by volume or larger), it becomes unnecessary to add potassium fertilizer to the mix.

Since propagation is foremost in the minds of many, it should be pointed out that the desirable physical conditions of a growing medium are commonly employed in the preparation of propagating media. The only difference might be the elimination of chemical additives, since fertility is not an essential factor in propagation and can sometimes be inhibitory. It might be mentioned, however, that the addition of certain amendments such as lime to peat/perlite mixes often improves rooting response. The effect of pH on root initiation is, we believe, worthy of additional academic research. Two crops showing marked response in our experience have been peperonia and poinsettia.

SOIL MIX FORMULATION BY FACT AND LOGIC

1. The first step is that of selection of bulk ingredients. Materials which satisfy the practical and economic requirements should be prepared in various ratios until properties of infiltration rate and water holding capacity appear satisfactory.

2. The chemical properties of each bulk ingredient should be thoroughly reviewed and an estimate made of chemicals

most likely to be required to attain optimum fertility. This may require analysis of each component or an analysis of the final physical mix.

3. Since missing or low elements must be supplemented, it will be helpful to have in mind normal rates of addition which will result in good nutrient supply without excess. Both form and quantity of additive must be considered. For instance, it is undesirable to add materials which will contribute to high ammonium nitrogen availability for sensitive crops such as bedding plants, carnations, and numerous bare-root cutting crops. Also, it must be kept in mind that maximum tolerable quantities to avoid salinity effects will vary with the buffer capacities of the physical components. For instance, one pound of potassium nitrate per cubic yard of sand is high, but the same amount per cubic yard of clay or peat moss is low. Following is a list of commonly used chemical fertilizers and amendments and an average rate for an hypothetical container mix:

	Typical Addition Rate	*Elements Supplied*	
Chemical Fertilizer	(Am't /cu yd)	Primary	Secondary
Blood meal or other high N organic	2 - 5 lbs.	N	
Calcium nitrate	1 lb.	N	Ca
Calcium sulfate (gypsum)	2 - 5 lbs.	Ca, S	
Iron sulfate (ferric or ferrous)	1 lb.	Fe	S
Lime - calcium carbonate	0 - 20 lbs.	Ca (rise in pH)	
Lime - dolomite	0 - 20 lbs.	Ca, Mg (rise in pH)	
Magnesium sulfate (Epsom Salts)	2 lbs.	Mg	S
Potassium nitrate	1 lb.	N, K	
Potassium sulfate	1 lb.	K	S
Potassium chloride (muriate)	1 lb.	K	Cl, B (?)
Sodium borate (Borax)	1/4 oz.	B	
Sulfur	1/2 lb.	S (lowers pH)	
Superphosphate, 0-20-0	2 1/2 lbs.	P	Ca, S
Superphosphate, 0-45-0	1 lb.	P	Ca
Synthetic slow release	Mfrs. instructions	N, etc.	

Considerations should include elements supplied or not supplied in the irrigation water. If the planted crop is to be placed on constant liquid feed, no reserve nutrient (e.g. blood meal) will be required. This will allow young plantings to be placed on the same program as old. Phosphate will normally be added in sufficient quantity to last for the full crop life or at least one season.

4. After the best estimate of formula has been tabulated, a trial mix should be prepared for test growing and for laboratory analysis. Following this, some minor modifications may be required. Once a good mix has been developed, any

changes should be made only after careful comparison of growth results.

One very important consideration for any growing medium is freedom from disease. Ideally, the mix will be steamed or fumigated prior to use. This is a necessary part of soil mix preparation.

MODERATOR TICKNOR: Our next speaker, Mr. Fred Petersen, is from the same firm. He is going to talk on the subject of aerated-steam. Fred:

COMMERCIAL APPLICATIONS OF AERATED STEAM

FRED H. PETERSEN
Soil and Plant Laboratory, Inc.
Santa Clara, California

STEAM-AIR OR AERATED-STEAM. These terms are used to describe a system or method of soil treatment in which treatment is obtained by exposing soil to a mixture of steam and air. The temperature of the resulting mixture is controlled below 212°F. by adjusting the ratio of steam to air according to established physics. While any treatment temperature between that of ambient air and 212°F. is possible, the temperature range between 140°F. and 160°F. appears most ideal.

PROGRESS. If measured by the number of successful installations now operating at high efficiency, and yielding daily benefits to nurserymen, such progress in my opinion can be summarized as:

California — Disappointing to a point of concern.
England — Encouraging as expected, since the concept is British.
Australia — Enthusiastic, as evidenced by the manner in which Australian growers installed systems after a brief, but complete, introduction to the benefits aerated-steam offers.
Eastern United States — Encouraging, as indicated from fragmentary reports.

However, if progress is measured by the quantity and quality of words already spoken or written, such progress would in my opinion, place California in a paramount position. Paramount, I maintain, because of the excellent papers and speeches which have been presented to California growers by many experts, foremost of which is Dr. K. F. Baker of the University of California at Berkeley.

Nurserymen the world over have been literally blessed with much of Dr. Baker's early work, the most familar of which is his editing of University of California MANUAL 23, the *UC SYSTEM FOR PRODUCING HEALTHY CONTAINER* changes should be made only after careful comparison of growth results.

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GROWN PLANTS, published in 1957⁽¹⁾ Section 10 of this Manual contain these words which are as applicable now as they were in 1957:

"Any successful mechanized nursery program must include, indeed must be built around, soil treatment".

In Section 9 brief mention is made of aerated-steam, concluding with the statement:

"This method is not yet ready for commercial application".

Steam and its ramifications have been discussed thoroughly by others. Why then is it important for us to re-focus our attention on this time-old subject? For the following reasons:

1. Toxins are often released from soil mineral and/or organic constituents by high temperature treatment. This effect is virtually eliminated at lower temperature treatment. (Manganese toxicity is a common problem at the higher temperatures.)
2. Although all pathogens are killed at 140° F., many saprophytic organisms survive. These remaining organisms constitute a biological buffer against chance re-invasion by plant disease organisms. At higher temperatures most of the saprophytes are killed.
3. Spores of certain dormant saprophytes may, by low treatment, be induced to germinate, thus increasing the biological buffer.
4. Many plastic containers can be exposed to temperatures up to 160°F. without damage. Soil treatment in plastic containers has not been possible at the higher temperatures.
5. It takes less energy to raise the soil to a temperature of 140°F., hence the average savings in steam (and therefore cost) can be as high as approximately 50%.

To achieve these benefits soils are best treated with aerated-steam.

How do we obtain this material labelled aerated-steam? Who sells it? What equipment is required? What does it cost? Answers to these and other questions can be found in the following publication which I encourage you to obtain and study: Proceedings: *TURF, NURSERY AND LANDSCAPE TREE CONFERENCE*. University of California — Davis, California, February, 1966.

Dr. Baker writes in his paper: "Growers can now heat soil, stationary or moving, to any desired temperature in any of the standard equipments used in California", and: "aerated steam is thought to be complicated and difficult to use. The only additional equipment involved is a blower. Operation is similar to, and no more complex than use with ordinary steam. Grower experience is in accord with this fact".⁽²⁾

Mr. Robert Brazelton, Extension Engineer of the University of California, Agricultural Extension Service, follows Dr. Baker's paper with an excellent discussion of the subject from an engineering point of view. The specific system he describes was designed by Laboratory personnel following an earlier design reported by F. W. Taylor in Australia. Mr. Brazelton's paper contains sufficient information to permit any mechanically-inclined nurseryman or well-advised welder to construct satisfactory equipment. Mr. Brazelton wisely states advice I would repeat and encourage you heed: "Do not, however, think that if you wait 2 years, the bugs will be ironed out, and you will have necessarily gained an advantage, because the units as they are now designed are sufficiently efficient and durable to be classified as unqualified successes as is". (2)

HISTORICAL REVIEW

1954-1955 — English work on the subject of aerated-steam by Morris and Bunt was discussed in UC Manual 23. (1)

1957 — U.C. Manual 23 was published with all of its ramifications regarding steam sterilization.

1961 — Dr. K. F. Baker, on leave at the Waite Agricultural Institute, Adelaide, South Australia, published: Principles of Heat Treatment of Soil and Planting Material. (3) This paper led to F. W. Taylor's work: *A Method for Heat Treatment of Soils Using Steam and Air Mixtures at 140°.* (4) This work by Taylor described and contained plans of a system installed at Paramount Nurseries in Australia.

1962 — Dr. John Ferguson and Mr. Paul Ecke, Jr. described a steam-air system utuilizing a Venturi. (5) This approach has since been, for all practical purposes, discarded because of lack of precision, back-pressure problems, and cost.

1962 — At Brown Bulb Ranch, Capitola, California, the first known vault-type aerated-steam system in California was installed. Total modification cost to an existing vault was approximately $50.00. In-field tests were performed by Dr. Carl Olsen, then a graduate student of Dr. Baker's at Berkeley. This system is in use and is yielding excellent results, particularly in the treatment of seedling flat media.

1963 — Our Laboratory published a brief note in an advisory form to our clients pointing out key factors involved in aerated-steam.

1963 — At Kitagawa Nursery in Redwood City, California, the first known California-built bulk type soil treatment system, patterned from Taylor's paper, (4) was constructed by Mr. Richard Kitasoe, owner of Kitagawa Nursery. This system was evaluated by Dr. Arthur McCain and Dr. R. H. Sciaroni. (6) Though describing the system as installed, and reviewing some aspects of aerated-steam, their work apparently did not stimulate significant progress. The key points of biological antagonism and potential toxicity reduction were apparently overshadowed by the paper's stress upon chemotherapy methods.

1964 — At Sunnyside Nurseries in Hayward, California, a large vault-type system for treating flat material was constructed. This system still requires substantial modifications to overcome present well-understood defects including: high radiation loss through steel walls, excessive size, and noise. This system, however, did demonstrate the practicality of treating plastic containers, and in-field tests conducted by Dr. Baker, Dr. Olsen, and Mr. Bill Fuller of the Department of Plant Pathology, University of California, Berkeley, indicated extremely uniform temperature distribution, and basic conformance to principles.

1965 — A system utilizing a concrete mixer was described by Griffin, Maire and Humphrey in University of California Agricultural Extension Publication AXT-177.(7) The concrete mixer method has the obvious advantage of being an extremely inexpensive system. This approach, however, may have the deficiency of a prolonged cool-down period introducing the possibility of over-kill. The quality of temperature control, and of temperature measurement are also of some concern, since the treatment container is constantly in motion.

1955-1966 — At Azalealand Nursery in Mt. View, California, the owner — Mr. Mario Pocchini — constructed a portable, bulk-treatment trailer, specially designed for treatment of peat moss. Design parameters were established by the Laboratory following Taylor's basic concepts, (4) as further modified by the suggestions of Dr. Baker, Dr. Olsen, and Mr. Brazelton. Performance tests were made by Dr. Baker, Mr. Bill Fuller, and by Mr. Brazelton who had earlier provided valuable back-pressure data. Test summaries and conclusions indicated several advantages of the Azalealand unit, including:

(1.) The portable nature and tilt-down side design permits its use as a potting bench.
(2.) The plenum chamber aerated-steam introduction technique permits rapid "turn-around" time, since media rises to the treatment temperature in approximately 20 minutes, and can be cooled to ambient temperature in approximately 40 minutes after the treatment period. Potting, therefore, is practical 1½ hours after loading.
(3.) The design yields excellent temperature control, and distribution of heat once the desired treatment temperature is reached.
(4.) With a minimum of further investment, such a system could be completely automated.

Materials of construction could quite likely be improved in further units of this type, as more specifically detailed by Mr. Brazelton in his paper presented on this subject. (2)

SUMMARY — The use of aerated-steam is probably the most significant pathological soil treatment advance in nine years. It is unfortunate that more widespread advantage has not been taken of this opportunity.

In retrospect, several factors have apparently combined to limit more common useage of the aerated-steam technique. These factors probably include.

(1.) Delay and procrastination on the part of our firm in publishing results such as were obtained with the Azalealand unit reviewed by Brazelton.(2)

(2.) Apparent lack of physical capability of the Agricultural Engineering Department of the University of California. Resources of this Department are seemingly strained, and if supplemented in the future, additional capability could probably be developed utilizing the skill and efficiency of the present staff whose enthusiasm was amply demonstrated by the assistance rendered in the Azalealand project.

(3.) Lack of demand from the growers best summarized by the "Let the Other Guy Go First" philosophy.

(4.) Hesitancy on the part of industrial suppliers of required equipment. Many suppliers contacted saw an apparently limited market for equipment, and because of economics would not devote a substantial research and development effort. As demands increase, and sales projections rise, industry can hopefully be encouraged to devote a greater share of research and development capability in this direction. The result could be availability of complete, professionally engineered systems.

THE FUTURE — At the present time the "Let The Other Guy Go First" philosophy does not appear to offer a valid excuse for lack of progress. Though imperfect in some ways, the systems now in use have provided a sound basis from which other growers can logically proceed. The expert comments and advice of Mr. Brazelton and Dr. Baker would appear to substantiate this. Additional efforts by the University of California, Agricultural Extension Service, in communicating and expanding upon information already developed would also be helpful to California growers who depend heavily upon the communications and advice of the Extension Service at the Farm Advisor level. Farm Advisors in California undoubtedly would be pleased to render additional service in the future depending upon the climate of reception at the grower level. It would appear, therefore, that not many new words can be found, but that many new systems can be constructed.

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MODERATOR TICKNOR: Thank you, Fred, for a most stimulating discussion. Now we will have Dr. Falih Aljibury speak to us on controlled-release fertilizers.

CONTROLLED-RELEASE FERTILIZERS

F. K. ALJIBURY
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In recent years there has been considerable interest in the use of the so-called "slow-release" or "controlled-release" fertilizers. The use of such products has offered several advantages:

(1) They can be applied at the rate required by the plants without causing excessive loss by leaching.
(2) The nature of the release allows for reasonable mistakes and over-application without burning the plants.
(3) Frequent application of fertilizers will not be required.

The characteristics of the slow-release and long-lasting fertilizers described in this paper are attributed to the following techniques:

A. *Membrane Coating.* Fertilizers are coated by membranes of various sources and thickness. When the fertilizers are in contact with moist soils, water enters through the membrane and dissolves some of the fertilizers in the capsule. The dissolved fertilizers diffuse out of the membrane into the surrounding soil. The rate of release is manipulated by the thickness of the membrane. This technique may provide a release rate of one to two per cent per day.

B. *Metal Ammonium Phosphates* — Divalent metals such as magnesium, ferrous iron, zinc, manganese, and copper can be found in slowly soluble compounds. When the fertilizer comes in contact with water, it dissolves until saturation. When the nutrients are used up by plants, the equilibrium is upset and thus more fertilizer is dissolved. The rate of release is influenced by pH and the degree of soil wetness. The rate of release is also influenced by the size of the particles and the method of application. Incorporating the fertilizer in-

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C. *Synthetic Organic Nitrogen* — Kaempffe of UCLA showed that under best environmental conditions, nitrogen in urea-formaldehyle is mineralized at the following rates:

25 — 35%	in in three weeks
35 — 50%	in four weeks
50 — 75%	in six months
6 — 10%	free urea available at once

Temperature, aeration, moisture and pH affect the rate of mineralization.

D. *Natural Organic Nitrogen* — Most of these materials mineralize in about four to six weeks. Since they don't mineralize immediately, their use has been considered by many to be safe. In recent years, it has been observed that these materials have become more expensive and less available.

Moderator Ticknor: We can now start in with the questions. Who has the first one?

Voice: In treating the soil chemically, is the equipment flow-rate timed with the tractor speed so that the application is not guess work?

Jerry Hanes: Yes, that's right. Our method now is to use a flow regulator that is related to the speed of the tractor so that if the speed is increased because of the soil being hard or slowed down because it's fluffy, the metering device is regulated so the fumigant flows through at a desired rate. Then we can have different rates; we can apply anything from 100 lbs. per acre to 600 lbs. per acre.

Voice: That's done manually —

Jerry Hanes: Yes, that's all done manually.

Voice: Then, the next question is, what is the cost per acre?

Jerry Hanes: Well, that depends on the proportion of methyl bromide and chloropicrin used and the rates of application. An average treatment of two parts methyl bromide and one part chloropicrin, at 300 lbs. per acre, in a ten-acre field, runs about $300 per acre applied.

Ron Hurov: How long do you treat the soil with air-steam?

Fred Petersen: Thirty minutes. A three cubic yard load of peat moss reached uniform temperature in 18 minutes and the treatment temperature was held for 30 minutes and the cool-down was approximately 45 minutes to get it back to ambient — so we figure in this system we have about 1½-hour to a 2-hour "turn around" time. That is fill, treat, cool-down, and pot, which offers some advantage. This cool-down phase has been neglected by others but is quite important both in preserving the biological community as well as enhancing the economics of it.

JIM HINES: I have another question for Mr. Petersen; two or three questions, actually. You have criticized us for not using this air-steam. You've passed this problem along to us and blamed everybody.

FRED PETERSEN: Including myself, you know. First of all, I listed ourselves.

JIM HINES: I may not be up on these things, but how do you treat 100-cubic yards a day?

FRED PETERSEN: Fumigation would undoubtedly be the fastest method. As a matter of practice, I don't think there are equipments available for air-steam. I think the technique could be modified for a continuous flow system. However, an increasing number of nurserymen concentrate their highest level of sanitation at the liner, seedling or propagation phase and depend upon other methods, such as fumigation, for treating soil in the magnitude of 100 cubic yards a day. We only work for one client, I think, that has capability of producing soil-mix in that quantity. In his soil stock pile, a self-generating heat process is used; tests were run — that is, biological plating was done of material removed from the bottom of this pile. It was, disturbingly, too clean! That is, it had essentially cooked itself out. In our repertoire of clients I know of only one container nurseryman who is still steam sterilizing his soil. I know of one, up north, who is still steam-sterilizing every bit of soil; that is, from the liner, flat, seedling, propagation stage. I think, if the demand for a system such as you require is made, it's simply a matter of enough steam and of enough air and a moving system; it would be practical. I think Dr. Baker has covered this quite thoroughly. One system which he originally stressed was a continuous-flow; it would just be a matter of mechanics.

JIM HINES: Would the mechanics get out of proportion — in cost — to what you're doing?

FRED PETERSEN: Well, I think it has been a matter of economics which has kept people from steaming large volumes of soil initially. That is, neither a vault nor a tarp method lend themselves particularly well to efficiency, in time. The only client, again, that I know is steaming is doing it in the back of a truck, which is a bit unwieldy. If a person was presently steaming 100-cubic yards of soil a day, all I can say is that he would be expending substantially fewer dollars to convert to this system. Can you give me some idea, for example, of how a person is steaming 100-cubic yards a day?

JIM HINES: We're using methyl bromide.

FRED PETERSEN: I think it would be prohibitive to convert to a steam process for that quantity of soil simply because you've already decided, I think, to use fumigation, rather than steaming, for the reason of economy.

JIM HINES: Then the other question, what is the cost of dry heating versus steam?

FRED PETERSEN: I do not know if you have reference to heating cables or to a conduction rotating kiln, type heating: such conductive heating is strongly discouraged by most qualified plant pathologists and is felt to be quite hazardous from a standpoint of toxicity because you lose the basic value of steam when you go to conductive heating. Steam has the unique ability to flow to a cold point, then condense, so you are actually heating only the particles which requires heating as opposed to a conductive method. For example, in a rotating kiln — as in used in asphalt production — there is a heated surface; a popcorn cooker I guess would be a good analogy. Here the particle has to be physically heated by contact. Aside from the toxicity standpoint of charring, the biological problem is very real because the pathologists would tell us that most organisms are best controlled in the moist condition and conductive heat would not work well because we have to heat so much water.

JIM HINES: One last question, you brought up the idea concerning a nursery that is using a composting effect, or storage pile, and is building up this heat. What temperature does it get to?

FRED PETERSEN: It was over 170°F.

JIM HINES: How does he sterilize the outer edges of the pile?

FRED PETERSEN: Fumigation.

JIM HINES: There's no way to capture the heat that so the whole pile will be sterilized?

FRED PETERSEN: Attempts have been made by tarping, but unfortunately the piles were 30 to 40 feet tall and in a windy area. Repeated attempts to get an economical tarp were pretty difficult, that is a tarp that would stay in place long enough to conserve and trap this heat. A tarp such as Jerry suggests was satisfactory for the overnight period for surface fumigation.

I think the greatest value of aerated-steam in a container nursery is in the propagation phase. In general, experience suggests that this is where most people are placing most emphasis on sanitation. That is, the old secret of let's get a clean, healthy, vigorous- growing, liner. By the time a liner reaches a gallon can, it has been handled many times mechanically. The likelihood is that it has been infested to some degree, even under the strictest levels of sanitation; so to put that liner into something aseptic is breaking one of the cardinal rules of pathology. This is why I make the remark about the stockpile soil. In the opinion of an eminently qualified pathologist, that soil was too clean. It had no biological antagonists.

JIM HINES: Now then, you've brought up another question. I think your company recommends methyl bromide for fumigating large piles of soil and at the rate we're required to put it on, we are ending up with a sterile medium with infected liners.

FRED PETERSEN: I seriously doubt whether you're winding up with sterile media. With methyl bromide, it's my understanding that it is a good herbicide, a terrific nematocide, but there are a lot of disease organisms, a lot of fungi, that it will skip.

JIM HINES: This is one of the reasons for adding chloropicrin, is it not?

FRED PETERSEN: Right. So it would appear that if you are fumigating with methyl bromide alone, you are leaving a substantial fungus population. You would have to.

ROBERT BODDY: This is another question for Fred Petersen. Has any determination been made on the size of a boiler — BTU capacity — that would be required for a small scale operation, say one cubic yard a day, or five cubic yards a day, or a continuous operation that might build up to five cubic yards a day?

FRED PETERSEN: Yes. The numbers, Bob are well defined. We use the factor: 200 times the cubic yards — if you want to jot this down — 200 x yards, cubed = pounds of steam per hour required. This is a good safe ball-park figure, probably a bit on the high side; pounds of steam, of course, can be translated back into the capability of any boiler system. In general, it works out that for something around 10 cubic yards, as I recall without referring to notes, it is around 25 to 30 "boiler horsepower"; "boiler horsepower" is not a particularly efficient way to gauge a boiler.

ROBERT BODDY: You mentioned this one party converted to air-steam for $500. That is assuming he already had his boiler.

FRED PETERSEN: Yes, he had the boiler.

ROBERT BODDY: A 25-horsepower boiler would be worth about $5000.

FRED PETERSEN: Oh, yes. In fact we have recently been in the process of looking at flash steam generators, and the price is no small item. This particular one, I believe, was a 50-horsepower — with all the goolie-bobbers on it — for around $7000. However, it's the same old question — what does it cost per liner?

PETER VERMUELEN: Dr. Aljibury, have you found a direct relationship between rate of release of your slow-release fertilizers and soil temperature?

DR. ALJIBURY: Yes. This would be particularly true for urea-formaldehyde. It has been reported that there is not much correlation between release from the capsule, or from the coated materials, and temperature — but with a urea-formaldehyde type and with metal-ammonium-phosphate, there is such a correlation between increasing temperature and greater release.

PETER VERMUELEN: We had a sad experience with some azalea crops in 2¼ - inch pots. We lost quite heavily on the crop with a product that you mentioned. This was attributed to a higher soil temperature than is normally experienced outside. This happened to be in a greenhouse and has been acknowledged by the company.

VICE-PRESIDENT ISHIDA: Our final session this afternoon is on tissue, or meristem, culture and the moderator will be Mr. Richard Maire, Farm Advisor from Los Angeles County. Dick —

MODERATOR MAIRE: Thank you, Henry. I think if we have anything new or exciting in the field of plant propagation, this topic is one of the most exciting. We have two people who are well qualified to cover this subject. Dr. Toshio Murishige from the University of California at Riverside and Dr. Wes Hackett from UCLA. Dr. Murishige, who will speak first, was at the University of Hawaii before he came to Riverside. He has been working in the field of tissue culture for quite some time. OK, Toshio, let's amaze them with some of this "space-age" propagation.

PRINCIPLES OF IN VITRO CULTURE

TOSHIO MURASHIGE
Department of Horticultural Science
University of California,
Riverside

Introduction

Increasing use of the *in vitro* approach in botanical investigations and the expanding store of information prohibit a thorough coverage of the subject. This article is intended to simply acquaint the unfamiliar with some highlights of principles. Citations to original research should be viewed only as examples for illustration. More extensive coverage, including the historical development, can be obtained from several reviews and symposium publications now available (4,5,8,11, 13,21,27,28,34,35,39,42,43).

The term "plant tissue culture" has been popularly used indiscriminately to denote cell, tissue and organ culture. It is desirable to distinguish between cell and tissue on one hand and organ on the other, since their behavior and requirements in culture are markedly different. The preferred term which encompasses each of these cultures is "*in vitro* culture" and it is therefore used in this article.

Fundamentals which apply to any *in vitro* culture shall be examined first. This will be followed by some of the more specific aspects of cell, tissue and organ cultures. Finally, we shall consider some applications of the *in vitro* approach in plant propagation.

General Considerations

Whether it be cell, tissue or organ culture, these aspects demand fundamental consideration: asepsis, nutrition, physical environment, and the *in vitro-in vivo* relationship.

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General Considerations

Whether it be cell, tissue or organ culture, these aspects demand fundamental consideration: asepsis, nutrition, physical environment, and the *in vitro-in vivo* relationship.

Asepsis: Usually the freshly isolated plant part has bacteria, fungi, etc., which must be excluded. If the contaminating organisms are present only externally, they can be easily eliminated by treatment with mild disinfectant. Solutions of sodium hypochlorite, calcium hypochlorite, alcohol, detergents, etc., are commonly used. Internally-contained organisms will require more elaborate exclusion steps, such as culturing with antibiotics and other chemotherapeutic substances (6,22). Viruses are very difficult to eliminate, therefore it is best to use only plant parts known to be virus-free (14).

Nutrient media are rendered free of infectious organisms usually by autoclaving. For volumes of medium normally employed, 15 minutes at 15 lbs/sq. in. is adequate. With heat-labile substances the sterilization must take another course. Concentrated solutions of such substances are passed through microbial filters and then suitable aliquots are combined with the autoclaved, non-labile components.

The surgical and planting manipulations often require special facilities. The primary source of contaminants during manipulations is the air. The preferred practice has been to provide a transfer room or chamber in which filtered air is supplied and in which a positive pressure prevails.

Nutrition: The specific nutritional provision varies with type of culture, plant part, species, and the investigation's objective. Nevertheless, certain characteristics are generally applicable. A supply of inorganic salts, sugar and water is the minimum requirement. Several salt formulae are presently available, e. g., those of White (42), Heller (10) and Murashige and Skoog (20). Sucrose has been generally effective as the sugar, although glucose has been preferred in some cultures of monocot tissue and organs. Demineralized water has been routinely used.

The more specific organic constituents include the B-vitamins, particularly thiamin and inositol; hormonal substances, especially auxin and cytokinin; and reduced nitrogen compounds, such as amino acids or their amides. Coconut milk, yeast extract and other complex addenda of natural origin are also frequently used, although sometimes unjustified.

Physical Environment: Perhaps the most critical of the physical environment is aeration. Satisfactory aeration can be achieved by using an agar-gel medium or, if a liquid is used, by constant vigorous agitation (5,23), bubbling air into the liquid (23), or by providing filter-paper supports (10).

Closures for culture vessels must provide aeration, yet exclude contaminating organisms. Non-absorbent cotton or synthetic sponge plugs and polypropylene or stainless steel covers are commonly employed.

The temperature and light needs should be systematically determined for each cultured material. While constant temperatures in the neighborhood of 25° C has been routine, the best temperature is expected to vary from species to species.

When growth alone is desired, constant darkness seems most favorable for cell and tissue cultures. The induction of differentiation in cells and tissues, however, may necessitate illumination. Organ cultures which involve shoot parts apparently benefit from light, whereas those of root parts may not. The light used is ordinarily of low intensity. Since sugar is provided photosynthesis in the usual sense is not critical, but the synthesis of growth factors may depend on a small quantity of light. Diurnal periodicity with respect to temperature and light is a factor which has not been adequately considered with *in vitro* cultures.

The pH of the nutrient medium is also important. The pH found generally satisfactory has been in the range of 5-6. By providing adequate buffering capacity, changes in pH associated with nutrient utilization can be minimized.

In Vitro-In Vivo Relationships: The primary objective of *in vitro* cultures has been to provide tools with which developmental phenomena can be explored more effectively. Thus, the behavior of a cultured plant part must be reflective of the potentialities *in vivo*. Instances of cultured cells and tissues having undergone polyploidization are not uncommon (25) and, as to be expected the chromosomal change is accompanied by an alteration of cellular behavior (36). It is therefore incumbent on the investigator to examine this possibility in his cultures. The chromosomal change may not be apparent in the gross morphological characteristics, so it will have to be ascertained through nuclear examination.

Specific Aspects

Tissue and Cell Cultures: By far the most extensive investigations have been with cultures of tissue and the most widely cultivated tissue has been callus, or wound tissue. Callus cultures have been established from virtually every part of the plant, including root (3,32,36), leaf (9,41), fruit (30), and even endosperm (33) and pollen (38). Those from the stem are beyond enumeration. Callus cultures have also been obtained of lower plants, such as the fern (15). The callus cultures have been used to explore a range of phenomena, from the basic developmental processes of cell division and tissue and organ differentiation (9,17,18,31 36,37) to the synthesis of secondary biochemical products (5).

Callus is most commonly grown on an agar-gel medium. Once established, it is indefinitely maintainable by periodically subculturing small pieces in fresh medium. A distinction can be made in the nutrition of dicot and monocot tissues. The callus of many dicot species is culturable in media of defined composition. The basal ingredients have been inorganic salts, sucrose, some B-vitamins, and often auxin and/or cytokinin. Monocot callus, with few exceptions, have not been cultured in defined medium and complex addenda such as coconut milk or yeast extract have been routinely used.

Plant cells, in differing from animal cells, tend to adhere together more tenaciously. Thus, the complete dissociation of tissue into unicellular units and their maintenance as such have been virtually impossible. Even the most successful attempts have resulted in cultures containing both single-cells and tissues. Indeed, the delineation into cell culture and tissue culture has been an arbitrary one.

Dissociation of tissue, giving rise to a proportion of unicellular units, is possible through nutritional and mechanical manipulations. Suitable conditions of nutrients have often been found to render plant tissues friable (18). Some cells from such tissues can be either teased free individually (18) or separated en masse in a vigorously agitated liquid medium (23). Through continuous agitation and periodic transfer of aliquots of culture suspension to fresh nutrient solution single cells and few-celled clusters can be maintained indefinitely.

The significant discovery has been that, for yet unestablished reasons, a singly isolated plant cell is incapable of multiplication. Successful induction of cell division has been accomplished by employing a nurse-callus (16), plating a dense suspension of cells (3) or by employing pre-conditioned nutrient medium (12). In the nurse-callus technique a piece of tissue is cultured on nutrient agar, a layer of filter paper is laid over this tissue and the isolated cell is set on the filter paper. The tissue piece provides nourishment to the cell and the filter paper enables movement of substances while preventing a union between cell and tissue. In the plating technique the cells in liquid suspension are simply dispersed onto suitable nutrient agar. The concentration of cells in the suspension to be plated is critical. Moveover, since both cell aggregates as well as free cells are involved, some step must be taken to ascertain which are the single cells. A single isolated cell can also be induced to proliferate into a tissue in the absence of other cells if pre-conditioned medium is used. A pre-conditioned medium is one in which tissue and cells have been previously cultured for a short period.

One of the disturbing characteristics of cell and tissue cultures has been their high degree of genetic instability. With few exceptions, every culture which has been critically examined has shown a degree of polyploidization (25). The longer a tissue is kept in culture, the higher is the frequency of polyploid cells; ultimately a completely polyploid population may be attained.

Organ Culture: The object in organ culture has been to obtain development of a plant part *in vitro* which is as nearly as possible comparable to that *in vivo*. It is desired that the same degree of differentiation and organization be retained *in vitro*.

(a). *Root Culture*: The first successful *in vitro* culture of a plant material was that of the excised tomato root by White in 1933. This culture is still being maintained in a vigorous state now 33 years later. Evidently culturability of isolated roots differs between herbaceous dicot species on one hand and monocot and woody dicot species on the other (4,34). The roots of many herbaceous dicots have been successfully grown in a nutrient solution containing mineral salts, sugar, B-vitamins, and some organic reduced-nitrogen compounds. In contrast, root cultures of monocots and woody dicots have been more difficult and largely unsuccessful.

(b). *Shoot Tip Culture*: The shoot tip of several higher plant species has been successfully cultured, but not the apical meristem. This distinction deserves emphasis, since some investigators have carelessly applied the term "apical meristem culture" to what was correctly. "shoot tip culture". The shoot tip, which consists of the apical meristem plus a few subjacent leaf primordia, has been grown to complete plants *in vitro* (1). This has not been the case of the apical meristem itself (2).

(c). *Leaf Culture*: With respect to leaf cuture a distinction in the behavior can be made between ferns and higher plants (7). The youngest leaf primordia of ferns develop into complete plants when isolated and placed in culture, whereas the oldest develop only as leaves. The leaf primordia of higher plants, regardless of degree of maturation when excised, invariably develop into leaves.

(d). *Ovary Culture*: The ovary of many herbaeceous plants has been cultured *in vitro* into mature fruit (24). If the source of ovary is a pollinated flower, development can be obtained in a relatively simple nutrient medium. However, the ovary from an unpollinated flower must be supplied with diverse growth factors, including auxin. Fruits obtained *in vitro* generally have been considerably smaller than those developed *in vivo*. Nevertheless, comparable degrees of differentiation and flavor are retained.

(e). *Anther Culture*: Only limited research has been conducted with anther culture and much of this has been confined to work with the Liliaceae. The available information shows that meiosis can occur and functional pollen can be obtained *in vitro* (40).

(f). *Embryo Culture*: The development in vitro of embryos of higher plants has been achieved in several instances. This development, however, has been possible only with isolates which are at least 50-celled in dimension. No success has been attained by starting with the zygote. Experience with embryo culture has shown that the requirements change as development progresses from the relatively undifferentiated, few-celled structure to a fully differentiated embryo (26). It is thus not appropriate to suggest a culture medium which is generally useful.

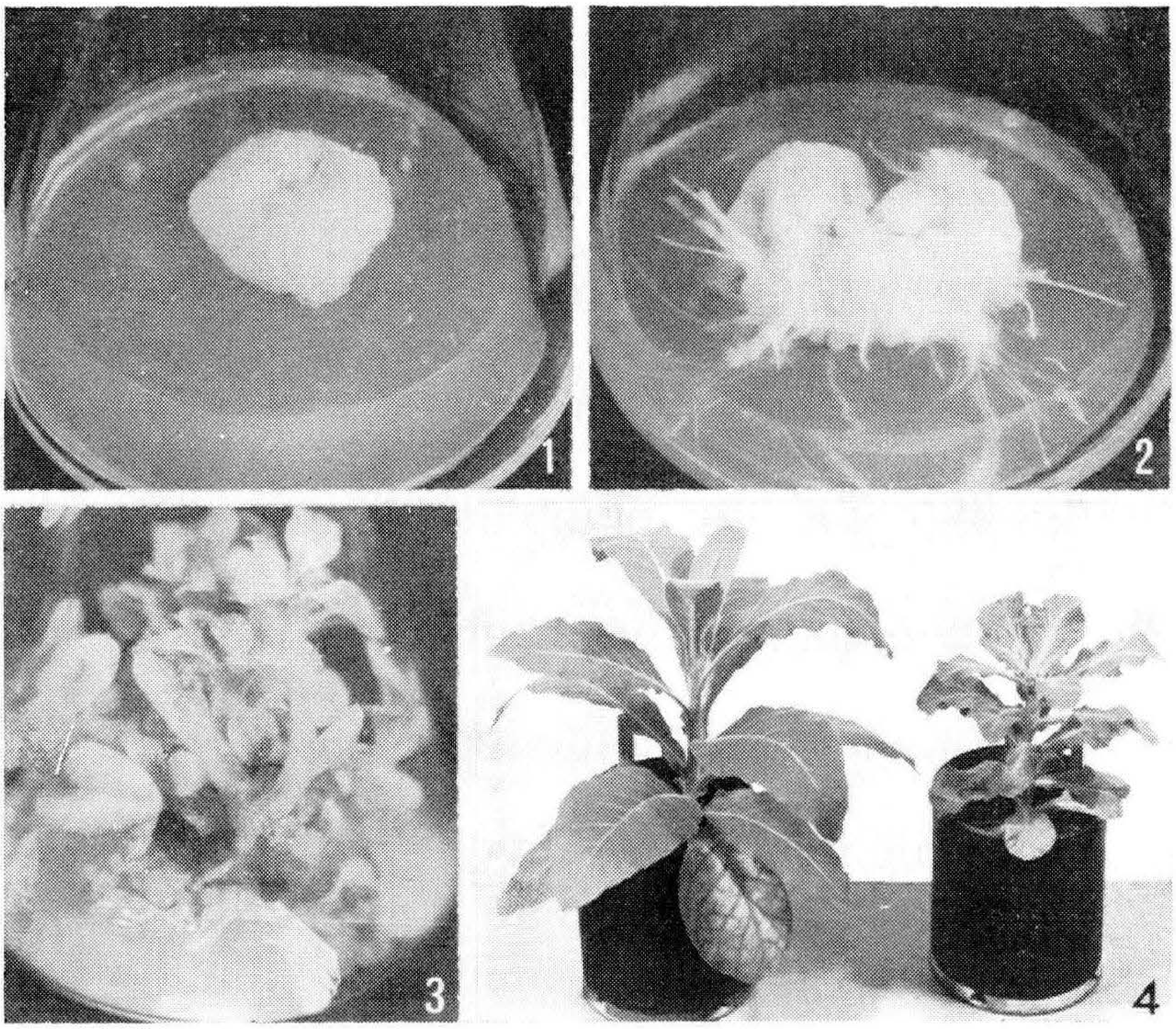
Applications in Plant Propagation

The *in vitro* culture approach has already been applied in plant propagation, but there are still several instances in which this approach might be helpful. Problems of root and shoot initiation can be explored very effectively. Studies with tobacco callus have disclosed a basic mechanism in the formation of these organs. Root initiation has been related to a high auxin-low cytokinin condition, whereas shoot differentiation has been associated with low auxin and high cytokinin (31). Gibberellin inhibits both root and shoot formation (17).

Asexual propagation of many species has been enhanced by the *in vitro* approach. Unlimited supply of orchid plantlets has been obtained from cultures of the excised shoot apex (29). In tobacco (19). carrot (9,32), endive (41), and others, a similar increase in plantlets can be achieved through callus cultures derived from stem, root and leaf.

Embryo culture has long been used to obtain seeds of many plant hybrids (27).

Cultures of shoot tips are often employed to obtain disease-free plants from infected plants (14). Disease-free plants might also be obtained by starting with single cells and reconstituting the plants.



Figs. 1-4. Morphogenic manifestations of a tobacco cell *in vitro*. — Fig. 1. Undifferentiated callus obtained through nurse culture of a single pith cell isolate.—Fig. 2. Roots resulting in a culture medium of high indoleacetic acid and low kinetin. — Fig. 3. Formation of stems and leaves as result of high kinetin-low indoleacetic acid provision. —Fig. 4. A tetraploid plant, right, reconstituted in vitro from a tetraploid pith cell; pith cell was isolated from a diploid plant similar to the one on left.

Finally, another potential application of *in vitro* culture is in obtaining polyploid plants. Polyploid cells may be found in either the plant or tissue culture. These cells might be isolated and cultured to give rise to polyploid plants. This has been achieved with tobacco (19).

Summary

This article considers some principles of plant cell, tissue and organ cultures. Generalities with respect to asepsis, nutrition, physical environment, and *in vitro-in vivo* relationship are first examined. These are followed by some characteristics more specifically associated with each of cell, tissue and organ culture. Finally, a few applications of the *in vitro* approach in plant propagation are considered.

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MODERATOR MAIRE: Isn't that exciting! It just — I don't know — you let your mind go wild just thinking about the possibilities that may develop from all of this sort of thing we are calling "tissue culture".

Anyhow, now we're going to go on and find out what are some of the possibilities that this type of tissue culture — or meristem culture — offers. We now have Dr. Wes Hackett who has done considerable work on this subject. He received his doctorate at the University of California at Davis. Wes, we'd like to hear what you have to tell us about what is happening and what is going to happen in this field.

APPLICATION OF TISSUE CULTURE TO PLANT PROPAGATION

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Department of Agricultural Sciences
University of California, Los Angeles

Some very interesting and exciting experiments have been carried on in the past 15 years to show that shoots and roots can be caused to form on masses of undifferentiated tobacco callus tissue cultured under aseptic conditions (13). It has also been shown with cultures of carrot callus tissue that embryos which ultimately will become normal carrot plants can be obtained from single cells (2, 14). These are examples of organogenesis and embryogenesis from undifferentiated tissue (tissue not recognizable as normal plant organs such as leaves, stems, or roots). In both cases relatively large numbers of new plants can be produced in a relatively small space under controlled conditions.

It is interesting to speculate on possible potential uses of such tissue culture techniques in plant propagation. Several possibilities come to mind:

1. The use of tissue culture as a means of rapid propagation of new cultivars, especially hybrids which require a complicated seed production system.
2. Tissue culture techniques may allow us to propagate vegetatively species which resist conventional vegetative (asexual) methods of propagation.
3. The use of tissue cultures to maintain pathogen-free plant material for long periods of time in a small amount of space.
4. Establishment of a tissue culture bank as an economical means of long-term storage and maintenance of germ plasm (breeding and propagating stock).

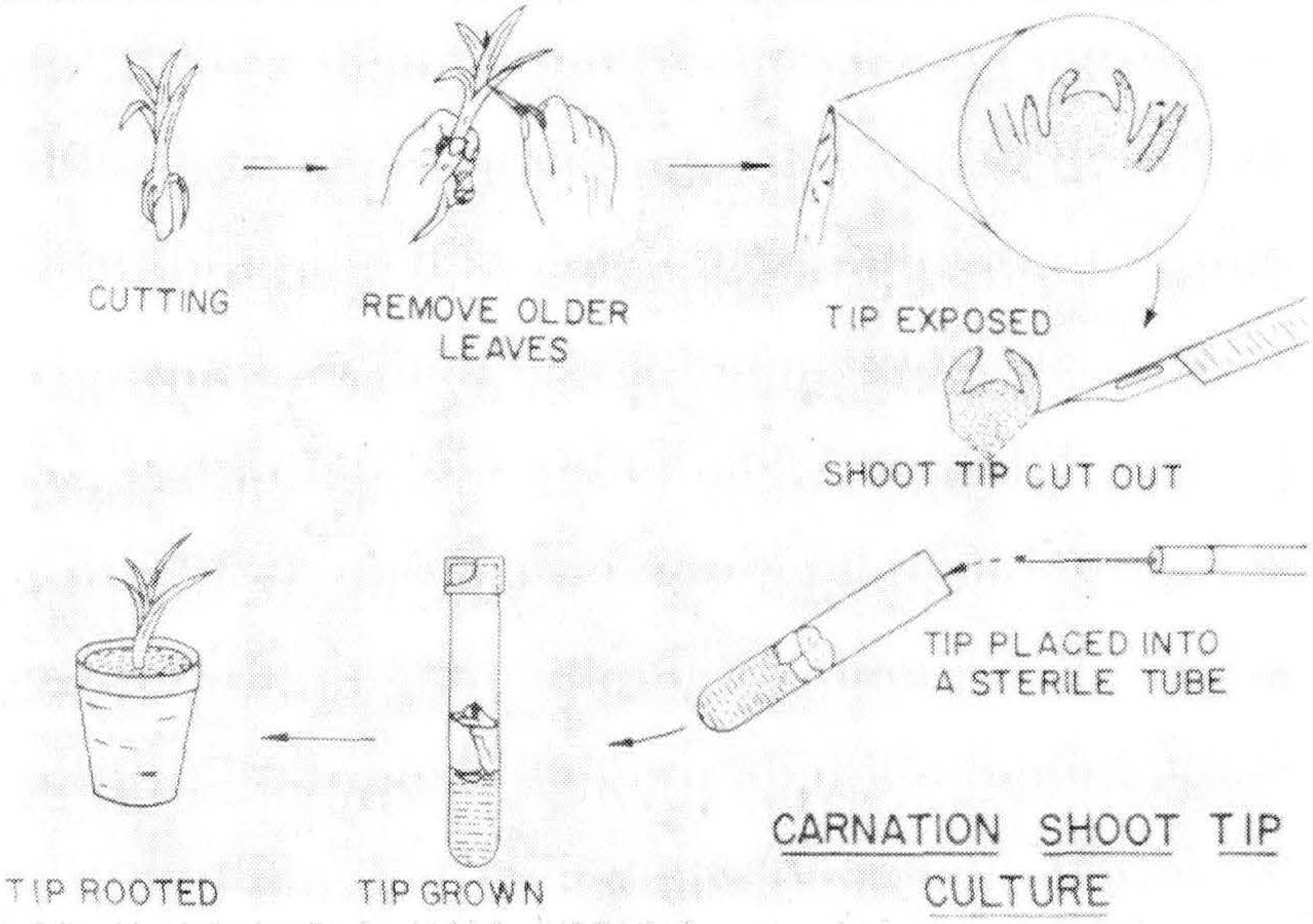
Unfortunately very little is known about the control of organogenesis and embryogenesis and the examples given above seem to be rather isolated cases of success in obtaining new plants from undifferentiated tissue. Even if regeneration can be controlled in a wide variety of species, there may be problems such as gene mutations or changes in the chromosome number. Much work is needed before complete regeneration of plants from undifferentiated tissues can be used as a propagation technique but some day such techniques will probably be used.

If tissue culture is defined broadly to include the culture of plant organs, segments of organs, and embryos on controlled media under aseptic conditions, several applications of tissue culture to plant propagation can be enumerated.

The aseptic culture of embryos or seeds has been used as a method of propagation for many years. This has been the usual method for germinating orchid seeds which have a very simple undifferentiated embryo that won't germinate under normal seed germinating conditions (4). It has also been used to obtain hybrids of some plants whose seeds fail if left to develop within the fruit (16) and to obtain prompt germination of certain dormant seeds (5).

More recently, interest has arisen in the aseptic culture of shoot apices as a method of obtaining virus-free plants from clones of vegetatively propagated species which are wholly infected with viruses. As compared to other parts of the plant, many viruses are not found in high concentration in the shoot apex. This technique has been called shoot-tip culture or meristem culture and has been used with Dahlia (8), potatoes (9), carnations (1, 12) and orchids (6, 7). In most cases the shoot tip or meristem technique has been used in conjunction with a prior high temperature treatment of the plants which inhibits virus multiplication while the shoot is able to carry on growth (3).

In carnation, the technique (Figure 1) involves growing a mature plant from the shoot apex (0.2-0.5 mm. in length) of a heat-treated cutting (15). This is done by stripping off the older leaves macroscopically and then taking off the small young leaves under a dissecting microscope with a sterile dissecting needle or scalpel. The exposed shoot apex or tip consists of about four primordial leaves and the apical meristem. This tip is sterile and can be cut off and transferred aseptically to a suitable nutrient medium. Several media are suitable



but the one formulated by Murashige and Skoog (10) is particularly good. With carnation, each tip implanted yields only one mature plant.

The technique for orchids (6, 7) is much the same as for carnations but instead of forming leaves and roots very quickly as with the carnation, the orchid shoot apex first forms a small, round body with root hairs. This body is identical with the protocorm derived from orchid seed (11). In time a plant with leaves and roots will develop from the protocorm. However, it has also been found that this protocorm divides or produces lateral protuberances and that this phenomenon can be induced by agitation in a liquid culture medium or by wounding (quatrering of the protocorm) on a solid medium (7, 18). This process provides a means of vegetative (clonal) propagation at a very high rate. Morel (7) states that if each protocorm gives only four new ones per month, it is possible to obtain more than 4,000,000 plants in a year from a single shoot apex. Modifications of Knudsen's media (4) are used with orchids.

Recently, at the University of California, we have developed an aseptic tissue culture procedure for multiplying and maintaining carnation shoot apices. The starting material (the shoot apex) is very similar to that used for the shoot tip culture method of obtaining pathogen-free carnation plants, where one plant is obtained from each implanted shoot apex. The results of the procedure are comparable to those obtained with Cymbidium orchids where one shoot apex is implanted and in a very short time with proper manipulations a large number of potential plants are obtained.

In this procedure a shoot apex which is about 0.5 mm. high and which has about four primordial leaves is used. In the axils of these four-leaf primordia are primordial buds (primordial shoot apices) which are potential plants. By mutilating the leaf primordia at the time of excision and by placing the excised shoot apex on a medium high in inorganic nutrient salts and high in naphthaleneacetic acid (NAA) further development of the terminal meristem is inhibited and the primordial axillary buds are forced into growth. However, these lateral bud axes are also soon inhibited and their axillary buds are forced into growth. The result is a rapid proliferation of very short shoots which are potential plants. Once established, this proliferation tissue can be cut up into small pieces (subcultured) and placed on fresh medium and be maintained and increased many fold. Such proliferation cultures have been carried for 18 months.

These proliferation cultures have little resemblance to carnation plants. However, by cutting them into small pieces and placing them on a medium suitable for shoot development and elongation (lower in total inorganic nutrients and devoid of NAA), normal carnation shoots, some with roots, develop. These normal shoots can be taken out of the culture vials and planted in a light soil mix. If they are not rooted, they can be treated with a root-promoting compound to induce rooting. These plants, or potential plants, are rather fragile and so they must be treated with care for a time.

It should be pointed out that the White Sim carnation cultivar (which is a periclinal chimera) sometimes reverts to a red flower color when cultured by this technique. This indicates that the outer layer of cells of the meristem has broken down, allowing cells of the core layers to break through and take over. Perhaps by changing the procedure to reduce the possibility of injury to the meristematic areas, this problem could be overcome.

This procedure, and the concept of utilizing the primordial axillary buds as sources of new plants, may have practical application as a method of propagation and as a method of maintenance of pathogen-free plant materials. With this procedure it is possible to hold pathogen-free carnation tissue for many months in a small space without exposing it to possible re-infection in a greenhouse or screenhouse. However, more work is needed to perfect the procedure.

The applications of tissue culture to plant propagation are few in number and relatively unimportant from an economic standpoint. It is not known whether such procedures are generally applicable to many species but work to determine this is in progress. Also, these methods and procedures have not been evaluated over a long period of time so their potentials and problems are not known.

Tissue culture has many potential applications for the field of plant propagation and disease control and deserves investigation by universities and experiment stations. There is a need for fundamental information concerning control of organogenesis and embryogenesis and a need for research to develop procedures for the utilization of tissue culture techniques in plant propagation and disease control.

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MODERATOR MAIRE: Now I'm sure there are some questions so who would like to start?

BRUCE BRIGGS: Dr. Murishige: What is the strength of the Clorox solution you used?

DR. MURISHIGE: Normally we use a ten percent solution. We take the commercial preparation and dilute it one to ten. We expose the tissue anywhere from 10 to 20 minutes. You can also use Purex or any other similar commercial preparation.

BRUCE BRIGGS: The reason I asked is because we also use it as a pre-dip on cuttings. I wondered how strong we could go without injuring the cuttings.

RON HUROV: Have you determined why you have so much polyploidy appearing in tissue culture?

DR. MURISHIGE: No. This is a real problem; most people working with tissue culture have experienced this. We know that this occurs as a normal process in the plant, only it occurs slowly. If you look at any mature tissue in the plant you are bound to run into a few polyploid cells. In tissue culture this occurs more rapidly. Why, we don't know. This is a problem we'd like to have resolved as soon as possible.

RON HUROV: What about apical meristem culture as opposed to callus culture?

DR. MURISHIGE: Well, apical meristem culture is a different situation since you're working with very young cells. In tissue culture we tend to take mature cells; in the case of carrots from the storage root — the part that you eat — things of that sort. These are non-growing cells, normally. We reactivate them. We find that when this is done there is a greater tendency to run into polyploids. Now, with the meristem itself it's very difficult to get callus formation.

THURSDAY EVENING SESSION

October 13, 1966

VICE-PRESIDENT ISHIDA: Our panel this evening will discuss "The Anatomy of the Plastic House" and the moderator will be Robert Boddy. Bob —

MODERATOR BODDY: Thank you, Henry. We have assembled a panel of experts this evening to speak on the subject of plastics and the anatomy of plastic greenhouses as pertains to our profession. The plastic structure is basic to our industry. All of us have something to do or have had something to do with plastic houses. It is almost as basic today as the propagatgating knife. I don't know what people did 10 or 15 years ago when there was no plastic. Now we just assume that it is available. Furthermore, this is a subject which is not like meristem culture, or some of those more complicated subjects that were presented just before dinner — here is a subject that you can all handle with a pair of scissors, a hammer, and a saw. I would like to introduce our speakers quickly, one by one. We have George Oki of the Oki Nursery in Sacramento ; Jim Perry of Perry's Plants in La Puente; Joe Klupenger from Oregon — Klupenger's Greenhouses; Ken Inose of Gardena; Al Holland — from the Agriculture Extension Service in Orange County; and Tokuji Furuta, Extension Specialist, University of California, Riverside. Our subjects will cover the construction of a house, how you cover it, the use of plastics in different operations, such as Joe's — which is basically a pot plant business, and Jim Perry's — which is basically a bedding plant business. The first speaker on our panel this evening will be Mr. George Oki, recent President of the California Association of Nurserymen. George —

ANATOMY OF A GREENHOUSE

GEORGE S. OKI
Oki Nursery, Inc.
Sacramento, California

Webster's Collegiate Dictionary still defines a "greenhouse" as; "a glassed enclosure used for the cultivation or protection of tender plants." In the last decade, a greenhouse has taken on the sophisticated title as an "enclosure for environmental control."

While it is true in days past that heat was the primary element added to protect and cultivate tender plants in greenhouses, very little was done toward cooling. The only control for high temperature was accomplished by ridge and side ventilators.

With the advent of "pad and fan" cooling the entire concept of greenhouses was altered. Continuous ridge and furrow type houses became a standard. With temperature and humidity control, crops could now be cycled with pinpoint accurcy with maturity dates as prime objectives.

In the past several years, cycled lighting and black cloth have made many technological advancements for the horticultural industry especially in blooming crops. Controlled photoperiods has sophisticated many crops and is gradually making its usefulness known to other segments of the industry.

CO_2 in greenhouses has changed the quality of many crops, especially in the flower industry and some greenhouse vegetable crops. Only a few CO_2 generators have been installed in nurseries and most of these are in the bedding plant industry.

With the improvements of greenhouses in the past few years: heat, air in movement, humidity, cooling, controlled photoperiods, addition of advantageous gases, we can now truly say that a greenhouse is an enclosure for controlled environments.

In 1938, the British extruded the first polyethylene sheet film. However, it was not until the early 1950's that this material was used in the nursery-floriculture industry and it has made a very sizeable impact in production techniques.

Since the advent of polyetheylene, we have seen a host of other materials used. PVC, Mylar, and fiberglass are but some of these plastic films or panels used today. Each material with its inherent qualities must be wisely used to obtain the optimum useful purpose to glaze or cover the "greenhouse" structure.

Plastic greenhouses have two distinct advantages. One is the economy of temporary structures for high seasonal use. The second is that many growers have built these structures during off-season periods with many materials already at hand.

One of the major problems with plastic structures is inadequate frame work construction. This has resulted in many crop failures due to the rupture of the plastic sheets. It has also raised the annual cost per square foot, calculating investment, depreciation period, and maintenance.

By its very nature of being temporary, heating and ventilation have been poorly provided and this has resulted in many crop failures. One must definitely keep in mind that to grow a decent crop of greenhouse quality — heating, ventilation and cooling must be properly and adequately supplied. Therefore, the cost should be nearly identical per square foot for adequate heating and cooling, whether it be a glass or plastic house.

The cost of the various types of greenhouses, whether glazed with glass or plastic, vary widely by areas. Building codes and weather also govern many costs. The degree of "sophistication" will also govern and influence the cost of many structures.

A recent study shows that plastic type houses may cost from 2.5 to 75c per square foot or from 10,000 to 30,000 dollars per acre. Glass greenhouses vary in cost from $1.00 to $3.00 per square foot or $40,000 to $120,000 per acre. Calculated cost per year per square foot, oddly enough, is very close for both types. These costs include interest on investment, taxes, maintenance, and depreciation, and are calculated on an acre size unit; averages are — for glass, 15c to 26c per square foot per year, and 11c to 19c per square foot per year for plastics.

The market today demands quality products, and profit and quality are keys to all successful business operations. Physical facilities must be well-planned, heated, ventilated and highly mechanized and automated; tempered with the rapid urbanization of the nursery neighborhood, the key to your choice, the type of greenhouse structure you should build.

MODERATOR BODDY: Thank you very much George. Our next speaker is Jim Perry, who will discuss his use of plastics in the production of bedding plants. Jim was voted the outstanding nurseryman of the year at the recent California State Nurserymen's Convention, receiving the Pacific Coast Nurseryman Award. Jim:

ANATOMY OF THE PLASTIC HOUSE

JAMES C. PERRY
Perry's Plants, Inc.
La Puente, California

The use of plastics has greatly increased during the past few years and, until something better comes along, I feel that plastics will be used for many years as coverings for preservation of heat and for climate control in the growing of plants.

Perry's Plants has benefited greatly by the use of plastics in our growing procedures. We are currently using polyethylene sheeting, 4 mil, for winter covers and protection, as well as the corrugated PVC (polyvinylchloride) for a permanent structure.

The polyethylene sheeting is used for covering, during the winter, our temporary structures, which are made of bent ½″ pipe, giving the shape of the quonset hut, with a curved dome top. We have taken a standard 21-foot length of galvanized pipe and with the use of a homemade jig, bent the pipe to conform to the shape that we desire. There is a three-foot straight leg on each end and the rest of the pipe between these three-foot legs is curved into a half-circle. The reason for the straight legs is to give us a perpendicular wall to accommodate the benching and growing close to the outside edge; the curve then swings over the top. Our houses are constructed with about 6′6″ clearance in the center. This gives us a floor space 16 feet wide. The bow is then fastened on the inside of a 1′ x 12′ (a 2′ x 12′ could be used) that stands on edge as an outside wall. Pipe clamps are used to secure and hold this bow in an upright polars per acre. Glass greenhouses vary in cost from $1.00 to $3.00 per square foot or $40,000 to $120,000 per acre. Calculated cost per year per square foot, oddly enough, is very close for both types. These costs include interest on investment, taxes, maintenance, and depreciation, and are calculated on an acre size unit; averages are — for glass, 15c to 26c per square foot per year, and 11c to 19c per square foot per year for plastics.

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With all the ribs of this house fastened in place, in order to secure the top center, we have used a one-inch mesh metal wire screen fastened to each of the bows to act as a stabilizer for the bows; they also give support to the crown of these houses for the plastic, so that the rain water will not be trapped in a sagging pocket on the top. At each end of the house we have two 4 x 4's (you could use rough 2 x 4 posts) on each side of the doorway at each end to support the outside rib and to give strength to the end for closing in. A framework is put up at each end and covered with fiberglass or polyethylene, or any desired covering, whether it be permanent or temporary, as the needs might be.

The two posts at each end is all that holds the house down, in addition to its own weight. We use a sliding door at each end that runs on an overhead track. In this way we do not have swinging doors to get broken and be caught by the winds. This makes a house 16 feet by 98 feet long. The reason it is designed in this fashion, on length as well as width, is that this fits a standard size roll of polytehylene. The poly is spread out over the top of these bows and fastened to the boards on each side at the bottom; the ends are fastened to the framework previously mentioned, so that all edges are fastened down securely. With this 20 by 100 foot roll of plastic, there is no fastening in the center, only on the edges.

The only ventilation used or needed is by opening the doors on either end. Ventilators could be put in the tops if desired, but we have not found it necessary for the type of material that we are growing. We have constructed also a little larger sized house where we have used 1½ lengths of pipe, coupled together, and bent in the same fashion as formerly mentioned; this makes a house 24 feet wide by whatever the desired length might be. On this framework we used a 32 foot x 100 foot roll of plastic to cover these rib bows, which would have a length of 31½ feet.

In all of these houses heat is provided as needed. We do not try to maintain a high or even temperature. The heaters are manually lighted during the colder spells in winter.

Our more permanent structure is built like a greenhouse and now looks like a greenhouse, although the original framework was designed as a chicken house. The metal trusses come prefabricated, 30 feet in length, but we have added a 6-foot extension on each side of the 30-foot trusses, making a 42-foot house, 210 feet long. We have two walkways, the outer edge of each lining up with the end of the 30-foot trusses, which must be supported by posts. These posts are on 9′6″ centers throughout the house. This was designed so that the

18-inch flats could be placed on the benches without having the post interfere as they would if they were on 10-foot centers. Wooden stringers are used over the metal trusses, supported at the ends only; sheets of corrugated PVC are then nailed to the wooden stringers.

We find that plastic-covered structures are much tighter than the conventional glasshouses. We have three comparatively new glasshouses that are not nearly as tight as the plastic structures. This may or may not be an advantage, but care should be given if you are accustomed to glass house conditions and then switch to plastic; with the latter there is much less air seepage and more condensation.

MODERATOR BODDY: Thank you, Jim. The next speaker is from Oregon. Joe Klupenger is recognized as one of the leading pot plant growers of the Northwest. He grows a complete line of flowering plants and foliage plants. He is also in the nursery business with the production of rhododendrons. Joe is very active in the American Association of Nurserymen and has been active in our Plant Propagators' Society — Western Region. He has spoken to us before at West Linn, Oregon, about his new operations at Wilsonville. We're looking forward to Joe's further remarks on the use of plastics in Oregon. Joe —

PROPAGATION AND GROWING UNDER FIBERGLASS AND POLYETHYLENE

J. H. KLUPENGER
Klupenger's Nursery
Portland, Oregon

Our experience with propagation and growing under polyethylene and fiberglass gives us encouragement for the future. I would like to give a few pointers resulting from our experience in propagation and from the changes we have made over the past few years. At one time we would not propagate rhododendrons under any condition other than enclosed cases in the greenhouses. At a later date we decided we could do a better job of propagation in closed greenhouses but in open benches, although with no ventilation for fear of the cold air "chilling" the cuttings.

At the present time we are propagating in open benches but with air-conditioning fans (on thermostatic control) moving the air directly over the cuttings. We are having a greater percentage of rooting now than ever before.

At earlier dates, we were cautious as to the type of mist nozzle used so as not to get too much water on the cuttings. Now we are using Foggit nozzles; their output is three-gallons per hour. Formerly we used one-gallon per hour nozzles which did not cover the area as well as the nozzles now in use.

Our plans for next season are to move our propagation

18-inch flats could be placed on the benches without having the post interfere as they would if they were on 10-foot centers. Wooden stringers are used over the metal trusses, supported at the ends only; sheets of corrugated PVC are then nailed to the wooden stringers.

We find that plastic-covered structures are much tighter than the conventional glasshouses. We have three comparatively new glasshouses that are not nearly as tight as the plastic structures. This may or may not be an advantage, but care should be given if you are accustomed to glass house conditions and then switch to plastic; with the latter there is much less air seepage and more condensation.

MODERATOR BODDY: Thank you, Jim. The next speaker is from Oregon. Joe Klupenger is recognized as one of the leading pot plant growers of the Northwest. He grows a complete line of flowering plants and foliage plants. He is also in the nursery business with the production of rhododendrons. Joe is very active in the American Association of Nurserymen and has been active in our Plant Propagators' Society — Western Region. He has spoken to us before at West Linn, Oregon, about his new operations at Wilsonville. We're looking forward to Joe's further remarks on the use of plastics in Oregon. Joe —

PROPAGATION AND GROWING UNDER FIBERGLASS AND POLYETHYLENE

J. H. KLUPENGER
Klupenger's Nursery
Portland, Oregon

Our experience with propagation and growing under polyethylene and fiberglass gives us encouragement for the future. I would like to give a few pointers resulting from our experience in propagation and from the changes we have made over the past few years. At one time we would not propagate rhododendrons under any condition other than enclosed cases in the greenhouses. At a later date we decided we could do a better job of propagation in closed greenhouses but in open benches, although with no ventilation for fear of the cold air "chilling" the cuttings.

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Our plans for next season are to move our propagation under fiberglass. We find that with a high light intensity we have less burning and we are sure of a greater percentage of rooting but with fewer problems of damping-off, and other fungi, developing. As to growing-on in the liner stages for both rhododendrons and azaleas, our present procedures give us a better quality plant with heavier caliper stems and foliage. This has been our experience resulting from growing liners under poly and fiberglass; this is due to higher light intensity, giving top quality results with no burning of the foliage.

We established a test plot this summer growing plants under clear fiberglass using air-conditioning fans but with no cooling pads. Using several varieties, we find this fall that the plants have come through in top condition with a good bud set.

Later in the summer, approximately late June, we completed building 18 000 square feet of house, covered with inexpensive fiberglass (acrylic-treated, 4½ oz., clear, corrugated). Upon completion, we filled these houses with several varieties of potted azaleas which were to finish for fall, 1966; this was budded stock for dormant shipping. Although we were very late in spacing this stock, we were fortunate in finishing this block of stock off in first class condition with a good early bud set.

We have an overhead sprinkler system using Superior nozzles which are tapped into the lines at 10 ft. intervals. Each line covers a 20 ft. wide house. We are using three 4-ft., ¾ HP, 220 V. fans for air-conditioning and cross ventilation on our nine houses. Temperatures did hit 100°F. inside the houses when it was 90°F. outdoors, but with enough water and with the cooling fans, our azaleas came through in No. 1 condition.

MODERATOR BODDY: Thank you very much, Joe, for coming all the way down from Portland to deliver that fine talk and for the detail with which you gave it. The next speaker on the program is a specialist in ivys. He is going to tell us about it tonight. It's my pleasure to introduce Ken Inose of Gardena, California. Ken —

AIR-SUPPORTED PLASTIC GREENHOUSES

KEN INOSE
K & Y Nursery, Inc.
Gardena, California

PURPOSE: To propagate ivies, which is my principle crop during the fall, winter and early spring, with a structure that could be erected quickly when needed and then dismantled after the winter season. This type of house can easily be used during the summer with the addition of more coolers.

Two houses were in use from September, 1965, through March, 1966. The dimensions of each were as follows: 30′ x under fiberglass. We find that with a high light intensity we have less burning and we are sure of a greater percentage of rooting but with fewer problems of damping-off, and other fungi, developing. As to growing-on in the liner stages for both rhododendrons and azaleas, our present procedures give us a better quality plant with heavier caliper stems and foliage. This has been our experience resulting from growing liners under poly and fiberglass; this is due to higher light intensity, giving top quality results with no burning of the foliage.

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Two houses were in use from September, 1965, through March, 1966. The dimensions of each were as follows: 30′ x

50′ x 15′ in height at the highest point. The height is always one-half the width with this type house since it is built in a half-circle. Each Airhouse was equipped with a desert cooler on the south end-wall; a 100,000 BTU heater, thermostatically-controlled, was integrated with a squirrel-cage blower on the north end-wall. One or both of the blowers was in constant operation at all times to keep the houses up. During the heat of the day both blowers were in operation in order to move as much air as possible to keep the houses cool. With approximately 17,000 cubic feet of air in the house, the estimated air change was once every two minutes at 4500 C.F.M. per blower, with both blowers running. This would decrease to once every four minutes with one blower. During the night, only the heater blower was kept in operation, with the heater turning on at the preset temperature level. Ventilation was achieved through a weighted flap located on the top center of the house.

CONSTRUCTION: The houses were made out of 20-mil vinyl, each panel 42″ wide, hand-fabricated with the help of a machine that looks like a rotary iron. P.V.C. glue was used to laminate the panels together; no heat was applied in any way. The Airhouses were anchored to the ground by an 18″ diameter water tube which was laid around the perimeter of the house. The water tube was held in place in an 18-inch deep ditch. This was the first mistake we made. The ditch was one of the causes of failure of the Airhouse during heavy rains in December, 1965. Heavy runoff from the roof of the Airhouse filled the ditch with water; because there was some air in the watertubes, they floated up and the water inside the tubes drained out. The winds which usually follow a rainstorm got underneath the water tubes and the house collapsed. There was little damage to the plants but there was some tearing of the vinyl. This was easily repaired by patching. The rain problem was partially solved by placing a swimming pool vacuum pump into the ditch each time it rained.

Entry into the Airhouse was gained though a six-foot zipper located at each end of the house. The zippers gave trouble after about three months use. The answer to this problem possibly is an airlock system using two sets of doors. In this way fairly large pieces of equipment can be easily passed through. The house was loaded with flats through a 12″ x 20″ opening located in the center side of the house. A hinged Aluminum flap was used here and it was pushed open from the outside. The flap was kept closed just by the air pressure within the house.

To fill the house with flats, the flats were rolled down a 25′ conveyer through this opening and then carried to where they were to be placed.

PLANT GROWTH: Using a regular glasshouse for comparison, plants in the Airhouse had similar growth but with less fungus problems; this is probably due to fresh air circulating at all times. As a practical example, I could get a crop out of both kinds of houses ready to sell in six to eight weeks. These were the Hahn's and the English Ivy. This amounted to three crops plus during the fall and winter months.

CONSTRUCTION COSTS: These were approximately $1.00 per sq. ft., including heater, blowers, and coolers. Heating cost were about $50.00 per month per house with the thermostat set at 68°F. Since my crops are not a high value type, as compared to other greenhouse crops, for economic reasons I had to lower the temperature setting to 50°F. Even at this setting, on a cold night the heater burned continously. A better method would be to recirculate the air, with an arrangement of louvers or ducts, bringing in fresh, outside, air only for the burner. The burners on the heater would not fire-up unless the blowers were turning as a safety factor. All operations for cooling were done manually. This includes watering the plants by hand.

CONCLUSION: I would say that the economic feasibility of an airhouse for a commercial grower will be based primarily on the longivity of the type of material used. There are coatings available to prolong the life of vinyl. Much more experimentation will have to be done by growers, much of it on a hit or miss basis. A more efficient method of fabrication could be attained if the plastics manufacturer could make wider sheets, thereby eliminating as many seams as possible; this alone would greatly reduce the cost of fabrication.

MODERATOR BODDY: Thank you very much, Ken. The next speaker on our program is Al Holland, the Agricultural Extension Service representative from Orange County, California. He, too, has worked very closely with air-supported houses and has spent considerable time with Ken's house. He has additional information, however, and at this time I'll call on Al Holland to give us that information. Al —

DEVELOPMENTS IN AIR-SUPPORTED PLASTIC GREENHOUSES

A. H. HOLLAND
Agricultural Extension Service
Anaheim, California

Dr. Errol Rodda, Department of Agricultural Engineering, University of California, Davis, prepared a paper with the above title. It reports on two air-supported, water-anchored greenhouses which were used experimentally over chive plants. Construction details and estimates on costs of maintenance as well as production of some other crops are reported. It also briefly discusses air-supported row-covers.

From my experience I expect to see air-supported plastic greenhouses become quite common. There will be a diversity of designs for diverse uses. Some will be for long life and great durability against heat, cold and winds. Others will be lating at all times. As a practical example, I could get a crop out of both kinds of houses ready to sell in six to eight weeks. These were the Hahn's and the English Ivy. This amounted to three crops plus during the fall and winter months.

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A few suggestions I might take are the following:

1. A water anchor may have considerable value for certain conditions. I believe it can be most effective as a separate, one-foot diameter (more or less) tube and inserted in a larger fold-back tube made from the main greenhouse sheeting and running the full length of both sides of the greenhouse.

The fold-back tube could be cut at one or two-foot intervals to facilitate inserting the smaller tube into it. The inner tube could then be fully inflated with water, making possible an intimate seal to the ground with uniform anchorage regardless of soil unevenness or level. This would still allow the strong tear-drop shape of the outer tube. Stress points would be at a minimum if an open head is maintained at the highest point of the inner tube.

2. Larger capacity low-pressure fans appear to be very satisfactory, provided their vents can be closed and higher pressures built up by higher pressure capacity fans during strong windstorms.

3. A very low-volume fan can be adequate for quiet, cool, nights although much loss of heat is by radiation.

4. Modular construction might be considered. That is, end-domed areas having framed doors and vents (instead of zippers) could be made of nylon reinforced plastic sheeting. These might be constructed to connect to the main running area of a greenhouse by use of zippers. Do not use zippers which might corrode.

5. Cheap pressure control devices are possible. They could be installed to prevent rapid collapse of a greenhouse during a power failure.

MODERATOR BODDY: Dr. Tokuji Furuta is an Extension Specialist in Ornamental Horticulture and is servicing the entire state of California, operating out of the University of California campus at Riverside. Tokuji has been with us about a year and he's certainly become one of the most widely-traveled people in the state of California. Tok —

ANATOMY OF THE PLASTIC HOUSE — The Arkansas Razorback

TOK FURUTA
University of California
Riverside, California

Dubbed the "Arkansas Razorback" by the editor of *Jed's Jottings,* this greenhouse was designed by Joseph W. Vestal and Sons, Inc. of Little Rock, Arkansas, a large producer of floricultural products. The clear span structure is simply constructed of prefabricated steel pipe arches and is covered with plastic.

The initial houses were 30 feet wide without posts or used with a minimum of cost but with greater risk of destruction.

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The initial houses were 30 feet wide without posts or trusses. Later models are 40 feet wide. The steel arches are made from 1¼ inch steel tubing. For the 30-foot house, 21-foot lengths of pipe were used while 26-foot pipe was used for the 40-foot model. The pipes are joined at the top of the arch.

The ends of each arch are inserted into a length of 2-inch pipe, 2 feet of which is below ground and 1 foot above. The rows of anchor pipes are 4½ feet apart and adjacent houses overlay by this distance. Thus, the arches from adjoining houses intersect approximately 6½ feet above the ground. Channel iron, or "V" shaped wooden gutters are placed in this junction.

Along the length of the house the arches are placed 8 feet apart. Steel pipe purlins are used to join the arches — 3 are used on the 30-foot house. In addition, wooden 2 x 4 inch purlins are placed on top of the arches 4 feet apart for the attachment of the corrugated panels of rigid polyvinyl chloride. All steel members are spot welded together.

MODERATOR BODDY: Thank you, Tok. Now are there any questions? Yes —

RON HUROV: I am wondering if any people who use clear plastics here have had any experience with ultraviolet stabilized plastic? We use quite a bit of plastic in Hawaii. In fact, 70,000 acres under plastic, and we get quite a bit of variation. In the past few years some of the companies have tried various stabilizers. Some of them are pretty good; they have doubled and tripled the life of some of the clear polyethylene.

MODERATOR BODDY: Is there anyone who can comment on the question of ultraviolet stabilizers for polyethylene?

BRUCE BRIGGS: We have used UV plastic now for about four years. The only problem is the cost factor. We can go two winters and one summer with a UV plastic and with clear we can only go one year.

MODERATOR BODDY: Is your conclusion then to use the UV plastic?

BRUCE BRIGGS: Yes, I think if you figure the price of labor, it really pays to use it.

PETER VERMUELEN: Just some general observations on this subject. Gering Plastic Company in Kenilworth, New Jersey, is putting out what they call DBL-TUFF. We haven't used it because you have to buy it in 400,000 sq. ft. lots, and we haven't quite got up to that quantity yet; but some of the growers have used it with good success and it has quite a bit of longevity — beyond, I think, the UV polyethylene. Pricewise it's about the same as their light-stabilized plastic.

Another observation. White plastic — has anybody here used white plastic? We're using it quite extensively on the East Coast. This is valuable where you might have a shading problem; you can also reduce your heat considerably by using the white plastic. You don't have this large heat build-up that you do with clear plastic.

In making temporary structures we're now using electric conduit; it's a steel conduit put out by Republic. We were formerly using the 21-foot lengths of half-inch galvanized pipe, which cost us 12.6c a foot. This electric conduit is 9.6c a foot, and we're using the ¾ inch size. The people at Republic say it has a higher tensil strength than ½ inch galvanized pipe, and you're cutting your cost by a considerable amount. It only comes in 10 foot lengths, however; you have to use a connector in the middle.

MODERATOR BODDY: Does the white plastic last as long as the ultraviolet resistant type?

PETER VERMUELEN: No, it doesn't last as long as the ultraviolet resistant poly — it lasts as long as ordinary poly. The cost is about the same as the UV-resistant polyethylene.

MODERATOR BODDY: How about the transmission of light? Is it still pretty good?

PETER VERMUELEN: Good enough, I would say, for storing. For growing, probably not sufficient. For propagating it may not be sufficient on a dark day, but for propagating sometimes you want a lower light intensity.

RON HUROV: There's one point that I'd like to bring up. There is a considerable variation in polyethylene. Probably just as much variation as in various grades of paper. I think both the manufacturers and the users have a lot to learn about it. We had some black polyethylene this year; it broke up in two months. In another case, we had polyethylene that was supposed to be the same but it lasted two to three years.

GEORGE OKI: In buildings with wooden trusses, we found that by painting the surface upon which the polyethylene will rest, the polyethylene life will usually lengthen by a slight bit. Now, I've also noticed that many of the cut-flower growers are using a wider slat — wider than the two by four — it seems that the polyethylene will usually fracture right on the edge of the two by four area.

JOE KLUPENGER: Fiber glass has been the most talked about material, I believe, in the last ten years for covering greenhouse structures. There has been lots of discussion of fiber glass but not too much has been done about it. I think it's because of the high cost. Now we have about 35,000 sq. ft. under fiber glass — both a 20-year guarantee material, and a competitive material that's not guaranteed. It's a 4½ ounce grade. We're building another structure now for pot plants — 65,000 sq. ft.; about 30,000 sq. ft. is going to be fiber glass at a 20-year guarantee. We were asked why didn't we go ahead and build the entire structure of fiber glass. Well, although it's got a 20-year guarantee, there's a lot to learn about fiber glass as far as the lasting qualities, although they do have 18 and 20 year guarantees on it; but if you run for 18 or 20 years and have to recover 65,000 sq. ft. all at one time, it would be quite a chore. We are going in smaller portions at a time, so if we do have to recover we wouldn't have to do too much area at once. What I'm getting at is this, that in the next ten years where you want a permanent structure, you're going to find that in 80 to 90 per cent of the cases, fiber glass will be replacing glass and that the structural costs will come far below that for glass structures. We will be able to build a less expensive structure that will be permanent. Now polyethylene makes a good temporary building but for something permanent that has good growing qualities it seems like we're farther ahead with fiber glass than we are with glass. With the new acrylics that they have now perhaps in the near future, on the less expensive material, we can go up there in the summer months and spray this acrylic resin or coating right on the fiber glass — which would give perhaps, another 18 or 20 years life, if you catch it in time. I was talking recently to a manufacturer of fiber glass. He said that once our industry develops some figures on approximately what they could use of a guaranteed material, so that they could have something to shoot for, they would be able to put on the market in the very near future an 18-or 20-year guaranteed material at the price of around 18c per sq. ft. Now it is hard to find anything under 24c. I think that we're heading in the right direction but we should be doing a little of our own research, gathering this information that would be a great help to the manufacturers to let them know what our thinking is for the future.

AL HOLLAND: The other day a fiber glass fabricator called at my office and made the comment that duPont has a material they can incorporate into fiber glass now and keep it clear.

VOICE: I'd like to ask these gentlemen if they have any condensation problem with any of these polyethylene, fiber glass, or PVC structures.

JOE KLUPENGER: This is a question that I've heard lots about over the past five years, especially up in the Northwest where we have a high moisture condition; people have said we would have condensation dripping on plants. If you have too flat a roof you'll have trouble, but with a standard greenhouse pitch — which I think is about a quarter pitch — and with fan-driven heaters and air-conditioning fans I think this will eliminite a lot of the problem. The worst problem with condensate drip in our area would come about March and April. We noticed this year, with the standard greenhouse pitch, that there were drips on the ground in the trails, but you could walk through the house and brush the plants anywhere and you wouldn't get your hand wet. Most of it is going down to the drip gutters. From what I viewed this year I wouldn't hesitate to grow any pot plants, such as pot mums or poinsettias, under that type of fiber glass with ordinary greenhouse pitch roof.

VOICE: How much air "leakage" do you have with glass, vs. polyvinyl chloride vs. fiberglass covered houses?

JOE KLUPENGER: I would say that there is less leakage, either on a good tight polyethylene or fiber glass house, than with glass. Now on glass, of course, it depends on what you're talking about. With new glass, properly constructed, there is very little leakage, but more leakage than with fiber glass. Fiber glass seems to be a little easier to heat, or takes less BTU's to heat a given area, than does glass. Polyethylene, I would say, takes double the heat — BTU's per square foot — since it is such a thin film.

VOICE: I'd like to know how Joe fastens the seams on his fiber glass construction.

JOE KLUPENGER: Well, first of all, we have the fiber glass sheets manufactured in 54-inch widths rather than two feet. Then we get it cut to specified lengths — so we have to do no cutting for the roof at all. We have a little — what we call — lap nut. There's a little piece of angle iron about ¾ by ½ inch, bent into the shape of an L with a hole in it; just at the laps between the purlins we have about 4½ feet. We use one or two of the these and run a metal screw right through them — no sealer or anything; use about two of them between the 4½ foot purlin spaces. On these inexpensive fiber glass houses which we've just built, we used a plain galvanized pipe strap, one inch pipe cap over one-inch purlin and then run our metal screws right down from the outside, the hex nuts, the neoprene head metal screw, right into the pipe strap. That holds it onto the purlin; spaced at about 14 inches.

VOICE: I'd like to ask Mr. Holland how he held the plastic airhouses down.

AL HOLLAND: We had a water-filled ring. It was a ten-mil clear, polyvinylchloride ring in a loop around the house. We never did fill it full. It was 18 inches in diameter, engineered to stand an 80-mile wind, and it withstood 60-mile winds, not completely filled.

BOB BODDY: I just want to comment further on condensation drip. In a small propagating quonset-type house that formerly was covered just with polyethylene, we had a lot of drip. We use a chicken-wire-like material, to frame the house and we found that if we put saran cloth under the polyethylene that we didn't get any drip. The only places that dripped was where the saran had a seam. We used scrap saran and where the seam was, the water collected and it dripped in that place, but the saran seemed to eliminate the bad drip problem.

BILL CURTIS: I have a quonset type plastic house, 17 x 98 feet. On either end I have a 4 by 8 foot door and a window above the door, and when we cover it in the fall we cover the whole thing up, but I do have a V-opening right at the peak. The first year we took a knife and opened this V for ventiliation so that we wouldn't have a problem when we had our

High-Low heater burning. The second year, for some unknown reason, we didn't cut out this V. I never thought anything about it. We closed the house up. The weather got cold and we lit the High-Low heater. I went in in the morning and the place was full of smoke. I figured that something was wrong with the heater. Another one had worked well in a shed-type plastic house that I have, so I changed heaters. The next night the same thing happened again. Then it dawned on me that I had the house so tight that it had cut off all the air and there wasn't sufficient oxygen for the heater to operate; so I went up there with my knife, cut in the holes, and I've never had any trouble since where I have this little V in the top. The plastic house is real tight.

We now have Mr. Peter Vermuelen who will give some of the Eastern views on "How Modern Marketing Affects Propagation". Peter —

HAS MODERN MARKETING AFFECTED PROPAGATION AND, IF SO, HOW?

J. Peter Vermeulen
John Vermeulen & Son, Inc.
Neshanic Station, New Jersey

There can be no doubt that marketing, whether it be modern *or* ancient, does affect propagation. There is a line, sometimes broken or dotted and sometimes weaving but nevertheless a line, from the cash register to the propagator's list. Few ornamental plants really taste good. When one considers propagation in its pure sense however it would appear initially that propagation techniques in themselves would not be altered markedly by marketing or, for that matter, any other factors that are normally associated with growing as against propagation, *per se.*

In my lifetime practical propagation has advanced from a largely methodical and emperical concept to one of a more techno-scientific nature. Our nursery has always specialized in commercial propagation and the sale of liners and so we have tried to keep abreast of new methods and techniques and even to look into the future through research, our own and that of others. It seems to me that change in propagation has been brought about by the same general factors that have influenced most other products. Since I was to speak here today on the subject, I decided to explore beyond our particular opration and observations and so wrote to a number of propagator friends throughout the wide geographical base comprising the Eastern Region of our Society. Replies were received from New Jersey, of course, Pennsylvania, Connecticut, Rhode Island, Virginia, Ontario, Georgia, Ohio, Nebraska, Wisconsin and Alabama.

Allow me first, however, to comment on how marketing has altered our propagation at John Vermeulen & Son. Like many others, we have been heavily engaged in mist propagation for some years. Initially all of our work was in greenhouses. Gradually we fitted this technique to our particular environment, facilities and requirements and over the years were able to achieve personally gratifying and commercially rewarding results. But there remained problems of environmental control specifically involving light, heat and air that could not be overcome without extensive and expensive capital investment. Additional investment would be required due to increasing quantities and additional items. So we turned to mist beds outside, first experimentally and then, as we learned our lessons and our knowledge accumulated, working up to large quantity production. There the unit costs are considerably less and the results consistantly good to excellent.

As the demand for certain items increased, especially for peat potted items for container growing, and because we were not alone in finding this technique rewarding, competition became more keen. We therefore started to think about and experiment with rooting cuttings directly in a rooting-growing medium in containers. Our work has been reported to this society on three occasions and many others have been busy with this technique in various methods. The literature cited in my paper "Rooting-Growing Media", published in the Combined Proceedings, I.P.P.S., Volume 15, is a handy though not complete reference to discussions of rooting cuttings in rooting-growing media. I will therefore not speak of it at this time other than to say that "PROPICON", meaning "propagation in containers", has proven outstandingly successful for us on a long list of plants. There seems little reason to doubt that seeding, rooting, budding and grafting directly in the ultimate selling container is practical and will become a more widely used technique as time goes on.

"PROPICON" then represents the major change in our propagation techniques but I can not say that it was brought about solely because of modern marketing although such was a definite factor of influence.

One other technique that we and others have used to some extent, and which I believe will bcome more widely used as we become more proficient with it, is that of starting with much larger cuttings and scions than usually used. Very large cuttings will root and they do cut the total time considerably from cutling to saleable plant.

Now let me go back to the survey. If I were to summarize briefly on this limited survey it would appear that modern marketing has affected propagation mainly as change relates to items and quantities produced but that propagation techniques, in general, have not changed appreciably. To illustrate and also to bring forth some points to ponder and perhaps discuss here, I will excerpt from the letters.

From Nebraska: "In our operation ...... the propagation techniques have not altered to a great extent over the years. If one considers the sales end of marketing (or vice versa), then certainly propagation lists have changed drastically."

From Connecticut: "The only way modern marketing has affected our propagation is that we seem to grow fewer and fewer varieties" .... "It disturbs me sometimes, that we are giving up some of the good varieties, because I personally like them; however, business-wise, I am convinced we have been doing the right thing".

From Ohio: "Modern marketing is moving larger numbers of individual items. The nurseryman today has the alternative of increasing the size of his operation or taking the dangerous alternative of reducing the items on his list".

From Alabama: "Only that the demand for specific types (such as dwarf growers, rotund and columnar varieties) has caused us to be more careful in planning our cutting list."
From Virginia: "The idea of modern marketing seems to be a cheaper item with less cost." . . . . "We have had to speed up in some areas to meet the rising costs".

From New Jersey: "Modern marketing has, of course, affected our propagation, principally in the selection of varieties grown" . . . . "The development of container-growing has also put us back into the propagation and sale of varieties which we formerly had given up" . . . . "The other change in marketing which has altered our propagation is the greatly increased demand for clonal shade trees of improved varieties".

From Pennsylvania: "Modern rooting technology can easily lead to overproduction which must be carefully watched. Since we are now a wholesale nursery only, we have reduced the numbers of varieties we grow although we have increased acreage and number grown".

From Rhode Island: "With modern marketing the volume of plant material being sold has increased two-fold in my business. This calls for "positive propagation" . . . . "Today a propagator has to set high percentages in his propagation to keep up with the demand" . . . . "I am trying to get a larger plant from the start . . . . I always use as large a scion as my understock will support" . . . . "I would say: modern marketing has kept me seeking newer and faster ways of propagation while meeting present-day demands with old and reliable methods".

From New Jersey: "Yes, I believe that modern marketing has affected my production program in requiring large quantities of specific items which are being promoted for volume sales".
From Georgia: "This means we have to start with a big liner and have little or no shock in the transplanting process". "It means also the elimination of varieties that grow poorly for us".

From Wisconsin: "In summary, modern marketing practices have not affected our basic methods of sticking and treating cuttings or planting our seeds, but it has prodded us into giving a great deal more consideration into the cultural practices that take place once the cutting has rooted or the seed has germinated".

From Pennsylvania: "In our greenhouse operation, we are keyed to the production of plants that are more readily adapted to growing-on in containers and are now planting many plants in Jiffy pots, which go directly into containers rather than being transplanted in the beds before being sold or lined out in the field".

From New Jersey: "Availability of mist has allowed us to consider rooting in a rooting-growing medium".

From Ontario: "My answer is yes, but not to such an extent as to radically change our procedures. We do propagate more items directly in pots to be shifted into larger containers or planting-on which we formerly handled bare root. Our main interest is in faster and more economical production, such as *in situ* propagation, rather than in better or newer marketing procedures. I naturally envisage a more and wider use of containers but, at present, have no immediate plans due mainly to over-wintering problems and to customer acceptance".

From Indiana: "All this adds up to one thing; as for propagation, it means the need for far more plants . . . not only must we meet the demands of a more affluent society, but also the demands of the cash and carry shopper — the one who is satisfying an impulse by purchasing the smaller plant — one he can carry home and plant (and one he can afford)".

From Pennsylvania: "An exerted effort is made now toward mass production in containers, utilizing polyethylene for winter protection, sparing no expense in growing excellent plants in the shortest possible time through constant feeding, multipruning, all grown under highly concentrated conditions".

From Ohio: This one was difficult to excerpt. In summary he stated that modern marketing has seemed to take the craftmanship, with its resulting pleasures and pride, out of propagation —trading skills for dollars — and has tended to create a mass production and buying attitude that does not properly respect the quality plant but rather the popular ones, and these mostly because of price.

These comments, plus what we have gathered from our own experiences as well as reflections on the future, lead me to conclude that the demands created by modern marketing when integrated with the developments in propagation techniques require that the present-day nurseryman choose between one of two possible areas of specialization:

(1) Mass production of any or many of the popular and fast-moving items, or

(2) Patient production of the more difficult, more costly, slower growing, rare and unusual plants, for which, I am happy to say, there is an increasing demand.

Happy is, and hats off to, the one who can do both!

TOK FURUTA: Our next speaker is Jack Matsuda. He will discuss the effect of modern marketing on propagation as it pertains particularly to bedding plant growers. Jack:

MODERN MARKETING EFFECTS ON PROPAGATION

JACK MATSUDA
Union Nursery, Inc.
Gardena, California

Propagation in the bedding plant industry has been basically the same for many years — sowing seeds, transplanting, *From Ontario*: "My answer is yes, but not to such an extent as to radically change our procedures. We do propagate more items directly in pots to be shifted into larger containers or planting-on which we formerly handled bare root. Our main interest is in faster and more economical production, such as *in situ* propagation, rather than in better or newer marketing procedures. I naturally envisage a more and wider use of containers but, at present, have no immediate plans due mainly to over-wintering problems and to customer acceptance".

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Propagation in the bedding plant industry has been basically the same for many years — sowing seeds, transplanting, and hoping for the weather to break at selling time. However, there has been many changes in modern marketing.

Discount houses and mass outlet retail centers have mushroomed around suburban living. To become more familiar with marketing trends of today, we must become more merchandising-oriented so that we may better serve our sales outlets.

Timing, distribution and packaging are some of the factors involved in marketing.

If you read your newspaper ads you will no doubt become aware that all retail outlets have anniversary sales, 1c sales, birthday sales and what have you, besides their regular holiday specials. To feature a certain plant for their ads, the grower must be informed well in advance since most stores place their copies ahead. We use our IBM system for computing and planning by categorizing our sales. No matter how much planning is involved, timing on certain crops is critical, especially when color is needed for appeal factor; therefore the importance of controlled environment for growing is considerable. This involves usage of chemical growth regulators, a fertilization system, lights, black-cloth, CO_2 and perhaps a UTOPIA-type of growing house.

Packaging and distribution becomes another factor resulting from marketing. We at Union Nursery have developed a shipper display unit we call the "Union's Shelf-Rak" for merchandising our product. This unit consists of a package 18″ x 18″ x 47″ to hold six flats of bedding plants. We have overcome much of our distribution problems by utilizing this package for shipping by common carrier. Since we use a lightweight mix, this unit only weighs about 60 lbs. It also has many features for the retailers, such as self-service, sales appeal, ready display, reduced handling, no flat deposits, and a higher dollar return per square foot of space.

Modern marketing involves many changes in our growing methods. I have just touched on some of the changes involved in the bedding plant industry. However, I feel this could be generalized in the whole nursery industry. We must utilize the ideas of our allied industries, our Agricultural Extension Service, and our Universities to keep pace with our changing economic picture.

TOK FURUTA: We will withhold questions until the Question and Answer period and go right on to our next panel which deals with "In-Service Training" of employees. Actually, we are going to be talking about a topic which is very important and very dear to the hearts of most of us — or all of us, I should say — since the future of our industry depends upon what kind of people we bring in to it and how well they are trained.

A few weeks ago, in an address to nurserymen, I stated in part: "The greatest strength of the community, and at the same time the biggest problem faced by the community, is people—those that make up the community and those that come to the community for its products and services. There is need in the community for more people to spend more time thinking. We should not be hidebound with preconceived notions or with tradition. We should let our imagination soar. We should put ideas from everywhere to work . . . "

We hear that we are not able to attract the type of employees we want. I would ask if we really know what we want in terms of skills.

You must be willing to invest in the future of your firm by paying competitive and attractive salaries, and by developing more and more proficient training programs. Training programs serve to impart the skills needed by your firm and also to identify the employees with management capabilities.

Fortunately, leaders of the community are paying more and more attention to these problems. In-service training is not something to be handled only occasionally when the time permits. It is not something to which little thought is given. Rather, a regular program should be established, not only for the new employee, but for the retraining of the permanent staff. The authority and responsibility should be delegated to a definite and identifiable person. It should not be put off until tomorrow. The consequences of putting it off until tomorrow can be serious.

Now, for our Panel — I would like to call first on Dan Veyna, Orange County Nursery, now in Visalia, Tulare County. California.

IN-SERVICE TRAINING

DANIEL C. VEYNA

Orange County Nursery, Inc.

Visalia, California

As I see it the purpose of in-service training is to have a labor force that can operate a smooth and efficient, profit-making business. Before we go into how and what we as a business are doing about it, please ask yourselves these questions: Are you so important in your work that your business couldn't do without you? Would your business suffer a serious setback, or go broke without your services or the services of one of your key employees. If your answers are in the affirmative the chances are that your in-service training has room for improvement. I personally believe that *no person* from the lowest paid employee to the boss *should be indispensable.* With a good program of training, your work should be able to continue with or without you. Hopefully, of course, no one should be quite as good or do as well, otherwise we would be out of a job.

In our own business we have a lot of "chiefs"—so, at the managerial level, we shouldn't be running short for awhile.

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In our own business we have a lot of "chiefs"—so, at the managerial level, we shouldn't be running short for awhile.

In fact, I have a younger brother that works with me at the Visalia and Tulare County area, that can well take over when I am gone. In due time he may even do better than I can. How about yourselves? Somebody had to carry-on, while you are here enjoying this very wonderful Plant Propagators' Meeting.

Getting back to my level of responsibility — our greatest recruitment of labor is at the harvest time when we dig out our bare-root fruit and shade trees. All throughout the year we've been telling our permanent help to spread the word that for harvest time, beginning the last week in November, we'll need all the help we can recruit. (One thing we emphasize is to leave the lazy ones at home.) Most of the time they do a pretty good job. Word spreads that we need more people and usually, if the weather isn't too bad during the winter harvest season, we get all the help we can use. In training during harvest, our permanent crew make up the graders, tractor drivers, leaders, labelers, etc. All of the new help is first used in pulling out the trees behind the digger and later in tying right in the field. We usually start out slowly the first couple of days with the older hands teaching the new people how to pull and tie the trees. As we go along and are enlarging the crew, we observe which of the new hands have or show more promise or ability to learn. Thus we make more graders, leaders and so on. Thus our in-service training begins; we don't have a formal program that would come out of a manual or hold classes in instruction, but we do look for the natural qualifications such as any employer would do. These are:

1. Desire to work
2. Willingness to learn
3. Education
4. Past experience in related work
5. Physical stamina

By the time our harvest season is over, about a month and a half has elapsed and we have had ample time to observe and to some extent, do considerable training. The ones that have given the least service are the first ones to be laid-off. Harvest being over, our crew is usually cut in half.

By the latter part of January, we start collecting propagating wood and making cuttings — either to heal-in in sand or to put in cold storage. Soon after the first of February we start stubbing-back or cutting-back. Here again the older hands are teaching the newer employees. In all important operations one of the older employees is always present or working with the new people. You may wonder what we've been doing all this time; whenever possible, we're right there getting things started and, thereafter, making periodic checks at irregular intervals to see that the work is being carried out to our satisfaction.

This same procedure is carried out through planting, grafting and budding. Naturally, in budding and grafting, only our more experienced employees skilled in these jobs perform the work. In these areas our propagators are provided with helpers and tyers from the more promising of the new employees. Thus through each operation the newer people are learning and acquiring new skills and, of course, earning more as they learn more. So the cycle ends and is ready to begin all over again.

To sum it all up: In-service training is very necessary and never-ending, be it a formal classroom and laboratory type or direct demonstration and application. The program must be positive so that the employee knows where he stands and can take satisfaction in the knowledge that through improving his skills his paycheck will also increase. The boss should also be happy because an efficient and productive employee is the greatest asset any company can ever have.

TOK FURUTA: Thank you, Dan. We should like to continue our "In-Service Training" panel; the next speaker needs no introduction to you, so all I'm going to say is — here is "Jolly".

TRAINING WORKERS

O. A. BATCHELLER
California Polytechnic College
Pomona, California

"Nothing succeeds like success," and no one really learns to work at his top level until he has the responsibility and the rewards of his efforts.

It is difficult in a classroom or college situation to bring all of the factors of a commercial concern into bearing, for the time we have the students is only a part of their total commitment and they cannot live their entire time in the stress and strain of an economic situation.

We have found several different ways by which we can supplement the student's scientific training, and we feel we have succeeded to a large degree.

First and most important is that the material we present in the courses is of a practical and applied nature, presented by instructors who have had wide and successful experience in the field.

Second, and perhaps equally important, is that field trips are arranged to places of business which are engaged in the type of work we are studying. In this manner we can show the student the extent of the enterprise. It is also an opportunity to show the detailed planning and scheduling of all activities so as to make maximum use of the facilities and to return the greatest profit. Here the student can see and appreciate many things, such as the increased turnover by quicker rooting, the greater saleability by careful care and proper culture, grafting and budding. Naturally, in budding and grafting, only our more experienced employees skilled in these jobs perform the work. In these areas our propagators are provided with helpers and tyers from the more promising of the new employees. Thus through each operation the newer people are learning and acquiring new skills and, of course, earning more as they learn more. So the cycle ends and is ready to begin all over again.

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Our hosts for our field trips have been most generous with their time and effort, and the impact of their words is far greater than ours, though most of the time we are giving the same message.

A third method and, in my opinion, of greater value than those already mentioned, is to have the students employed in a part-time position with the industry while they are enrolled at the College. Our records show that over 50% of our students are working their way through school, and I am happy to report a great many of them are employed in the horticultural field. We find such students working in the field not only get a great deal more from their course work, but add greatly to the discussions. The astuteness of their comments and judgments is most surprising and it is not surprising that their fellow students respect them and listen.

A fourth method is the Foundation Project System we have available at the College. In this system a student outlines his intended growing project with (1) an estimate of what he plans to do; (2) an estimate of the cost of the plants and materials plus a schedule of operations and activities; and (3) where, how, and how much he expects to make from the operation. This is carefully studied by the instructor in charge of the particular project. If necessary, or if we feel it desirable, the entire staff will meet with the student and have him defend his plan. Once the plan is approved and signed, he makes the necessary requisitions which are countersigned by the advisor, and the materials are paid for by the College Foundation. The student is required to keep a record of all activities and costs in a project notebook, and the advisor keeps close watch over the activities. As the crop comes into production, it is sold and the money is deposited to the student's Foundation account. Some material is sold to students and staff at the Ornamental Horticultural Unit, but most is sold directly to nurseries which have been contacted. Often it is the boy's parents who are engaged in the nursery business.

During the project a student learns many things—propagation and growing procedures, scheduling, bookkeeping, and — as his profit or cash in hand is the difference between cost of operations and sales — the student gets a real good practical course in economics. Not all projects make a profit, and if a student fails to take care of his project properly, it is taken away from him and managed by the Ornamental Horticulture Department.

I should mention the Foundation which finances the projects is reimbursed for all expenses and shares ⅓ of the profit. We feel this is sufficient compensation for use of facilities and utilities and makes the operation a little more realistic.

A fifth method, though similar to the second, is the employment possibilities within the campus Grounds Department. This is under the direction of the Ornamental Horticulture Department, as we act as advisors with regard to the planning and planting. We feel that the student's knowledge is enriched by his work experience on the grounds for which he receives pay.

A sixth and important aspect is the speakers who are brought to the campus as guest lecturers. Often these are former students who are now established in business. Because of their former student status we feel they are most effective in directing the student's attention to the various phases of the industry.

I would be most remiss if I did not close by indicating the importance of our teaching staff. At Cal Poly we are, of course, concerned with a proper educational background for our instructors, but of equal importance is his interest, knowledge and experience in industry in the area in which he is teaching. All of our staff have been successful in industry and are now not only teaching in the subject area of their academic training but also in the areas which they have successfully handled in industry.

It would be naive to believe that formal education at the College will fit all men for all jobs. We realize that every firm has its own "modus operandi" and because of this feel that an orientation or "in-service training" should be carried on continually. By this procedure communications in both directions is usually improved. This generally results in better understanding, greater efficiency of operation, and a generally improved morale factor.

TOK FURUTA: Thank you, Jolly. We have one more panel member now. Mr. Ed Gardner of Stribling's Nurseries will give us his views of "In-Service Training", Ed:

IN-SERVICE TRAINING

ED GARDNER
Stribling's Nurseries
Merced, California

Have you ever heard the expression, "Get out of my way. I can do it in less time and a lot cheaper than by standing here, watching you fumble around." Does this sound familiar to you? Maybe not, but a good many of us have heard a variation of this at one time or another in our lives, especially in the formative years in our work.

This somewhat exaggerates a very real problem that we have when training personnel for our nursery operation. Few nursery operations are organized and fully staffed in all departments so that a new employee merely has to imitate the man who is directly in charge of him. If your situation is typical of our operation you may find yourself with a new employment possibilities within the campus Grounds Department. This is under the direction of the Ornamental Horticulture Department, as we act as advisors with regard to the planning and planting. We feel that the student's knowledge is enriched by his work experience on the grounds for which he receives pay.

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The diversified nursery that we have consists of field and container grown ornamentals, deciduous tree and vine growing, farming of cotton and beets, a complete propagation facility and peach seed harvest. Also selling, on a wholesale, commercial and a retail basis. With this diversification we find ourselves with only a few men who are able to spend their full time in one division. Many must rotate from one division to another. Today a man is a budder of trees, tomorrow he is assembling plants for delivery. He may be putting in pipe lines, or inventorying the stock, and then he may very well be the one to deliver this stock to our customers. This, you can see, is a very versatile man; but, also a very hard man to train on an organized basis.

I personally find that there is a certain amount of "sink or swim" attitude that must be exercised in order to make this new employee or trainee realize he must demonstrate some personal judgement. He must use his "noodle". This, I find, is a shocking experience to some. However, after the shock, I find that they are very adept and appreciate the new confidence they have found in themselves.

For example, I have a tree-packing operation to struggle with each year on a crash program. We do 60 days of packing in 30 days time. This pressure brings out the worst or the best in leadership.

It has been my misfortune to start each packing season with a new packing and warehouse foreman. Sometimes the bench crews know what is going on but the new foreman must gain control and make production schedules and learn the operation at the same time. I must point out to this man that he must do two things—gain the respect of the crew and get the job done. This is no small task when you are under such pressure. But most of all *he must not try to do all the work himself*. He must delegate authority. This must be done if there are two men or 100 men. He must delegate and follow up.

In our production division, large crews are formed on a seasonal basis and these crews are generally staffed by an experienced employee. This trained employee does not conduct classroom sessions or give training lectures, but he does get right to the meat of the problem. He gets the crew moving and thinking and he does this by simple demonstration. He must constantly follow up his demonstration to see that everyone is doing his assigned task.

If you were to ask one of these foremen to give a resume of how he teaches and how he plans to get results it might prove quite difficult for him, but you can be sure that those men working for him have received his message and understand what he means very well. This, then, is a never-ending training program that goes on at our nursery day in and day out, but I find it hard to put my finger on any part of it to say, "This is our formal training program. This is our way of teaching a new employee the skills of a nurseryman."

Training is often done on a buddy system. Budders and tiers are often the foremen of our work crews. Each season they are called on to work on their hands and knees in the field. They work in teams of two. The budder generally chooses his tiers and trains him in the process of budding and tying. This training is done while working on a piece-work basis; the better performance receives the better reward. Each year a few of the tiers advance to be the budder and they become the teachers. The budders are highly skilled in budding, but are short on text-book theory for teaching. Yet, I am always amazed at the proficiency with which these men train their helpers. I am sure the good pay they receive for the piece work has something to do with it but I am also sure that a certain amount of pride and integrity is involved when one team is scored against the other for quality and quantity of budding.

Now this pride and integrity is what I have been leading up to, for without these two basic ingredients most of us would find our jobs very dull and uninteresting regardless of the pay. So, when we speak of training and education of employees, we must also consider what we can do to instill pride and integrity into these employees as well. It seems hard to relate pride and integrity with our personal program at times, but it is a very real part of it.

We don't often use these words when speaking to our employees, so there must be some other way that this is conveyed for it surely is a part of our business. So my thought is—that the lack of text-book terms does not mean that a training program, however informal, needs to lack in quality, a quality that shows in an employee as a man who has pride in his work and integrity in his dealings with others.

TOK FURUTA: At this time it is with great deal of pleasure that I present to each of our speakers, as was done for all the other speakers, a "Certificate of Appreciation" for their participation. I hope that each of you individually has had an opportunity to see one of these, but in case you have not, I should like to take this opportunity to read it. "International Plant Propagators Society — Western Region, takes pleasure in presenting this certificate of appreciation as an expression of our gratitude and high esteem for your interest in the art of propagation. We sincerely appreciate your generosity in sharing with us your knowledge, and your time in addressing our members".

Now is the time for questions and answers, so now the floor is yours for questions to any of the panel members from this afternoon or to the members of the firms we visited this morning.

BILL CURTIS: In regard to this employee relationship, what do you people feel is the best — to give a person who comes to work for you a raise right away, a big raise, or to give him a series of small raises? Which gets the best results?

JOLLY BATCHELLER: You've got to earn them all.

MARGARET FLEMING: We feel that if the starting wage is not so marginal that the guy is starving while he's learning, then it would be better to give him a series of small raises. They earn it first, then we pay them. They earn some more, then we pay them more.

JERRY MAILMAN: On the Monterey Peninsula, California, at the cities of Seaside, Marina, Pacific Grove, and Carmel the groundskeepers are now required to take six units of Ornamental Horticulture, which is a four-hour class, one night a week for 17 weeks. This program is strictly related training, no manipulative work at all other than demonstrations; these are for the purpose of upgrading units for salary increases. Such programs could also be used perhaps in the propagation and nursery business in cooperation with the local high schools or junior colleges.

TOK FURUTA: In this regard, I might point out that I had the privilege of working with Program Teaching, Inc., Palo Alto, Calif. I don't know how many of you know of this firm but they specialize in developing program text material for industry and for schools. They have been working under contract with the Office of Economic Opportunity last year and have developed a course which they call Landscape Aid; they are now embarking on the development of one more advanced or in a little more detail. They haven't really titled it, but it would be in terms of nursery employees; some of you may be interested in this, perhaps trying to work this type of program material — which is really a self-teaching type of thing — into any training program that you are developing. Any further questions?

JACK WICK: I'd like to ask if at the Lewis Azalea Garden they water the azaleas in their cold storage house.

MR. LEWIS: No, we don't. There are two theories of how azaleas should be pre-cooled. One, which we do not follow, suggests cooling at about 45° to 50°F. with added lights and watering the plants as they use the water. We store in complete darkness, below 40°F., generally around 36°F. The respiration, transpiration, all functions of the plant are so limited that water consumption is quite low. We have supplementary humidification in the boxes. The coils are designed for minimum moisture removal. The fan speed is adjusted once the plants are brought to temperature to an absolute minimum movement so that dehydration is reduced just as far as practical. The greatest problem we have is to get the plants into the cooler thoroughly wet. For plants that go in wet we have kept them at that stage for 12 to 13 weeks.

VOICE: I'd like to ask a question about the potted azaleas plants. Are they fully budded when they're put in cold storage? Fully developed?

MR. LEWIS: Yes, they are — but that's something with which we're still experimenting. No one could actually tell us what we should do so we're doing it on a "try and see if it'll work" basis. We're progressively putting the plants in at a lesser stage of maturity. We don't exactly know what point is too immature for the pre-cooling to work. However, we're putting them in primarily to "even" the bud. Since bud development is uneven without the cooling, if we try to wait until all buds are mature, some of them would be in bloom; so we have to pick the plant, say with the furthest advanced buds, to just the maximum point that we feel we can leave that plant out, and then put it in. Some buds will be so small that you can hardly see them, but the pre-cooling over a long period of time does even them up. It seems to work satisfactorily.

HERMAN SANDKUHL: I have another question for Mr. Lewis. Do you find an acceleration or deceleration when you take them out of the cooling chamber to bring them into bloom — or do you send them straight to market from there? In comparison with plants in a greenhouse at about the same budding stage, will they come into bloom all at the same time or are the ones in cold storage slower coming in bloom?

MR. LEWIS: Well, that's a complicated question. Here in southern California we probably have the most ideal conditions for budding an azalea without greenhouse treatment that exists in the United States. We have no trouble preparing the plants for Christmas delivery — forcing without this pre-cooling; plants for Christmas (pruned in May or June) can be forced into flower in about six weeks. We bring them into the greenhouse in November and have them ready for Christmas delivery. Now the pre-cooling is sort of an extension of nature in the fact that we are providing this artificial fall and winter cold at any time of the year that we desire, so the same situation occurs with plants from cold storage as occurs with plants that have not received it, depending upon the season. We can fool the plants in thinking that they have had the fall cold. Plants of the same variety cooled approximately the same time as they would have been naturally out-doors will bloom in approximately the same length of time.

MECHANIZATION IN THE ROOTING OF CUTTINGS: 1906 to 1966

WILLIAM E. SNYDER
Department of Horticulture & Forestry
Rutgers, the State University
New Brunswick, New Jersey

The plant propagator is apt to take for granted many techniques of mechanization which were unknown to his predecessor sixty years ago. Continued mechanization in the propagation of plants is a necessity in today's competitive production of plants. Reduced labor costs, elimination of "human error" in judgement and accurate control of the environment of the cutting will more than pay for the costs of mechanization. Therefore, for a few moments, let us take a brief look at past and present methods of regulating the environment.

I have chosen to compare today's equipment with those described in the 10th edition of L. H. Bailey's "THE NURSERY BOOK—A Complete Guide to the Multiplication of Plants", published in 1906 (1).

First, we shall compare the aspects of the environment—atmospheric and soil—considered of importance sixty years ago and today. Second, we shall take a brief look at some of the structures used to regulate these environmental factors, then and now. Finally, we shall examine some of the methods used to regulate temperature and moisture.

Sixty years ago, Bailey discussed the importance of moisture and temperature of the air; today we not only recognize these two as important considerations, but also are concerned with the three aspects of light (intensity, quality and duration), with the carbon dioxide content of the air and with wind movement. In 1906, moisture, temperature and aeration were considered important aspects of the medium. Since that time, we recognize that three additional aspects of the medium are important—pH, nutrients and organisms. It is as true today as it was sixty years ago that the moisture and temperature relationships of both the atmosphere and the medium exert the greatest influence on the rooting of stem cuttings. And it is only natural, that as we refined our knowledge of and improved our methods to control moisture and temperature, we could then recognize the importance of other factors on the rooting of cuttings.

The structures in use sixty years ago were designed primarily to regulate moisture and temperature. Bell jars, handglasses, propagation ovens, propagation tanks, outdoor and indoor covered frames and the Forsyth cutting-pot were common structures used to regulate moisture conditions. Various methods of shading were used to reduce the heat of the sun; crude heating devices, without any means of automatic regulation, and manure were used to supply bottom heat.

The structuures in use today are also designed primarily to regulate moisture and temperature. Covered frames are used and are an effective means for propagating a wide variety of plants. Polyethylene enclosed structures are very satisfactory. The use of intermittent mist and controlled humidification systems have made open benches and outdoor beds effective structures for many kinds of cuttings. Thermostatically-controlled heating units are used to supply a uniform bottom heat. Special structures have been devised and used to good advantage. These include the relatively simple techniques employed in Nearing's Solar Frame and Hancock's Burlay Cloud — to the more sophisticated techniques of Templeton's Phytotektor.

The maintenance of good water relations in the plant tissue is essential for the successful rooting of cuttings. There are two different ways whereby we can help to conserve the plant's water. The first is to maintain a high moisture content in the air. The second method is the application of a film of water to the foliage in order to reduce the tissue temperature. Both methods, alone or in combination, are effective and have been employed by propagators for many years. For example, the simplest way, but one which requires the utmost skill, is the frequent hand syringing of cuttings to reduce tissue temperature and wetting down of the walks and other ground areas to help maintain a high moisture content of the air. I wonder how many hours have been spent in the past sixty years in the propagation house using a watering hose.

Closed structures, such as the hand-glass, bell-jar, propagation box and covered propagation frame, were commonly used in 1906 to maintain a high atmospheric humidity in the small volume of air surrounding the cuttings. Double glass and shading furthered the effectiveness of such structures. There was, however, no good means of maintaining uniform conditions from day to day.

Covered propagation frames are in use today. One major change is the use of polyethylene film instead of glass to cover the frame.

About 25 years ago, the use of a constant level, sub-irrigation system was recommended for maintaining a uniform level of moisture in the medium. A simple float valve was used to maintain the water level. However, unrooted cuttings can absorb only limited quantities of water and the cuttings in the sub-irrigated structure need almost as much care as those just mentioned.

Controlled humidification as an aid to the vegetative propagation of plants was the title of a talk presented at the first meeting of this Society in Cleveland in 1951 (2). Dr. Chadwick described the results of his experiments in which, by the use of humidistats, he was able to maintain the relative humidity of the air at fairly uniform levels. The development of an accurate and sensitive humidistat was necessary before controlled humidification could be used.

Within a few years, the propagator's attention was directed toward the use of mist applied directly to the foliage. The development of nozzles to produce a fine spray, of mechanical and electronic mechanisms to control the frequency of mist, and the use of solenoid valves to control the flow of water have made the misting of cuttings a successful technique. The use of intermittent mist results in a reduction of tissue temperatures and permits propagation with little or no shading. In the simplest terms, intermittent mist is mechanized syringing.

Let us now turn our attention to the changes during the past sixty years in the control of temperature. We are concerned with both heating and cooling of the atmosphere and with heating of the medium.

Various methods of shading and the use of manually-operated ventilators in the greenhouse were, and still are, in use to reduce air temperature. With the advent of mist, however, the necessity of using heavy shading for the cuttings has been largely eliminated. Automatic systems for the opening and closing of the ventilators are activated by thermostats. More recently washed-air cooling systems have been shown to be effective in reducing the air temperature in the greenhouse by as much as 15 to 20 degrees. Washed-air cooling systems can be controlled manually, by time clocks, or by thermostats. Refrigerated cooling systems do not appear to be economically feasible for greenhouse propagation, at least at this time, but may be used for propagation by meristem culture.

The development of efficient heating systems for buildings has resulted in better heating of the greenhouse. Accurate and sensitive thermostats, solenoid valves and greater efficiency in heat distribution systems are now available. Greenhouses can be made relatively air tight by using aluminium bar caps and by the addition of a layer of polyethylene inside the glass, thus more uniform air temperatures can be obtained.

Sixty years ago the sources of bottom heat were the sun, rotting manure, small lamps and manually-controlled hot water systems. Today, the hot water or steam systems are controlled by thermostats. Electric heating cables with thermostatic control, were first used for propagation about 35 years ago. Quite recently low voltage electric heat has been shown to have many advantages over other methods of supplying bottom heat.

At this time, I will not discuss mechanization for the control of other environmental factors we now recognize as important for successful rooting. Hopefully, other members of this panel will discuss mechanization of the treatment of cuttings with root-inducing chemicals, of the wounding of cuttings, and of handling cuttings in units rather than individually.

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1. Bailey, L H. 1906 The Nursery Book—A Complete Guide to the Multiplication of Plants. Macmillan, 365 pp. 10th Ed.

2 Chadwick, L. C., 1951 Controlled humidification as an aid to vegetative propagation ' *Proceedings, Plant Propagators' Society*, I 38-39

PERCY EVERETT: Again we thank you, Bill, and we also thank the Eastern Region for letting us have you occasionally. We have been fortunate to have at least four of the Eastern members with us this morning. We're going to introduce to you now a man that has, perhaps, not been so well acquainted with the Western members. It's not his first visit to California, by any means, but I think it is his first visit to one of our meetings. Vincent Bailey, of the J. V. Bailey Nurseries, St. Paul, Minnesota, is going to discuss our next subject — the mechanization problems that he has had, what they are doing now, and how they have met competition. Mr. Bailey was raised in the nursery business, which was started by his father, J. V. Bailey, in 1905. Vince was a graduate of the University of Minnesota — in horticulture — in 1929. He's been President of the American Association of Nurserymen, 1960-1961, and was President of the Eastern Region of the Plant Propagators' Society in 1964-65. He is very active in the management of the J. V. Bailey Nursery, in the production areas particularly. So now, Vince, will you come up and tell about the various means you have of meeting present day competition?

MECHANIZATION IN MODERN PROPAGATION

VINCENT BAILEY
J. V. Bailey Nursery
St. Paul, Minnesota

Technically this subject involves the idea of the use of machines in propagation; however, I am going to deviate or take some liberties with the assigned subject. I am sure you will agree that the word propagation implies to the nurseryman and the research man not only the successful reproduction of a plant but further involves the successful establishing of this liner in a media for growing on to a useful size for distribution to the final consumer.

Webster says, "A machine is any contrivance to increase and regulate motive power, an engine, a light carriage, or vehicle." Some of the methods we, at the Bailey Nurseries, are now using do not truly involve machines, but they do involve implements which greatly improve the results and lower the labor costs. We are all interested in improving the quality of our liners, and this it as it should be. Most producers are finding that the buying public is very much interested in high quality and, what is more important, they are willing and able to pay for it.

I will confine my remarks to propagation by cuttings even though this is only a small part of the interests of this group. First, let me talk about our methods of handling hardwood

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I will confine my remarks to propagation by cuttings even though this is only a small part of the interests of this group. First, let me talk about our methods of handling hardwood cuttings. Such common items as *Lonicera, Philadelphus* and *Spiraeas* give us little or no trouble, but we have cut our costs almost in half by adopting certain methods.

In school we were taught to make a clean cut at the base of each cutting, but a few years ago we became a little skeptical of the need for this. We experimented with the use of a fine-tooth band saw and found that the percentage rooted was very near to results obtained under the old method. The use of this machine increased the output per man-hour many fold. We make approximately 1,000,000 hardwood cuttings each year, so you can see the saving is tremendous. This work is done in the slack period of late winter. The cuttings are packed in used orange crates with moist peat after a quick dip in IBA; most of the cuttings then go into refrigerated (34°F) storage until planting time, usually April and early May in our area.

Planting is done by hand; however, we use trenchers for opening furrows. Three blades spaced two feet apart or five blades spaced one foot apart are mounted on a frame with a three point hitch on the tractor. I shall show slides of the machine and the plants a little later. This requires six foot tread of tractor wheels. Only an ordinary vegetable cultivator is necessary. Digging in the fall is done by mounting a blade on this same tractor.

You may wonder why I devote so much time to such a common procedure as production of plants from hardwood cuttings, but I feel these methods have yielded great returns. Figures indicate the value of the crop per acre varied between $1,000 and $10,000. This is all for a one-season crop. Very few of these liners end up on the brush pile, but we review our planting schedule annually.

Now let me very briefly tell of our mechanization of softwood cutting production, leaving out procedures that have been discussed at recent meetings. We make plantings in the greenhouses and in outside beds. Pure sharp sand is used as a rooting medium — also IBA hormone where needed. The three houses are air-conditioned and equipped with humidity controls. Our outside beds are 22 feet in diameter with the sprinklers set in the center. This is inexpensive and has proven quite successful for many species.

We harden the plants off by November 15 and then roll them up in polyethylene sheets, 250 to 500 per bundle. Most nurserymen then pot these rooted cuttings, but we feel we are getting better quality at much lower cost by planting directly in the field or in containers the next spring. Think of the labor saved in just getting 100,000 of these bare-root plants to the planting site versus transporting 100,000 liners in peat pots.

Soon after November 15 we put a crop of conifer cuttings into the greenhouses using the same humidification and air-conditioning systems. About May 20 (after danger of frost is over) these rooted cuttings are placed directly into containers or into beds. This method of bypassing the common practice of potting these rooted cuttings is producing a better quality liner and saving many thousands of dollars. Those placed in beds are handled in the same manner as described earlier for the hardwoods.

Cuttings placed in containers are watered by the overhead Skinner system. Fertilizer is alternately applied through the irrigation system and as a solid, slow-release material. Potting material is a U. C. mix (one-half peat and one-half sharp fine sand). All mixing and container handling is completely mechanized.

Our methods definitely would not apply for all propagators, but some adaptation of these methods will result in savings. After all, the commercial grower must make a profit while keeping quality in mind. We, as propagators, have an obligation to the American public to supply the very fast expanding market for plants. I know that we can meet this challenge by being alert to change and adopting new and improved methods.

PERCY EVERETT: Thank you, Vincent. Now we come out to the West Coast, in particular to the southern California area, to hear what the Research Director of the Monrovia Nursery Company has been doing and wants to tell you about. Conrad Skiminia is a graduate of the University of Illinois, 1955, and his field is principally agronomy and soils. He is with the Monrovia Nursery Company, considered, I believe, to be one of the largest producers of container-grown nursery material in the world. They have become so large they need Research Directors in the various fields, and Conrad holds this position. This is a way some of the larger organizations have of meeting the present day needs of our industry.

Conrad, will you come up and tell people how you handle things at Monrovia?

MECHANIZATION AT MONROVIA NURSERY COMPANY

CONRAD SKIMINA
Monrovia Nursery Company
Azusa, California

Mechanization is the use of devices, facilities or systems which will reduce labor requirements or create a more efficient operation. With the increase in costs, the nurseryman has to look for ways of cutting down expenses. One way is to develop a machine or a system that reduces expenses. Not all machines are made to save on labor directly, but their intrinsic purpose is to reduce labor costs whether directly or indirectly. For example, soil sterilization may be used *directly* to control plant diseases — however, this indirectly reduces labor because plants can be produced in a shorter time with less labor.

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Designing a machine to do certain tasks in a nursery presents many problems normally not encountered in manufacturing. For example,

1. We are dealing with *disuniformity.* Every plant is different — and, it is dynamic — always changing. At Monrovia we have over 1000 varieties of plants and each variety has its peculiarities. In contrast, in the manufacturing industry the basis of automation is uniformity and exact duplication.
2. *Abrasion* — from sand, soil, and grit is another problem. It is murder on fine machine parts.
3. The *physical* problem of soil bridging, clumping, stickiness, resistence to flow, adhesion — all add to the complexity.
4. The *chemical* problem of moisture plus chemicals is hard on machines.
5. The *potential disease* problem is ever present. For example, in order to design an automatic pruning device you have to remember that this is an excellent way to spread certain diseases. You have to design with this in mind.

I will now show some slides of certain production devices and facilities in use at Monrovia Nursery.

1. This is our steam pasteurization chamber for propagating media. Flats are filled with propagating mix, set on a rack and then moved into the chamber. I like to call this our pasteurization chamber since we do not sterilize at 212°F., but at 140°F. The rack of flats is left in the chamber until the coldest flat reaches a temperature of 140°F. for one-half hour. We do not mix the steam and air at the point of entry into the chamber, but recirculate it *after* it has entered the chamber.

2. This shows the ductwork in re-circulating the steam and air. A thermostat sensing-bulb is installed in the return duct to detect the temperature of the air plus steam mixture and it regulates the opening of a steam valve to allow a certain amount of steam to enter in order to make up the difference in heat required. We like to maintain an air-steam temperature of 150-155°F. until the coldest point reaches 140°F. for one-half hour. The time interval for this period has been predetermined for different times of the year so all that is necessary is to set a timer and the rest is automatic.

3. This is the type of electric cart and rack we use to haul flatted cuttings between the cutting department and the particular propagating structure.

4. This shows a birds-eye view of our new all-plastic, steel, and concrete propagating house. The sheathing is an acrylic-fortified polyester fiber glass; the structural members are steel, epoxy-coated; the benches are steel and concrete. The house is 90 x 185 ft. — all clearspan — no posts anywhere in the house. This is a controlled environment house — the atmosphere is maintained at a pre-set relative humidity by

hydraulic and pneumatic nozzles and cooling is effected by evaporative coolers. The benches are heated by conductivity — that is, the heat transfer is from a liquid to solid to solid, i.e., from hot water to pipe to bench to flat.

5. Each side aisle in this greenhouse has a sliding door on both ends. The purpose of this is to facilitate traffic and future mechanization. Some time in the future, we will be designing a narrow cart to haul flats directly from the cutting department to the bench with the minimum of handling.

6. This is the interior of the house. All members are painted with a white epoxy to increase the amount of reflected light.

7. This shows preliminary construction details of the benches. The support frame is steel; the top will be concrete.

8. A close-up of these benches shows the copper tube heating grid to conduct hot water through this bench. A one-half inch layer of Styrofoam was laid down to reduce heat loss downward. This was followed by 4 x 4 reinforcing steel mesh upon which redwood spacers were placed; (to separate the overlying copper tubes from the steel) then the copper tube grid was installed and the entity encased in concrete. Our previous tests have indicated that 85% less heat is required to heat such a bench than conventional indirect, convection and radiation methods.

9. This is our "Paul Bunyan" soil shredder. It can mix, sift, water, and fertilize one cubic yard of soil every 40 seconds. It sorts out lumps, sticks or stones from a soil and ejects them to one side. We had designed the conveyor you see at the base; it carries this debris away from the machine and away from the prepared soil pile. We added the fertilizer hoppers you see at the top which add a set amount of limestone and superphosphate to the soil as it is moving along the belt. At ejection, water nozzles moisten the soil so that it has the optimum amount of moisture.

10. Since the soil shredder ejects one cubic yard of soil every 40 seconds, it was necessary to have a sufficiently large loader to keep this shredder supplied. A 1½ yd. Hough loader maintains a constant flow of soil from the shredder.

11. This is our fertilizer batching operation. We buy the basic ingredients such as ammonium nitrate solution, calcium ammonium nitrate, potassium salts, magnesium salts, phosphates, and blend them into our own formulas for our constant feed system. We make our own iron chelate for inclusion in our formulas. Liquid ingredients are metered into the batching tank; solid materials are weighed and added. All necessary ingredients are then blended and dissolved by hydraulic agitation until a true solution is obtained. It is then pumped to a central holding tank which feeds several fertilizer pumps so that there is very little actual truck hauling of concentrates. Some of our concentrate feed lines may run ⅓ of a mile to supply distant fertilizer pumps.

12. This illustrates the basic principle of our constant feed system. The flow meter measures the water flow in a main irrigation line. A signal is generated and after passing through a Servo system, regulates an injector pump. The resultant fortified irrigation water is then analyzed by a conductivity probe. This signal is then transmitted to a central recording panel which keeps a 24-hour record of electrical conductivities of all six of our injection points throughout the nursery.

13. This is our constant fertilization pump. It was designed specifically for us. It has a volumetric injection capacity of over 1000 to 1. The pump will respond from a flow of 40 gpm to 1200 gpm in 10 seconds. It begins to pump automatically with the flow and ceases to pump when the flow stops. It has a solid state electronic control system. It injects fertilizer at a pre-selected *linear* flow as opposed to pulsating or reciprocal feed pumps.

14. This is a gasoline meter which is used to measure the flow in the water line. A signal is generated by a tachometer and transmitted to the control cabinet. This is a direct displacement meter. However since it was built for gasoline service, bearing wear is high. On the other hand a water meter is grossly inaccurate. Because of corrosion and maintenance problems we will be experimenting with turbine and magnetic induction meters for measuring water flow. The magnetic induction meter has the greatest appeal from the standpoint of maintenance. It has no moving parts and all parts contacting fluids are resistant to corrosion.

15. We designed this combination spray-drench truck which can apply high pressure sprays or high volume — low pressure drenches. Any suspendable material can be applied as a drench — such as blood meal, cottonseed meal, hoof and horn, urea-formaldehydes, limestone, hydrated lime, herbicides, etc., or any sprayable material can be applied. All materials are hydraulically agitated. One or two pumps supply all of the energy for the system. This drench truck can apply a 125 ml suspension to a one-gallon can in 0.46 seconds per can. This cuts application labor costs at least in half.

16 This is our new straddle tractor designed for us for use directly over container beds. It is the first one of its kind in the United States for use specifically in container-growing operations. There are many pieces of equipment available for field crops, but there is no tractor for container-growing. This tractor was built to determine what operations would be feasible to do with equipment like this. The purpose here, of course, is to reduce hand labor as much as possible. The wheels can be turned 360° so that when the operator approaches a bed of one-gallon cans, for example, he can turn all four wheels 90° and enter the bed. Its purpose is to straddle the bed so that operations can be performed directly over the plants. Certain functions in this way can be performed with

greater ease, such as selection of material for orders, weeding, spraying, irrigation, fertilization, and transportation. Initially our intention was to build a one and 5-gallon canning machine. However the type of one-gallon canning machine we contemplated would turn out 50,000 gallons per day and present equipment would be inadequate to haul canned stock out to the beds fast enough. Consequently we had to build the horse before the cart — hence the tractor.

PERCY EVERETT: Our next speaker, O. A. "Jolly" Batcheller, is head of the Department of Ornamental Horticulture at Cal Poly, Pomona, California, and his problem is to train young people that are interested in horticulture to take over and to bring forth new ideas and to be able to operate the complex mechanisms Conrad Skimina has just shown us, as well as the more simple mechanisms. Jolly is going to introduce two of his students who will present papers on work in propagation they are doing.

I visited Jolly one time over in his working area. Of all the darndest little gadgets that fellow had worked up. I imagine he's going to show you some of those little gadgets today. Now I would like to introduce Jolly "Whistler" Batcheller:

CHALLENGING TECHNIQUES IN PLANT PROPAGATION

O. A. BATCHELLER
California Polytechnic College
Pomona, California

The advances made during the last 50 years in the production, handling, and germination of seed are well known to all of us. The quality and quantity of seed has become a constant and reliable factor. In the area of cutting propagation we have also made great strides by use of special rooting media, hormones, and mist. The one area where little has changed in the process of growing plants is that of transplanting and the handling of the seedling or cutting once it is rooted and is ready for transplanting. This is still the same process of carefully lifting the individual plant, carefully placing this in a container, and surrounding the new roots with potting soil. There has been little change, if any, regarding the soil, with the exception that it is now sterilized and perhaps more carefully prepared. It still is a loose, pliable mixture with just enough moisture to form a ball when held tightly in the hand, and yet of such a structure that it will break if this ball is dropped a few inches on a hard surface. Soil is still handled much as it has been over the centuries—wheelbarrow, shovel, trowel and by hand. Even hoppers with vibrators attached have been tried, but the difficulty of measuring out exact quantities is still a problem and usually necessitates over-filling of the container with the excess being scraped off. In the planting of new seedlings and rooted cuttings this is greater ease, such as selection of material for orders, weeding, spraying, irrigation, fertilization, and transportation. Initially our intention was to build a one and 5-gallon canning machine. However the type of one-gallon canning machine we contemplated would turn out 50,000 gallons per day and present equipment would be inadequate to haul canned stock out to the beds fast enough. Consequently we had to build the horse before the cart — hence the tractor.

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A year ago our advanced plant propagation class explored all possibilities of improving the present system and came up with the idea of using soil, not as a semi-dry, loose solid, but as a slurry. Taking a page from the plastering trade, it is possible to mix and move the desired soil mix under pressure through heavy hoses. With this in mind, it is also easy to meter out exact amounts of the material to uniformly fill containers to a consistent level. Because of the semi-fluid nature of the mix, it is possible for it to flow between and around roots or ball and make immediate moist contact with all roots. This is aided by a slight vibration which can easily be provided at whatever point is desired. The removal of the excess moisture in the soil mix (such as the University of California mix) is done by the use of a partial vacuum. This not only reduces the moisture content to a desirable growth condition, but it also firmly holds the cutting or seedling in place at its desired position and depth.

I am sure you realize that no funds, or time, are available at California State Polytechnic College for research and, therefore, it has not been possible to actually establish a working model of the proposed operation. However, the process was studied by a group of senior students in the Mechanical Engineering School and all of the suggested mechanical ideas were found to be already in operation in other fields. No phase was considered in any way to present a problem.

I would now like to turn the presentation over to my students, Steve Hillmer and Mitchell Hoyles, who will give a brief demonstration of the principles and some of the units they have developed while working on their senior project (undergraduate thesis).

MECHANIZED POTTING

STEVE HILLMER
California Polytechnic College
Pomona, California

The handling of rooted cuttings and seedlings is perhaps one of the most difficult aspects of the nursery industry to mechanize. The plants are small and tender; their roots are not well established, and are quite fragile. Machines are generally too rough in their operation to handle these small plants.

In the past it has always been not only more economical, but safer, to handle the transplanting of these small plants by hand. As has been pointed out, rising costs of labor, and a disappearing labor pool increasingly lead us to mechanize wherever possible. There have appeared numerous potting machines for transplanting larger plants into sizeable containers, and several semi-automatic machines to aid in trans-not feasible and the placing of young roots into a dibbled hole has a tendency to misshape or crowd the roots.

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In the past it has always been not only more economical, but safer, to handle the transplanting of these small plants by hand. As has been pointed out, rising costs of labor, and a disappearing labor pool increasingly lead us to mechanize wherever possible. There have appeared numerous potting machines for transplanting larger plants into sizeable containers, and several semi-automatic machines to aid in transplanting small cuttings and seedlings. What Mr. Hoyles and I hope to accomplish is to develop a machine that will automatically handle and transplant these liners.

To achieve our purpose, the machine must not only be capable of handling and potting these plants, but must do it accurately and economically. We are attempting to develop a basic system that will accomplish this as simply as possible. Once this is proven to work, there are a number of modifications and sophistications possible that will increase the machine's scope of operation.

I hope now to show you quite quickly our present approach to solving some of the numerous problems that such a machine must overcome. These ideas are not yet in the blueprint drawing stage, and may seem a bit rough in places. Should you feel any of these ideas to be impossible, or have any suggestions, we would appreciate your comments.

The first problem such a machine must overcome is that of handling these fragile plants. In the prevalent practice these are seeded or stuck into a wood flat containing the media. As the plants develop, their roots twine about each other, making it difficult to separate them. When the plants are bare-rooted, many of these roots are broken, or at the least disturbed.

A possible solution would be a compartmentalization of the flat so that each plant has its own autonomous block of media. The compartment would prevent the roots from mingling, but would be open on the bottom to prevent root curl. This could be accomplished by the use of a plastic gridwork in the flat similar to the larger plant bands now available. By designing the grid as a series of separate strips of three-sided cells, rather than individual four-sided bands, each strip holding a number of plants could be handled as a unit.

This is a rather radical departure from the standard way of propagating, but would put the plants into a form sturdy enough to be handled by a machine, and at the same time eliminate the set-back caused by bare-rooting. The plants could also be allowed to mature further before being transplanted, as a media nearer to the composition of a soil could be used. Now it is necessary to provide some means of planting this plant and its media block into a plastic pot and putting soil around it.

Here we are thinking of the plants in their plastic grid/band moving along a table, below which would be an endless belt with the plastic pots. The plants would be eased out of the plastic grid, through a hole in the table and down into a waiting pot. This would all be accomplished mechanically, with the operator only placing the flat of plants on the machine, and refilling the pot supply.

If we stopped here, that would give us a plant sitting in an empty pot and nothing more. Actually the soil could be added and tamped at this point by hand, but we would rather that the machine be able to complete the job.

The machine must then be capable of moving the potting soil to the pot, measuring it out, and placing it firmly around the media block in which the plant is growing. To accomplish these tasks we are thinking of a soil and water slurry, or "mud", that is semi-liquid and can be pumped. This "mud" would, in effect, be poured around and below the media block much as concrete is poured around a fence post.

To achieve this semi-liquid state, we find that we cannot use a standard U. C. Mix (½ sand, ½ peat) because it is just too coarse and inflexible. By adding about 1 part of loam soil or clay loam to 6 or 8 parts U. C. Mix, however, we are able to achieve enough fluidity to pump the mixture.

This "mud" could be pumped by several methods, though at present a helical auger similar to those used in moving grain seems the best. It would move the slurry from an agitated hopper through a tube and to the pot. The volume could be metered by use of a solenoid valve, or by controlling the number of revolutions of the auger screw. An alternate type of pump would be a diaphragm pump similar to an artificial heart which has but one moving part to wear, and that made of rubber or polyethylene.

But now we will have created a problem that the machine must overcome. This soil slurry must be rather soupy to properly flow about the plant. Before the plant can be moved to the field, it is necessary to remove this excess water. We propose to do this by use of a vacuum suction fitting in which the pot sits on the endless belt. As soon as the slurry begins to flow in, the vacuum would begin removing the excess water, leaving the soil firm but wet.

From there the potted plant would move along the conveyor belt to waiting empty flats and the job would be accomplished. The machine would, of course, have to be planting a number of plants simultaneously to make it economical. A whole flat, or two flats, of plants could be proceeding through the machine at one time, with a line of 20 to 40 plants being potted at once. Using such a method we think that such a machine should be able to pot between 4000 and 5000 plants an hour with two operators.

It will require considerable experimentation to develop each of these systems and coordinate each with the others. Because of the time available to us and, of course, our limited financial resources, our product will be a very basic prototype, handling three or four plants simultaneously, rather than the large production of which I have been speaking. We hope also to be able to develop specific modifications that would permit the machine to handle bare-rooted cuttings, to cull the dead plants from live ones, and to enable the machine to handle different plant and pot sizes.

MECHANIZED POTTING

MITCHELL HOYLES
California Polytechnic College
Pomona, California

The trend in all industries has been toward mechanization and the nursery industry is no exception. The mechanical operation of doing any job has proven itself to be an effective means of lowering the cost of producing a commodity. As long as man produces things, he will continue to create mechanical means to do it more efficiently.

Our senior project is concerned with the aspect of transplanting rooted cuttings and seedlings into plastic pots by machinery. This machine will automatically do all the necessary steps involved in potting. It will handle the plants, the soil and the pots.

An experienced worker can pot approximately 2500 cuttings a day. For any machine to be effective, it must do at least that. Hopefully, this machine will do many times more. In order for such a machine to operate certain theories must be examined and tested. One of these theories would be to eliminate bare-rooting the cuttings by compartmentalizing the flats. Another theory would be to treat the soil as a semi-liquid slurry and pump it into pots.

Our machine will be very simple. It will be designed merely to illustrate the principle. Before any machine can be constructed that will be competitive with hand labor, much research, testing and actual building must be done. We feel that if the principle can be effectively shown, a competitive working model will follow.

PERCY EVERETT: I think, Jolly, that you can be very proud of these two students and I would suggest that some of you nurserymen, if you're going to stay up on top of the game, better either grab these boys — or you'd better just quietly leave the nursery business. They're going to come up with some ideas that will probably put all your other mechanical gadgets out of working order.

Now at this time we will have a Question and Answer period. I'm sure that there must be a lot of questions.

DAVID ARMSTRONG: I'd like to ask Vincent Bailey what method he used for digging his plants.

VINCENT BAILEY: In the two-year, nine-foot, rows we used or designed a U-shaped digger with a lifter on it that could be attached to the same tractor that does the cultivating. We use an ordinary vegetable cultivator. Then we attach the ten-inch blade, with a lifter, and go along behind and pick up the plants and load them onto a truck. There's one farm that was bought specifically for this purpose because of the sandy loam soil.

DAVID ARMSTRONG: You're bare-rooting all your material?

VINCENT BAILEY: Yes.

LLOYD JOLEY: I would like to add, that at the suggestion of Dr. Hesse, University of California at Davis, we have successfully used slurrys around peach seedlings in transplanting from the greenhouse to the field. It works very well.

I would like to ask a question of Mr. Bailey. How do you protect your container stock during the winter at St. Paul?

VINCENT BAILEY: That's an embarrassing question. We're still doing some research on it. The University of Minnesota is very helpful. I don't think we made a dime with our production of roughly a half million container plants. We're still hopeful. We have trouble over-wintering some of the so-called hardy plants in the area; things like Pfitzer junipers that never give us any problem in the field. There's an answer, I'm sure; we're still looking for an efficient and economical mechanized means of over-wintering container-stock.

EDWARD JELENFY: In field-grown stock — how often is it root pruned or is it?

VINCENT BAILEY: Well, for instance with *Prunus cistina,* we do not root prune them in the field. They are grown only two years and we get two to three foot plants in four-foot spacing of the rows. We have tried growing them three years and find that the root system is not as fibrous and concentrated as it should be. I think we'll restrict growth to two years and transplant if we want a larger size. We do not do any root pruning of that class of stock in the field.

VOICE: Mr. Bailey, I'm curious to know what happens to your two-year-old junipers that you dig bare root until they reach the consumer.

VINCENT BAILEY: They are dug in a dormant condition in the spring, which for us is April to, perhaps, the tenth of May, and anything which isn't immediately shipped out is put in storage at 34°F., (automatic humidification, no packing) and we plant probably 50 to 70 thousand per year in our own fields, but we do have a certain amount of them to sell. You ask what happens — they go into a balling field, spaced roughly 3 by 5 or 5½ feet. In most parts of the United States this procedure is more common than it is here in California.

VOICE: Do you dig or do your balling at this specimen spacing, or can it be done by hand?

VINCENT BAILEY: We have anticipated buying one of the balling machines which was developed within 20 miles of us, but we're not sure that we will. We dug a few hundred plants this fall by hand; where you dig everyone in the row they are spaced close together. This is a new type of product for us. We're aiming at the garden center market with this three-year plant and we need a hundred per cent. The off-shaped ones will need to be thrown away or transplanted into what we call our "balling" field; it's a new type of market and we're not sure yet if we're going to use a mechanical baller or hand balling.

MARTIN USREY: Percy, I have an observation to make on the mechanization of the cart we've built, or a potting machine, or canning machine. If any individual firm goes into it it's quite expensive. We will probably have $20,000 in this cart we've built. If there's some way that the propagators of the nursery industry can get manufacturers to take some of these things over and produce them, they can be produced for one-third the cost — but the question is, how can we get them to do it?

PERCY EVERETT: I suppose it's a matter of demand on the part of the nursery industry and, perhaps, there are not enough nurseries in the United States that are of the large operation that your firm is, Martin.

MARTIN USREY: No, I think that there is a demand, even if this one wants one and that one wants one; say we need 25 and if you start around the country, perhaps in total the nurseries would want a hundred or two hundred. How can we get this idea over to a manufacturer to go into production with it?

ED WOOD: Well, since we heard from the immediate past-president of the AAN, we should also tie in and make this a plug for the Horticultural Research Institute, which is head over heels in this thing. It costs you $100 a year. It's helping the industry. It's doing the thing that Martin's talking about. They are now working on mechanization needs of the industry, all the big balling machines; they are doing anything and everything you can think of —directly with Royer and the other nation-wide manufacturers — hoping to fill this void that we have from producer to manufacturer to get what we need to work with.

PERCY EVERETT: Ed, I think you and Martin better get together on this. I would imagine, too, that just from what little I know about it that the agricultural engineering departments of the universities, the state universities, work closely in this area. They certainly do in the production and the harvesting of many crops; I would think nursery products are a very legitimate crop. Undoubtedly the universities are doing something.

We're now going to continue our panel along the general area of "Challenging Techniques in Plant Propagation", by introducing a man that so many of us always says needs no introduction. He has grown up in the nursery business from the very beginning. It gives me a great deal of pleasure to introduce Bruce Briggs from Olympia, Washington. He is going to tell you about his additional work with "air propagation". Bruce —

AN EXPERIMENT IN AIR-ROOTING

BRUCE A. BRIGGS
Briggs Nursery
Olympia, Washington

Stimulated by the far-reaching talk[1] by Dr. J. P. Nitsch of France entitled "Propagation in the Year 2000"; we were inspired to attempt a experiment in "air-rooting". The principle was to induce rooting in a mist chamber, rather than in the usual media of sand, peat, etc. I have proceeded using basically an open case with the tops of the cuttings exposed. Another nurseryman in Olympia, John Eichelser of the Melrose Nursery, has conducted similar experiments using a closed case, but still confining the misting to the basal part of the cuttings.

The case was made similar to a grafting case with a 1 x 12 board used on each side. Flats made with wooden sides and 1½ mil polyethylene bottoms were set on top of this case. The cuttings were inserted through the plastic, leaving the tops above and putting the basal part down into the closed chamber. Black polyethylene was found to induce better rooting than clear poly. A single layer was adequate for summer rooting, but a double layer provided additional insulation during the winter months to maintain higher bottom heat. It also served to keep the tops cooler in the closed case.

The cuttings were prepared in the same manner as for insertion into conventional media. They were treated with a drench of Captan, dried, dipped into Jiffy Grow[2], left to dry a few minutes, and then stuck through the plastic. In order to avoid washing off the hormones applied that day, no water was applied to the base and only a light misting on the tops for 24-hours. After that, moisture was applied 24-hours a day to the bases within the chamber.

An insulated water pipe was used to carry hot water (120°F.) from a water heater to the chamber. It was misted onto the base of the cuttings through fogger nozzles spaced closely enough to create a dense fogging. An interval of 5 seconds every 6 minutes was necessary to maintain enough warmth in the chamber. In the spring when the weather warmed, overhead misting was applied through #300 brass, Flora-Mist, nozzles set for 5 seconds every 12 minutes during the heat of the day.

After about a year of testing, we determined that some of the cuttings were receiving too much water and were rooting poorly or too slowly so we devised a new way of misting the roots using two Standard automatic humidifiers. To broaden the scope of the experiment, two new chambers were set up, each one having a section of closed case and open case. One chamber received fog containing hormones with 1% active ingredients, which were fed into the humidifier at the rate of 1 ounce per 3 gallons of water. This was applied constantly for

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[1] International Plant Propagators' Society, Combined Proceedings Vol 14, pp 316-324 1964

[2] Active ingredients I B A and N A A (0.5% each), phenylmercuric, boron

a few days and then tapered off to only afternoon application with the mist turned off during the night.

We were working toward checking fungicide dips, relationship of hormone strength with and without bottom feeding, reactions to hormone strength in the closed case, top feeding, use of sugars, kinins and other factors affecting rooting as reported by Richard T. Vanderbilt.[3] During this last summer, we had some sun damage from lack of adequate shading, so only part of the work was done, and no heat was used in these new chambers.

During this last summer, we also continued further testing using the original hot water chamber. We installed 3 M. P. proportioners and used one check, testing different liquids applied to the cutting bases through the hot water under both closed and open frame conditions. Additional work will be necessary to prevent excessive loss of heat as the water passes through the proportioners.

This "air-rooting" has been an interesting and rewarding experiment. At the present time, it hardly seems suitable for commercial propagation, but the basic principle is sound. We have been able to root most plants equally as well in air as in the conventional media. There are added advantages of additional control of hormones, water, and heat. Further, you can actually watch your cuttings rooting. This makes it an ideal method for basic research, the classroom, or practical research around the nursery.

At the present time, after two years of experimentation, we could summarize our findings as follows:

1. Some cuttings will root in the light, but for the best results darkness around the basal part of the cuttings is necessary.

2. Both the amount of water and sunlight affect "air-rooting", the same as rooting in conventional media. Too much water slows down or inhibits rooting, either by leaching auxins, hormones, co-factors, or other materials.

3. The amount of hormone and the method of application must be geared to the specific rooting conditions. Equally good results may be obtained by basal, pre-dipped, or foliage applications when in the proper proportions. (a) The concentration of hormone ordinarily used for rooting cuttings under mist, causes burning when used under closed-case conditions. applied either as a pre-dip or fed later through the mist. (b) Heavy misting requires a heavier application of hormones than light misting. (c) Foliage feeding of hormones on some easily rooted plants results in the formation of too many roots near the top of the cutting.

4. "Air-rooted" cuttings may be transplanted in the normal fashion and will proceed without setback toward a normal growth. The roots formed on "air-rooted" plants in many cases seem tougher and more hardened than those formed in

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[3] The auxin effects of some common fungicides and other chemicals The Plant Propagator, Vol II, No 3, Fall, 1965

soil. The timing of the transplanting is no more critical than for other media. Cuttings may be held in the rooting chamber for three months or so after rooting and will continue to grow without additional feeding.

We intend to carry this research further, working to gain more control of heating and watering, and to develop a better insulating material to hold the cuttings. With such additional refinements, this "air-rooting" can point the way to discovering more about the "how" and "why" of conventional rooting and lead to improved practices in the commercial field.

PERCY EVERETT: Bruce, we again thank you for your very able presentation.

Now we come to a man, Wes Humphrey, who has helped in so many different ways in putting on this program. I have found this to be true of the Agricultural Extension Service wherever we go. When people come and ask me about certain problems they're having, and I certainly don't know many of the answers, I always refer them to their Agricultural Extension Service. Often they are quite ignorant of the fact that there is such a service. I'm really concerned that this should be so. Wes, will you take over now and tell us about the use of CO_2 in growing and propagating plants?

FOLIAGE PLANTS RESPONSE TO INCREASED CO_2

W. A. HUMPHREY AND P. E. PARVIN
Agricultural Extension Service
University of California
Anaheim, California

Higher daytime temperatures are used for foliage plant production which results in longer daytime periods when greenhouses are closed compared to many other greenhouse crops grown in southern California. A closed greenhouse during the light period offers an opportunity to utilize CO_2 injections for growth stimulation. A study was conducted to determine if foliage plants would respond to elevated levels of CO_2 in the atmosphere during the daylight period when the ventilators were closed. This was done in cooperation with Bob Weidner at Buena Park Greenhouses, Inc., Brea, California.

Two 18-foot-long greenhouse sections were used, one in each of two separate greenhouses. Each section was isolated by a polyethylene film curtain at each end of the 18-foot length and sheets of polyethylene film were tacked inside the remaining glass area except for the ventilator area. Temperature, light, irrigation and nutritional levels were maintained as nearly alike as possible in both units.

The study was conducted from February to June, 1966, using a variety of foliage plants. CO_2 was added in one of the sections from a dry-ice convertor furnished by Pure Carbonic Co. Levels of CO_2 were measured by the use of a Beckman nonsoil. The timing of the transplanting is no more critical than for other media. Cuttings may be held in the rooting chamber for three months or so after rooting and will continue to grow without additional feeding.

We intend to carry this research further, working to gain more control of heating and watering, and to develop a better insulating material to hold the cuttings. With such additional refinements, this "air-rooting" can point the way to discovering more about the "how" and "why" of conventional rooting and lead to improved practices in the commercial field.

PERCY EVERETT: Bruce, we again thank you for your very able presentation.

Now we come to a man, Wes Humphrey, who has helped in so many different ways in putting on this program. I have found this to be true of the Agricultural Extension Service wherever we go. When people come and ask me about certain problems they're having, and I certainly don't know many of the answers, I always refer them to their Agricultural Extension Service. Often they are quite ignorant of the fact that there is such a service. I'm really concerned that this should be so. Wes, will you take over now and tell us about the use of CO_2 in growing and propagating plants?

FOLIAGE PLANTS RESPONSE TO INCREASED CO_2

W. A. HUMPHREY AND P. E. PARVIN
Agricultural Extension Service
University of California
Anaheim, California

Higher daytime temperatures are used for foliage plant production which results in longer daytime periods when greenhouses are closed compared to many other greenhouse crops grown in southern California. A closed greenhouse during the light period offers an opportunity to utilize CO_2 injections for growth stimulation. A study was conducted to determine if foliage plants would respond to elevated levels of CO_2 in the atmosphere during the daylight period when the ventilators were closed. This was done in cooperation with Bob Weidner at Buena Park Greenhouses, Inc., Brea, California.

Two 18-foot-long greenhouse sections were used, one in each of two separate greenhouses. Each section was isolated by a polyethylene film curtain at each end of the 18-foot length and sheets of polyethylene film were tacked inside the remaining glass area except for the ventilator area. Temperature, light, irrigation and nutritional levels were maintained as nearly alike as possible in both units.

The study was conducted from February to June, 1966, using a variety of foliage plants. CO_2 was added in one of the sections from a dry-ice convertor furnished by Pure Carbonic Co. Levels of CO_2 were measured by the use of a Beckman nondispursive infra-red analyzer, provided through the cooperation of Beckman Instruments, Inc., Fullerton, California.

The level of CO_2 maintained in the elevated section while the ventilators were closed, i.e. when daytime temperatures were below 80-82°F., varied between 750 to 1800 parts per million. The daily addition of CO_2 varied with the season. For example, in March it averaged four hours per day while in May it was 5.75 hours per day. Another way to look at this would be that in April a total of 130 hours of increased CO_2 was maintained out of a total of 416 daylight hours. The CO_2 level in the other unit was at or near the ambient air level at all times.

Two principal types of measurements: length of leaves and numbers of leaves per plant, were used to determine whether any growth differences occurred between the section in which CO_2 was added and the regular section. *Fatsia japonica* plants, treated with additional CO_2, had close to a 25 per cent increase in length of the largest trifoliate leaf on each plant when measured 15 weeks from seeding date. With plants of *Deifenbachia picta superba,* started as unrooted tip cuttings, an approximate 20 per cent increase in the number of leaves was evident in two months on the plants in the CO_2 unit over the non-CO_2 unit plants. Another type of plant which responded with increased growth in the CO_2 unit was the *Bromeliads. Guzmania pecocki* showed 16 per cent additional growth in the CO_2 section when leaf measurements were compared.

Additional observations indicated that when unrooted cuttings were placed in the respective units, those in the CO_2 unit developed larger root systems. It was noted also that there was a tendency for some of the species to elongate more in the CO_2 unit than in the non-CO_2 unit. The light conditions were very similar. Temperature differences were practically nonexistent. It is expected that the elongating was due to crowding with the additional growth in the CO_2 unit.

I should caution you in interpreting the above growth differences to mean total difference in growth. This is not the case. What we were actually comparing is just as indicated—various aspects of the growth difference rather than total over-all growth differences.

You may be interested in the difference in cost in operating these two units. The cost of the addition of the CO_2 averaged 46c per day for the total greenhouse area of 1330 cubic feet, based on 120 day's use. This would figure out to be 0.4c per square foot of bench area per day.

CARBON DIOXIDE LEVELS IN PROPAGATION UNITS

W. A. HUMPHREY AND T. FURUTA
Agricultural Extension Service
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Adequate amounts of carbon dioxide (CO_2) in the atmosphere during the daylight hours for plant growth is a topic of much current discussion. Adequate CO_2 levels should be important in the propagation of plants from leafy cuttings.

There is little information to indicate the levels of CO_2 in various types of propagation units. Through the cooperation of Beckman Instruments, Inc. and Select Nurseries, Inc., Brea, California, measurements were made in several types of propagation units of the levels of CO_2 during the light and dark periods. Measurements were made in cold-frame units, mist chambers and in a closed greenhouse maintained with a high humidity, commonly called a fog house. The cold frame units in which cuttings began to root and new leaves initiating showed marked deficiencies of CO_2 during part of the light period. (Table 1) Only slight deficiencies during the light period occurred in the mist chamber and in the fog house. Where the normal level of CO_2 in the atmosphere is 308 parts per million, in the cold-frame units, which are enclosed plastic units kept completely sealed, deficiencies dropped to as low as 150 ppm and were below 308 ppm for as long as eight hours during the light period. Repeat measurements were made and more than one unit was sampled with different lots of plants to validate these measurements.

The low levels of CO_2 measured would indicate that, at least in the cold frame units, it may be of value to vent them, once rooting begins to take place. One venting may be sufficient; however, two to three times may be better to maintain at least a level of CO_2 close to normal air levels. This need not be done until the mid-morning period. The reason for this is that during the dark period in this type of unit, the CO_2 level builds up as high as 1350 parts per million. This supplies a fair amount of additional CO_2 for use by the plant leaves during the early light period. Apparently in the mist chamber there occurs sufficient venting to give a more normal level of CO_2. This also appeared to be the case in the fog-house propagation unit. In these latter units, there was also more air volume in proportion to the plants and cuttings.

PERCY EVERETT: Thank you very much, Wes. As always, you give a very dramatic and wonderful presentation. I think this leaves a lot of thoughts and a lot of questions that are in everyone's minds and perhaps next year we'll come back with more definite answers.

Are there any questions now of either Bruce Briggs or Wes Humphrey?

Table 1 Carbon Dioxide Levels in Atmosphere Around Cuttings in Various Propagation Structures at Select Nurseries, Inc., Brea, Calif.

Propagation Unit	Plant Species	Per cent Rooted	Average CO_2 content Minimum ppm	Average CO_2 content Maximum ppm	*Hours below normal
COLD FRAME	Thuja		230	932	7.75
	Gardenia	0	283	1144	1.40
	Gardenia	50	171	1171	7.14
	Gardenia	100	138	1275	8.06
	Elm	100	165	838	8.75
FOG HOUSE	Juniper		263	392	8.90
MIST CHAMBER — Unit 1	Bougainvillea & Lantana		295	465	1.0
MIST CHAMBER — Unit 2	Bougainvillea & Lantana		275	475	5.0

*Normal CO_2 level in the air is 308 ppm

Table 2 Light Intensities in Various Propagation Units at Select Nurseries, Inc. as Measured on July 28, 1966

Time	Outdoors	Fog House	Cold Frame 1	Cold Frame 2	Mist Unit 1	Mist Unit 2
	ft c	ft c	ft c	ft c	ft c	ft c
9:30 a.m.	3600	190	440	485	270	300
12:15 p.m.	9300	625	1900	1500	450	----

JOLLY BATCHELLER: I'd like to ask Bruce. What is the objection to having rooting on the stem? I should think that this would be a way that you'd have a greater root area. I should think this would be far more desirable than having all roots come out of the bottom where there's a chance for them to curl in the pot. Where is your objection? You said this is not desirable, or I understood you to say this.

BRUCE BRIGGS: That is correct, Jolly; maybe I can turn this question over to Ed Wood who grows a lot more herbaceous plants than I do and has done much more transplanting. Did you find any particular objections when you ran into this problem?

ED WOOD: Yes, Bruce, usually we got many roots up on the stem before we got them at the base.

PERCY EVERETT: One question I would like to ask — it may be rather dumb; but why can't you cut the pieces up and use each one of those rooting sections as an individual plant?

ED WOOD: We like to make money too. The bigger we root them, the quicker we sell them. If you have to start chopping them up, you have to grow them for a long time; it's a matter of economics.

RON HUROV: I'd like to ask a question directed to Wes. Wes, in the pineapple industry we use ethylene gas absorbed onto charcoal and water for forcing pineapple. I was wondering if you had any experience with spraying carbon dioxide absorbed onto some absorbent, like charcoal?

WES HUMPHREY: No, I have not, although I have seen references to such an effect even in the household magazines — taking bottled CO_2 and squirting it onto plants and apparently getting some growth response. How much scientific work along this line has been done, so you can actually make some true measurements, I don't know.

MRS. WHALLEY: In making conifer cuttings quite often there will be just one root coming out from one side, a very luxuriant root, but we find that it's not advisable to leave that one root on; we feel that we have to start all over, cut it off, dip it, and start over because in potting it never makes a good root system. That's what we believe. Can anyone tell me why this occurs in conifers? Other growers in our locality have this same experience. Some wound their cuttings and some do not; it still occurs in both cases.

MARION STEPHENS: We've carried on experiments for one year to study the effect of timing in rooting cuttings. We've found this situation to be true in rooting coast redwood. Certain times of the year you'd get one root. You can't plant such cuttings because the root will break off. It seems that other times of the year a wonderful root system will develop. We think the time of year we take the cuttings has a lot to do with it.

MRS. WHALLEY: Well, this would just be an occasional cutting. Most of them would root fine.

VINCENT BAILEY: Our observation is that the juvenility of the cutting is a factor in this; secondly, use of hormones seems to be a great factor in eliminating these one or two roots per cutting.

MRS. WHALLEY: We always use hormones. Do you mean perhaps that they aren't as evenly treated as they should be? We aways dip our conifer cuttings — either in a powder or a liquid.

VINCENT BAILEY: We at our place like the liquid best. We think we get more uniform distribution. We use IBA.

ED WOOD: I would like to ask Vince was it the more juvenile or the more mature conifer wood that had a tendency to grow the lone root?

VINCENT BAILEY: The more mature wood, in our experience, has a tendency to form only one or two roots per cutting rather than a group of roots.

CHIKO HARAMAKI: The first speaker is Mr. Zophar Warner from Willoughby, Ohio who will speak on fogging machines vs. intermittant mist.

FOGGING MACHINES VS. INTERMITTENT MIST

ZOPHAR P. WARNER
Warner Nursery
Willoughby, Ohio

Since the use of intermittent mist is common, it should not be necessary to review the various controls and ways in which it is used. However, since the use of fog is not so common, it would be well to explain again how it differs from intermittent mist.

Both systems are used to control the water content of the leaves. The mist system acts by keeping the leaf surface covered with water droplets, or at least covered at close intervals. The fogging machine acts by breaking the water into tiny sized particles which spread out and cover all areas of the cuttings; in effect, it is instant and constant humidity.

In dealing with mist and mist nozzels, the capacity is measured in square feet of surface, in the case of fog machines it is cubic feet of capacity.

Humidifiers, which fog machines actually are, have become fairly common in recent years both in homes and in industries. The measure of capacity of a humidifier must be measured by the amount of water the machine can break up in a given time.

The volume of space that can be served with a specific amount of water depends on the temperature of the space involved and by preventing, as much as possible, condensation and dissipation. In other words, it is necessary to use an unventilated, tight, poly-lined house to make the machine effective. If an unlined glass house is used, the fog will condense and run off the glass much faster than it can be manufactured by the machine. This is especially true on cool sunny days. If the greenhouse is properly prepared and the capacity of the machine fits the volume of air space, it should be possible to maintain virtually 100% humidity.

Temperature in the fog house will run high, but since 100% humidity is maintained, most things will root well in temperatures higher than one would think desirable. Ninety degrees Fahrenheit is a good rooting temperature and 100° Fahrenheit apparently does not hurt most cuttings. To control the temperature, a fairly heavy coating of whitewash should be applied to the house. Since the fog itself acts as a shade, the glass near the gutters should be more heavily covered with the shading compound. If enough shading compound is put on the glass to control the temperature on the bright and hot days, it will be too dark on the cloudy days. Therefore, it is necessary to also use supplemental shade to roll on and off the house on a daily basis whenever it is sunny. I believe we are inclined to confuse light and heat, or at least to consider, during the summer months, that they are more or less synonymous. Most every house has a thermometer but how many do you see that have a light meter? If fog is used successfully, it is absolutely essential to apply and even remove the supplemental shade with meticulous attention given daily to weather and day length. In other words, keep the light level as high as possible for as long as possible each day without allowing the heat to become too high. On dark days and at night the amount of fog can be controlled by adjusting the rate of discharge and or running the machine at intervals.

Cuttings are stuck in flats with a mixture of propagating grade peat and perlite, then carried into the fog house. The mixture should have only enough moisture to prevent drying from the base of the cuttings. Watering should not be necessary during rooting, which is quite rapid. Cuttings should be hardened gradually by removing the flats to an intermittent mist area covered with shade. Both mist and shade are gradually removed until the cuttings are growing under normal conditions and can be transplanted. It is fatal to transplant the cuttings and remove them from their high humidity environment at the same time.

It would also be possible to harden the cuttings in the fog house by adjusting the fog from full time to intervals. But during this time you could be well on the way to rooting the next crop.

Detailed account of fog house propagating was given before this Society by Mr. Stroombeek in 1958 and is printed on pages 47 through 53 of the Proceedings of that year. Anyone contemplating a fog system should read this article. My remarks are of a general nature with emphasis on things we have learned through additional experience.

Fog or mist — which to use? First of all, I would like to say to anyone having success with mist, burlap covered frames, sweat boxes or whatever, DO NOT CHANGE! Now that most of the problems of rooting have been solved by advances in Chemistry and equipment, the total capabilities of the Propagator are not exhausted merely by 100% rooting of the cuttings.

It is the common failing of Propagators, especially those not self employed, to confuse change with progress and to install a different system that at the very least is costly to build. This time and money might be better spent in training personnel, and re-evaluating the propagation list. Perhaps good items that have been dropped because of failures could be restored to the propagating schedule.

A fog machine can be used to good advantage in existing greenhouses where the ratio of bench space to cubic feet of air space is high. In other words, it would work well in a low propagating house; or, you might modify the high houses by partitions of poly. Since heat is already available in the greenhouse, this is quite an advantage. Cool summer nights and heavy rains are often a hazard in outdoor mist propagation.

The additional cost of the fog system is easily balanced by the increased production brought about by rapid rooting and turnover of space used. Those difficult softwood cuttings that wilt and rot or callus without rooting under mist, will for the most part do better under fog. This is also true of plants where continuation of terminal growth is essential.

There are some drawbacks to the fog system of propagating. Pure water is required. Impurities may not be concentrated enough to be detremental to the cuttings, but will accumulate on the rapidly rotating parts of the machine causing an imbalance and subsequent damage. My experience with humidifiers is limited to the Defensor, manufactured in Zurich, Switzerland. This may not be a problem with all makes of humidifiers.

While the water must be pure, much less water is used than is required with a Mist System. If your present water supply is too impure, it would be practical to buy water and use a humidifier. A low house 10′ x 50′ can be maintained with 15 to 25 gallons of water per day.

The fog system for Propagating works best during the long hot days. The prime wood conditions for fog propagation occurs earlier than wood selected for other methods. Varying the length and amount of shade on a daily basis is a problem. I do not know of a method of varying the intensity and length of light that is practical for a small operation. More attention and maintenance is required to keep a fog system going than a mist system.

In placing the fogging system in its proper place among the various propagating facilities and equipment, I would place the Nearing Frame on one end and the fog system on the other. The Nearing Frame is a slow, fool proof method that can easily be operated by following simple procedures. The fog system is a sophisticated system to be used where immediate results are desired. Constant optimum heat, light and water must be maintained under highly skilled personnel. The intermittent mist system's place is between the two.

CHIKO HARAMAKI: Thank you Mr. Warner for giving us some facts on which we can base our decision whether we should install a fogging system or continue with intermittent mist. Next on our program we have something new—we have a large number of foreign members, but the distance is too far for them to present papers. So our program chairman has started something new, a taped talk with slides.

SOME ASPECTS OF WOOD PLANT PROPAGATION IN ENGLAND

BRIAN HUMPHREY
Hillier and Sons
Winchester, England

Mr. Chairman, ladies and gentlemen, may I say what a great pleasure it is to be able to talk to you even thought I am very sorry I am not able to appear before you in person. Here at Hillier's now we have quite a happy band of Plant Propagators' Society members. With Pete Dummer, head propagator, and Asger Laursen in charge of mechanization on the nurseries. The next slide after this rather horrible apparition which must be on your screen at the moment is one of Asger on one of those special narrow row tractors and the following slide shows Pete Dummer at work in one of our rather old-fashioned English propagating houses. Next we see Pete at work on one of the older types of grafts, the Rhododendron saddle graft which was up to a few years ago very popular here. We find, however, that this graft shows very little advantage over the side-veneer graft recommended and described by Mr. Wells in his book on propagation. It is surprising how tradition dies hard for the side-veneer graft which we can see on the next slide is a very much better proposition for our beginners and has proved to be very successful and relatively simply. We do like to pick stocks with young green bark rather than older more woody stocks which are suitable for saddle grafting. I'll say more about grafting later on. But let's move on to propagation by cuttings. Here we see a good old mist propagation system which was installed on a glass house at Kew Gardens many years ago. This was one of the original mist installations in the country. The type of system used here was the Mac Penny type which has the misting nozzle coming up in a stand pipe through the bench. This system has the advantage of simplicity and lack of support needed to carry overhead lines which were used in the N.I.A.E. — National Institute of Agricultural Engineering system which we can see in the next slide. In this slide we can see a MacPenny mist system in the foreground and the N.I.A.E. system labeled on the bench behind. The N.I.A.E. system has the advantage over the MacPenny system where it comes to using containers on the benches. There is absolutely no obstruction whatsoever to these containers by the stand pipe which comes up through the bench on the Mac Penny system. Other advantages claimed for the MacPenny type system are the relative freedom from drips and the MacPenny nozzles themselves are a very well made job and do give extremely fine atomization of the water. Generally speaking most mist installation in this country are installed in glass houses. An exception, however, may be seen in an outside installation using a number of Dutch lites layed on their sides, the mist nozzles are situated inside, and the whole frame is covered with a roll of slatting. This system works very well for cuttings inserted during the summer months but they do not make any use of this equipment in the winter and it's turned off. When I last looked at this installation there were many choice plants including *Magolia soulangeana*, which were rooting very well indeed under these conditions. They do have bottom heat fitted in the form of electric cables which are thermostatically controlled. Humidification or as I believe you call it, fogging, has not become very popular. Quite honestly the climate is so humid anyway, I wonder if we would really need a fogging installation.

The next slide shows a humidifier system fitted to a glass house in Boskoop. This house was double glazed — that is two layers of glass spaced about ⅝ inch apart by specially adapted glazing bars. One of the important points said in the use of humidifier was to have a house with a high ridge. In other words a large cubic capacity. This prevented the fog from condensing readily on the glass in addition of course to the insulating effect of the double glazing and prevented excessive amount of drip which is supposed to be one of the big drawbacks of the fogging system. The experimental station in Boskoop has carried out trials comparing the use of double glass, mist and humidifier systems and the last time I was over there, about two years ago, they were considering giving up the use of the humidifier system completely as it appeared to be inferior to the other two systms. I must say, however, that this opinion wasn't shared by everyone in Boskoop and some of the very best growers and very best propagators seemed to be very keen and very enthusiastic about the humidifier system, thinking that it has advantages over any other propagating system for cuttings. It is important to remember I think though that this isn't the only means of propagating cuttings and we attempt to make good use of some of the more traditional methods which were popular before the introduction of mist. One of these is rooting cuttings in a cold frame, or in summer time it is frequently called the sun frame. And here we propagate more easily rooted types of plants such as forsythia, weigela, spiraea, etc. and the technique is briefly to put a layer of sand 2 - 3 inches deep on natural soil which should preferably be well drained. Erect on top of this some boards and then place frame lites, Dutch lites, English lites, or this year we've tried polyethylene over the sand. It is necessary of course to hand spray. We are considering installing a hand operated misting system. Having mentioned sand reminds me that pH is a very important factor we think in the rooting of cuttings. And we did take great care to search for a grade of sand which had the necessary low pH. After some months we found a sand which has a pH of 4.5 and we check this reading occasionally to be sure that we are being supplied with an even sample. It does vary somewhat but it's surprising once you hit upon a seam of sand which is acid in reaction, it appears that it tends to stay that way.

We have heard a great deal about the use of fungicides such as Captan on cuttings. On some varieties of Rhododendron, the effects of Captan are quite outstanding and I might say this response isn't uniformly shown on all varieties and all species of Rhododendron by any means. I wish it were. It would appear that Captan is acting as a growth substance rather than as a fungicide because the cuttings without Captan which have not rooted have not in fact generally rotted.

These Rhododendron and the *Acer palmatum* shown on the next slide were treated with IBA in quick dip form. I think we can claim to be one of the pioneers of the use of quick dip hormones commercially and we have now had some four to five years experience with their use. We are quite convinced that for species which require high concentrations of rooting hormone, the quick dip method of application is by far the best. The *Acer saccharinum* which we see here was inserted on the 1st of June and the photograph was taken on the 18th. In other words a very extensive root system can be built up in a cutting in a matter of a fortnight with *Syringa vulgaris* varieties we do occasionally get rooting in 7 - 10 days. This is using extremely soft cuttings and the optimum concentration of IBA. The strength of IBA varies considerably of course from species to species and even from cutting to cutting. And I don't believe it is possible to get the absolutely perfect optimum concentration for every cutting. What we aim to do and this I think is a rather new concept, certainly for English propagators anyway, is to use a concentration of IBA above the optimum. In other words we deliberately set out to damage the base of the cutting by a high concentration of IBA. This is once again I must stress with species such as Rhododendron and Acers, and Azaleas which do appear to be tolerant of high concentrations in any case. With *Syringa vulgaris* as well we are not all perturbed by killing off the bottom quarter or half inch of the base of the cutting by a strong application of IBA. It's roots that we want and not callus and the fact that a cutting is callusing up well at the bottom is usually an indication to us that the IBA concentration was not sufficiently high. We find that by applying a rooting hormone in a quick dip form, that wounding is generally unnecessary. And it would appear that the alcohol content of the quick dip carries the rooting growth substance into the stem sufficiently well to make wounding quite superfluous.

Using these ideas we are now rooting most of the so called hardy hybrid Rhododendrons — Pink Pearl, Cunningham's White. We have been able to root *R. sinogrande* using 3% IBA dissolved in 60% alcohol, but rooting results are never consistent and never very high and we still favor grafting for these types at present anyway.

I though you might be interested in this next slide which is of the nurse seed grafting technique which was described in one of the Plant Propagators' Proceedings. I have shown this for two reasons. Firstly, it forms a convenient bridge between techniques of propagation by cuttings and by grafting which I hope to discuss next. The other reason is to make just one comment on this technique. When Professor Moore described it, he did say that the scion inserted into the germinating seed produced roots. Pete Dummer and I carried out this technique a while ago and I am sorry to say we were never able to see these roots breaking from the scion. From our observation, the roots always appear to come from the cut stumps of the cotyledons. These rooted very readily indeed and we found the longer they were left after cutting, the more roots we produced. But as I have said we never have been able to see any roots coming from the scion itself. As far as we can see they have no real commercial application. Growth seems to be very slow indeed and the only real benefit we could see would be the complete freedom from suckering which you would get with this type of plant.

The next picture shows our beds of potted understocks ready for grafting the following spring and summer. In order to avoid some of the high labor involved in potting up these stocks we are naturally interested in the idea of grafting onto bare rootstocks. And although it is often perfectly feasible, the next slide which is of walnuts shows one of the effects at at least that you are liable to get by using bare rootstocks. We have compared the growth rate of grafts worked onto an established understock and a graft worked onto a nine-month-old unestablished rootstock. As you will see the rootstock established in a pot for 2 years showed considerable gain in growth over the unestablished stock.

Of course grafting the wide range of plants we do at Hillier's, one of our big problems in grafting is the question of compatibility and incompatibility. For example, with magnolia we need to grow five different stocks to insure compatibility of all the scion varieties which we use. We grow 4 or 5 different maples and 3 or 4 different Quercus species as understocks to avoid incompatibility problems. Oaks are notoriously bad for forming a good union and we always treat them with great care up to 2 - 3 years after the grafting procedure. They are always weak at the union for this stage and losses in the nursery can be heavy if you have some rather big footed nursery workers.

The next slide shows the importance of temperature during the grafting period. A discussion of the condition necessary during the grafting stages I'm afraid is out of the question in the short time at my disposal. I can only express the extreme importance of thoroughly drying the understack before grafting. This was touched on by Dr. Dorsman in his paper recently at the International Horticultural Congress. And we, for our part. always so far as possible insure the stocks are as dry as possible at the grafting stage. Temperatures are generally best in the 60 - 65°F. region, but some genera do appear to have a higher temperature requirement and Juglans are quite happy in temperatures up to 80°F. Generally speaking we do not have remarkedly good results by budding, certainly in this part of England at least. I often read with envy some of the successes that you have in the States by budding techniques. Whether the fault is ours or of the climate I do not at this moment really know.

Well now ladies and gentlemen if no one has yet turned me off, I'll close on the next slide which I suppose must be one of the most famous horticultural views in the world — it's of the palm house at Royal Botanic Gardens at Kew and wish you every success for the following lectures in your meeting and thank you very much for listening to me.

CHIKO HARAMAKI: Our next speaker is our program chairman, Stu Nelson, from Saskatoon, Saskatchewan.

THE ROLE OF BOTTOM HEAT IN THE ROOTING OF CUTTINGS

STUART H. NELSON
University of Saskatchewan
Saskatoon, Saskatchewan
Canada

Bottom heat is a practice of supplying additional heat to the medium and is not limited to the rooting of cuttings as we propagators might think. In fact, it possibly has more use in the forcing of growing plants than in the rooting of cuttings. I suppose that the first use of bottom heat can be traced back before the "Dark Ages" as with most of our horticultural practices, but I have not tried to do this. Rather, I will limit my remarks to the use of bottom heat—mostly electrical—as we know it today. It would seem that the acceptance of electricity, rather than manure, could be dated at around 1930 and in the early 1930's, there were a number of reports from different countries describing the installation and economics of such a procedure (1, 4, 7, 15). The economics of electricity over manure would seem to have been easily proved (5, 23) but I am not sure that I can say the same, without considerable reservation, for the beneficial effects on rooting.

By the way bottom heat is tossed around in conversations at this meeting, one would suspect that it might be the password to success and that the literature would abound in references. Neither would appear to be true. In fact, good experimental comparisons, either in favor or against bottom heat as a tool to aid rooting, are very few. It would be diffore grafting. This was touched on by Dr. Dorsman in his paper recently at the International Horticultural Congress. And we, for our part. always so far as possible insure the stocks are as dry as possible at the grafting stage. Temperatures are generally best in the 60 - 65°F. region, but some genera do appear to have a higher temperature requirement and Juglans are quite happy in temperatures up to 80°F. Generally speaking we do not have remarkedly good results by budding, certainly in this part of England at least. I often read with envy some of the successes that you have in the States by budding techniques. Whether the fault is ours or of the climate I do not at this moment really know.

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Saskatoon, Saskatchewan
Canada

Bottom heat is a practice of supplying additional heat to the medium and is not limited to the rooting of cuttings as we propagators might think. In fact, it possibly has more use in the forcing of growing plants than in the rooting of cuttings. I suppose that the first use of bottom heat can be traced back before the "Dark Ages" as with most of our horticultural practices, but I have not tried to do this. Rather, I will limit my remarks to the use of bottom heat—mostly electrical—as we know it today. It would seem that the acceptance of electricity, rather than manure, could be dated at around 1930 and in the early 1930's, there were a number of reports from different countries describing the installation and economics of such a procedure (1, 4, 7, 15). The economics of electricity over manure would seem to have been easily proved (5, 23) but I am not sure that I can say the same, without considerable reservation, for the beneficial effects on rooting.

By the way bottom heat is tossed around in conversations at this meeting, one would suspect that it might be the password to success and that the literature would abound in references. Neither would appear to be true. In fact, good experimental comparisons, either in favor or against bottom heat as a tool to aid rooting, are very few. It would be difficult to say why there are not more references because we cause we all know that bottom heat has been and will continue to be used extensively even though the only benefit reaped may be a psychological effect on the operator.

In this review, I have limited myself to where bottom heat is used during the entire rooting process and I have not included some rather elaborate techniques used for precallusing cuttings in this country, Europe and Russia. Right from the start, bottom heat for the propagation of cuttings has not received wide acclaim. In the early 1930's, there were isolated reports that bottom heat (75-79 degrees F) was necessary for citrus in cool climates [Halma (8)], was beneficial at 60 to 70 degrees F for softwood cuttings of trees and shrubs in outdoor frames in Alberta, [Ure (19)] and was used with softwood cuttings of apple [Stoutmeyer and others (18)]. In the same decade, however, a Russian report (21) summed up that the 600 varieties, including 479 species and 118 genera, did not, for the most part, require bottom heat. Since the 1930's there have been further isolated reports. Crossley (6) reported that bottom heat did not seem to be necessary for *Ilex aquifolium* where a greenhouse was available but that it might be of benefit in outdoor frames covered with glass or plastic. According to Bergh (2) soil heating (65 degrees F) greatly enhanced the callus formation, root development and rooting quality on cuttings of shy-rooting rhododendron varieties. Electricity or some other means of heating the cutting beds is necessary for Mulberry in Japan (9) and in the United States bottom heat at 70 degrees F profitably increased the rooting of blueberry cuttings in March but was not needed in June (17). There was a further report (13) of a three-year study on a commercial nursery in Texas which indicated that the time required to root and grow nursery stock to a suitable size might be reduced by 12 to 24 months with the use of electrical soil heating cable and that greater yields of sturdier, more uniform plants could be obtained.

Although temperatures around 70 degrees F have been mentioned above, a few other references were found. In Europe, Jacobs and others (11) reported that begonia rooted well at 72.5 degrees but most cuttings at 77 degrees F had scorched rootlets. Both, however, were better than the 65 degree control, that *Aeropanax reticulata* rooted well at 77 degrees but 82 degrees F was too high and that *Ficus decora* rooted better at 88 degrees than at 82 or 77 degrees F.

In trials at Wooster (12), bottom heat at 70 degrees F was generally best but this report showed that air temperature in combination with bottom heat was very important. Air temperatures of 50 degrees was better than 60 or 70 degrees F.

The combination of moisture with bottom heat is also an important consideration. Riehl (16) emphasized the importance of maintaining the proper levels of light and moisture when propagating at high temperatures. He found that rooting in a moist medium at 61 degrees was quicker than rooting in a dry medium at 73 degrees F. Working with rhododendrons, Bergh and others (3) found that better rooting occurred in propagation frames heated with hot water than with electricity because the rooting medium was damper, and Wells (22) suggested that bottom heat (75-85 degrees F) was desirable for holly provided a high humidity was obtained; intermittent mist provided excellent conditions.

Mist propagation has become very popular and bottom heat has been used. Henrada (10) reported that, with the exception of *Chamaecyparis lawsoniana,* 77 degrees was better than 86 degrees F with the fifteen succulent, herbaceous and woody plants tested. Piringer (14) reported that 70 degrees gave more main roots on *Buxus* than 80 degrees F but with interrupted light during the night to yield more branching, 80 degrees F was better for *Buxus* and 70 degrees F for *Ilex.* Van Doesberg and Ravensberg (20) reported that in some cases the rooting of rhododendron cuttings was improved by soil warming with mist.

Summary of Work at Ottawa

Over a five-year period, work with intermittent mist, with and without bottom heat, was conducted in the greenhouse and out-of-doors. In the early part of this period many comparisons of the effect of bottom heat was made but later, these comparisons are less frequent because it was already apparent to me that bottom heat played a minor role. Facilities were used more and more in the testing of other propagation techniques. Although some 200 taxa were tested over this period, only 88 are included in this summary. With some taxa tested, no comparisons were made and in many areas, the use of bottom heat and no bottom heat was not tested over a wide enough range of hormone treatments to be included.

A summary of this work is included under the following five classifications:

1. Bottom heat beneficial in all treatments tested.
2. Bottom heat beneficial only in check treatments and equal results, in general, obtained with hormones.
3. Bottom heat beneficial only in combinations with hormones.
4. No beneficial effects of bottom heat.
5. Bottom heat detrimental in practically all treatments.

The propagation methods have been coded as follows:

IMI—intermittent mist in the greenhouse
IMO—intermittent mist outdoors
CTI—cheesecloth over greenhouse benches—no mist
PTI—plastic tent over greenhouse benches—no mist
* Denotes better results in some other propagation bed
/—before name denotes 50-60 percent rooting only
//—before name denotes very poor rooting, 30 percent or less

Although these classifications will be published in full, there is not time to itemize them all in this talk. In classsification 1 there are only six items listed where bottom heat was of benefit in the respective propagation beds and in four instances, better rooting was obtained elsewhere without the aid of bottom heat. There are seven entries under classification 2 and one entry had better results in another type of propagation bed without bottom heat. It was interesting to note that there are no plants to be found in classification 3 which covers beneficial effects of hormone and bottom heat together.

The majority of the taxa fall into the group showing no beneficial effects, ie, classification 4. There are 65 entries in this group. There are 14 entries (the second largest group) in classification 5 which indicated detrimental effects at practically all hormone levels.

From the above classification of plant material, there is little evidence to support the use of bottom heat of most plant materials. I think, however, that one must admit that its use can speed up rooting and possibly give increased rooting percentages under adverse conditions. Hormones applications can achieve the same effects in an easier manner and there is no evidence that the effects of bottom heat and hormone treatments compliment each other.

As mentioned previously, some of the plants in the various classifications are indicated as having better results in another propagation bed than listed herein. Without exception, this was a polyethylene tent with intermittent mist but no bottom heat outdoors (PTO). It is also interesting to note that the deciduous material seemed to prefer this hot humid atmosphere while the coniferous plant material performed equally or slightly poorer in this atmosphere.

Appended to the paper is a further list, including another 70 taxa not included above, where 80 to 100 percent rooting was easily obtained without bottom heat but could not be classified above because no comparison with bottom heat was made.

Classification 1 Bottom heat beneficial in all treatments tested

Berberis piorettii (IMO)*
Chaenomeles japonica (IMO)[1]
Juniperus sabina (IMI)*
Malus robusta 5 (IMI)*
Taxus baccata repandens (IMO)
/*Thuja occidentalis filiformis* (IMI)

Classification 2 Bottom heat beneficial only in check treatments and equal results, in general, obtained with hormones

Juniperus chinensis pfitzeriana aurea (CTI) (IMI) (IMO)
Juniperus sabina tamariscifolia (IMI)

Lonicera tatarica "Carleton" (IMO)*
Taxus baccata repandens (IMI)
Thuja occidentalis lutea (*elegantissima*) (IMI) (IMO)
Thuja occidentalis saundersii (IMO)

Classification 3 Bottom heat beneficial only in combination with hormones

NIL

Classification 4 No beneficial effects of bottom heat

Buxus microphylla koreana (IMO)
Cornus stolonifera flaviramea (IMO)
Chamaecyparis pisifera plumosa argentea (IMO)
Chamaecyparis pisifera plumosa aurea (IMO)
Chamaecyparis pisifera plumosa squarrosa (IMO)
Daphne burkwoodii (IMO)
Forsythia ovata (IMI) (IMO)
Genista pilosa (IMO)
Genista tinctoria (IMO)
Ginkgo biloba (IMO)
Hydrangea arborescens (IMI) (IMO)
Hydrangea paniculata (IMI) (IMO)
/*Juniperus chinensis blauwii* (IMI)
Juniperus chinensis hetzii (IMI)
Junperus chinensis keteleeri (IMO)
Juniperus chinensis pfitzeriana aurea (PTI)
Juniperus communis depressa aurea-spica (IMO)
Juniperus horizontalis douglasii (IMI) (IMO)
Juniperus horizontalis plumosa (IMO)
Juniperus sabina (IMO)
Juniperus sabina tamariscifolia (IMO)
//*Juniperus scopulorum* (IMO)
Kerria japonica (IMO)
Ligustrum vulgare (IMO)
Ligustrum vulgare pyramidale (IMO)
Lonicera prolifera (IMO)
Malus baccata (2 selections) (IMO)*
Philadelphus coronarius aureus (IMO)
Philadelphus lemoinei "Dame Blanche" (IMO)
Philadelphus virginalis "Minnesota Snowflake" (IMO)
Philadelphus virginalis "Silvia" (IMO)
Physocarpus opulifolius aureus (IMO)
Polygonum reynoutri (IMO)
Prunus fruticosa (2 selections) (IMO)
Prunus tenella (IMO)
Prunus triloba (IMO)
//*Rhamnus dahurica* (IMO)*
Rhamnus frangula (IMO)*
Ribes grossularia (2 selections) (IMO)
Ribes nigrum "Consort" (IMO)
Ribes rubrum "Red Lake" (IMO)
Rosa multiflora (IMO)

Rubus henryi (CTI) (IMI)
Spiraea media (IMO)
Spiraea trichocarpa (IMO)
Spiraea vanhouttei (IMO)
//*Tamarix pentandra* (IMO)
Thuja occidentalis "Columbia" (IMO)
Thuja occidentalis ellwangeriana (IMI) (IMO)
Thuja occidentalis fastigiata (pyramidalis) (IMI) (IMO)
Thuja occidentalis globosa (IMI)
Thuja occidentalis hoveyi (IMO)
Thuja occidentalis "Little Gem" (IMI) (IMO)
Thuja occidentalis "Patmore" (IMI) (IMO)
Thuja occidentalis "Rheingold" (IMO)
Thuja occidentalis saundersii (IMI)
//*Ulmus americana* (IMO)
Ulmus pumila (IMO)
Viburnum lantana (IMO)

Classification 5 Bottom heat detrimental in practically all treatments

Berberis thunbergii artopurpurea (IMO)*
Betula pendula delecarlica (IMO)
Cotinus coggygria (IMO)*
Cotoneaster acutifolia (IMO)*
Euonymus alatus (IMO)
Lavendula officinalis (IMO)
Picea abies maxwellii (IMO)
Picea abies ohlendorffii (IMO) (IMI)
Prunus tomentosa (2 selections) (IMO)
Malus robusta 5 (IMO)*
Spiraea arguta (IMI) (IMO)
Thuja occidentalis hollandica (IMO)
Viburnum prunifolium (IMO)*
Vinca minor (IMO)

Classification 6 No comparison with bottom heat but 80-100 per cent easily obtained without bottom heat

Acer ginnala (PTO)
Acer tatarica (IMO)
Caragana arborescens (IMO)
Caragana frutex (IMO)
Cornus alba spaethii (IMO)
Kolkwitzia amabilis (PTO)
Pachistima canbyi (IMO)
Pachysandra terminalis (IMO) (PTO)
Philadelphus burfondensis (IMO)
Philadelphus burkwoodii (IMO)
Philadelphus cordifolius (IMO)
Philadelphus coronarius multiflorus plenus (IMO)
Philadelphus cymosus "Atlas" (IMO)

Philadelphus cymosus "Voie Lactae" (IMO)
Philadelphus falconeri (IMO)
Philadelphus grandiflorus (IMO)
Philadelphus insignis "Souvenir de Billiard" (IMO)
Philadelphus laxus (IMO)
Philadelphus lemoinei "Avalanche" (IMO)
Philadelphus lemoinei "Enchantment" (IMO)
Philadelphus lemoinei erectus (IMO)
Philadelphus lemoinei "Fleur de Lis" (IMO)
Philadelphus lemoinei "Frosty Morn" (IMO)
Philadelphus lemoinei "Innocence" (IMO)
Philadelphus lemoinei "Manteau d'ermine" (PTO)
Philadelphus lemoinei "Mont Blanc" (IMO)
Philadelphus lemoinei ochroleucus (IMO)
Philadelphus lewisii "Waterton" (IMO)
Philadelphus nepalensis (IMO)
Philadelphus nivalis (IMO)
Philadelphus pekinensis chachybotyris (IMO)
Philadelphus polyanthus "Favorite" (IMO)
Philadelphus polyanthus "Pavillion Blanc" (IMO)
Philadelphus satsumanus (IMO)
Philadelphus scbrenkii (IMO)
Philadelphus speciosus (IMO)
Philadelphus virginalis "Albatre" (IMO)
Philadelphus virginalis "Argentine" (IMO)
Philadelphus virginalis "Glacier" (IMO)
Philadelphus virginalis "Mrs. Thompson" (IMO)
Philadelphus virginalis "Patricia" (IMO)
Philadelphus virginalis "Purity" (IMO)
Philadelphus virginalis "Thelma" (IMO)
Prunus dropmoreana (IMO)
Syringa hyacinthiflora "Necker" (IMO)
Syringa lovaniensis "De Louvain" (IMO)
Syringa prestoniae "Alice" (IMO)
Syringa prestoniae "Audrey" (IMO)
Syringa prestoniae "Calpurina" (IMO)
Syringa prestoniae "Celia" (IMO)
Syringa prestoniae "Elinor" (IMO)
Syringa prestoniae "Ethel M. Webster" (IMO)
Syringa prestoniae "Jessica" ((IMO)
Syringa prestoniae "Ursula" (IMO)
Syringa perstoniae "Virgilia" (IMO)
Syringa swegiflexa x *S. reflexa* "Fountain" (IMO)
Syringa vulgaris "Geheimrat Singlemann" (IMO)
Syringa vulgaris "Mme. Lemoine" (IMO)
Syringa vulgaris "Mare Micheli" (IMO)
Syringa vulgaris "Montaigne" (IMO)
Syringa vulgaris "Paul Thirion" (IMO)
Syringa vulgaris "Perle Von Stuttgart" (IMO)
Syringa vulgaris "Pres. Lincoln" (IMO)
Syringa vulgaris "Ronsard" (IMO)
Syringa vulgaris "Victor Lemoine" (IMO)

Viburnum juddii (PTO)
Weigela florida (IMO)
Weigela wagneri “Bristol Ruby” (IMO)
Weigela wagneri “Eva Rathke” (IMO)
Weigela wagneri “Stelzneri” (PTO)

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CHIKO HARAMAKI: Thank you, Stu. I am sure your comments will stimulate some heated discussion. Our next speaker here is Mr. Harvey Gray.

CELLOTHERM "BOTTOM HEAT"

HARVEY GRAY
State University at Farmingdale
Farmingdale, New York

The concept of generating heat with electric power by the device known as Cellotherm was discovered by accident. It is said to have grown out of an attempt to formulate a ski wax. Somewhere along in the preparation of the ski coating, it was discovered that when an electric current travels across a film of colloidal silica and graphite, heat is generated.

To put this principle to practical use, the graphite-colloidal silica film is made up as a sandwich. The graphite-silicia is the meat and the asbestos, two thin layers, is the bread. If the sandwich is to come in contact with moisture it must be made water tight. Laminated plastic films accomplishes this. The electric power is introduced into the sheet by the way of two embedded copper electroides along the edges of the sheet. In September, 1965, the manufacturers' field man contacted us regarding Cellotherm's possible application in hotbed heating. Out of this contact our trials developed with greenhouse propagation.

The tests consisted of duplicate open and plastic enclosed benches. The lead coated electric cable was used in all the tests as a comparator for the Cellotherm. The bottom heat was controlled by thermostat, set at 72 degrees.

The media for narrow leaved evergreens, Taxus and Juniperus, were sand and sand/perlite mix. The media for broadleaved evergreens, Ilex and Rhododendron, were peat and peat/perlite mix.

The Ilex and Rhododendron were wounded, hormone treated and either inserted in mass media or the medium in #3″ square plastic pots.

The narrow leaved evergreens were hormone powder treated but not wounded.

The tests were made in a 55-60 degree house with no hot water coils under the benches. The open bench trials with narrow leaved evergrees presented no heat-dry out problem. The rooting percentages were excellent with both bottom heat systems.

In the enclosed plastic case heated by cable we had trouble with excess heat. The excess heat did not develop in the Cellotherm. Rooting of cuttings was excellent in both sources of heat but high temperture caused excessive plant loss. The plant loss with the enclosed case, cable heat, might have been prevented if the micro-hydrologic cycle within the case could have been favorably cotrolled.

Our conclusions based on one test are —

1. Cellotherm appears to be a perfect source of heat for bottom heat
2. Lead coated electric heating cable may cause excessive heat

3. Cellotherm may be used in ground or raised beds
4. Power consumption is 2.7 less with Cellotherm than with electric cable

CHIKO HARAMAKI: Next, we have something special, a symposium on unusual techniques. Our leader will be Mr. Ray Halward.

UNUSUAL TECHNIQUES

RAY E. HALWARD
Royal Botanical Gardens
Box 399, Hamilton, Ontario, Canada

Through the years at these meetings, many and varied techniques have been explained by fellow propagators. Many of us returned home full of ideas how we were going to adapt these innovations to our own particular propagating facilities.

Let us briefly review some of the earlier techniques that inspired many of us to change our old ways for new. In 1953 *The Phytotektor Method of Rooting Cuttings* by Harvey Templeton explained the rooting of cuttings in soil using mist controlled by a humidostat and timer. He related at that time that the techique was an attempted union of the English sunframe and new mist humidification. An idea he obtained from an article he had read on mist, by James Wells.

A Simple and Inexpensive Time Clock for Regulating Mist in Plant Propagation Procedures by Charles Hess and William Snyder was the title of a paper that aroused a great deal of interest in electrical and mechanical controls in mist propagation.

In contrast to these techniques, Leslie Hancock described the rooting of cuttings in soil in raised beds under burlap, supplying the necessary moisture manually.

In 1954 Vincent Bailey explained their propagating facilities and the use of the Binks system of humidity control for propagating softwood and coniferous cuttings. Excellent results were obtained by varying the percentage of humidity from 90 to 70 during the rooting period.

From these and other similar systems many techniques have been developed. The system I use is a good example. I started using mist in 1956 and at that time various electronic leaf controls were in use. Being undecided which one to use I began experimenting with different materials for a leaf control in conjunction with a Humidomist controller. More by chance than deliberation I tried Bee's wings suspended between two carbons from flashlight batteries. These were inserted through a piece of plastic and wired to the controller. This is used under a double layer of plastic. It has provided excellent control for intermittent misting and the wings last all season.

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Last winter I heard about an unusual technique. The propagating beds are set on a bog area. The bog is covered with three inches of a 5 sand, 1 peat mixture. A fungicide in powder form is mixed well into the media. When the cuttings are stuck they are covered with plastic covered sash. The rising humidity from the bog eliminates the necessity of watering or spraying. In the evening both ends of the frames are opened to allow free circulation of air. The cuttings are left in these beds until the following spring. This is the method used by Mr. William Ellerbrok of Sydney River, Nova Scotia.

RAY HALWARD: Do we have any other unusual techniques to report?

DAVE PATTERSON: After hearing Bruce Briggs last year, I went home and took a deep flat, about six inches deep, and knocked the bottom out. Then I stretched black polyethylene over it and stuck the cuttings through the polyethylene. Then I put them in a mist bench. Most of the medium in the bench had been taken away. We had about 120 cuttings of about 10 different things and most of the things we rooted such as *Ilex crenata, Ilex glabra,* and *Juniper pfitzeriana* rooted 7 to 8 out of 10. We also rooted 5 out of 10 skiadoptis cuttings.

PETE VERMEULEN: Your mist was applied on top of the cuttings while in Bruce Briggs' case the mist was applied to the stems under the plastic.

BRUCE BRIGGS: This year we tried a few different things. We applied hormones underneath. We used fog as well as mist underneath and found it didn't make any difference as long as it was moist. Actually, soil (or a medium) is not an important thing at all, it actually can be eliminated. The thing we are after is control.

DICK FENICCHIA: I have been working with a chamber in which you can regulate both top and bottom temperatures. I have some interesting results and would encourage others to try the same thing.

CARMINE RAGONESE: I have found a technique which is very helpful to root hybrid Rhododendrons. If I place the cuttings in a plastic bag and leave them in a plastic bag with just a little bit of humidity and place them in the dark for about two weeks, they root like a weed. I also found that some cuttings which are not rooting in the greenhouse, if I exclude light for a day or so, they will then root.

CHIKO HARAMAKI: The next speaker needs no introduc-
He is Mr. James S. Wells.

"COST OF PRODUCTION AND HOW TO DETERMINE IT"

JAMES S. WELLS
James S. Wells Nursery, Inc.
Red Bank, New Jersey

A casual glance at this title would seem to indicate that our Society has gone "way out" in choosing a subject which would have very little direct connection with Plant Propaga-

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Red Bank, New Jersey

A casual glance at this title would seem to indicate that our Society has gone "way out" in choosing a subject which would have very little direct connection with Plant Propagation. But I hope to show you that this is not correct, because with the highly competitive market and ever-increasing labor costs of today, we have to consider each and every operation and try to determine the most efficient and least costly method of producing our crop. To determine these costs we inevitably must consider some form of cost accounting.

That I, of all people, should get involved in cost accounting is really rather ludicrous because if there is one thing I dislike, it is office work and figures. But, before giving you what I believe to be a very simple but very accurate solution to this whole question, I want to explain how I became involved.

When I first came to America in 1946, to manage the Koster Nursery at Bridgeton, New Jersey, they were growing Rhododendrons entirely by grafting. During that first winter in 1946, we grafted about 35,000 plants. I hadn't been here very long before I was initiated into the problems of disease, particularly *Phytopthera cinnamoni,* associated with the production of Hybrid Rhododendrons. This was something quite new to me because the disease is practically non-existent in England.

As our crop progressed through the winter af 1946-1947 and on into the second summer, it became immediately clear that I had better get involved with this disease or stop growing Hybrid Rhododendrons, because losses were continuous in all stages of production. Thus it was in the summer of 1947 that I really got down to "brass tacks" with the problem of determining direct costs.

I was very fortunate to have the resources of the Seabrook Farms Company to draw upon. But even so, we were breaking completely new ground. At that time our operation required the steady employment of about thirty-five men. This was increased up to one hundred men during the Spring shipping season. How could one possibly determine where all these costs were to be allocated?

Well, a great deal of thought was given to this and the more we considered it, the clearer it became that it would be utterly impossible to record every fine detail of exactly where and how money was spent. To give a couple of examples: if we had a shipment of 500 bales of peat, which was going to be used for mixing rooting medium and preparing beds for planting Rhododendrons and Azaleas were we going to keep a close record of every bale of peat, where it was used, and charging it to the appropriate crop? Obviously we could not. To do this, each foreman would have to be a Certified Accountant. And then, what of the men who were engaged in packing and shipping . . . or the maintenance men? What about the foremen loading the trailers? Would you split up their time among the Taxus, Dogwood or Arborvitae which were being loaded on the various orders? Again, obviously "no." Some more simple system had to be devised.

Eventually, we decided to work on what we called "direct labor costs," using this as a yardstick to gauge and allocate all other costs. A simple form was developed and one man was employed to record, four times a day, just what each man was doing, and to attempt to allocate as much of each man's time to a given crop as he could, with the assistance of the foremen.

This was what we called "direct labor." It was that amount of work which could reasonably be charged directly to some crop. We had a code which simplified the recording of the daily hours and we included symbols in this code which indicated indirect costs, such as packing and shipping, maintenance, etc. This system ran for nearly five years.

Before I give you the distilled essence of this five years recording, I would like to quote one or two figures that came out of the system at the end of the first year. A grafted Rhododendron, lifted from the bench, cost us 43.8c at that time and at the end of the first year the cost had risen to 62.4c. A rooted Rhododendron cutting cost us 13.9c and at the end of the first year the cost had risen to 32.2c, just half of the cost of the graft. But the Rhododendron graft cost us $6.04 at end of the second year and this was due to the fact that we had substantial inventory losses in the second summer, from the Rhododendron Wilt Disease, which attacked the understock used for grafting. But a two year old Rhododendron, raised from a cutting, cost us only .66c. The importance of these figures are therefore clearly of value in determining the method of propagation to use, especially in view of the fact that we were selling two year old plants then for $3.50, thus showing a net loss of $2.04, on each grafted plant sold.

But let me give you another example: grafting Hybrid French Lilacs. Again, due to inventory losses after planting, we found that our one year old plants were costing us 27.4c per plant. As we were selling these for $25 per hundred, we were losing .024c on every plant sold. But if we carried those plants over for a second year, the cost of production only rose from 27.4c to 35.4c, and our selling price for two year old material was $50 per hundred, thus showing a reasonable profit.

The value of these figures therefore, clearly indicated that we had to change our method of production or remove our one year French Lilacs from our sales list and sell them as two year olds. So much, therefore, for the immediate returns which appeared from this system.

Now, let us jump ahead five years and I will describe how I think you can use these ideas very simply and directly, to determine costs. At the end of the five year period, we found the following to be true: if the total amount we had to pay for operating the nursery amounted to, say $100,000, then our total payroll was almost 50% of this. Let me say that the $100,000 figure included every possible cost, depreciation, taxes, overhead costs of all kinds. Everything that was needed to keep the nursery running was included. Next, we found that we could only charge one half of the total payroll to any given crop. Our direct labor costs were therefore one half of our payroll or 25% of our total operating expense. This is the important point which I want to get over to you, because we found that we could abandon the laborious and somewhat complicated system of daily recording, if we chose, and simply record whatever operation, or series of operations we wished and at any point we could draw a line, determine the direct labor cost involved so far, and then multifly this figure by four, to arrive at a total actual cost. This loaded cost, divided by the inventory of plants produced, gave a reasonably accurate loaded cost of each plant.

Example: Let us assume that we decide to raise a batch of Taxus. From the moment we commence to prepare the bench to receive the cuttings, the direct labor costs are recorded . . . the cost of filling the bench with rooting medium . . . the cost of gathering, making and looking after the cuttings while they are rooting . . . the cost of lifting and transplanting them and looking after them for one, two, three or four years, if necessary. All these direct labor costs are accumulated until the producer decides that he either wants to sell the crop or would like to know how much the cost has been for that crop, so far. Whenever this point arrives, the direct labor costs are totalled and multiplied by four. This sum is then divided into the inventory and the figure thus obtained is the unit loaded cost of each plant. It should be noted that in this system, no separate record is kept of any other costs other than direct labor costs. No recording or allocation of costs is made for materials . . . peat, sand . . . or light, power, paint, maintenance costs or any of the other multitude of costs involved in running a nursery. All of these are allocated in proportion, when the direct labor costs are multiplied by four.

Let me illustrate with a few figures. We will assume that a crop of 100,000 plants has been rooted and is now growing in the fields. The total cost recorded in direct labor is $10,000. The total loaded cost, therefore, is $40,000. This means that the individual loaded cost of each plant is 40c. If a Taxus liner is sold for 45c, then you are making 5c net profit. It should be obvious that the producer can choose to draw a line and make this simple computation at any point in the development of the crop. He can determine, within very close tolerances, the cost of the crop at any given point of development. He can use the same system for a rapid time-study, as related to these costs. For instance, if people are making a large amount of cuttings, or, in fact, are carrying out any operation, the direct labor cost can be recorded for one, two or three days or longer, if you prefer, and then arrive at the true cost of the operation — the sum spent in direct labor, multiplied by four.

This, then, is the very simple formula which developed from the mass of data which we accumulated over the five year period. Following this, I transferred the system to the

Hill Nursery in Dundee, Illinois, where I understand it is still being used.

In both cases, we found that this formula was very close to the actual recorded costs . . so close that it became unnessary to carry out the detailed and onerous task of daily recording all expenses. I believe, therefore, that this recording of direct labor costs only, multiplied by four, is a simple accurate and workable method that anyone can use to arrive at the true cost of any plant or crop that they are growing.

I am quite sure that if you apply this method, you are in for some shocks. We were astounded when we began this system, to find out just where the money was being made or lost. You may well decide that the application of this procedure to every plant and operation on your nursery is unreasonable, but rapid spot-checking, using the formula on any crop about which you are doubtful, can be most revealing. The real value of it, of course, becomes immediately apparent when there is a substantial inventory loss, for one reason or another.

I would like to give you one last illustration of the importance of this to the plant propagation methods used. Back in 1946 we were grafting our crop of Japanese Maples and placing the plants in sweat boxes. We had real problems with fungus disease while the grafts were callousing, and our loss was high. The actual cost of each graft rose to a point where it was obviously impractical for us to continue grafting in this manner. The cumulative cost of grafting, when taking into account the inventory loss sustained in the grafting process, showed that we were losing money and this meant that we had to bear down on the problem and either find an answer or stop growing Japanese Maples. As a result of this pin-pointing of the problem, we tried different methods of grafting and found that we could get excellent results by dipping the dormant grafts in parafin wax and placing them on the open bench, without double glass covering. When this was done the problem from fungus disease was eliminated, the cost of production dropped substantially and the crop was once more profitable.

I believe that every grower needs as much of this type of guidance as he can get and this brief discussion is presented in the hope that the relatively simple formula which we developed can assist growers with similar problems.

CHIKO HARAMAKI: This is a very important subject. I am sure there are many growers who have little ideas of their costs. We now have time for some questions.

JOHN ROLLER: Jim, can you determine the approximate cost on any item or is this a unit at the end of the year?

JIM WELLS: No, it is not instant cost accounting. You can't tell in a few minutes unless you have been recording your direct labor costs. You really have to run the system for at least a year.

JOHN ROLLER: Can you use this system to determine the cost on any given variety?

JIM WELLS: Yes. It all depends upon your recording completely. You've got to do it daily. You must record what is going on with that specific plant. One side effect of record keeping happened at Koster. We did record each day the production of each worker. The next day each man's production was put up on a notice board. This wasn't very popular for a few days. But after they got used to it, then they found it invigorating and we got into some healthy competition as to how many grafts they could do per day. Our production went up and the costs went down.

HUGH STEAVENSON: Now if I understand you correctly, you can apply this formula to any operation or activity if you recorded the time for this operation. For example, if you were balling trees and you found your direct labor costs for balling a tree is 25c, so do you multiply that by 4 to get your total costs including a 10% profit?

JIM WELLS: No profit, just total costs.

HUGH STEAVENSON: That's particularly pertinent because I've seen so many cases where fellows would figure out the cost of balling by just doubling their cost.

JIM WELLS: I talked with Roger Coggeshall about this and he gave me a bit of a stop. He made me realize that the basis of this whole formula is one ratio of labor costs to your total operating costs. You will recall that I said the formula works if labor costs were 50% of operating costs. You will have to look at your balance sheets to see if this is true for you or not. I've always felt that 50% of the operating costs as labor represented a fairly average level of efficiency and below 50% was more efficient and above 50% was less efficient. Now if your labor costs in relation to total costs are higher or lower this must be taken into account. If it is 50%, my formula will work fine. I define labor as total personnel payroll.

THURSDAY AFTERNOON SESSION

December 8, 1966

The afternoon session convened at 1:15 p.m. and began with a symposium on the propagation of specific plants. Dr. Charles E. Hess served as moderator.

MODERATOR HESS: Our first speaker this afternoon is an old friend to all of us, Al Fordham of the Arnold Arboretum who will tell us about the propagation of hard to root woody plants.

HARD TO ROOT WOODY PLANTS

ALFRED J. FORDHAM
Arnold Arboretum of Harvard University

In 1954 the Arnold Arboretum received a plant of *Kalmia latifolia rubra* from the Weston Nurseries of Hopkinton, Massachusetts. It was one of six selected from many thousands grown there through the years and was thought to be a seedling from one of Charles O. Dexter's specimens. Together with his important Rhododendron accomplishments, Dexter also made efforts to assemble superior forms of mountain laurel at his estate in Sandwich Massachusetts.

In 1957 when Roger Coggeshall was at the Arnold Arboretum, he worked with this clone and by using 2,4,5-TP succeeded in rooting 21 of 35 cuttings. They were made on the 20th of September and potted on the following 12th of February. The slides which follow show cuttings taken from plants of that propagation and they therefore are in a clonal line. Six 3-foot plants were moved into the greenhouse in the summer of 1965 so that soft wood cuttings could be processed as described by Alan D. Cook in Volume 10 of the Plant Propagator. However the pressure of work was such that they remained through summer and on until March of 1966. Cuttings were taken from growth lignified to a degree where stem bases were brown in color and firmly woody. Bases were wounded on opposite sides as is the practice with rhododendron cuttings.

Nine treatments were tested, using formulations furnished by Mrs. Barbara Emerson of the Amchem Research Department, Ambler, Pennsylvania. The 2,4,5-TP preparations were in powder form while IBA, and IBA plus NAA combination was in a stock solution. The limited amount of material available provided 10 cuttings for seven treatments and five each for two. All cuttings were lifted and evaluated on June 29, 1966.

A quick dip treatment using a 1% solution of IBA led to seven cuttings rooted and three callused.

A dip in 2% IBA solution led to five rooted cuttings, and 5 with small calluses.

A combination of 500 ppm each of IBA and NAA resulted in 7 cuttings rooted and 3 with small calluses.

The most successful treatment proved to be a combination of 1000 ppm each of IBA and NAA. Ten cuttings rooted uniformly and developed excellent root systems.

As a control, five cuttings were wounded and inserted without chemical treatment. By June 29, two had rooted, one cutting had a large root system and a second one was starting.

Five cuttings were also treated with a preparation of 8 mg IBA in a gram of talc (similar to Hormodin #3) with the fungicide thiram added at the rate of 15%. Two of these were rooted.

2 4 5-TP at 1000 ppm resulted in 10 cuttings rooted.

2,4,5-TP at 5000 parts per million led to 8 rooted and 2 with calluses.

Treatment with 2,4.5-TP at 10,000 parts per million led to a production of outsized calluses. Five cuttings went on to root above the callus while 5 did not. They were returned to the propagating case for another month. When examined after that time the calluses had increased in size and 6 cuttings had initiated roots above the callus. By November 21 all were rooted but only one had produced a growth flush, which may indicate that the buds have been inhibited by the strong 2,4,5-TP dosage.

IBA plus NAA at 1000 ppm each was the most effective treatment followed by the 1000 ppm 2,4,5-TP. However, it should be emphasized that these cuttings, though hard and woody, came from greenhouse material which may have had an effect. A new series of cuttings taken out-of-doors and inserted in August of this year look promising, leading to the suspicion that this particular clone has the ability to root well.

At the Arnold Arboretum the propagation of broad-leaved evergreens is carried out in polyethylene chambers. The benches are six inches deep and are constructed of ¾ inch transite. A 2x4 inch mesh welded wire known as turkey wire or utility wire is used to support the plastic covering. It is bought by the roll and can be cut and bent to any desired shape. The medium for broad-leaved evergreens is sphagnum peat moss and perlite mixed in equal parts. Bottom heat is maintained at 75°.

Albizia julibrissin stem cuttings will not root except in the juvenile stage but this species will propagate well from root cuttings taken in spring. Root pieces about ½ inch in diameter and 3 inches long were placed vertically in pots and 8 out of 10 cuttings were successful. Frequently shoots will appear in clusters from root cuttings of *Albizia.* When the surplus shoots are removed and inserted as cuttings they root readily as they are juvenile. Shoots that develop from root cuttings of *Koelreuteria paniculata* behave in a similar manner.

Many cuttings which root readily present a first winter survival problem, for they go into dormancy and never recover. By leaving them undisturbed in the rooting medium and providing a cold period, loss can often be avoided. Cuttings of *Magnolia stellata* were inserted on the 24th of July and moved to cold storage the following November. On March 23rd they were returned to the greenhouse where 94% came into growth. Cuttings handled in this manner produce outsized root systems and therefore grow quickly when they are transplanted.

In another experiment 40 cuttings of *Magnolia kobus* x *stellata* were divided into two lots and inserted under polyethylene plastic. Lot #1 was placed in a chamber with bottom heat at 75°, while Lot #2 was put in a chamber without bottom heat. All cuttings in Lot #1 rooted heavily but only one cutting in Lot #2 did so.

During past meetings of this group *Taxus baccata repandens* has been discussed as subject considered difficult to root. A specimen at the Arnold Arboretum was acquired in 1890 and is now about 7 feet tall by 15 feet in diameter. Professor Ray Keen of Kansas State University visited us last year and requested that we root cuttings selected only from excurrent shoots which it produces abundantly. He suspects that propagants from this part of the plant might lead to specimens with characteristics similar to the cultivar known as 'Rams' — Horn Yew'. With the thought that propagational information might be acquired, the cuttings were treated in three different ways. Lot #1 was treated with a trade product called Hormo-Root-C which comprises 8 mg of IBA in a gram of talc together with 15% thiram. Lots #2 and #3 were treated with powder formulations of IBA at 1% and 2% respectively. Lots #1 and #2 each rooted 100% but the root systems of Lot #1 were far superior, probably due to the fungicide. During the 1962 Plant Propagator's Society meeting, Dr. Charles Hess described work at the Boskoop Experiment Station where the rooting of cuttings was greatly improved by adding captan to root inducing substances. After hearing his remarks we prepared a mixture as follows: fifty grams of Hormodin #2 and #3 were each combined with 10 grams of captan 50% wettable powder. During the 1963 summer season the wide variety of species that we routinely propagate were treated with these on a comparison basis. The results were so strikingly favorable that all powders since that time have contained a fungicide. At the Arnold Arboretum we make it a practice to use large cuttings when dealing with such subjects for we feel they root faster, better and often save years in producing specimens.

References concerning the propagation of *Cytisus* by cuttings often recommend specific sizes, one mentions cuttings two to four inches long, another suggests slender side shoots. Such small cuttings are neither essential nor desirable. They root but produce slender, brittle roots difficult to process. Cuttings of *Cytisus praecox* ranging in length from 2 to 40 inches were gathered in late November, wounded, treated and placed in containers on an open greenhouse bench. In about six weeks all had rooted, with the larger cuttings producing apportionately large root systems.

The following is an example of the odd and sometimes perplexing things that may occur in plant propagation. On the 22nd of May, 1959, the director brought a branch of *Viburnum opulus* 'Notcutt's Variety' to the greenhouse. The plant was destroyed by vandals over the weekend and had lain in the sun for a couple of days. Spring growth had just begun and the new shoots were about ½ inch long — it was badly wilted and appeared hopeless for propagation. If anyone else had made the request it no doubt would have been tossed into the trash as soon as he rounded the corner. However, we made 15 cuttings comprising 3 sets of nodes. In two weeks, to our astonishment, extensive roots appeared at all nodes both above and below the medium, along the stem and even on the leaf ribs.

The propagation of woody plants difficult to root would have been a simpler topic fifteen or twenty years ago than it is today. A long list of subjects considered impractical to root at that time are now propagated commercially as routine practice. It has been said that with the advent of anti-biotics the science of medicine emerged from the dark ages. It may also be said that technological advances have accomplished much the same in the science of plant propagation. Root inducing substance procedures, intermittent mist and polyethylene chambers have been developed to a high degree of perfection. Many of the great strides made during recent years may be credited directly to this organization, the International Plant Propagator's Society.

MODERATOR HESS: Thank you, Al, for a fine presentation. Our next speaker is Tom Pinney, Jr., one of the Society's most progressive nurserymen who utilizes sound production techniques, cost accounting procedures and who has contributed tremendously to the Society and the industry. Tom will tell us about the propagation of birch.

THE PROPAGATION OF BIRCH

THOMAS S. PINNEY, JR. AND GENE W. PEOTTER
Evergreen Nursery Co., Inc.
Sturgeon Bay, Wis.

Our nursery has sold Birch to the nursery trade for the past 100 years. During this time we have had many complaints and unhappy customers because the stock was collected and had notoriously poor root systems with crooked stems. The situation finally became so disturbing, and the demand was so great, that we decided that we must meet this problem with positive thinking and somehow develop a program of mass producing Birch in the nursery. As a result, 6 years ago were gathered in late November, wounded, treated and placed in containers on an open greenhouse bench. In about six weeks all had rooted, with the larger cuttings producing apportionately large root systems.

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GREENHOUSE CULTURE

The first step in the successful propagation of Birch is the collection of viable seed. A germination test is the most accurate measure of viability of a specific seed lot. The Birch seed crop varies from year to year and we attempt to collect several years supply when it is available. The seed is stored in either polyethylene or cloth bags which are kept in large steel barrels at 35-40 degrees F.

In January or February a second germination test is made to determine the best lots for seeding. The seedling media is prepared by mixing 2 parts of our transplanting mix and 1 part sharp sand. Both the transplanting mix and sand have been steamed previous to mixing. We will describe the transplanting mix later. This media has excellent drainage properties. The seed is broadcast over the entire flat and the flat is then covered with a plastic film. These flats are placed in a germination box with bottom heat maintained at 65 degrees F by electric cables and thermostat. Germination takes place in 7-10 days. The seedling flats are then placed on the open bench where they remain for 14-21 days. During this time we will start them on a very low constant nutrient program. The net solubridge reading at the beginning is approximately .75.

Extreme caution must be exercised in not contaminating the seedlings with damping off organisms. In recent years we have used several commercial drenching solutions prior to seeding and start a preventative maintenance program after germination, with captan and other fungicides as needed.

After working closely with a large commercial florist, we finally developed a transplanting media that met our requirements. It consists of 60% peat moss, 25% soil and 15% perlite. The soil is a sandy loam. The perlite is recovered from our greenhouse operation from benches used to stick our cuttings. It consists of ½ Ryolex #6 and ½ Krum. Two and one half pounds of triple superphosphate is added per yard of mixture. The preparation is then steamed for 30 minutes at 180 degrees F. Since we are primarily concerned with the problems of aeration and good nutrient retention, we have attempted to tailor the media to meet these requirements. We use the high percentage of peat moss to bolster the nutrient retention capacity of our rather low organic type soil. Both the peat moss and the perlite seem to give an optimum drainage situation. We have developed a perculation test using 6" standard clay pots. The same pots are used each year and some of the previous years soil is saved for comparison. The pots are filled with the media and struck off even with the top of the pot. They are given four consecutive 250 cc applications of water. The temperature of the water used is approximately 55-60 degrees F. By the time the fifth 250 cc watering is applied, the media has been thoroughly soaked. We feel that a satisfactory perculation test occurs when all of the water in the last test has disappeared from the surface of the media in 35-45 seconds. These tests are made after steaming since this procedure may improve the perculation time by as much as 85%.

After the second true leaf becomes visible, the seedlings are transplanted into 2¼" square peat pots or strips. Each flat contains either 54 or 60 pots depending upon whether squares or strips are used. Three seedlings are placed in each pot, to form a clump.

After transplanting, the flats are placed in a shallow pan containing a dilute solution of nutrients and allowed to soak up from the bottom. The plants are then placed on benches in plastic greenhouses 16′ x 97½′. The fertility program is gradually increased until a net solubridge reading of 1.5 is obtained. A 20-20-20 type soluble fertilizer is used and injected through the line with each watering.

A preventative maintenance program for pest control is followed with applications of the combination of Isotox and Captan once a week. Occasionally specific pests are encountered and other pesticides are utilized. The temperature is kept between 65 and 75 degrees F. during the day and 55 to 60 degrees F. during the night. The temperature is varied depending on the type and amount of growth desired. The plants remain in these greenhouses for approximately 6 weeks, where they develop at a very rapid rate.

FIELD CULTURE

It is essential to obtain a high nutrient level in our nursery soils before transplanting the Birch to the field. This is accomplished by using a green manure crop of corn planted with a grain drill at the rate of 2½ bushels per acre. Sufficient fertilizer is added to insure good growth and tests have indicated we plow down as much as 6000 pounds of dry weight material per acre. We have found the corn to be an excellent indicator plant of major nutrient deficiencies. The area is then treated with dieldrin to eradicate any white grubs that might be present.

The peat pots of Birch clumps are then transplanted to the field after all danger of frost is past, sometime after June 10 in our area. Prior to the actual planting, the area is presprayed for weeds with 2 pounds of Sesone and 1/4 pound of Diuron per acre. We have tried 1/4 to 3/4 pounds of treflan per acre with uncertain results. Care must be taken in use of herbicides at this time since the Birch are in an extremely active state of growth and are very susceptible to herbicidal damage. This past year we still did some hand weeding of the area.

We use four deep tiller shoes behind a three point hitch tractor to mark off the beds and rows. These shoes loosen the soil sufficiently in the rows to allow for easy pushing in of the little peat pots. Our beds are on 79″ centers with four rows to each bed, spaced 12″ apart. The large aisle is necessary because of the drooping over of the plants into the aisle toward the end of the season. A composted manure is placed in each row prior to transplanting.

Proper summer culture is vital to the success of this operation. It is important to keep as many growth factors at optimum as possible. Unfortunately we have not learned what these optimums are for many of the factors. Immediately after transplanting we begin a supplemental irrigation program. The water is applied through Skinner lines with automatic water motors attached. This system applies approximately 1/8″ of water per hour of operation. Depending upon the humidity, wind and other conditions, we apply approximately 1-1½″ of supplemental water per week. Our fine, sandy loam soil has excellent drainage, but unfortunately has a low water holding capacity. Throughout the entire summer we apply nitrogen in the form of ammonium nitrate once a week. Early in the summer we start 15 pounds of ammonium nitrate per 600 gallons of water and gradually increase this to 25 pounds. Our liquid fertilizer apparatus involves a 600 gallon tank, trailer, pump, tractor and boom. One man is able to operate this with reasonable efficiency. The 600 gallons of fertilizer solution is applied to 1400 running feet of bed or approximately 11,200 square feet. On the next trip the operator will apply clear water as a wash to the same area. When sufficient area has been fertilized in the above manner, the irrigation lines are turned on for approximately 1½ hours.

A preventative pest control program is the most desirable kind. However, during the past year we have been testing several systemics to control our major pest, Birch leaf miner. Presently we feel that Di-syston at 3 pounds per acre when irrigated in, is the most promising. Lesser rates of this chemical have not done a satisfactory job. Meta-systox-R has given erratic results. We have used 1½ pints per 100 gallons. In years past we have used DDT and Malathion, alternating these two chemicals on a weekly basis. This has given us very satisfactory control of the miner and other insects, but was a rather expensive procedure.

DIGGING

There are three major ways in which we begin to help nature harden off these very actively growing plants. First, we stop all fertilization on approximately September 10. Secondly, we do no additional watering after this time unless we have an extreme drought condition. Lastly, we undercut the Birch with our power digger on approximately September 30. If these procedures are strictly followed, we have had little or no difficulty in causing the leaves to drop on papyrifera and popufolia. Sometimes alba is a little more stubborn.

The lifting operation actually begins between November 10 and 15 depending upon how fast the hardening off procedure has developed. The plants are then dug twice with our digger blade in it's maximum lifting position and the plants manually lifted, tied into bundles and removed to our storage by trailers with aluminum houses.

GRADING AND SHIPPING

Unfortunately we still carry out the standard nursery practice of grading by hand. If we were able to grow all of the clumps with three evenly matched stems, our grading problem would be greatly reduced. However, many of them vary in size and must be pulled apart and put into their proper grades. This is a major problem as only 15-20% of the clumps actually have three stems that fall into the same grade category. The uneven development of the stems is one of the most perplexing problems to challenge our thoughts. Although we are not able to solve this problem during the first seasons growth, we have discovered it can be solved the following year by clumping in the field single or double stems from the same grade. This allows a further flexibility to the customer since he can plant as many stems per clump as he wishes and pattern them according to his own tastes.

Shipment can be made to the customer anytime after fall digging. By the end of March we have most of our orders shipped as we are anxious to do this before the onrush of our spring shipping season.

FIGURES

A brief look at figures numbered 1-5 will reveal some rather interesting data that we have collected.

The first figure, entitled "average growth rate of Birch stems", indicates the growth rate of the Birch stems in inches per day. The data is based on a representative sampling of 20 plants, including three varieties, involving 48 individual stems. Measurements were recorded once a week to the nearest .25 of an inch. The total population of the field included 35,000 papyrifera clumps, 10,000 alba clumps and 5000 popufolia clumps. The top line represents the tallest stem of each clump, while the bottom line represents the shortest stem of each clump. The middle line represents all of the stems involved

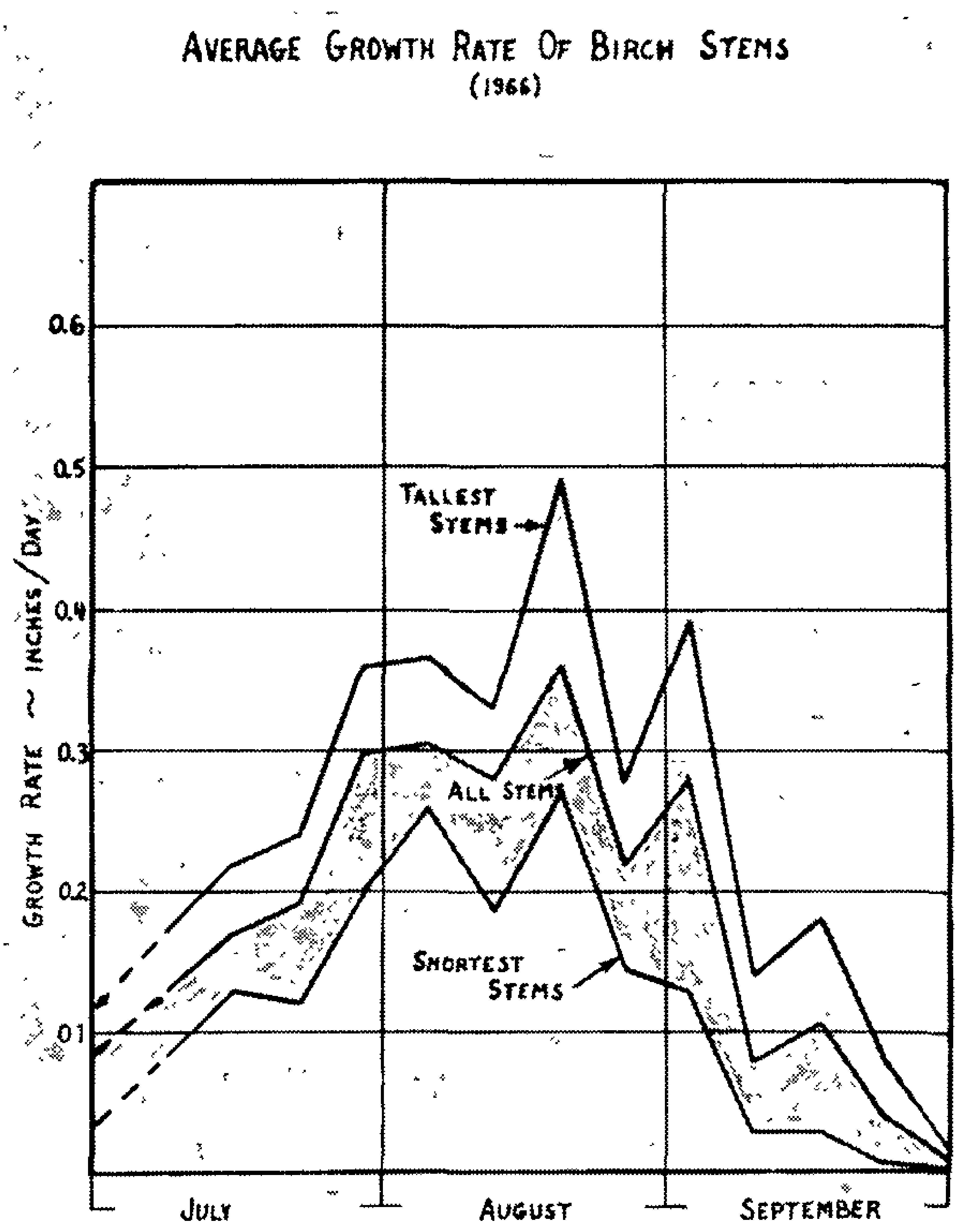


Figure 1

in the test. Some clumps measured had only 1 or 2 stems. Note how each line dips sharply during the third week of July, the second week of August and the fourth week of August. Each of these dips coincide perfectly with periods of water shortages to the growing area. This summer we experienced one of the most severe droughts that our county has had in many years. As a result, on these three weeks the water was rationed to the area. Notice that the growth rate was cut almost 50% during the fourth week of August. From past years experience, we can be reasonably sure that we would have achieved at least .60 of an inch of growth per day by mid to late August if we had not encountered the water shortage. The slight rise in growth rate during the second week of September is due to a natural rain that occured after we had ceased watering.

The second figure, entitled "average height of Birch stems", clearly points out that if the clump has uneven stem height when it is transplanted to the field, the problem will be accentuated rather overcome. Note the much greater spread at the end of September than when the plants were originally transplanted to the field. From this, we can see that the basic problem of uneveness occurs between the time of transplanting to the peat pots and the time they are planted into the field.

The third figure, entitled "growth rate of the three Birch varieties", is very interesting because it confirms a suspicion we have had for a number of years. It clearly indicates that papyrifera is a much more vigorous grower than alba and popufolia, with us. Because we were suspicious of this in the past, we have even planted our alba first in our greenhouse production and therefore they often reach the field as a larger size. This poses an interesting question—now that we can prove that it costs more in our case to grow alba than papyrifera, can we successfully adjust our pricing schedule accordingly? This might take a little courage even when we have the facts.

The fourth figure, entitled "size distribution of graded Birch clumps 1965", is based on data recorded from the 1965 crop which involved 55,000 clumps. When viewing this chart, remember that it costs just as much to grow the 3-6" plant as it does the 4-5′ plant. I might point out that in our operation, the break even point is within the 12-18″ grade.

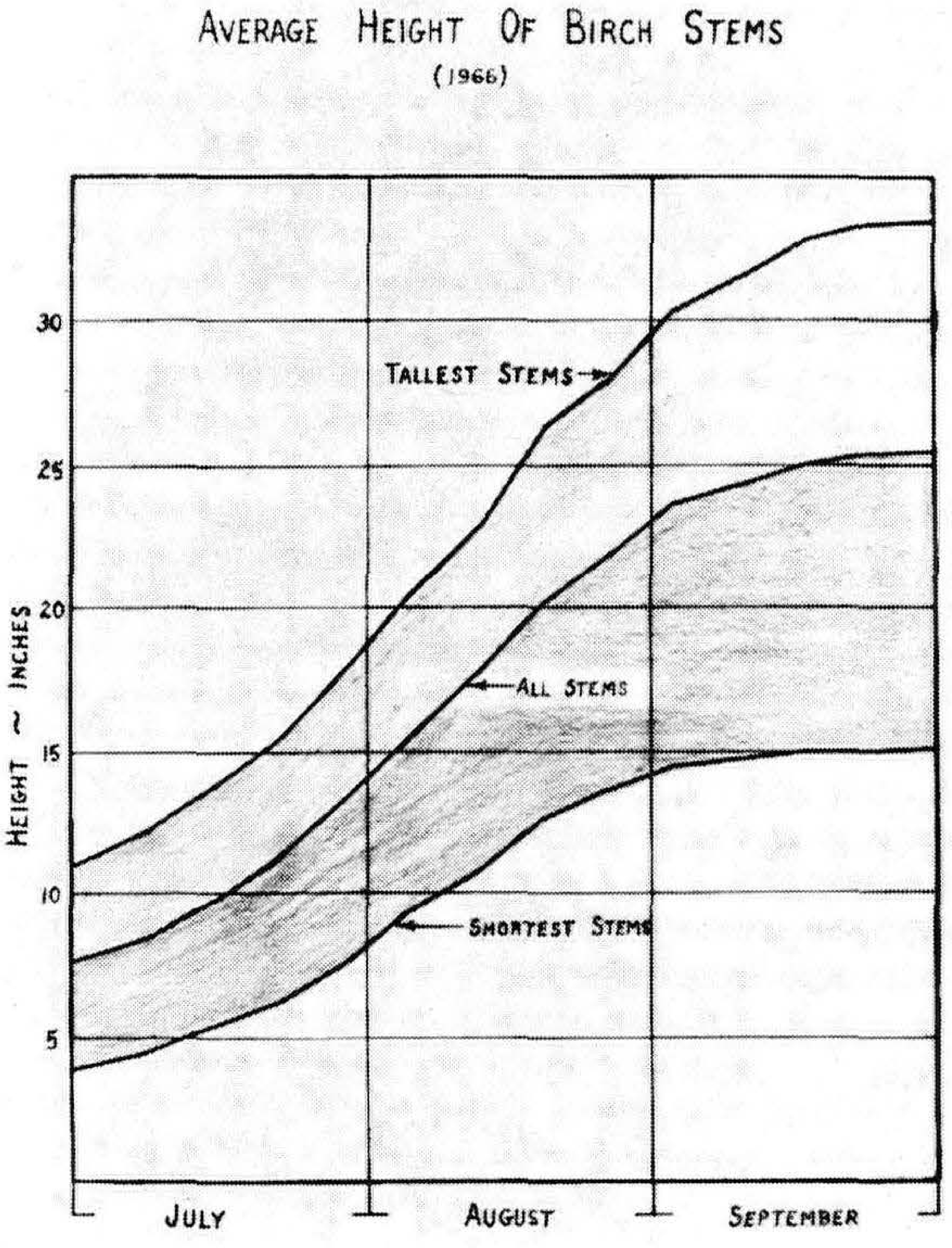


Figure 2.

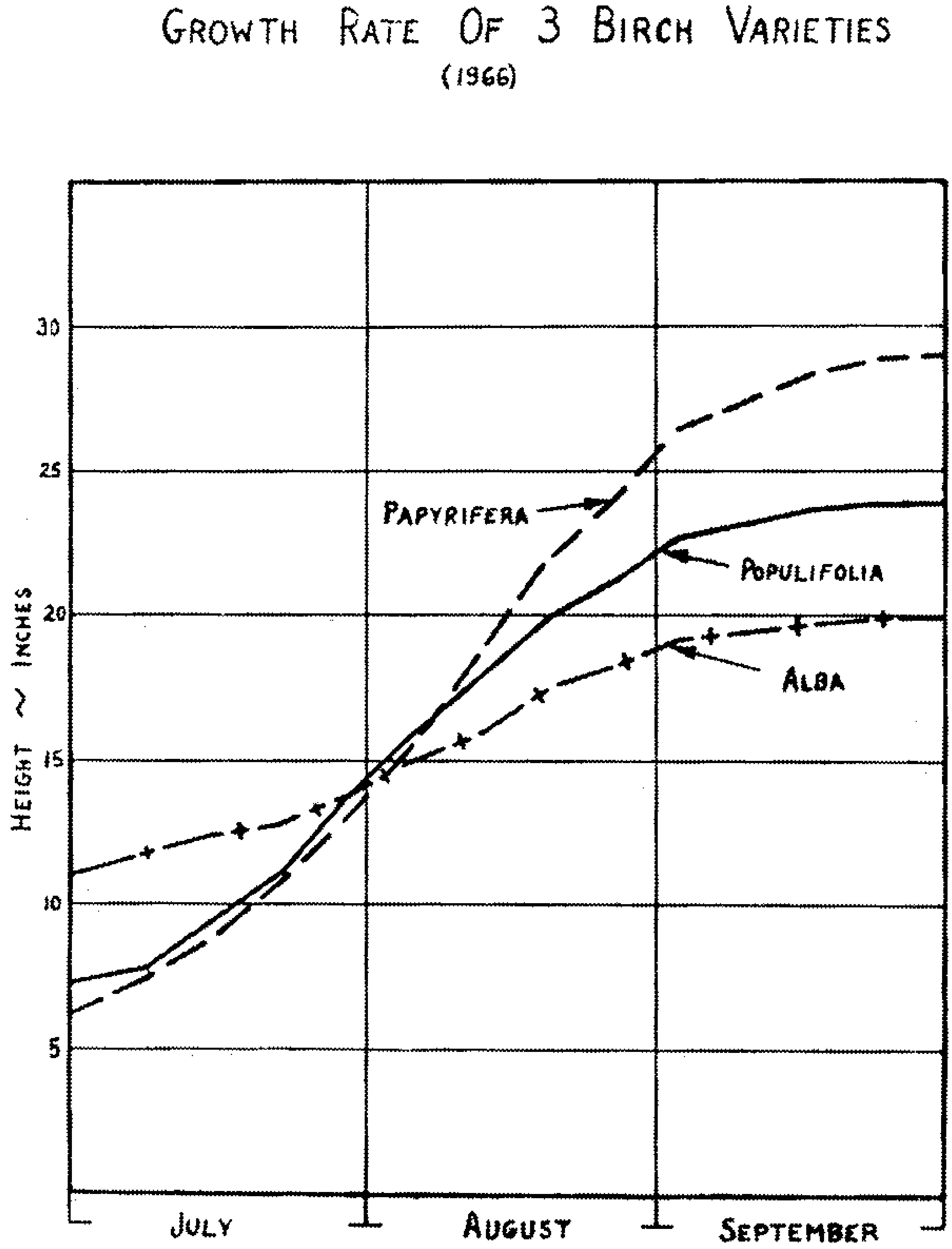


Figure 3

Figure number five, entitled "cost of Birch production by operations 1965" is relatively self explanatory. The 22.5% involved in grading is high, primarily because of the uneveness of the stems. This same problem comes back to haunt us over and over again. In looking at the distribution of direct labor, overhead and materials, it is easy to see that we start with a very small investment in materials, but put a tremendous amount of labor into producing this quality plant. We based our overhead on 250% of direct labor in the year 1965. The actual figure was 249%. It must be emphasized that this is based on *direct labor* and not total labor. Each year this figure varies as we develop our departmental P&L statements. The cost of production when broken down to dollars and cents has been within 2c per clump over the past three years.

SUMMARY

In conclusion, I would like to again emphasize that what success we have gained has been through a team effort of our whole organization and many helpful hints from people like yourselves and those in the florist industry. We have much to learn about the culture of plant life, especially it's nutrition. Certainly this program is not the ultimate—far from it, as there is much to be done yet and we hope to expand it into other areas of production.

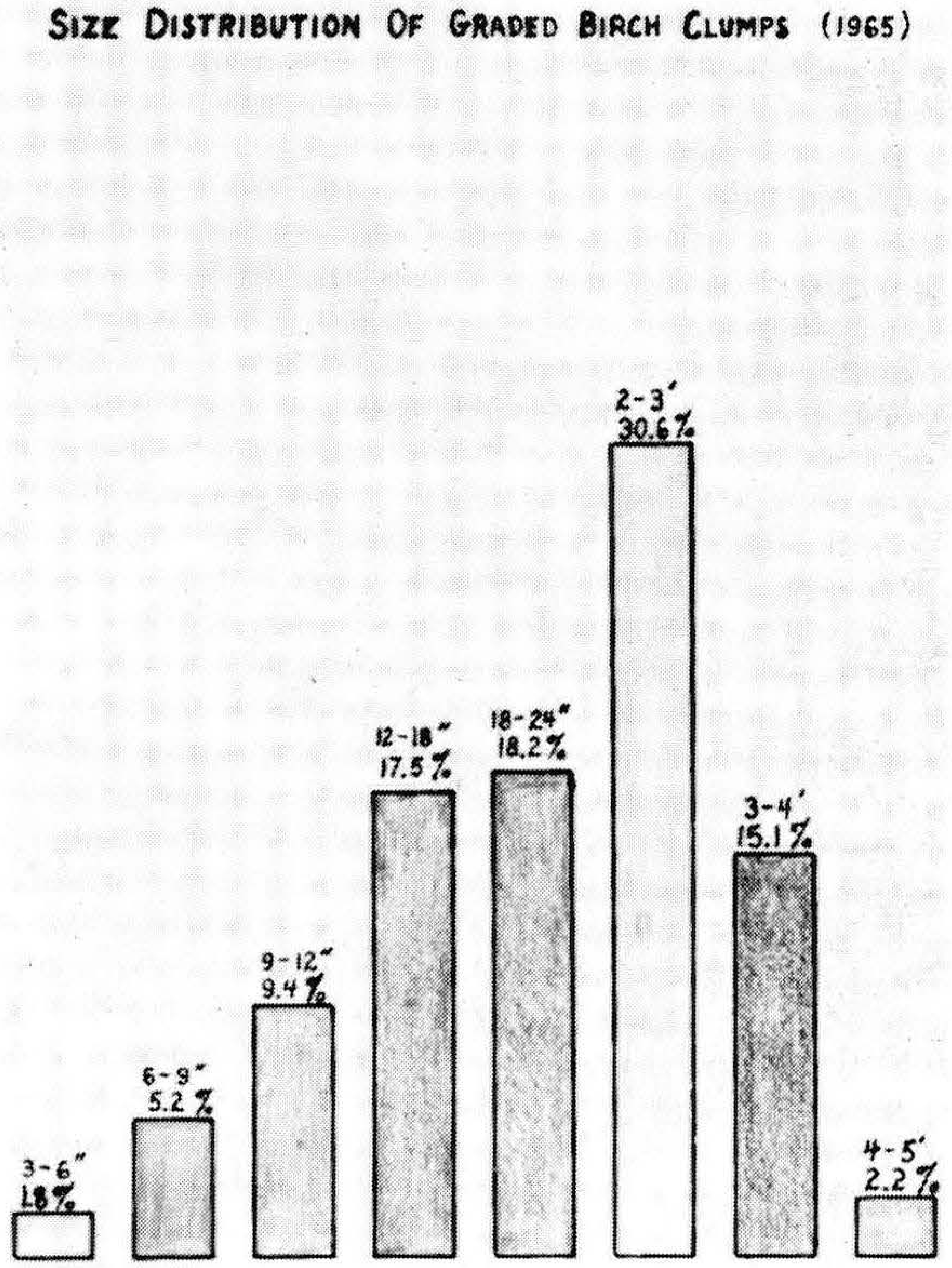


Figure 4.

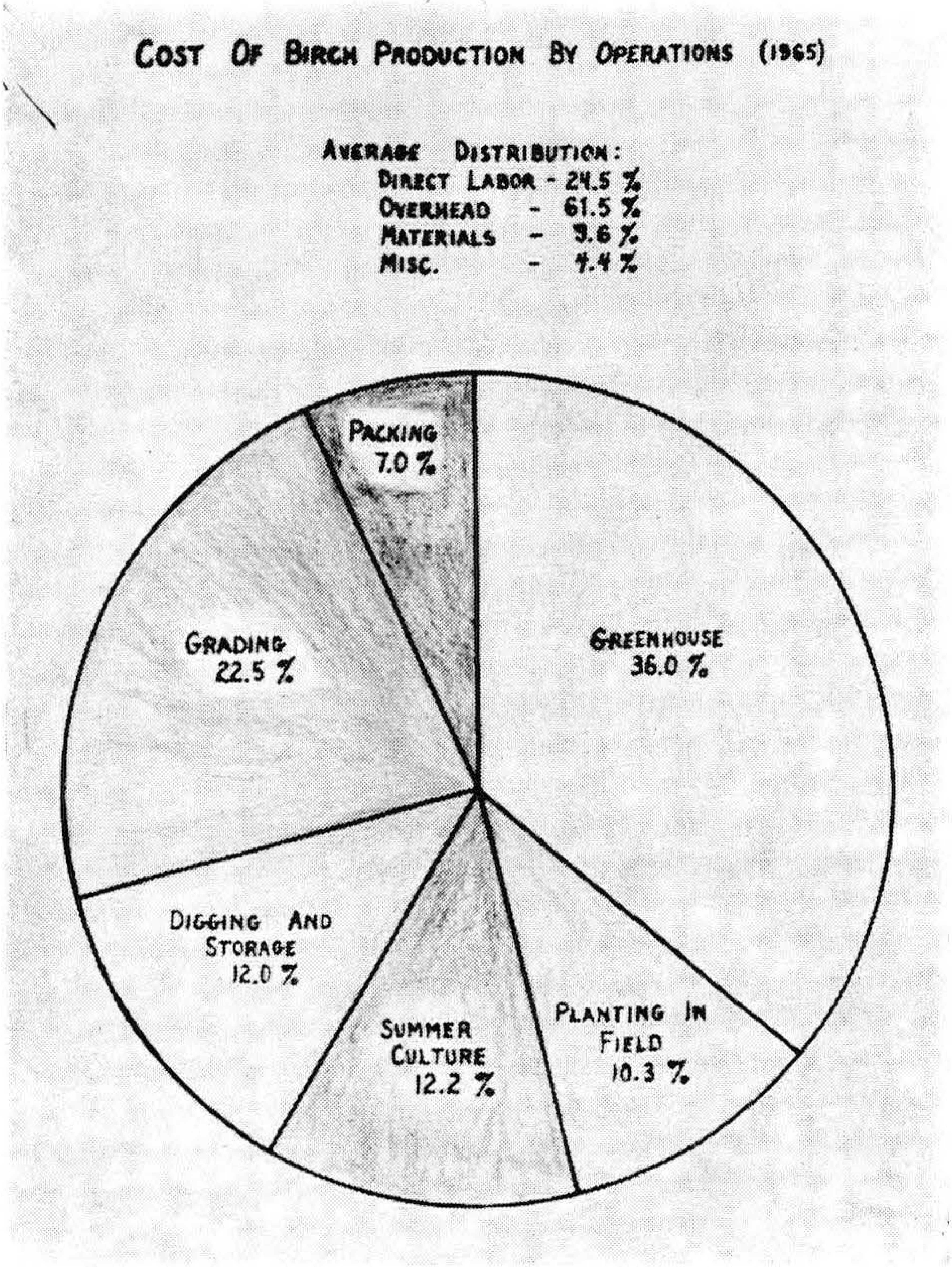


Figure 5.

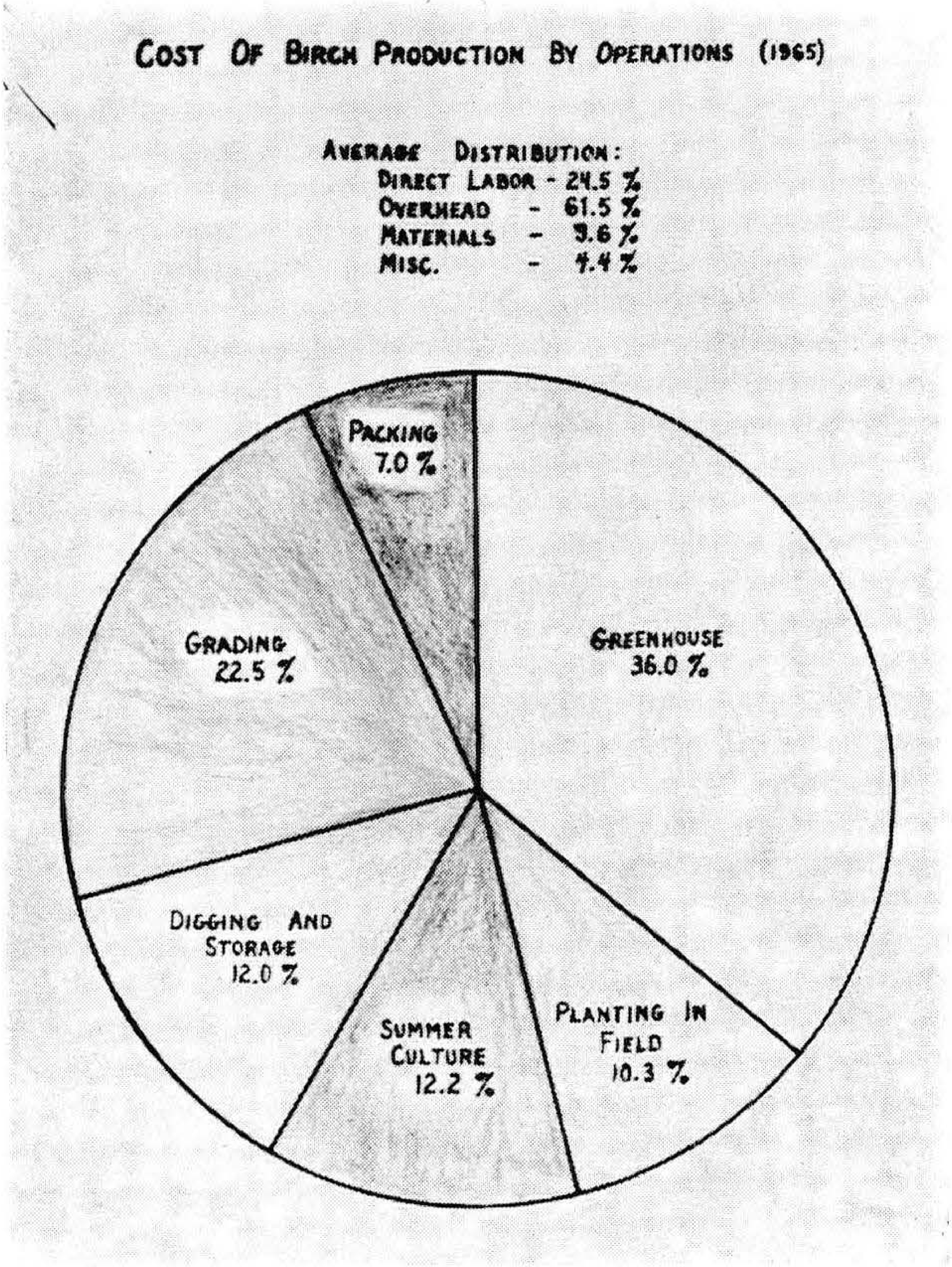
MODERATOR HESS: Thank you, Tom, for an outstanding paper. Our next speaker is well known to all of us and is the father of President Pete. It is a real pleasure to introduce John Vermeulen.

PROPAGATION OF RHODODENDRON UNDER OUTDOOR MIST

JOHN VERMEULEN
John Vermeulen & Son, Inc.
Neshanic Station, N. J.

This topic was on the list of suggestions and as we had some limited experience in this field for 2 or 3 years I offered to tell you what little I know.

For some years we had given up the propagation of Rhododendron from cuttings as it interfered with other items to be propagated in October-November. But 4 years ago I was asked to trim some Rhododendron Mrs. C. S. Sargent in early



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July. There were a number of very nice cuttings on those plants so I could not just throw them away but took them home. It was a very hot day and we had no ice or anything to keep them fresh. We picked out about 100 cuttings, made them and put them in flats under outdoor mist. The result looked very poor after a few weeks so I lost interest in them but when in late October I came to clean out the frame I found about 50% rooted.

This helped me make up my mind to try again the following summer. We again made about 100 cuttings of Mrs. C. S. Sargent which, by the way, is one of the more difficult varieties. We gave it better care and got a 65-70% stand. Then we decided to go a little better in 1965 and we put in about 900 cuttings in 20 or more varieties. Very good care was taken of these and the result was 90-95%. These cuttings were put in flats in 50% peat and 50% fine perlite so we had to pot them after rooting during the winter months. They were not all the very easy to root varieties as they included Mrs. C. S. Sargent, General Grant, Dr. Dresselhuys, Charles Dickens, etc.

So here was the 1966 summer coming on and we extended the amount of cuttings to about 6,000. We also changed from putting them in flats to sticking them directly into 3½" peatmoss pots, 18 to the flat, so transplanting would not be necessary.

We also had to make a change of location as our outdoor bed did not give us enough room to put them there. We put them on top of a bench in the greenhouse which had no glass but a protection of Saran cloth. However this has cost us a loss of about 12% of our cuttings. The reason of this is that there was more drift of the mist and we were using our oldest misting set up so we were constantly troubled with clogging nozzles and through this we did not get proper coverage. It is a must that mist is 100% available at all times for all cuttings, even so we have an 82% stand. We ran from 55% in poorly misted cuttings to 98% in others. We also put in some cuttings 3 weeks later in flats under outdoor mist in our ground beds. The result — 95%. The reason, better mist coverage.

The powder we used is 50%, 4% I.B.A. and 50% 4X CUTstart and 1/16 PHYGON or any good fungicide.

VOICE: Why do you use the fine grade of perlite?

JOHN VERMEULEN: We feel the coarse grade provides too much aeration and if the liner is planted in a heavy soil it will not become established as well as it would if it was in a fine grade of perlite.

JIM WELLS: How did you wound your cuttings?

JOHN VERMEULEN: With a razor blade in a holder. You can make a very fine wound.

AL LOWENFELS: What hormone did you use?

JOHN VERMEULEN: We used what is known as Germain

LIST OF VARIETIES AND RESULTS

	Stuck	Rooted	Not Rooted	Dead
Dr. Dresselhuys	252	138	66	48
Catawbiense Grandiflorum	108	80	18	10
Parsons Gloriosum	54	51	3	—
Atrosanguinea	108	94	8	5
Purpureum Elegans	252	240	12	—
General Grant	106	96	8	4
Boule de Neige	252	192	17	43
Fortunei #1	103	102	—	1
E. S. Rand	108	36	34	38
Mrs. C. S. Sargent	108	60	22	26
White Gem	108	108	—	—
Van Weerden Poelman	108	108	—	—
English Roseum	252	243	—	9
Charles Dickens	108	101	6	1
Catawbiense Alba	252	251	—	1
Roseum Elegans	252	223	15	14
Ignatius Sargent	124	70	13	41
Scintillation	54	54	—	—
Cunningham White	105	91	—	14
Charles Bagley	234	200	20	14
Everestianum	36	34	—	2
H. W. Sargent	90	75	12	3
F. D. Godman	139	90	15	34
Lee's Dark Purple	252	170	57	25
Smirnowi	36	36	—	—
Mrs. P. Den Ouden	108	95	9	4
Caractacus	252	167	33	52
Roseum Superbum	108	84	4	20
Catawbiense Boursault	108	104	4	—
Dr. Rutgers	146	118	3	25
Nova Zembla	630	556	33	38
America	612	378	132	102
Gloxiosa	16	12	4	—
Seedlings #1, Red	54	43	6	2

powder. We got the material from a brick layer or plasterer in Philadelphia who was an amateur propagator. His name was Germain. The mixture is one part 4% IBA mixed with 1 part 4X Cutstart and 1/16 part phygon or other fungicide. It doesn't burn.

CASE HOOGENDOORN: Don't you get bud inhibition by using such a strong hormone?

JOHN VERMEULEN: We cut out the center buds, most of them are flower buds anyway. But we do get good strong growth with no inhibition.

AL LOWENFELS: When do you take the cuttings?

JOHN VERMENLEN: In July. Roughly around the second week in July. The wood is just about sturdy.

MODERATOR HESS: Thank you very much, John, for a paper which stimulated much interest. Our next paper on the propagation of *Carya illinoensis* will be given by Booker T. Whatley. Booker is the head of the Horticulture Department at Southern University and, I am proud to say, a Ph.D. graduate from Rutgers University.

PROPAGATION OF CARYA ILLINOENSIS (PECAN) FROM CUTTINGS

BOOKER T. WHATLEY, STANLEY O. THOMPSON
AND JACK H. JEFFERSON
Southern University — Baton Rouge, Louisiana[1,2,4]

The pecan, *Caryo illinoensis,* is propagated commercially by budding or grafting on seedling rootstocks. There are three major disadvantages encountered when one grafts or buds varieties onto seedling rootstocks:

1. Considerable time and expense are involved and often with only moderate success.
2. Seedling rootstocks have a tap root with a few lateral fibrous roots. This characteristic has been associated with poor survival of transplanted trees.
3. Each seedling rootstock has the potential of being genetically different.

The need for an improved method of propagation of pecan has, therefore, been recognized for some time.

There appears to be only three published reports in American Horticulture literature that deal with the propagation of pecans by cuttings. Stoutemeyer (5) rooted dormant Greenriver pecan cuttings by pre-callusing and treatment with indolebutyric acid (IBA); no report was given on whether the rooted cuttings were transplanted. Gossard (1) reported the rooting of pecan softwood cuttings under continuous mist. None of the rooted cuttings survived when transplanted (2). Sparks and Pokorny (4) studied the effects of wound treatments and root-inducing chemicals on rooting of terminal pecan cuttings taken at four different dates. These investigators reported that:

1. Rooting was inversely related to the maturity of the terminal.
2. IBA plus a light wound gave the highest rooting percentage.

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[1] This work was supported in part by a grant from the Society of the Sigma Xi and RESA Research Fund

[2] The authors express their appreciation to Dr Barton R Farthing, Professor and Head, Department of Experimental Statistics, Louisiana State University, for his advice and assistance regarding the experimental design and statistical analysis

[3] The authors express gratitude to Dr Robert J Herschler, Crown Zellerbach Corporation, Camas, Washington for the supply of DMSO and the Bark Paint

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3. Root quality was poor.

It seems that no method has been developed for growing rooted pecan stem cutting or rooted layers into trees (2).

This paper is the first in a series dealing with the rooting and survival of pecan cuttings as they are affected by various chemicals including the solvent Dimethyl Sulfoxide (DMSO), (3).

MATERIAL AND METHODS

A randomized block experimental design with eleven treatments replicated five times and ten cuttings per treatment per replication was employed in this study.

The cuttings used were terminal softwood, six inches in length and twelve to fifteen mm in diameter at the base, with five leaves. The cuttings were taken from eight year old stock plants of the Stuart variety. The rooting medium was vermiculite, in 2¼ inch round jiffy pots. The potted cuttings were placed on the propagation bench and watered in, and propagated under intermittent mist without bottom heat. The treatments were:

01 Girdled shoot six inches from apex
02 Bark Paint — The paint consisted of:
  1.5 parts NAA
  50.0 parts DMSO
  40.0 parts Acetone
  10.0 parts glycerine
03 Simpson Dip — Consisted of:
  5 grams IBA
  500 ml ethyl alcohol
  100 ml of the above solution diluted with 100 ml of ethyl alcohol and 200 ml of distilled water. Cuttings soaked in this solution for one minute.
04 Fifteen minutes soaking in a solution containing 1000 ppm IBA and 0.5% DMSO
05 Thirty minutes soaking in a solution containing 1000 ppm IBA and 0.5% DMSO
06 Forty-five minutes soaking in a solution containing 1000 ppm IBA and 0.5% DMSO
07 Control — no treatment
08 500 ppm IBA in talc
09 5,000 ppm IBA in talc
10 10,000 ppm IBA in talc
11 20,000 ppm IBA in talc

The data were obtained by counting the number of roots that penetrated each jiffy pot and transferred to punch cards and computer analyzed. An analysis of variance and orthogonal comparisons were used to determine differences among treatments.

RESULTS AND DISCUSSION

The mean number of roots that pentrated the jiffy pots for the respective treatments varied from 0.3 for treatment

TABLE 1 ANALYSIS OF VARIANCE

Source of Variation		d./f.		S.S.	M.S.	F
Total		549		34,486		
Replications		4		44	11	
Treatments		10		29,769	2977	162.85**
7 vs others	1		1,675			90.14**
1 vs (2-6 & 8-11)	1		396			21.67**
2 vs (3-6 & 8-11)	1		743			40.62**
3 vs (4-6 & 8-11)	1		35			1.95 N.S.
(4-6 vs (8-11)	1		644			35.25**
4 vs 5 & 6	1		13,200			722.12**
5 vs 6	1		25			1.37 N.S.
8 vs (9-11)	1		2,709			148.22**
9 vs 10 & 11	1		192			10.50**
10 vs 11	1		10,201			588.04**
Experimental Error		40		731	18.3	
Sampling Error		505		3942	7.8	

06, soaking for forty-five minutes in a solution containing 1000 ppm IBA and 0.5% DMSO, to 23.3 for treatment 10, 10,000 ppm IBA in talc. Highly significant differences were found among the various treatments (Table 1). When the cuttings were soaked from 15 to 45 minutes in a solution containing 1000 ppm IBA and 0.5% DMSO, the mean number of roots for the 15 minute soaking period was 20.7 and highly significant when compared to the thirty and forty-five minute soaking periods with 1.3 and 0.3, these being no different from control (Table 2). Bark Paint, Simpson Dip and girdling hav-

Table 2 Effects of Soaking Treatments on Rooting of *Carya illinoensis* Cuttings in Solution Containing 1000 ppm IBA and 0.5% DMSO

Time (Min)	Number of Roots
15	20.7**
30	1.3 N.S.
45	0.3 N.S.
Control	3.2 N.S.

Table 3 Effect of Girdling, Bark Paint and Simpson Dip on Rooting of *Carya illinoensis* Cuttings

Treatments	Number of Roots
Control	3.2 N.S.
Bark Paint	13.2**
Simpson Dip	9.9**
Girdling	6.6**

Table 4 Effect of Levels of IBA in Talc on Rooting of *Carya illinoensis* Cuttings

IBA (ppm)	Number of Roots
20,000	3.2 N.S.
500	3.8 N.S.
5,000	10.7**
10,000	23.2**
20,000	3.0 N.S.

ing a mean number of 13.2, 9.9 and 6.6 roots per plot respectively, (Table 3), were significantly better than the control. The effects of levels of IBA in talc as indicated in Table 4 shows that 5000 and 10,000 ppm were significantly better than the control while 500 and 20,000 ppm were not different from the control. Level of 10 000 ppm was significantly better than 5,000 ppm (Table 4).

Rooting was first observed forty-five days after the start of the experiment and all cuttings were completely defoliated at that time. The absence of leaves appear to have little or no effect on rooting.

SUMMARY

A randomized block experimental design with eleven treatments, replicated five times with ten cuttings per treatment per replication was employed to study the effects of these treatments on rooting of *Carya illinoensis* terminal cuttings. Highly significant differences were found among the treatments. A level of 10000 ppm IBA in talc was found to be best, having a mean number of 23.2 roots per plot. Fifteen minute soaking in a solution containing 1,000 ppm IBA and 0.5% DMSO was the second best treatment having a mean number of 20.7 roots per plot. Treatment with Bark paint, 5,000 ppm IBA, Simpson Dip, and Girdling having a mean number of 13.2, 10.7, 9.9 and 6.6 roots per plot, respectively, were significantly better than the control. Thirty, and 45 minutes soaking in solution of 1,000 ppm IBA and 0.5% DMSO, and 500 and 20,000 ppm IBA in talc with a mean number of 1.3, 0.3, 3.8 and 3.0 roots per plot, respectively, were no better than the control which had a mean number of 3.2 roots per plot.

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MODERATOR HESS: Thank you, Booker. Our next speaker is Joseph Cesarini who has a very fine collection of dwarf and rare plants in Long Island. Joe will talk to us about the propagation of dwarf conifers.

PROPAGATION OF DWARF CONIFERS

JOSEPH CESARINI
Johnson Avenue Rare Plant Nursery
Sayville, New York

I am very honored to appear here today. In view of the limited speaking time, I have elected to speak on a few specific varieties of the many dwarf conifers I have available. The varieties of conifers I shall discuss have been selected alphabetically.

ABIES

The first genus is *Abies*. The *Abies* family is a very large genus of forest size trees which has given us relatively very few dwarf forms. We root and graft some of these dwarf forms. In our part of the country, grafting dwarf firs presents somewhat of a problem because of the selection of understock. The understock we prefer is *Abies pectinata* or *Abies alba;* however, we do not raise our own understock and these species are difficult to find as seedlings in the trade in this area.

Abies balsamea presents a problem because our winters are not cold enough and our summers are a little too warm.

Abies concolor is readily available but grows so vigorously that it does not do justice to the dwarf forms. To overcome this problem, we graft the firs very close to the root stock and we plant them extra deep hoping they will eventually grow on their own roots.

We have a very interesting form of *Abies balsamea nana.* This plant roots very easily from cutting. We take the cuttings after the stock plant has been hit by a heavy frost. We use the current year's growth which is usually about 1¼" to 1½" in length, strip the last half inch of the leaves, dip them in Hormodin #3; using sand as a media we keep them in a real cool greenhouse. It is a very slow rooter. After it roots, it does not like to be disturbed so we leave it in the sand even after it makes new growth. After the new growth hardens off, we transplant it. This is the only fir in my experience rooted from cuttings that continues to make good growth.

We are able to root a dwarf form of *Abies pinsapo glauca.* However, this plant makes one or two roots on one side only and looks like a hockey stick. After we transplant them, they just sit without making any new growth. The root system gets bigger and very, very coarse during this time, so we produce them by grafting.

Abies procera prostrata is an interesting dwarf which we also produce by grafting.

Abies lasiocarpa arizonica is another variety produced by grafting. It is rather reluctant to make leaders in the beginning but in time they shape up very nicely.

It is not yet commercially feasible to produce the other forms of dwarf firs which we have succeeded in rooting.

CEDRUS

Cedrus atlantica glauca to my knowledge has not yet produced a dwarf form. We have examined many, many specimens for witches broom to no avail.

We have a weeping form of *Cedrus deodara* which could be considered a dwarf. This roots fairly good from cuttings which are taken in early winter. We use the current year's growth, make a slight wound, dip them in Hormodin #3 and once again use sand as a media. By Springtime, they are usually well rooted. Even after transplanting, these cuttings make good growth immediately showing their characteristic form.

We have a dwarf form of *Cedrus libain.* There are reports that this *Cedrus* can be rooted but our stock is very limited so we prefer to graft them. We use *Cedrus deodora* seedlings for understock—potted in the spring, and grafted around January or February.

Just out of curiosity, we have tried to root *Cedrus atlantica glauca pendula* and the straight *Cedrus atlantica glauca*, but to date, we have been unsuccessful.

Cedrus deodoro roots quite readily. In fact, at one time, we were considering rooting *Cedrus deodora* for use as understock for *Cedrus atlantica glauca* and the Pendulus form.

CHAMAECYPARIS

The next conifer I am going to discuss is *Chamaecyparis.* We have many species of this genus and anyone of these give us some interesting dwarf forms.

Chamaecyparis lawsoniana is reasonably new in cultivation, but it has given the trade numerous cultivars. They are relatively all very easy to root. We treat them all the same way. Since they are slow growing and dwarfed, to make a sizeable cutting, we go back on two or three year old wood, wounding and dipping in Hormodin #3. We use perlite and peat moss at a ratio of one bag of perlite to seven and one-half cubic foot bale of Irish peat as a media. The results are very satisfactory. The timing is not too important. In fact, at times we root these in the summer under mist. However, they root equally as well during the winter in the greenhouse where the media is kept at a temperature of 65° to 70°F. After rooting, they perform satisfactorily with the exception of *Chamaecyparis lawsoniana forsteckensis.* This one roots at a good percentage but the root system is very poor. Even after they have started growing in the field, they do not like to be transplanted. We have tried many different methods, at various times, but the loses were so great that we gave up.

Chamaecyparis obtusa nana gracilis is one of my favorite plants. We root this very easily from cuttings. We take the cuttings in the early part of the winter. Most of the time wounding is not necessary because stripping the lower portion of the cutting leaves enough wounds. We use 2% I.B.A.

(in talc), the same media and the same greenhouse conditions that we use for *Chamaecyparis lawsoniana.* Within ten to twelve weeks. They have a fantastic root system. We have been able to root these plants in straight perlite but the root system is not satisfactory and is very coarse. We also noticed that the selection of the cutting wood is very important because we can produce different variations from the same plant. A little tuft at the end of a branch (not specifically on the upper section of the plant) will produce a very compact plant. However, a cutting from the middle, which tries to reach for light, roots equally well but does not produce a good plant. We also graft some of these on high standards using *Chamaecyparis pisifera* or *lawsoniana* for under-stock. These produce good conversation pieces. The age and condition of the stock plant does not seem to have any affect on the results. As for the size of the cuttings, sometimes we go back to three or four year old wood. This also applies to *Chamaecyparis obtusa aurea nana.* This also applies to *Chamaecyparis obtusa* "Minima". In fact here, to make a little cutting, we have to go back on four or five year old wood. We root *Chamaecyparis obtusa pygmea* the same way but the selection of the wood is not important. In time they all end up with the characteristic fan spray.

We root other forms of *Chamaecyparis obtusa,* such as *Chamaecyparis filicoides* and *Chamaecyparis obtusa filicoides compacta* (this one seems to root easier with just Hormodin #3). Once again the cutting stock is very limited, so we must be satisfied with rooting just small cuttings. I have not had any experience in rooting big cuttings of this variety.

There is also an unnamed seedling which roots equally well.

Chamaecyparis obtusa torulosa is very easy to root. We treat this the same as the *Chamaecyparis obtusa nana gracilis.* It forms a very nice plant in a short period of time. This plant is not to be confused with the *Chamaecyparis obtusa coralliformis.*

Chamaecyparis obtusa tetragona aurea can also be rooted from cuttings. Our experience with this plant indicates that cuttings taken towards the end of November root quite readily; but, if cuttings are taken after they have been hit by heavy frosts, they form a very heavy callus. In this case, in order to root such cuttings, our experience has been to break off the callous, re-dip the cututings in powder and re-stick them. Following this proecdure, we have produced many interesting little plants.

Our experience has indicated that *Chamaecyparis obtusa lycopodiodes* is very stubborn. We have tried many different off the callus, re-dip the cuttings in powder and re-stick them. Following this procedure, we have produced many inways, different types of media, different cutting sizes, different periods of time, using different hormones and have never been able to root a single one. We produce it by grafting on unrooted cuttings of *Chamaecyparis pisifera plumosa* with satisfactory results.

Chamaecyparis pisifera plumosa roots very readily in both summer and winter. In fact, before we could afford a greenhouse, we rooted them in cold frames.

MODERATOR HESS: Thank you, Joe, for a tremendous job. Our next speaker will be Dick Fenicchia who will talk on the propagation of the dove tree from seed.

PROPAGATION OF THE DOVE TREE FROM SEED

RICHARD A. FENICCHIA
Monroe County Parks
Rochester, New York

In 1869 the French missionary priest, Abbe David, discovered a remarkable tree while making botanical collections in the western Chinese province of Szechuan. In 1871 it was named *Davidia involucrata* for its discoverer. Nineteen years later the hairless-leaved variety which has proved to be usually hardier than the first hairy-leaved type, was found in the same province and another explorer sent seed to the French horticulturist, de Vilmorin, who raised one plant. The news of this rare discovery reached the Veitch Nursery in England, then at the height of its prominence. They sent E. H. Wilson on his first expedition to China (1899-1901) for the sole purpose of bringing this plant into cultivation. This was a successful venture since from the fruits sent back at this time the Veitch Nursery produced thirteen thousand seedlings. In 1903 and 1904, Wilson collected the pubescent-leaved type for Veitch who now were able to offer his diary of 1910 and the entry for May 30 and 31:

"On a precipitous slope facing our lodgings, a score or more Davidia trees occur; they vary from 35 to 60 feet in height and the largest is six feet in girth. The bark is dark and scales off in small, irregular flakes. The flowers and their attendant bracts are pendulous on fairly long stalks, and when stirred by the slightest breeze, they resemble huge butterflies hovering amongst the trees. The bracts are somewhat boat-shaped and flimsy in texture and the leaves often hide them considerably but so freely are they borne that the tree looks, from a short distance, as if flecked with snow. To my mind, Davidia involucrata is at once the most interesting and beautiful of all trees of the north temperate zone."

W. J. Bean of Kew points out that Davidia stands much apart in the vegetable kingdom; its nearest ally is considered to be Nyssa. In the latest study of the forests of China by C. W. Wang (Harvard University, 1961), both forms of Davidia occur in the mixed deciduous forests of both eastern and western Szechuan Province in China; Davidia is locally abundant in eastern Szechuan at elevations of 1,600 to 2,400 been able to root a single one. We produce it by grafting on unrooted cuttings of *Chamaecyparis pisifera plumosa* with satisfactory results.

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Fruits were gathered about the middle of October from several plants in Durand Eastman Park, Rochester, New York.

Seeds were immediately given an after-ripening warm period of five months. Seeds stratified between layers of sand in a tub and kept moist at all times. They were stored in a warm temperature of 65 to 70 degrees.

Seeds were stratified in this mixture from middle of October 1964 until March 3, 1965. On March 3, 1965, seeds were removed from stratification box — washed and cleaned — all pulp removed from stones.

After a drying period of several hours, the seed was then dusted with fine sulphur. Seeds were then stratified in layers of sand in stratification box. Seeds were then subjected to a cold period March 3, 1965. Box was set outdoors to freeze under natural conditions. Seeds remained outdoors all summer and sand was kept moist at all times. After twelve months of stratification to March 3, 1966, seeds were removed from stratification box, brought into the greenhouse and planted in flats.

(Seeds received two warm after-ripening periods and also received two cold dormancy periods.)

While removing seeds from stratification box, I noted radical and cotyledon development. Media used in the planting of these seeds comprises equal parts of sand and sandy loam.

After seeds were inserted in this mixture of soil they were firmed in at soil level and then covered with ½ inch of sand. Sand was firmed in; flat was immediately watered in, set in the greenhouse at a temperature of 65 to 70 degrees. The following day the flats were saturated with a fungicide (Captan or Fermate) — three or four weeks after flats were brought into warm greenhouse, sporadic germination began to take place. Seedlings are subject to stem and root rot. Fungicide sprays are helpful in preventing spread of diseases. Watering also plays an important part during the germination of the Dove Tree. During the germinating period, the soil should be on the dry side. Water should be given only to maintain soil moisture. During the germinating period and as the seedlings progress to a height of three inches more water can be given to the flats. Actually, the Dove Tree consumes a lot of water.

About the middle of July, seed flats were put outdoors to acclimate and harden them off. After several light frosts, seed flats were taken into a root cellar to be stored for the winter months.

MODERATOR HESS: Thank you, Dick. Joerg Leiss will next tell us about trials with three juniper understocks.

TRIALS WITH THREE JUNIPERUS UNDERSTOCK

JOERG LEISS
Sheridan Nurseries
Oakville, Canada

This paper is a continuation of a previous paper by Mr. C. deGroot and credit for these trials should go to Mr. Constant deGroot, a member of this Society from its early beginning. It was he who had the idea of using the various understock, while I worked with him. We started searching for better understocks after using *Juniperus virginiana* (Platte River source) entirely for years, but ran into a number of problems over the years. Heavy losses after grafting in the propagation bench from phomopsis blight were aggravated by uneven stands in the field, failure of seed to germinate and last but not least a poor root system and consequent transplanting losses, even after root pruning. To say the least, we came to a stage where you could say we were fed up. You have to consider that even a 20% loss of 60000 which we grafted at that time represents a large number of plants.

Our trials are concerned with the following Juniperus species and/or varieties, and I will briefly describe them as they are not all very familiar.

1. *Juniperus hetzi* which was discovered before 1948 in a batch of seedlings from the West Coast received by Hetz Nurseries in Fairview, Pennsylvania. It is believed to be a cross between *J. virginiana glauca* as seed plant and *J. pfitzeriana* as pollinator, is easily rooted, transplants readily and produces very even stands after grafting. It also accepts all Juniperus species we have tried readily and there seems to be no incompatability. We have used it for *J. chinensis, J. communis, J. sabina, J. scopulorum, J. squamata, J. virginiana* species and all their many varieties, and have found all of them to grow well and transplant well.
2. *Juniperus pseudocupressus* is of unknown origin and botanists cannot seem to agree how to classify it. We received our stock from H. den Ouden in 1924 who got it from Hesse Nurseries in Germany. It roots fairly good, has a very fibrous root system and is a terrific fast grower, so much so, that under wet soil conditions it freezes back at the tips. *J. pseudocupressus* transplants very easily. There is incompatability with some *J. virginiana* varieties. It grows well from cuttings.
3. The third is a chance seedling which came up in a stone stairway, was called "Stone Step" and has been renamed for marketing "Grey Rock". It is an upright growing plant with whipcord like grey foliage and of semi-open habit, but more compact than *J. virginiana glauca.* We propagate our under-

stocks from seed of the grafted plants. It seeds heavily, germinates very well and produces a good root system. It seems to be phomopsis resistant as we have not lost a single understock to this disease since using it. This is without any preventative spray programme. It is also one of the hardiest Juniperus varieties we grow, and does well in the province of Quebec. We have also found some interesting seedlings among them.

We became involved with *J. hetzi* after hearing about cutting grafts in 1959. We tried some, had good success to heal them, but were unable to promote roots at that time, partly because of too high humidity in the grafting case where this trial was made, and the timing of the experiment (late February). Grafting method used was side graft tied with rubber. Seradix 3 treatment. The next year we tried again with *J. pseudocupressus.* The results of this trial were published in 1960 by Mr. deGrott in the Plant Propagators' Society proceedings, page 124. They show very poor results with *J. virginiana glauca, burki,* and *canaerti,* fair with all *J. chinensis* varieties and very good with *J. virginiana,* Hills Dundee. We have, by the way, abandoned cuttings grafts as we believe in potted grafts and there is no saving in space or grafting time by using cutting grafts, — as a matter of fact, it took us nearly double the normal grafting time.

In 1962 we tried *J. pseudocupressus* again, this time as potted, well established understocks. The following *Juniperus* were grafted 30 each:—

J. chinensis blaauwi	— 29 — field planted and counted 1 year later
J. chinensis japonica	24
J. chinensis keteleeri	25
J. chinensis pfitzeriana Armstrong	29
J. chinensis pfitzeriana compacta	25
J. chinensis sargenti glauca	28
J. communis depressa nana aurea	28
J. communis Pencil Point	26
J. sabina tamariscifolia	25
J. scopulorum Hills Silver	27
J. scopulorum Moonlight	26
J. scopulorum North Star	22
J. squamata meyeri	29
J. virginiana burki	29
J. virginiana canaerti	29
J. virginiana glauca	20
J. virginiana Hills Dundee	21
J. virginiana Nova	28
J. virginiana pyramidalis	28
J. virginiana Skyrocket	27

none of these were root pruned.

The growth of these plants has been good and they are bushier than on *J. hetzi* or *J. virginiana* with the exception again (as before when cutting grafts were made) *j. canaerti, J. glauca, J. burki* which are, if not dead, only 2 feet tall, while all other upright varieties are 5′ on an avearge. spreaders have reached as much as 3′ in *J. squamata meyeri.*

On all three trial understocks we found that the roots of all *J. chinensis* are reasonable to good, while the roots of the 3 *J. virginiana* varieties which grew well are very coarse while the 3 *J. virginiana* which showed signs of incompatability with *J. pseudocupressus* have kept the fine root system of the understock *J. pseudocupressus.* I would at this point suggest there is, as in many other plants, a definite influence between scion and understock and which has been well documented in the case of fruit trees and their respective vegetative propagated understocks (E. M. and M.M. clones for Malus and the various Quince types for Pyrus. Plum clones for plums and peaches). We still feel the ease of propagation and transplanting outweighs any drawbacks we might encounter and makes it worthwhile for us to continue to use these understocks. The main point in favour being their resistance to disease and very high percentage of success in grafting.

MODERATOR HESS: Thank you, Joerg, for an excellent presentatation. The balance of this afternoon's program will deal with weed control and will be moderated by Roger Coggeshall.

MODERATOR COGGESHALL: Our subject of weed control is one we are all interested in. It is a controversial subject. As you know some people are successful, others are not. We are fortunate this afternoon in having two men to speak to us. The first I would like to introduce is Dr. Alfred Pridham, Cornell University, Ithaca, New York.

WEED CONTROL FOR THE NURSERY

ALFRED M. S. PRIDHAM
Department of Floriculture and Ornamental Horticulture
Cornell University
Ithaca, New York

Weed — A weed is a plant out of place or an unwanted plant.

Some weeds carry plant diseases and insect pests while the mere presence of quackgrass in a plant ball is enough to restrict trade by quarantine in some states.

It is now 20 years since the selective action of "Carrot spray" was found to apply to the weeding of evergreen seed beds and that Dinitro killed seedling weed growth promptly on contact but that woody stems were merely defoliated.

Large scale soil fumigation was in use 20 years ago in production of Hawaiian Pineapples and mulch paper was laid by machine. Young cuttings or offsets of pineapples were set through the paper mulch and early growth proceded with a minimum of interference from weeds. Those weeds that again (as before when cutting grafts were made) *j. canaerti, J. glauca, J. burki* which are, if not dead, only 2 feet tall, while all other upright varieties are 5′ on an avearge. spreaders have reached as much as 3′ in *J. squamata meyeri.*

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Large scale soil fumigation was in use 20 years ago in production of Hawaiian Pineapples and mulch paper was laid by machine. Young cuttings or offsets of pineapples were set through the paper mulch and early growth proceeded with a minimum of interference from weeds. Those weeds that did grow were removed by hand usually by a weed patrol of two workmen much as "spot weeding" is done during the growing season in some nurseries today.

Today soil treatment is a professional job for custom applicators and much in demand in horticulture. Care and calibration of equipment for injection purposes are critical matters. Laying plastic and applying asphalt emulsions are also critical but results can be spectacular from low rates of weed killer operating under conditions for maximum effectiveness on germination and early growth of weed seedlings i.e. through ample moisture, uniform temperature and with prolonged herbicide effect.

The Howard hoe and other rototillage equipment was new in 1940's and has changed control in weedy nurseries. The budding-in-row weeder was later developed to weed carrots but does an excellent job of weeding and hilling nursery liners and even larger stock in weed free sandy soils. Last year this conference was introduced by Mr. Asper K. Laursen to weed control using compressed air. The machine has been used for six years in Canada and longer in Europe. More new practical equipment is welcome as an alternative to the use of chemicals. Present advances in mechanical harvesting will likely provide new efficient equipment.

Keep the dosage level within those listed on the label and be sure that spray equipment is tested by trial runs with water to see that nozzles operate properly and to determine the volume of spray discharged per acre and thus avoid over dosage and irregular spray patterns of herbicides. Spray equipment needs thorough cleaning and calibrating. The use of wetting agents and similar additives should be confined to cases in which they are actually specified. Directions for application should be checked and trial runs made before application takes place.

It has been estimated that 100 million acres of the earths surface are treated each year with herbicides in the production of food and fibre crops so that present concern about pesticides is not without some justification, hence selection of herbicides for nurseries should be limited to those whose fate or breakdown is known.

Nursery Weeds

Only a few weeds make up "Nursery Weeds". A survey was conducted by correspondence with nurserymen several years ago and repeated last winter with few changes. The weed list includes 19 perennial weeds, 7 winter annuals and 16 summer annuals. The American Weed Society lists some 2700 weeds.

Perennial weeds of nurseries include quackgrass and mugwort or Artemisia also thistles and bindweeds sowthistle and nutsedge. These weeds have stolons or other forms of underground stems which respond to a limited group of herbicides through abnormal cell division and death of translocation and storage tissue.

Since plot margins tend to remain clear cut between treated and untreated areas the movement of these herbicides within stolon tissue is probably quite limited in comparison to movement of herbicides and other solutes downward through the soil itself except for absorption in soils of loamy nature or where suitable absorbing agents such as activated charcoal are introduced.

Pure stands of mugwort (Artemisia) or of quackgrass can be dealt with in regular crop rotation without using herbicides but this is a question of time and cost which the nurseryman has to decide for himself. In any case thoroughness and persistance are necessary to achieve good control.

Winter annuals — germinate in autumn and include mayweed or stinkweed, mustard and yellow rocket, annual bluegrass and chickweed. They all germinate in October and attain some true leaves before winter. Simazine spray or granular 5 pounds active ingredient or less is effective according to soil type but at a higher dosage rate than for seedling summer weeds. Dichlobenil, Diuron and other herbicides are also effective in granular or spray form. Crops are dormant and seldom injured, unless flooded or iced over for prolonged periods after the herbicide is applied, thus November treatment is perferred.

Presence of herbicides in moist soil facilitates the entry of these chemicals into seeds and etiolated stems so that growth patterns are modified in translocation tissue and food reserves used up before normal foliage developes to support growth. Normal true roots of woody plants appear to grow in herbicide treated soils without injury from treatments made on the soil surface. The extent and depth of the root system is important in survival. Dipping liner roots or root ball in activated carbon slurry or incorporating activated charcoal in the plant row before planting may help early growth by avoiding herbicide effects, however proper fertilization and irrigation are important for early vigorous growth.

Summer Annual Weeds

Summer annual weeds begin to germinate in late May. Crabgrass appears shortly after a three to five day period of weather in the 70's. Redroot-pigweed, lambs quarters, ragweed, and annual grasses follow quickly. Purslane is a nuisance since it will root from cuttings produced by hoeing. Summer annual weeds are best stopped at the time of planting liners and other nursery stock in spring. Complete the planting by irrigation and later after soil is workable but before weeds emerge, use herbicides and incorporate lightly, if this is called for, otherwise surface application is usually enough particularly if the crop is irrigated periodically.

An extensive research project on summer weed control is reported in the 1966 Plant Propagators Proceedings by Arthur S. Myhre at Western Washington Research and Extension Center at Puyallup. Rooted cuttings from propagating frames were lined out in the spring in nursery rows; a month later the soil was hoed so it is weed free. Weed seeds were then sown uniformily to insure adequate and uniform infestation. Herbicides were applied by a machine *properly equipped to provide good agitation of spray materials, accurate calibration and adequate and uniform coverage over crop and soil surface* except were incorporation of the herbicide was a required part of application procedure. The word incorporate is vague but usually means "mix into the soil surface to something less than an inch in depth" or to slightly above the depth to which seeds are planted or roots are placed. Myhre indicates that after herbicide application if rain was not imminent then irrigation was given. Otherwise some herbicides tend to volatilize from or become inactive on a warm dry surface, then the possibility of effective weed control is lost. Myhre repeated his tests for four years then removed the plants, rototilled the former plant row and sowed a test plant (oat) to evaluate any residual herbicide effect. No effect was found, and at Ithaca, New York with a similar 5 year period of repeated application no clear cut response was noted with oats. Present plots to which granular Neburon was applied for five years still show *reduced weed growth* and on sandy soil at Ithaca there is some indication of reduced weed growth following five years of Simazine and of Amizine at 5 pounds active ingredient levels.

Myhre tested sixty herbicides and of these Simazine, Casoron and Herban were outstanding. Simazine 80 W was tested for nine years and gave good all summer control of annual weeds at 2 pounds and 4 pounds per acre. Three azalea varieties and boxweed showed discoloration but many evergreens did not.

Myhre used the trade formulation Casoron 50W at rates of 8 to 12 pounds ie. the active ingredient Dichlobenil at 4 to 6 pounds. The tests continued for five years, with the comment "It has a fairly long residual life and has given good to excellent control of summer annual weeds at rates ranging from 8 to 12 pounds (Casoron)". No plant injury was observed in azaleas, rhododendrons, Pieris, Viburnum, Osmanthus, and Ilex crenata.

Herban 80W was also tested and gave good weed control under mild moist climatic conditions. Treflan was tested in 1965 only, so too, were combinations of Paraquat, a contact herbicide of note and used with Simazine and with Casoron and applied as a directed spray i.e. beside but not over crop plants.

The cool moist climate of Western Washington is duplicated in the Northeast during October or November but decidous nursery crops are approaching dormancy and are less likely to be injured by herbicides. Seeds of winter annuals are at germination stage and easily injured so that weed control in the plant row is a real possibility with the choice of bare soil or a crop cover — oats or weeds between the rows for winter protection and snow holding value.

READ AND USE LABEL INFORMATION

Label information indicates the purpose for which the product is intended, example Simazine 80W is for pre-emergence weed control on certain agricultural crops and specifies nurseries, Christmas tree planting and shelter belts.

Directions include — for those plants listed below and which have been transplanted for a year or more use 2½-3¾ pounds of Simazine 80W in at least 25 gallons of water per acre (of acre actually sprayed) in the fall or spring prior to weed emergence. Thirty-four species are listed on the label. A cautionary note is included in the box:

(a). Do not use Simazine 80W in seedling or cutting beds.
(b). Transplants for Christmas Tree and shelter belts should be 3 years of age.
(c). Do not apply 80W more than once a year.
(d). The lower rate is for sandy soil.

The Simazine 80W label also carries a caution. Keep out of reach of children. Harmful if swallowed. Avoid contaminating feed and food stuff. Avoid inhalation.

Beyond the cautions on the label is the matter of applying herbicides so that their coverage is uniform and at a predetermined rate and pattern usually so that the herbicide is directioned from the side to cover the soil band in which the crop is growing but without any greater contact with nursery stock than is necessary. Fall treatment is less critical since woody plants are dormat and hopefully only seedling weeds are present. Granular formuations can usually be handled in modified fertilizer spreaders or others of cyclone type.

These statements seem to make weed control with air as illustrated by Asper K. Laursen of Bowmanville, Canada to be an idea method with few difficulties.

Conclusion

Use sterile media for seed and cutting beds.

Use clean lining out areas free of perennial weeds. After plants are thoroughly watered and conditions for continued growth assured then use mechanical forms of weed control, otherwise low rates of Simazine or an other herbicide widely used in weed control in vegetable crops in your area.

In November and after cultivating or use of Budding-in-row weeder use minimum rates of herbicides applied earlier.

In early spring while plants are still dormant or near bud break use a contact herbicide such as Paraquat or cultivate. Hopefully no treatment is needed at this time but be on the alert for perennial weeds and for infestations of unsuspected annuals.

This is where a weed patrol system helps to keep one altered to needs before emergencies arise.

WEEDS OF NORTHEAST NURSERIES

1 Noted by nurserymen - 18
2 Noted by research workers - 11
3 Noted by Dept Agr Per - 45
N Noxious weed-Fed Seed Act

Names follow Jr W.S.A.
Weeds, Vol.10,
p. 255-274. 1962

A Annual
B Biennial
P Perennial
W Winter annual

1	2	3	N	P	Agropyron repens (L) Beauv	quackgrass
1	2	3	N	P	Allium canadense L.	wild onion
1	2	3	N	P	Allium vineale L.	wild garlic
1		3		A	Amaranthus retroflexus L	redroot pigweed
1	2			W	Anthemis cotula L	mayweed
1	2	3		P	Artemisia vulgaris L	mugwort
		3	N	A	Avena fatua L	wild oat
	2	3		W	Barbarea vulgaris R. Br	yellow rocket
	2	3	N	W	Brassica kaber (DC) Wheeler var pinnatifida (Stokes) L C Wheeler	wild mustard
		3		W	Capsella bursa-pastoris (L) Medic	shepherdspurse
1		3		P	Cerastium bulgatum L	mouseear chickweed
1	2	3		A	Chenopodium album L	common lambsquarters
1	2	3	N	P	Cirsium arvense (L) Scop	Canada thistle
1	2	3	N	P	Convovulus arvensis L	field bindweed
1	2	3	N	P	Convoluvulus sepium L	hedge bindweed
1	2	3	N	P	Cyperus esculentus L	yellow nutsedge
1	2	3	N	A	Digitaria ischaemum (Schreb) Muhl	smooth crabgrass
1	2	3	N	A	Digitaria sanguinalis (L) Scop	large crabgrass
1		3		A	Echinochloa crusgalli (L) Beauv	barnyardgrass
1	2	3		P	Equisetum arvense L	field horsetail
1				A	Erigeron canadensis L	horseweed
1	2	3	N	P	Euphorbia esula L	leafy spurge
	2	3		A	Galinsoga ciliata (Raf.) Blake	hairy galinsoga
1			N	P	Galium mollugo L	smooth bedstraw
1	2	3		P	Glechoma hederacea L	ground ivy
		3	N		Ipomoea sp.	morning-glory
1	2	3		W	Lactuca scariola L	prickly lettuce
1		3		A	Lamium amplexicaule L	henbit
1		3	N	W	Lepidium campestre (L) R. Br	field pepperweed
1		3		A	Oxalis stricta L	yellow woodsorrel
1	2	3		A	Panicum capillare L	witchgrass
1		3	N	P	Plantago lanceolata L	buckhorn plantain
1		3	N	P	Plantago rugelii Dcne.	blackseed plantain
1		3		A	Poa annua L	annual bluegrass
1		3		A	Polygonum aviculare L	prostrate knotweed
1		3		A	Polygonum pensylvanicum L	Pennsylvania smartweed
1		3		A	Portulaca oleracea L	common purslane
1	2	3		P	Rhus radicans L	poison ivy
1	2	3	N	P	Rumex acetosella L	red sorrel
1	2	3	N	P	Rumex crispus L	curly dock
1		3		A	Setaria viridis (L) Beauv	green foxtail
1	2	3	N	P	Solanum carolinense L	Carolina horsenettle
1	2	3	N	P	Sonchus arvensis L	perennial sowthistle
1		3		W	Stellaria media (L) Cyrill	common chickweed
1	2	3		P	Taraxacum officinale Weber	dandelion

ADDITIONAL NURSERY WEEDS
Transportable B & B, etc.

N	A	Abutilon theophrasti Medic	velvetleaf
P		Aegopodium podagaria L	goutweed
A		Amaranthus graecizans L	prostate pigweed
P		Ampelamus albidus (Nutt) Britt	climbing milkweed
P		Apocynum cannabinum L	Indian hemp
P		Asclepias syriaca L	common milkweed
N	W	Bromus tectorum L	downy brome
N	P	Cardaria draba (L) Desv	hoary cress
N	A	Cuscuta sp	dodder
N	P	Cynodon dactylon (L) Pers	Bermudagrass
N	B	Daucus carota L	wild carrot
P		Duchesnea indica (Andr) Focke	Indian strawberry
P		Helianthus tuberosus L	Jerusalem artichoke
P		Leontodon autumnalis L	fall hawkbit
P		Lonicera japonica Thunb	Japanese honeysuckle
P		Lysimachia nummularia L	moneywort
A		Matricaria matricarioides (Less) Porter	pineappleweed
P		Phytolacca americana L	pokeweed
P		Polygonum cuspidatum Sieb and Zucc	Japanese knotweed
P		Rosa multiflora Thunb	multiflora rose
N	P	Rubus fruticosa L	wild blackberry
N	P	Rumex altissimus Wood	pale dock
N	A	Setaria faberii Herrm	giant foxtail
A		Setaria glauca (L) Beauv	yellow foxtail
P		Sorphum halepense (L) - Pers	Johnsongrass
A		Spergula arvensis L	corn spurry
P		Stripa asiatica (L) Kuntze	witchweed
N	W	Thlaspi arvense L	field pennycress

WEED CONTROL IN NURSERY AND LANDSCAPE PLANTINGS - 1966

1. Important weeds in nursery and ornamental plantings.
   - (a). Stoloniferous perennials —
     - *Agropyron repens* — Quackgrass
     - *Artemisia vulgaris* — Chrysanthemum weed
     - Thistles, bindweed, etc.
   - (b). Seedling annual weeds in new spring plantings.
     1. Spring
        - *Amaranthus retroflexus* — Red Root
        - *Chenopodium album* — Lambs- Quarters
     2. Summer
        - *Digitaria sanguinalis* — Crabgrass
        - *Portulaca oleracea* — Purslane
     3. Late summer (a). annuals
        - *Poa annua* — Annual bluegrass
        - *Stellaria media* — Annual chickweed
     4. Late summer (b). biennals
        - *Barbarea vulgaris* — Yellow rocket
        - *Capsella bursa-pastoris* — Shepherds purse
        - *Anthemis cotula* — Mayweed

2. Common combinations of crop and weed populations in nursery and ornamental plantings.
   (a). Heavy stands of the perennial weeds, quackgrass and artemisia among 2 years and older woody nursery and landscape plantings.
   (b). Stands of perennial weeds in fall on land to be planted to young nursery or landscape plantings in spring.
   (c). The rapid appearance of seedling weeds, annuals, biennials or perennials, among new nursery and landscape plantings with new foliage and young shoot growth.
   (d). The rapid appearance of seedling weeds in fall among new or established nursery and landscape plantings at a time when buds, shoots and foliage is mature but seedling weeds are soft and active in growth at germination and first leaf stage.
   (e). Fall fertilizing may make seedling weeds more succulent but is taken up by woody ornamentals and stored for rapid new growth in early spring. Fall fertilizing and herbicide applications are compatible and can be orderly and efficient particularly with granular formulations.
   (f). Fall fertilizing and herbicide use can result in weed free soil through the spring sales or planting period. When new weeds appear cultural, mechanical or chemical treatments can be used as appropriate. Mulches used over herbicide treatments tend to prolong the period of weed control.

WEED CONTROL PROGRAMS

A. *Before planting and to free the soil of weeds by one or more procedures.*
   1. Crop rotation — fall plow, fit in spring.
   2. Plow or rototill for fall steam sterilization or fumigation.
   3. Combine herbicide with fall plowing for quackgrass and artemisia control. *Use one of the following*:
      (a). Use dichlobenil 10 lb. Aia. in fall, plow in spring.
      (b). Spray with amizine 5 lb. Aia. 10 days before plowing. If regrowth occurs respray with amizine 3 lb. Aia. 10 days before spring soil preparaation.
      (c). Use EPTC 10 lb. Aia. in fall, plow and work to incorporate in loamy soils; residual action is longer in muck soil.

B. *Early spring planting of dormant liners in weed free soil.*
   1. Plant liners, add fertilizer and irrigate. Treat when the foliage is dry.

2. When seedling weeds emerge, use granulars in the crop row as a band or use directional spray. Cultivate between rows

or use overall treatment for a month to 6 weeks of weed free growth. *Use one of the following*:

Herbicide	Rate lb Aia	Note
CIPC	4-6	4-6 WF*
DCPA	15	varies
Dichlobenil	2-4	4—8+ WF
Diphenamid	1-2	Incorporate, 4—6 WF
Diuron	1-2	4—8+ WF
DNBP	4	cool day, 4 WF
EPTC	3-5	Incorporate, 4 WF
PCP	10	4—8 WF
Simazine	2	4—8 weak on crabgrasses, etc.
Trifluralin	1-2	Incorporate, 4—8 WF

*WF - Weed Free period in weeks.

C. *Crop with mature basal foliage in summer; weeds less than one inch growing actively.* Use granulars on moist soil when crop foliage is dry or use directional basal spray (for summer annual weeds). Four to eight weeks control unless cultivated then new weed population is likely to develop.

Herbicide	Rate lb Aia.	Note
Amizine wettable powder	2-3	agitate
Dichlobenil	2-4	granular preferred Moist soil.
Diuron granular	1-2	Surface applied do not incorporate
DNBP	2-4	4-granular preferred
Paraquat	2-3	4-directional
PCP	10	6-8 granular preferred

D. *Fall seedling weeds after last cultivation in fall.* Ornamentals crops are mature or dormant; weed growth is young and active. Apply herbicides alone or with fertilizer at the rate of one ton per acre of 10-10-10; soil to remain weed free till June or later, i.e. 4-6 months or longer.

Herbicide	Rate lb. Aia.	Note
Amizine	3-5	directional
CIPC	5-10	granular
Dichlobenil	3-5	granular
Diuron	2	granular
DNBP	4-8	granular
PCP	15-20	granular
Simazine	5	granular

These are recommended for use among dormant woody ornamentals and for artemisia, quackgrass, etc. control in low growing evergreens used for ground covers. Use as granulars. Woody weeds (maple, mulberry, seedlings, etc.) are not controlled.

E. *Special weeds in ornamental plantings.*

1. *Polygonum cuspidatum* — Japanese Bamboo. Tordon granular 1-2 lb. Aia. Fall. Avoid use near water sources for greenhouse or domestic supply. Banvel-D granular 2 lb. Aia.

2. *Rhus Toxicodendron* — Poison ivy. Amitrole 1-2 lb. Aia. Can be used in fall until foliage drops. Stems spread along soil surface under grass and other plants; repeated spraying needed for complete eradication. *Read directions and warnings. Granular formulations perferred.*

F. *Landscape and nursery maintenance.*

Quackgrass, *Agropyron repens, Artemisia vulgaris,* and other stoloniferous weeds are difficult to eliminate. Fall application of granular dichlobenil at the base of woody ornamentals will kill rhizomatous grasses and other rhizomatous herbaceous vegetation leaving a weed free zone that will stay free of new weeds until mid summer, or later unless cultivated. Use dichlobenil at 5-10 lb. Aia. preferably as a granular applied from a crank duster or shaker. Wettable powder can be sprayed on, use 8-12 lb. Aia. 100 gallon i.e. 1 lb. active in 50 quarts (12½ gallon), do not incorporate i.e. do not hoe in. Do not use on Vinca, Hedera, Euonymus, fir, or evergreen seedling — liners. Granular herbicides used on clean soil and covered by a mulch of peat or sawdust, etc. increase the effective weed control among woody ornamentals.

G. New Plantings.

Petunias in pots and other ornamentals in containers may be treated with a slurry of activated charcoal by dipping, dusting or spraying the root ball at the time of planting. The charcoal serves to absorb certain herbicides in the soil and prevent damage to the ornamentals.

After planting the careful use of dichlobenil, simazine, and likely other herbicides as granules among newly planted, charcoal treated, ornamentals will keep plantings weed free for 4-12 weeks and also free of residual herbicide action. The amounts of activated charcoal range from 50 to 100 lb. per acre. A slurry of 1 lb. to 4 gallons of water to 1 lb. in 16 gallons of water would be a likely range or 1 gram/32 cc to 1 gram/130 cc. Keep the slurry stirred or agitated for satisfactory coverage of surface roots on the root ball.

Before applying herbicides, etc:

1. Check application equipment by trial runs over a measured area and collect the amount of spray or granular discharge so that the actual amount can be compared to the recommended amount.

2. When applications are to be made manually measure out the quantities of herbicide for the proper mix and apply the correct volume of herbicide to a limited area for trial and practice purposes i.e. 100 sq. ft. or 1000 sq. ft. Make at least 3 trial runs before field application. Check for uniform coverage, at least by inspection and better by measuring the volume or weight of several samples collected from 3′ x 3′, or 5′ x 5′. The more uniform the samples are the more likely that uniform results will follow. Danger of local over dosage is thus diminished and a familiarity with the appearance of correct distribution is gained before extensive applications are made.
3. Avoid over dosage and skips — over dosage damages or/and kills plants. Inadequate dosage is a waste of time and effort.
4. Reread and recheck recommendations for preparation, use and disposal of herbicides and containers. Give due regard to possible contamination of domestic and greenhouse water sources.

Prepared by,
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Cornell Ornamentals Research Lab
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MODERATOR COGGESHALL: Thank you very much, Dr. Pridham. Our next speaker in this afternoon's symposium is no stranger to our Society. I am very happy to introduce Mr. William Flemer.

HERBICIDES — Nursery Tool, Not Panacea

WILLIAM FLEMER, III.
Princeton Nurseries
Princeton, New Jersey

Not so many years ago, the program chairman of a nursery meeting who wanted to give a glimpse of the future would cast about for a speaker who knew anything about herbicides. After a long search, if he was lucky he would locate a college professor or extension specialist who had put out some test plots and could make some tentative recommendations, well hedged with the advice to go slowly. Now most nurseries use herbicides as a matter of routine, and each one has its favorites as well as some special combinations which particularly suit that soil and climate. Experiment stations have files full

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Despite this great body of experimental work and resulting information, the universal herbicide has yet to be perfected. Furthermore under the multitude of weather combinations of temperature and rainfall, varying amounts of crop injury occur in nurseries each year. A number of basic principles have emerged however, and they should always be kept clearly in mind whenever herbicides are applied.

1. All herbicides are just what the term means — plant killers, not just weed killers, but lethal to crop plants also if conditions are not propitious.

2. Herbicides work best of all if one special condition obtains — i. e. if the crop plant is relatively large and the weeds are as small as possible, perferably newly germinated from the seed. The smaller the crop plant is, the weaker the herbicide must be and the more critical the time of application becomes. The larger the crop plant is, the stronger the herbicide can be used with impunity and the less critical the time of application becomes.

3. Herbicide applications are most useful and effective in a wet year, when cultivation is difficult anyhow, and are least effective if not a total waste of money in a drouth year unless irrigation can also be applied following herbicide treatment.

4. Despite publications which plainly state otherwise, cultivation is necessary for optimum growth of nursery crops in the field. Blanket application of herbicides covering the entire row area will not replace the necessity to cultivate and are a considerable waste of material and money. Banded applications of herbicides on the area where the nursery crop is actually growing and cultivation of the rest of the row area will give far better results with a saving of ¾ or more of the material costs.

5. Safe and effective herbicide application is a job for an experienced specialist who has carefully studied this field and who is consistently cautious and careful in all applications. There are so many variables such as soil moisture, time of year, temperature, subsequent rainfall, speed of the applying device, and rate of application, that this is obviously no job for a dullard or a careless man.

6. A sufficient number of check rows should be left untreated in each block of stock each year so that if any abnormality develops in the crop, it can be easily ascertained whether the herbicide or some other cause was responsible.

Within the framework of the observations above, there is no question that for many nursery crops especially for roses and the various conifers which are very resistant, the development of herbicides has considerably reduced weed control costs. They have been less useful for broadleaf evergreens, especially young plants. At present it seems doubtful if herbicides will find much of a place in seedling beds except for treatment long in advance of sowing. Really safe and effective treatment for plants grown in containers has also yet to be developed. It is relatively easy to develop fool-proof herbicides and rates of application for standard farm crops grown on enormous acreages such as cotton, soy beans, and corn. The problem is vastly more complex for the average nursery with its wide diversity of crops, some coniferous, some broadleaf, some evergreen, some deciduous, and all at different stages of development. There is consequently no single herbicide or rate of application which can be used "for nursery crops" but rather many different chemicals have a place at varying rates of application. Some chemicals can be used in combination with each other. This sometimes exerts an apparent synergistic effect and superior results can be obtained at lower rates of application than for the same chemicals used singly. In any case, accurate records and constant experimentation should be the watch words of any herbicide program.

Our methods and materials at Princeton are not necessarily the best ones for other areas and climates. For example Neburon 50% wettable powder has long been the backbone of our herbicide program for deciduous shrubs, small trees, and conifers. We have had good weed control and minimal injuries with banded applications of this material, not 100 per cent weed control, for this is a condition we studiously avoid. However other workers have reported poor to no weed control with Neburon and the manufacturer has recently stopped making it. Apparently we were the only large user left and the volume sold was insufficient to merit continued manufacture.

The conclusion of this talk summarizes the herbicides we use for the crops we grow, with rates of application and materials costs per acre. I have purposely not given labor of application costs per acre, as these can vary so widely depending upon the equipment used. Such equipment can be the man walking down the rows with a cyclone seeder (and invariably with a fixed lunatic smile on his face) usually shown in nursery herbicide advertisements. Or it can be a multiple-row sprayer with a boom of nozzles spraying 4 or more rows at a time. The resultant variation in costs of application are obvious.

At the present time, we are using Chloro IPC as a post planting treatment for newly set out deciduous shrubs, conifers, and budding understock. In banded applications of 5% granules at an active ingredient rate of 8 lbs. per acre, C.I.P.C. costs $12.00 per acre for material. Our present applicator treats only one row at a time and we are working on a multiple row device.

For all treatments of coniferous evergreens planted the previous spring and in subsequent years, we are again using Simazine 80% wettable powder. However we use very low rates of application, only two lbs. active ingredient per acre in bands, and the cost is low too at $2.50 per acre for material. Here we can use a 3 row sprayer boom and labor costs are reasonable. We think we see some yellowing of Mugho Pine and possibly White Pine from this treatment, but this needs verification. After a small scale disaster with some newly planted Taxus many years ago, we learned not to use Simazine in that situation. Check rows clearly showed what the trouble was.

We have tried out a fair acreage with Casoron 5% granules. On the basis of present findings, the results have not been better than some other materials. In 4 foot rows banded at 8 lbs. actual ingredient per acre, the cost is very high at $26.00 per acre. Full coverage of the rows as a substitute for cultivation would be 4 times higher.

Diuron 80% wettable powder at 2 lbs. Actual Ingredient per acre, and Simazine at the same formulation and rate, in banded rows find a use in major and minor tree crops. The cost of materials for 4 foot rows is approximately equal for both at $2.50 per acre for materials. Residual effect is good. Late fall or winter applications are made in combination with liquid Dinitro (Dow Premerge) at 3 gallons per acre in bands. This very useful additive burns off the rosettes of winter annuals and such deep rooted weeds as dock. It is not supposed to have any residual effect, but we have found that it does, especially in a very early spring application.

Dinitro must be used with great care in the spring. We have had some sad experiences in the past when wet weather delayed application until after the crop plant buds had broken dormancy. The buds must be truly "hard" dormant. Such "open" or some what leafy buds as are found in Viburnum prunifolium, lentago, and cassinoides do not tolerate Dinitro.

Larger trees in wide rows are very tolerant of herbicides. Such crops are ideal from the herbicidal point of view, for here you have very large resistant crop plants which will stand almost any herbicide lethal to young weeds. Many years ago we were advised to spray such large trees with Sodium arsenite. This treatment surely controlled all weeds but it also burned the bark off of the trees and our losses in Red and Scarlet Oaks were phenominal. The whole painful experience taught us to take absolutely no recommendations without extensive small scale trials. The expert who advised us is now in another line of work, as you might guess.

We have not yet found a treatment which will kill out Chrysanthemum weed established in most nursery crops. Clearing the land of nursery stock and cover cropping with repeated very deep plowing is perhaps costly, but it is still the way to eradicate this weed rather than merely suppress it, at least under our conditions. Similarly, a field must be cleared completely prior to any really effective attack on bindweed and Canada Thistle. Nothing we have tried has had much effect on Nut Grass. Perhaps somebody will give the answer during or after this symposium.

In summary, I must reiterate that herbicides are a useful tool but not yet a panacea. Skill, experience and extensive knowledge of the subject plus a careful and orderly mind are prerequisites for success.

JOERG LEISS: What concentration of Dinitro did you use?

BILL FEMER: We used three gallons per acre diluted in water, in four foot rows, banded application and costs $4.00 per acre. In eight foot rows, that is with big trees, the cost is $2.00 per acre. That is for materials only, I don't have the application costs.

JIM WELL: How do you band granular material?

BILL FLEMER: It is an applicator with a little hopper with two big wooden wheels which straddle the row. It's pulled by a Farmall tractor. The big solid wood wheels which are made of plywood prevent the granules from spreading out particularly on a windy day. The wheels are 12 inches apart, with the hopper in between. The material falls from the hopper in between the wheels and just bands a 12 inch strip where the plants are. We have also used a little rubber flap that snaps the foliage and knocks the granules off. It's a very simple device, commercially available.

RALPH SHUGERT: When do you apply Casoron?

BILL FLEMER: We apply at varying times. We applied some July 1st, some on August 15th, and we've also made fall applications.

RALPH SHUGERT: The only reason I mentioned this is because the Casoron representatives are recommending late, late fall applications. Apparently in the Midwest and Plains area there has been a slight bit of trouble in late spring and summer application.

BILL FLEMER: Yes, you have to be very careful about the rate when you put on summer applicationss.

VOICE: Have you used Treflan?

BILL FLEMER: We have used Treflan with mediocre results. We had some crop injury and spotty weed control. It may be due to the dry summers we have been having.

JIM ILGENFRITZ: Do you have any injury on *Euonymous* when you use simazine?

BILL FLEMER: Yes, we do. Marginal yellowing, tremendous slow down in growth and we don't use simazine on any *Euonymous*, not even on *E. elata.*

KNOX HENRY: My experiences with Treflan has not been identical with those of other nurseries. We had several tests plots going from ½ the recommended rate to up to 10 times the recommended rate. In no case could we find any conclusive results to prove that it was of any real commercial value. We were very disappointed.

FRIDAY MORNING SESSION

December 9, 1966

The session convened at 9:00 a.m. in the Colonial Room Viking Hotel.

STU NELSON: To act as moderator for this morning we have Dr. Jacob Tinga who will also give the first paper.

BACKGROUND INFORMATION ON OVERWINTERING

J. H. TINGA
Virginia Polytechnic Institute
Blacksburg, Virginia

This is a broad subject touching many aspects of the plant growing business, but generally we can say we are concerned with the effect of low temperature on woody plants. Also, sun and wind have bad effects.

This effect is different for *different years.* I hear the old timers talk about the near famine winter of 1898 and the bad influenza and deep snow of 1917. Many here remember that all Baldwin apple trees froze in New York State in 1935. We are still recovering from the wind and ice of 1963.

The effect is different for *different months.* Most recent for me was May 6, 1966, when a 24 degree night took all the new growth from boxwood and Taxus. Tulip Tree and White Oak were defoliated in the forest. This damage was associated with the tender stage of growth of the plants. We call this a late spring frost. Then there was the early fall frost of October 7, 1965, with the same dramatic results. In addition, I remember the 60 mile wind and minus ten F. temperature of February 1, 1966.

So far, with all our billions of dollars and ingenious space study, we have not yet approached weather control in any large scale. Check with the Navajo rain dancers and snake handlers and woolly bears for the latest unreliable information on weather predictions.

Most of us are gullible enough to think and hope for a nice average winter, but that is because we do not take seriously the hard lesson of the history of weather. Will it be average or the worst possible winter?

Then take our nursery production practices. Tender varieties are moving north. Kurume azaleas are being sold at least one hardiness zone north of their area of good growth over the 30 year scale. Gardenias and Crepe Myrtles and Rhododendrons and Jap Holly are pushing against the north wall of their confined area, and you are helping them push to the northern market.

Then, worst or best, according to your point of view, is container production. It is possible to mass produce and market excellent plants in cans up to that exceptional day when the south side of the can gets too hot and half the roots die or the north side of the exposed root system get too cold and half the roots die or the top suffers from a common malady called winter drought and the exposed leaves burn or dry.

There are several learned papers on how wet and aerated a woody plant soil should be and how much nitrogen. phosphate, and potash a container grown root should be exposed to; but what is the condition in *your field* on December 9, 1966. Management sometimes finds it economically impossible to apply near optimum conditions to rooted cuttings or lining out stock. We *know* better than we *do.*

And I hear rumors that some of you have had trouble with herbicides on small plants in the field or in containers. On the first day of May it may look like winter injury, but close examination may show that the shallow woody plant roots were caused to be non-functional along with shallow chick weed roots.

Does the propagator have winter problems. Yes. What can he do? Consider all the facts and realize that the plant growing world *is not* a controlled environment. Therefore, *share the risk.* Share one year's risk with another by holding back some liquid assets (money in the bank). Share the risk on plant species. Don't get "over your head" in tender azalea varieties. Share the risk of container grown plants by *modifying* the temperature extreme that you might expect. This is the *insurance principle.* We have life insurance and fire insurance. Why not have winter injury to woody plant insurance? The risk is great, so the premium is high for gardenias and Camellias in Connecticut. Now we are down to the level of talking about *reasonable self-insurance costs* for reasonable risks.

In our work we routinely modify the air temperature over a Pyracantha or Chinese Holly in one gallon cans for 8 cents per sq. ft. a season. When it is zero outside, it is 20 degrees inside of our winter protection shelter. When it is 15 degrees outside, our gardenia in 3 gallon cans under the shelter may be 25 inside the leaf. This changes a hard winter into a mild winter with no heat bill.

The cost of building a safe, inexpensive structure is the insurance premium you pay for growing plants in a reasonable risk situation in winter.

If the same structure can be used for summer propagation (which ours is) the winter insurance may be cut in half.

Let us look at some of these structures and some effects on temperature and moisture. In a plastic covered structure we have dew almost every night, a sign of high humidity. Nonetheless, we find it advisable to water plants at least once a month. We can do this with our mist line which is drained after every winter use.

Let me give you a few results of the way plants responded to these various structures. In our heavily shaded structures we are getting short day effects. With 75% shade at noon, the sun goes down earlier — or so the plant thinks.

MINIMUM NIGHT TEMPERATURES RECORED UNDER FIVE PLANT STORAGE CONDITIONS AT BLACKSBURG, VIRGINIA, JANUARY, 1966, (DEGREES F)

	Outside at 6 in plant height, fully exposed	Sunken cold frame, 5 ft deep, heated with 2 x 100 watt bulbs per 333 sq ft	"A" frame with 4 mil poly sprayed with aluminum paint	"A" frame with 4 mil poly sprayed with more aluminum paint and inner layer of plastic	Lath house 50 per cent wind barrier
	8	34	24	26	12
	11	35	26	28	16
	13	34	26	27	18
	16	36	29	29	21
	21	38	30	31	25
Per Cent of Noon Time Shade	Zero	85%	75%	98%	50%
Actual Foot Candles	12,000	1,900	2,900	200	6,000

Plant Species Used In Winter Protection Studies

Treatments.

(1) A frame with 45 degree roof of clear plastic over lath shade—not mulched—watered once a month

(2) Under lath shade with the container covered with sawdust

(3) In open field with container covered with sawdust

The percentage of the number of normal leaves on the top half of the plant Top leaves influence saleability of plants in spring

	1	2	3
Aucuba japonica variagata, B & B, 24″	95%	84%	no trt
Azalea coral Bell, B & B, 12″	98%	79%	no trt
Azalea, Rose greely white, B & B, 9″	99%	69%	no trt.
Berberis Juliana, B & B, 24″	99%	80%	58% (leaf drop)
Camellia japonica, Victory white, B & B, 36″	96%	48%	no trt
Camellia japonica, Pink perfection, B & B, 36″	96%	51%	no trt
Camellia sasanqua, Mine no Yuki, B & B, 48″	96%	58%	no trt.
Cleyera japonica, B & B, 36″	96%	62%	no trt
Cotoneaster repens, 3 g c, 24″	90%	79%	55%
Gardenia florida, B & B, 48″	71%	5%	0% (dead to soil)
All plants chlorotic at start of treatment			
Ilex cornuta burfori	95%	55%	9%
Ilex crenata convexa, 1 g c, 18″	98%	72%	65%
Ilex crenata helleri, 1 g c, 12″	99%	74%	43% (tip brown)
Ilex pernyi, 5″ pot	98%	85%	no trt

Ilex vomitoria, 1 g c, 10″	95%	63%	22% (dead tips)
Lagerstroemia Indica, 1 g c, 18″	90%	12%	0% (dead to soil)
Ligustrum lucidum, B & B, 24″	98%	79%	38%
Osmanthus fortunei, 1 g c, 24″	99%	88%	30%
Prunus laurocerasus, Schipka, B & B, 30″	95%	78%	47%
Pyracantha coccinea graberi 3 g c, 36″	91%	7%	0% (dead to soil)
Pyracantha coccinea, Lalandi, 3 g c 36″	96%	40%	5% defoliated

Pyracantha fruit still good on April 1, only under A frame

MODERATOR TINGA: I hope I have successfully introduced the subject of overwintering for now we will have some experts who are going to give us the latest information. The first presentation will be by Richard Vanderbilt.

A LOW COST OVERWINTERING STRUCTURE

RICHARD T. VANDERBILT
The Conrad-Pyle Company
West Grove, Pennsylvania

The structure is a 14′ span polyethylene covered quonset house. The cost is about twelve cents a square foot in place and covered. We use it for winter protection of container grown material and to replace cold frames.

This structure evolved into a quonset house quite accidentally. We had considered, and to some extent, used the type of structures long since made famous by Bill Cunningham. Bill's designs are excellent and their only drawback is cost; about 50 to 60 cents a square foot. This cost can be sizeable when you need houses in multiples of miles. We have four miles of the 14′ houses up at present.

Up until three years ago we were using concrete reinforcing wire to support the polyethylene above our cans. It is a material that did do the job after a fashion. It is almost impossible to work around once put in place. Watering is very difficult. Pulling plants is impossible without tunneling in from the ends. Covering is a problem because of the many sharp edges that seem to always tear the polyethylene unless laboriously wrapped with burlap. To insure against collapsing, we have to use a center stake about every 4 feet. Finally when the time comes to remove the polyethylene, the whole unwieldy mess has to be picked up, carried out and stored some place.

Our first step to get away from this nightmare was to simply take a 10′ piece of ¾″ E.M.T. thin wall electrical conduit and bend it so it spanned six feet. The ends were drilled 4″ up, a nail inserted and bent over to act as a stop. We used a spacing of 5′ between hoops. They were then covered with 12′ wide polyethylene and the sides held down with soil. This worked beautifully. The hoops could remain in place summer and winter without interfering with cultural operations and

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It was not without problems, however. Checking of plants was still a dirty, disagreeable job of pulling up polyethylene and sticking your head in. Watering while covered was not possible, but this seemed the best we could do at the time.

Soon we were forced to make a hasty move to a gully-ridden field next to a pond with a marvelous spring, because of a lack of water in our original container area. We were at least not cramped for space. We laid out our beds so that between each set of 5½′ beds and 3′ aisle we had a 12′ road. This was a direct imitation of Jack Hill's layout. It has worked out very well for all the operations that go on in the area.

We had planned to cover each of these 5½′ beds with the hoops that I had described earlier. It was at this time that I was struck with the idea of covering the two beds and the aisle with a single hoop.

We took two pieces of conduit and bent them to span the 14′ bed area. This cost no more than 2 single hoops and included an enclosed 3′ walk. Hoops were again placed on the same 5′ centers.

Our original 14′ hoop was made of ¾″ E.M.T. thin wall electrical conduit. This ¾″ pipe was adequate so long as the snow loads were equal on both sides of the house. Last Winter we had drifts of 8 to 10′ over the houses. Where the 8 to 10′ drift was one sided it had the distressing tendency to collapse the house! A 2 x 3″ center post hinged on a wire over every third hoop prevented this. We are now using 1″ E.M.T. thin wall electrical conduit, which is 88% stronger than the ¾″. This makes the center post no longer necessary. In no case has polyethylene failed at 5′ hoop centers due to snow load.

We bend 10′ sections of conduit into the desired curve using an electric pipe bender. We then insert a ¾ x 2½″ nipple into one section and hammer another section onto it. This joint is then acetylene welded. Each end of the hoop is inserted into 1¼″ water pipe, placed on 5′ centers. The 1¼″ pipe is 4′ long. It is driven into the ground 2′. The 2′ out of the ground adds to our sidewall height, which is a help in accomodating taller material.

The ends of the hoops are drilled 4″ up from the bottom and a nail inserted and bent over the 1¼″ pipe to prevent slipping.

We are now using a continuous 1 x 4″ wooden purlin attached on the underside of the hoops at the center of the house, for lateral stability. 1″ pipe straps secure it. The bottom sides have a nailer edge of 1 x 6″ cypress attached on the outside of the 1¼″ pipe with 1¼″ pipe straps.

Gables are only curtain walls as they support nothing. Wind braces are used on each side of both ends. We are using 1 x 6″ cypress angled in from about 4′ up on the first hoop tapering to the ground by the third hoop. Again, attached with pipe straps.

Length of the houses are at this point as long as we can make them. At first we figured making them 86′ long so 100′ of polyethylene would cover the top and two gables. Now we use continuous coverage overlaping the polyethylene 3 hoops. Our longest houses at present are 980′. This simplifies covering immensely.

Gables are constructed of a bottom board of 1 x 6″ cypress and an H frame stuck in the center, again of 1 x 6″. The polyethylene around the H is tacked down except on the bottom. This flap acts as a door.

Covering is done by unrolling the polyethylene which is 24′ wide, but center folded, down the road. It is simply walked through and over the house. We put it on with the fold inside out. We find we get much less tearing on the seam this way. One side is wrapped in 1″ x 2″ cypress and nailed. The other side is pulled tight and then nailed with another 1″ x 2″ cypress.

After covering, we lace the poly down. We use 2 mil polyethylene, 18″ wide, for this. This lacing prevents flapping to such a degree that there is no noise from polyethylene flapping in a 30 m.p.h. wind. The lacing is pulled over the top and attached at the bottom of alternate hoops. It is continuous. It is wrapped around a nail which is then bent over. Another nail is then bent over the head of the first nail to prevent the polyethylene from pulling out. Lacing must be fished over with a line from one side. This is done so that each hoop has a lacing fastened at its bottom. Since it is on a diagonal, the centers of the lacings form an X between each hoop.

Ten men are able to cover and secure 2,000 linial feet of quonset a day, or 28,000 sq. ft. of ground covered. Labor cost for covering is under half a cent a sq. ft.

The quonset is the only shape, I know, that fully exploits the fact that polyethylene is a plastic material. In other words, the stuff bends! A frames, trussed A framed roofs all are designed for a rigid material. To put polyethylene on any of these shapes requires that much nailing down be done on rafters if the stuff is going to stay put.

Costs per 14′ x 5′ Sections are:

MATERIALS

Poly — 60′ x 18″ = 90 sq. ft. — 2 mil. clear @ $3.00 per 1,000 sq. ft. (For Straping)	.27
Poly — 24′ x 5′ = 120 sq. ft. 4 mil. white @ $7.00 per 1,000 sq. ft.	.84
2 pieces 1″ E.M.T. thin wall electrical conduit	1.82
1 ¾″ x 2½″ nipple	.063
1 Weld	.20
2 pieces 1¼″ x 4′ water pipe for stakes	1.50
2 pieces 1¼″ pipe straps	.06
1 piece 1″ pipe strap	.02

1 piece 1″ x 4″ cypress purlin	.23
2 pieces 1″ x 6″ cypress bottom board	.70
2 pieces 1″ x 2″ cypress lath @ 3c	.30
Nails	.20
	$6.20

$6.20 for 14′ x 5′ = 70 sq. ft. or: $.088 a sq. ft.

COST OF GABLES

In addition, each house requires 2 gable ends and wind bracing which must be figured into the cost. The longer the house the cheaper per sq. ft. for gables.

2 pieces 1″ x 6″ x 8′	$1.12
1 piece 1″ x 6″ x 14′	.98
1 piece 1″ x 6″ x 3′	.21
2 — 1″ pipe straps	.04
Wind braces — 2 pieces 1″ x 6″ x 14′	1.96
4 pipe straps — 1″	.08
2 pipe straps — 1¼″	.06
	$4.45 x 2 = $8.90

	Cost per sq ft ground covered
100′ house add: $.0063 per sq. ft. for cost of gables and wind bracing:	$.0063
Conard-Pyle Construction Labor:	.023
Covering labor:	.005
Materials:	.088
Total:	$.1223 sq. ft.

KNOX HENRY: How is the heat built up in your plastic house?

DICK VANDERBILT: We use white polyethylene and it seems the highest you go is 15° F. above the outside temperature at any time. The material will remain perfectly dormant right until May.

VOICE: What is the thickness of the polyethylene?

DICK VANDERBILT: It is 4 mil. I would like to add one thing here. We are in the midst of putting in some Panama canals. Down the center aisle of the houses we unroll polyethylene, the cans hold it up on the edges, and we fill these things up with water. The water is not heated but as it cools the water releases 1 calorie of heat per gram of water per degree drop centrigrade until it reaches freezing at which time 1 gram of water releases 86 calories of heat. So you have a lot working for you for nothing. Last year we had four of those 86 foot houses and we put in 700 gallons of water. We had a potential of freezing of 700,000 B.T.U. In some cases where tender material was hurt, in the houses with the water, not only were the same type of plants alive but roots were growing 6 - 7 inches out of the bottom of the can. In the spring time you get the reverse effect. It takes 86 calories per gram of water to melt the ice. So you have a cold storage.

PETE VERMEULEN: Do you have any problem with the breakdown of the white plastic?

DICK VANDERBILT: We are the asbolute experts in the whole world on white polyethylene. The stuff is horrible. It doesn't break down, Pete, but when they put in the pigment nobody can predict what it will do. Last year the quality control was horrible. This year the quality is good.

MODERATOR TINGA: Next we have outdoor overwintering structures by Mr. Paul Bosley, which will be presented by his son, Richard.

THE LESS ELABORATE POLYETHYLENE STRUCTURE FOR WINTER PROTECTION

PAUL BOSLEY, SR.
Bosley Nurseries
Mentor, Ohio

Container grown material constitutes a major portion of our nursery growing; and as a result, our methods of protecting plant material was originally built around our need to protect these particular plants.

We have been using polyethylene almost since the beginning of polyethylene, and many of our methods are a continuing evolution or refinement of what we have done previously. However, the basic principle of polyethylene has not changed. It is a flexible covering that will allow the passing of gases but will not allow the passing of moisture through itself. It took us a number of years to realize some of the basic advantages of this method. For example, we know that many of the Evergreen Azaleas and Rhododendrons will lose their bloom buds when the temperature drops to around to 10 below zero; and yet when temperatures dropped to 25 degrees below zero, Azaleas underneath polyethylene protection, did not have their bloom buds damaged in the slightest. We know that there is a relationship between the damaging effects of low temperatures with and without wind, and we have come to the conclusion that the loss of the plant's cell moisture is a more damaging condition than mere low temperatures as such. We again come to the principle that polyethylene does not allow moisture to pass through its walls.

We have used many devices to attain results. The original and probably the simplest protective method is illustrated by this picture. You will see where concrete blocks are set on end and 2x4's are placed on top of them and the whole arrangement made so that a standard 4 foot roll of snow fencing will span either a bed or a group of containers. The snow fencing serves a double purpose. It immediately gives 50 per cent shade during the winter time when there are periods of time you get the reverse effect. It takes 86 calories per gram of water to melt the ice. So you have a cold storage.

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This year, for the first time, we are using altogether the new white, and I mean white, not clear, polyethylene. This is sometimes known as highway film, and we have the road building people to thank because their wide use of this new material has made it possible for the nursery industry to have it. Whatever light comes through the white plastic is soft and diffused. We open the sides of these protective beds early in the spring; and as soon as possible, entirely remove the polyethylene but leave the snow fencing on for somewhat longer period.

It is a known fact that the intense ultra-violet light of the June, July, and August sun completely destroys the usefulness of polyethylene, but by removing it early, it is possible to get as many as four years use out of the same material. As a safety factor, we double the old polyethylene the second, third, and fourth years. At this point, we do not know how many years use, if any, additional can be gotten out of the new, white polyethylene.

Based on a 5-year use of snow fencing, 2x4's and cement blocks together with a single years use of polyethylene, we have figured the material cost of covering by this method to be 4 8/10 cents per square foot. I might also mention that once we have closed these units, they are not opened for any reason until spring.

Some growers have chosen to bend highway reinforcing mesh into a quonset shape and cover with polyethylene, but the results are disasterous if one should fail to ventilate on a day in January or February that becomes suddenly bright. We have had a 100 per cent loss on an experimental plot that was so constructed.

The next structure that we experimented with and have found most useful is a so-called A-frame house, which is illustrated here. This structure is built in rather small sections which are bolted together at the ridge and then bolted together in units to make any length house desired. I have had the plans and bill of material for this house written up and printed so that each of you may have one to take home. The wood members, especially the parts at the base are all treated with copper napthenate (cuprinol) and as you all know, copper napthenate extends the life of any wood at least five times. This house can be easily disassembled and re-erected at any other location. We use this particular structure to over-winter balled and burlapped material for our spring orders. The plants are double and sometimes triple decked; and we have found everything in the line of broad leafed evergreens kept in perfect condition with the exception of *Pieris Japonica.* We may yet find out what we did wrong with this plant. The south half of this house can either be covered with white polyethylene or perhaps black polyethylene or clear polyethylene that has been sprayed with paint.

The advantages of this structure are many. Any hammer and saw mechanic can build one. The end doors are constructed to a dimension that will allow a tractor to go into it. It can easily be heated, and adapts itself to double lining. Furthermore, it can be used for the overflow of spring annuals and for a sales building as well.

Mentor, Ohio, lays in a snow belt along the south shore of Lake Erie, and much of our thinking has to take this into consideration. A rounded or quonset type structure will shed its snow load. We have designed a simplified quonset structure which is now very economical. As a matter of fact, the cost of this new quonset structure is identical with the cement block and snow fence structure we started with originally. We bend ¾ inch thin wall conduit over a home-made form. You will note from the picture, that the form is a series of wood blocks bolted onto a board in an arc, which if continued would make a perfect circle. I should mention that the arc is less than a perfect circle; but when the conduit springs back, it assumes the shape of a perfect circle. These two pictures will give you an idea of how we do this part of the job. We cut one inch iron pipe into 15-inch lengths, and drive them into the ground within 2-inches of the surface. Two lengths of conduit are fastened together with a screw type of steel conduit connector, as shown by the illustration. Three-quarter inch conduits will slip inside of a one inch pipe, and we soon have a structure that looks like this picture. You will notice that we use a one by three strip of wood down the ridge to tie the whole structure together. In addition, we wire the four end units in an x fashion to attain almost absolute rigidity. The accompanying illustration tries to illustrate this, and you will notice the handkerchief that is placed where the two wires cross. This structure will take a 24 foot width of white polyethylene, and will allow approximately two feet to lay on the ground to be covered with sand, dirt, or gravel.

Inasmuch as we are using the white polyethylene, we do not fall into the pitfall of previous structures and get a big build up of heat. Various methods may be used to close the ends and one method can be as simple as allowing enough polyethylene on the end to gather it all together and tie it in a bunch as if it had an old-fashioned puckering string.

Still a fourth method which in itself is very simple, is shown by the next illustration where tall container grown material is laid on its side and then stacked up two or three high like a double or triple stacked row of barrels and then covered with polyethylene.

A variation of this arrangement is to lay two rows of material down with the tops heading toward each other and overlapping. Down through the center we put a 2x4, supported occasionally by up ended concrete blocks. This forms a ridge pole and polyethylene is draped over both rows of containers as shown by the picture which I feel illustrated them very clearly.

The last word has never been said on these methods, and I am sure that many of you will copy what we have done and vastly improve upon our methods. Frankly, we know right now some changes that we ourselves will make next year. I would appreciate knowing some of your ideas. Thank you all.

CASE HOOGENDOORN: Do you water that balled and burlapped material?

DICK BOSLEY: In the "A" frame structure we do ventilate and whenever you ventilate you have to water. On the *Ilex oppaca* in the large containers that were laid over, no, we don't water. We make sure they are thoroughly watered before they are covered.

MODERATOR TINGA: Our next speaker is Andrew Adams, Jr.

"OVERWINTERING AZALEAS IN TEMPERATURE-CONTROLLED PLASTIC GREENHOUSES"

ANDREW N. ADAMS, JR.
Ten Oaks Nursery & Gardens, Inc.,
Clarksville, Maryland

It became apparent to us back in 1955, if we were to continue in the Azalea business we would have to find some means of protecting our plants better in order to have saleable plants in the early spring with good foliage and buds.

Polyethylene plastic was just coming into the picture around this period so we constructed a small house (12'x96') by bending some old electrical conduit into a half circle and covering with some concrete mesh wire 6"x6", thus making a quonset type of house. We installed a small exhaust fan in one end and several louvers in the opposite end, plus a couple of propane gas heaters used for curing tobacco in the Southland. The idea was to keep the plants just above freezing, with plenty of air to prevent leaf drop. The following spring the results were so gratifying, plus the fact the Azaleas were gone in no time, that we decided to expand this idea.

We constructed 12 gutter-connected houses with a truss polyethylene on the end to gather it all together and tie it in a bunch as if it had an old-fashioned puckering string.

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We constructed 12 gutter-connected houses with a truss type roof design of ½ pitch for quick snow removal. These houses are each 23′x96′; holding approximately 15,000 4″ Azaleas. Each house has a 42″ two speed exhaust fan in one end. The opposite end of the house has a door 3′x7′ and two 3x3′ louvers. In each end of these houses we have suspended, from the rafters, a 75,000 BTU unit heater fired by propane gas. Both fans and heaters are thermostatically controlled with heater thermostats set at 40° F and fan thermostats set on 50°F in the winter. When the weather warms up above freezing outside, the fans run continually. Also, we have found through experience that if our heater fans run continually it keeps the air circulating in our house eliminating stagnant conditions which occur under poly in the winter.

As can be seen by the slides I will show, we have one double decker bench, 4′ wide and 5′ high, down the center of each house over our ground beds. Next year's crop of Azaleas are potted up during the winter and placed in these deck benches. This works very well and keeps the per unit cost down. These plants, being next to the heat and light, really start to hop in March.

Saran shade cloth, 40% shade, is put over the houses during the first week of June and left on until the first week of August when it is removed so the plants can be hardened off. We use 6 mil poly which is put on the last week of September or the first week in October.

Cost of this material annually, including labor for putting it on, is approximately 01½c per square foot. The cost of house, fans, heaters, heat and electricity per year is approximately 20c, 10c of this cost is amortized over a 10 year period for the houses and equipment. This works out to an approximate cost of 03c per 4″ Azaleas with 15,000 plants per house, or 24c per plant for 10/12″ plants.

We learned years ago, in order to have good saleable plants for spring sales you must spend good money, but this is a lot cheaper than not have anything to sell in the spring.

During my short 21 years experience, we have found no such thing as winter-kill in Azaleas. Most of your damage is done in the early fall with the first cold snap or freeze when everything is growing very lush and we get no hardening off of the plants. We call this Fall-kill at Ten Oaks. Nine times out of ten this will occur here either in the first or second week of October when temperatures suddenly drop in the 20's after being in the 70's with ample moisture.

As Azaleas go into the second or third year they seem to harden off or stop growing earlier in the fall; but for the younger, protecting under plastic seems to be the only answer if one is to have a saleable plant in the spring, and of course, the demanding market is there from March 15th on when one can't find a decent Azalea around.

ANDREWS ADAMS: We are changing some houses to fiberglass. We find that over a five-year period the cost is the same as polyethylene. The labor to put the polyethylene on is expensive and it comes at the wrong time of the year for us.

HANS HESS: How long have you used fiber glass?

ANDREWS ADAMS: We have had it on a lean-to greenhouse for 11-12 years. The fibers are starting to show. What we did this year was to put on a fiberglass refinisher. We coated the fiberglass and it keeps the dust from accumulating on the fibers. We really should have done it a little earlier. The material is available from Geiger in North Wales and is advertised in the American Nurseryman.

MODERATOR TINGA: The next talk we have is overwining container stock under plastic my Mr. Gil Nickel. He has 40 acres of containers.

OVERWINTERING CONTAINER STOCK UNDER PLASTIC

GIL NICKLE
Greenleaf Nursery Co.
Park Hill, Oklahoma

The need for cold weather protection of container grown broadleaf ornamentals became apparent at our nursery after severe losses during the winters of 1960, 1961, 1962. We are located in northeastern Oklahoma, in the Ozark Mountains. The average low temperature is 5 to 10 degrees F. below zero, and most broadleaf evergreens grown in containers, such as holly, pyracantha, euonymus, and some shrubs, are subject to varying degrees of winter damage. We felt that polyethylene covered houses offered the most promising solution to providing the needed protection, but several criteria had to be considered:

1. The houses had to be low in cost.
2. They had to be able to hold snow loads of 6″-12″.
3. They had to withstand winds in excess of 60 MPH.
4. They had to be easily erected and dismantled as we intended to put up the houses in the fall and take them down in the spring.
5. They had to do an adequate job of protecting the plants.

The structures I am going to describe are now being used for their third winter. We decided on A-frame construction because of its relative strength and simplicity. By making individual A-frame bows and joining any number of bows with stringers, a house of any desired length can be erected. The A-frame bow is constructed from two 2x6's - 19½′ long, with a 12′ 2x4 cross brace, and gussets of ⅜″ plywood, resulting in a bow 33′ wide, 11′ high, and each leg making an angle of 31 degrees with the ground. The bows are spaced 8′ apart with 2x4 stringers 16′ long, nailed at the bottom, middle and top. Diagonal braces are put at each end and, in the case of a long house (200′ or more), braces are put in the

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The plants are bunched and stacked three high, if necessary, so that a block of spaced plants 100′ wide will fit into 30′, with a 18″ aisle down the middle and a cross aisle every 40 feet. The stacking of the plants is very important. On the bottom layer the plants are put can to can. The second layer is can to can in one direction, but spaced the size of a can in the other direction. The top layer is spaced all the way. The result is, that for each 4 cans on the bottom layer, there are 2 cans on the second layer, and 1 can on the top layer. In the case of 1 gallon cans, this is 7 plants per square foot.

After the plants are stacked, the house is erected over them. The plastic sheets are ordered to fit the houses. During the summer the size and location of each house to be built is decided. The plastic is ordered about 10% too long to allow for adding a couple of bows, if necessary, and to allow for possible slight errors on the part of the plastic manufacturer in cutting the sheet. The sheets are all 40′ wide — I don't know of any plastic company manufacturing sheets wider than 40′. When the house is completely ready to cover the plastic is rolled out beside the house and carried over and draped in place. The sheet is then nailed down with lath at one end and stretched to the other end. It is important that the weather be suitable. It is virtually impossible to handle these large sheets in winds over 15 MPH, and a completely calm day is very desirable and makes the job much easier. The temperature should be 40 degrees F. or above on a clear days, and 60 degrees F. or above on a cloudy day, or it is impossible to obtain the necessary stretch on the plastic. The plastic is stretched and nailed to the middle stringer by a crew of 5 or 6 men on each side of the house pulling against each other. Then the plastic is stretched and nailed to the bottom. The plastic should be drum tight when the job is completed in order to withstand the winter winds. The plastic is then nailed over every other bow in order to break it up into small, repairable sections. The house is then sealed along the bottom with sawdust. Shading material is applied to the houses as desired. The doors are closed anytime the temperature is expected to go below 32 degrees. In the spring, cigar shaped holes can be cut in the plastic above the middle stringer to improve ventilation.

Now, let us evaluate these overwintering houses with regard to the criteria outlined earlier. First we said the houses had to be low in cost. Here is a cost breakdown on one A-frame bow:

40 feet of 2x6 @ .10c ft.	$4.00
12 feet of 2x4 @ .06 ft.	.72

40 feet of 2x4 @ .06 ft.	2.40
2 metal stakes 2 ft. long, plus 1 ft. of strap metal, plus labor	1.00
3 sq. ft. of 3/8" plywood @ .13c sq. ft.	.39
4 mil polyethylene, 8'x40' @ .006c/sq. ft.	1.92
Estimated labor to build bow	.50
Estimated labor to haul bows, erect buildings, and cover with plastic	2.00
50 feet of lath @ 1.80 bundle	.45
Nails	.15
Total for 240 sq. ft. usable space	$13.53

Thus the intial cost per sq. ft. is 5.6 cents. However, if we assume that the bows will last 4 years, the lath 3 years, the stakes 10 years, and that the labor to disassemble the houses is the same as that to erect it, we come up with a prorated cost of 3.5 cents per square foot per year. When it is considered that it is possible to stack as many as 7 one-gallon plants per square foot, the cost can be as low as ½ cent per one-gallon plant, which we feel is certainly reasonable.

Next, we said the structures must hold snow loads of 6"-12". The heaviest snow load we have had while using these houses, was 6"-8", but this didn't seem to be very close to the structural limit.

The houses have gone through winds in excess of 60 MPH, and the only damage was a few iron stakes pulling loose, and a few rips in the plastic, which were easily repaired. If stronger winds were expected, it would be necessary to use iron stakes more often, or an entirely different means of anchoring the houses to the ground, and to lath the plastic to every bow rather than every other bow.

Next, we said that the houses must be easily erected and dismantled. It takes a 6 man crew approximately 4 hours to erect a 300' house, if the materials are all close by. It takes 20 men about 2 hours to cover the same house.

The last criteria was that the houses had to do an adequate job of protecting the plants. I can say with no reservations, that they do an excellent job. Winter damage is practically a thing of the past for us. On a cold night the temperature inside is usually 20-30 degrees above outside temperature. In our climate the soil ball of the plants never freezes more than 1" deep. Here are two excerpts from temperature records I kept the first winter we used the houses:

> Dec. 22, 1963 — The outside temperature has not been above freezing for several days. It snowed approximately 3" last night. At 5:30 P.M. the temperature outside was 14 degrees, inside it was 32 degrees. The low outside during the night was 7 degrees below zero, inside the low was 26 degres.
>
> Jan. 13, 1964 — The low outside was 4 degrees, inside 26 degrees. High temperature outside was 30 degrees, inside was 56 degrees.

It is also important to note that the color of most plants overwintered inside is much superior to those left outside. This is certainly an important spring sales consideration. However, unless the houses are shaded, the plants will break dormancy 2-3 weeks before plants left outside. Also, it is necessary to water the plants once or twice a week, or even more often during a warm spell. We use #20 rainbird sprinklers, equipped with a baffle, spaced 20′ apart down the center of the house. Rodent damage in the houses can be quite severe, and it is necessary to maintain bait stations. The warm temperatures and high humidity in the houses are very conductive to insects and disease, so we spray every two weeks with Captan, and every four weeks with Sevin.

During the winter of 1964 we decided to experiment with white opaque plastic. We used two overwintering houses of the same width and length, located side by side, one covered with clear plastic and one covered with white plastic giving 40% light transmission. A maximum-minimum recording thermometer was placed in each house at identical locations in order to compare inside air temperature. Also, a continuous recording thermograph was placed in each house with the probe buried 6″ deep in a 5 gallon can to compare soil temperature. Finally, a continuous recording thermograph was placed outside to record outside temperatures. The following year, we covered approximately 1/3 of our overwintering houses with white plastic. In comparing clear plastic versus white plastic, we have some to the following conclusions:

1. The night air temperature is approximately the same in the clear and white houses. We had expected the white to be warmer at night due to reduced heat radiation. However, on a cold night a heavy layer of frost forms on the inside of the clear plastic, resulting in heat transmission approximately equivalent to the white plastic. Also the frost layer, from ⅛ to ¼″ thick, has some insulation quality.
2. The day time air temperatures are much higher in the *clear plastic houses, approximately 15-20 degrees difference.* The temperature in the white houses is about the same as the outside temperature during the day.
3. The soil temperature is more even in the white houses. The soil temperature in the clear houses fluctuates more, but is higher on the average.
4. The water requirements are much less in the white houses, requiring water only about every two weeks.
5. The plants stay dormant 2-3 weeks longer in the white houses, breaking dormancy about the same time as plants left outside.
6. Plant color is a little better in the white houses.
7. The clear plastic is much stronger than the white plastic. The white plastic on all the houses covered last

year failed before March 15th. This is a serious problem and forced us to abandon the use of the white plastic. However, it is possible we used an inferior grade of plastic in our tests.

I think that the advantages of the white plastic are too many to ignore, especially in the cold climates where it would be impossible to prevent the soil ball of container grown ornamentals from freezing solid without artificial heat. The white plastic would allow a slow thawing process that would probably be more benefical than quick temperature changes. However, the same result could be obtained by heavily shading clear plastic.

CORLISS INGELS: What thickness of plastic do you use?

GIL NICKEL: Four mil. We start covering October 15th.

MODERATOR TINGA: Our next paper is on the storage of budwood, scions, and rooted and unrooted cuttings. I will ask Hugh Steavenson to start.

HUGH STEAVENSON: Regrettably our good friend Darrell Holmes could not be with us today. Fortunately we have Jim Law who is the production manager of Stark Brothers who grew up in the nursery business and is working right in this very subject. So I think it is very fortunate that Jim could be here to read Darrell's paper and handle any comments.

STORAGE OF ROOTED CUTTINGS, UNROOTED CUTTINGS, SCIONS AND BUDWOOD

K. DARRELL HOLMES
Mount Arbor Nurseries
Shenandoah, Iowa

I am sure that many of you, perhaps all of you, have had much experience in storing ROOTED CUTTINGS, UNROOTED CUTTINGS, SCIONS AND BUDWOOD and probably have just as good a method as we, but I will try to give you complete information on our methods.

First — ROOTED CUTTINGS:

We do not have occasion to store great quantities of rooted cuttings for any period of time, but we do store rooted cuttings of Crimson Pygmy Barberry and several varieties of Taxus. These are stuck as semi-hardwood cuttings in greenhouse propagation benches during September. We carry them in the benches until about the first of February, then dig and wrap 100 per bundle in moist sphagnum moss and two millimeter polyethylene. We tie the wrap with a rubber band. We do not put the polyethylene over the tops. In fact, the tops of the Barberry cuttings are above the polyethylene about one-half inch, and the Taxus cuttings may be from one-half inch to three inches above the poly., depending on the length of the cutting that was rooted.

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We then pack these bundles of wrapped cuttings in standard greenhouse flats, store them in refrigerated storage on shelves, and carry the temperature at about thirty-six degrees.

I might add that in addition to the above we carry several thousand rooted cuttings in outside propagation beds in two to three inches of sand where they were rooted during the summer. These cuttings root on down into the soil. We put lath shades on the beds and cover the beds with wheat straw about the middle of November. The cuttings are carried over winter in this manner, and as they begin to take on new growth in the spring they are either planted direct to the field or potted and set in coldframes and carried over until the following spring.

UNROOTED CUTTINGS:

GREEN WOOD CUTTINGS —

I might comment briefly on green wood cuttings to say that we do not attempt to store them. There are occasions when we do *carry* them up to several days as we take cuttings at times from our stock blocks faster than they can be worked up and stuck in the propagation beds.

We have tables in the basement of our Propagation House work room. The tops of these tables are of ½ inch hardware cloth, and we run a mist line about eighteen inches above the table tops. We spread the cuttings out on these tables and place an electronic leaf just above them. With this method we can carry the cuttings over a weekend, or for several days, and have found that they will remain in excellent condition until we can get them worked and stuck.

We use this same method to carry Juniper cuttings for grafting. It is necessary to cut Juniper cuttings when the temperature is above freezing, and we like to cut enough to run our grafters for several days since we sometimes have several days when the temperature does not get above freezing.

DORMANT CUTTINGS —

I do not suppose that anyone has any trouble storing dormant cuttings, but to comment upon our methods I would advise that we handle dormant cuttings of only Honeysuckle, Poplar and Willow. We make cuttings seven inches in length, tie them about 100 per bundle, and pack in graft boxes (these are wooden boxes 19 x 19 x 35 inches). We pack the cuttings in good moist shingletow. These boxes of cuttings are then stored in refrigerated storage in thirty-six degree temperature.

The cuttings are usually made in early October, and we usually plant them three to four weeks later. However, if weather does not permit us to plant them all we carry them as mentioned above until we can plant them during the early spring.

SCIONS:

Scions referred to at this time consist of Apple, Flowering Crab, and possibly Pear, French Lilac, etc.

We try to take our scions from our stock blocks during December and January when temperatures are above thirty-two degrees. We tie the scions 250 per bundle as they are cut in the field, then take them to the seedling storage, which is a basement room that is frost proof but not refrigerated.

We place a thin layer of wet spaghnum moss on the floor and then pound the moss into the butt ends of the bundles of scions. These scions are then stored on shelves in this basement room until we finish grafting about March 10th.

BUDWOOD:

The storage of budwood will undoubtedly be much more interesting to many of you than the rest of this paper, so I will attempt to go into some detail regarding same.

The past several years we have stored and used *dormant budwood* on Plum, Prunus, Pear, Apple and Flowering Crab in the fruit tree group; *Prunus glandulosa alba* and *rosea,* also *Cornus elegantissima,* in the ornamental shrub group; Ash. Catalpa, Elm, Honeylocust and Linden in the ornamental tree group.

The budsticks are cut from stock block trees during late December and early January, at which time the trees are completely dormant. The budsticks are taken to a workroom where they are sorted, washed and tied fifty sticks per bundle.

The budsticks of the fruit tree and ornamental shrub group are then wrapped in wet newspaper and placed in a polyethylene bag. We use special poly. bags of .002 millimeter material that are ten inches wide and forty inches long.

We use poly. bags without air holes for the storage of budwood. The bag is tied securely at the top to make it air-tight. The poly. bagged budsticks are then stored in cold storage at 28 degrees from January until about June 15th., at which time we start to bud the Plum and Prunus.

The ornamental tree budsticks are handled differently in that we place a small amount of slightly damp sphagnum moss at the butt end of the bundle of scions and then place them in the polyethylene bags. These poly. bagged budsticks are then placed in cold storage at "above freezing" temperatures of about 34 to 36 degrees.

We do not put moist newspaper around these ornamental tree budsticks as we do not freeze these.

Going back to the fruit tree and ornamental shrub budwood that we freeze, or rather carry at a 28 degree temperature, I should mention that as we get ready to use this budwood we select the budwood that we expect to use the following day and remove it from the 28 degree storage to the 34 to 36 degree storage so that it will thaw out gradually for about 12 to 18 hours before being taken to the budding field where temperatures are at times as high as 90 degrees.

In general we get a much better bud stand with the dormant buds than with green buds, particularly on the Thornless Honeylocusts and the Plum and Prunus. We can also bud earlier in the season and get this budding out of the way before green buds are ready to use on other budding.

I am sorry it is not possible for me to attend this meeting this year, but if anyone has any questions and would care to write to me in care of Mount Arbor Nurseries, Shenandoah, Iowa, I will be happy to answer to the best of my ability.

MODERATOR TINGA: I am always surprised at the amount of hand labor required in these operations. My objective is to eliminate just as much hand labor as we can. Very often this means changing species and systems. But, if hand labor is the problem I think it is and is going to be, I think everyone has to think in terms of eliminating whole steps in production if that's necessary in order to come out on the net profit side. The next talk that we have will be seed bed treatments prior to seeding by Mr. Ralph Shugert.

SEEDBED TREATMENT PRIOR TO SEEDING

RALPH SHUGERT
Plumfield Nurseries
Fremont, Nebraska

Dr. Tinga, President Vermeulen, Society members and honored guests:

It is a real pleasure to discuss with you this morning the most fascinating, perplexing, and at times incomprehensible, phase of plant reproduction . . . seedling propagation. Over the years we have heard excellent papers presented covering many aspects of seedling production, and it is my intent today to discuss a few techniques we use at Plumfield Nurseries in Fremont, Nebraska.

Our seedling operation is divided between seed beds and seed rows, and most of the remarks and slides will concern the former. The field which encompasses our seed beds is very level, and the soil texture is quite sandy. There are approximately thirty acres of seed beds in this field. Perhaps I should pay more attention to the soil pH, and to N., P., K., but I don't — except that based on previous soil tests, we are quite high in both Potash and Potassium. These results are compiled on a response based on field crops. Soil pH is rather confusing due to the fact that one section of our field of seed beds, a strip seven hundred feet long, will show a pH variation from 7.1 to 8.0. The same species are seeded in this area, and little if any difference can be noticed in the growth of 1-0 and 2-0 seedlings. Perhaps a comment on weed control, that shall follow might provide an answer to this pH variation.

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Our seed beds are prepared and constructed quite simply. After the seedlings are lifted in the fall, the vacant beds are disced lightly to go into the winter. This ground is then kept disced down during the spring and early summer. The first week in August the seed beds are constructed, so that the seeding can start the first week in October. We prepare our beds with an Allis-Chalmers tractor, and all our beds measure four feet from center of alley to center of alley. The soil is raised about six inches with two rear discs, and leveled with two inch by four inch boards mounted at about a thirty degree angle to the front cultivator bars. After the beds are raised they are the harrowed, and ready for weed control prior to seeding.

The only weed control we use in seed beds is that of a pre-emergence, and the material used is Calcium Cyanamid, shipped in cars from Niagara Falls, Canada. The material cost is $61.00 per ton, FOB Canada, and our cost — which includes freight, unloading and labor to apply — will be close to $185.00 per acre, applied. This figure does not include overhead, but rather is a direct labor cost. We apply this material at the rate of seventy-five pounds per one thousand square feet of bed, in two applications. The tractor and spreader go over the bed the first time with one-half the amount and then the bed is harrowed. The second and final application is identical to the first. After a section of seed beds is treated the entire section is then watered. This material gives us about 20% Nitrogen which could explain the pH variation mentioned earlier, and the weed control is perfect until the wind blown weed seeds start germinating in mid-May. From this point on, until frost, all of the seed beds are hand-weeded.

Seeding starts the first week in October, with the stratified seed going in the ground first. This includes varieties such as: *Cotoneaster acutifolia, Juniperus scopulorum, Tilia americana, Tilia cordata* and *Viburnum* species. All of our seed is drilled in with a Planet Junior five row drill, and mulched with oat straw. We apply the straw immediately after seeding each bed. As the slides will point out, we have four seed rows per bed for increased light intensity. The center drill is plugged, and this gives us a seven inch row spacing between rows one and two and three and four. There is then fourteen inches of space between rows two and three. The straw is applied at the rate of one manure spreader load to a bed of three hundred and thirty feet. This gives us ample, but thin coverage. The straw is held in place with two inch mesh wire, pegged to the bed with steel pegs. We normally finish seeding by the middle of November, and our normal Nebraska winters will cover the beds for us with snow until spring. In the spring the pegs and wire are removed, but the straw remains on the beds. We will make our initial hand-weeding through the straw, allowing protection for the germinating seedlings. Many of the conifers are then shaded in early June with snow fencing, and in most cases the shades stay on the beds throughout the second year.

Now a short word or two about our seed rows, and then we shall show a few slides. The acreage involved in rows is between forty and fifty, dependent upon seed supply. We prepare soil by winter fallowing, and then discing all summer, prior to seeding in October. Immediately before seeding the ground is disced, harrowed and rolled, and the seed is drilled with a one-row Planet Junior drill. We ridge our seed rows quite high, up to a hill of about ten inches to go into the winter. This hill is removed in the spring, partially with a Budding In-Row-Weeder, and by hand with a potato hook. We apply a band of perlite when we seed, and this enables inexperienced laborers to know when they have gone deep enough with their hooks. This has saved us much embarrassment in having seed hooked, or raked, out of the rows. The rows are then maintained during the growing season by weeding with the In-Row-Weeder, while the seedlings are small, and then by weeding crews when they are larger. We do not use any type of weed control in the seed rows.

Before we view the slides, I would like to comment that we are growing a wide list of plant materials from seed. The acute problem today for the propagator growing seedlings from *Abies to Viburnum,* is that of seed source. We use private collectors exclusively, and rely strongly upon our own seed mother rows. It is not inexpensive to pick and clean seed, but it is well worth the additional cost to have the seed when you want it, and to be assured of viability and the germinative capacity necessary to assure decent seed stands.

The challenge in seedling propagation is probably no greater than that of vegetative propagation, but nothing gives me a greater feeling of exhilaration than to observe seedlings germinating in the spring. Another new growing year is approaching . . . "God's in his Heaven, all's right with the world."

PETE VERMEULEN: How much water do you put on?

RALPH SHUGERT: I have had several people say you need a very heavy water seal, but I have never followed this. I would say that if we used more than 1/8", I would be surprised. What we do is to water until the ground is black.

JOE HOULIHAN: How soon do you water after the material is applied?

RALPH SHUGERT: We apply the water immediately after application, section by section.

FRIDAY AFTERNOON SESSION

December 9, 1966

The session convened at 1:15 p.m. in the Colonial Room Viking Hotel. Mr. Hugh Steavenson was moderator of the speaker-exhibitor symposium.

STU NELSON: Our moderator this afternoon is Hugh Steavenson.

HUGH STEAVENSON: It gives me a great deal of pleasure to introduce Mr. John McGuire.

EFFECT OF TERMINAL APPLICATIONS OF IBA ON ROOTING OF WOODY ORNAMENTAL PLANTS[1]

JOHN J. MCGUIRE AND DAVID C. SORENSEN[2]

It has long been a practice to apply auxins in either a talc or an alcoholic base to the basal portion of cuttings to stimulate root initiation and growth. This has been effective, provided optimum levels of auxin were applied. If concentrations were too high, inhibition of root elongation occurred. If concentrations were too low, poor rooting resulted. There are a few reports of auxin application to the foliage of terminal portions of cuttings either before (4) or after removal from the plant (1) (3), but significantly improved rooting was not obtained.

Terminal applications could be advantageous if they improved rooting without injury to the plant, or if they could be applied as a spray to cuttings in the propagation bench. Theoretically, it is feasible to apply auxins to the terminals of cuttings. It has been established by Went and White (5), and more recently by Leopold and Guernsey (2), that when IBA was applied to the distal (terminal) end of a coleus cutting some auxin was transported to the proximal (basal) end. It is not thought to be in the form of IBA after it is transported.

The purpose of this work was to determine the effect of terminal applications of IBA when applied to woody ornamental cuttings. Preliminary work, done in 1963, with cuttings of *Ilex crenata convexa* Mak., provided information which was used in establishing treatments and procedures used for this experiment. A 1% solution of IBA in a 40-50% solution of ethanol or polyethylene glycol, was satisfactory as a terminal application either as a dip of the terminal bud and next two nodes together with leaves, or as a spray applied to the entire leaf area of the cutting.

Applications of IBA, IAA and NAA separately or in

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[1] Contribution number 1218 of the R I Agricultural Exp Station

[2] Assistant Professor and Graduate Research Assistant, respectively

combination with each other indicated that NAA could be used effectively at much lower concentrations than IBA or IAA, especially when in combination with one of the other two. The preliminary work also indicated that to be effective terminal treatments must be approximately five times as strong as basal treatments.

In the summer of 1965 comparisons of terminal and basal applications of IBA with NAA were made on a large number of species commonly propagated from softwood or semi-hardwood cuttings. The number of cuttings of each species varied, but there were at least 15 cuttings in each of three replications in each of three treatments in a randomized complete block. The size of cuttings also varied with species, but each cutting had a terminal bud and four nodes. The following three treatments were used:

1. A terminal dip to a depth of two nodes with leaves in a mixture of 1% IBA and 500 ppm NAA in 40% polyethylene glycol (Carbowax 400) for 10 seconds. Cuttings were immediately blotted to remove all excess.
2. A basal dip to a depth of one inch of defoliated stem in a mixture of 0.2% IBA and 500 ppm NAA in the same solvent mentioned above.
3. A basal dust to a depth of one inch of defoliated stem in a commercially prepared talc containing 0.3% IBA.

Cuttings were placed in flats containing sterile medium of equal parts horticultural grade perlite and sphagnum peat moss. Flats were placed under intermittent mist in a greenhouse equipped with fan-pad cooling. Temperatures were maintained at a maximum of 85°F during the day and a minimum of 68°F at night. Cuttings were examined periodically and those of each species were removed when cuttings in one of the treatments were found to be well rooted. Upon removal all media was washed from the roots and the number and length of each root was recorded. For analysis, the data were given a numerical value according to the following system. Roots less than ¼″ long were given a value of 1; roots ¼″ to ½″ long were given a value of 2; roots ½″ to 1″ long, a value of 3; 1 to 2″ = 4; and roots over 2″ were given a value of 5. Thus, a cutting with 1 root ⅜″ long, 3 roots 1½″ long, and 5 roots over 2″ long was given a value of 39. Rhododendrons were evaluated differently because the root system of this species makes counting and measuring individual roots impractical. The following scale was used. Cuttings with 20 or less roots were given a value of 1, cuttings with more than 20 roots in a ball up to ¼″ in diameter were given a value of 2, a root ball ¼″ to ½″ = 3, ½″ to 1″ = 4, and a root ball more than 1″ in diameter a value of 5.

Terminal application resulted in significantly greater root development than basal application for 3 species: *Rhododendron 'Dr. Dresselhuys', Viburnum carlesi compactum,* and *Viburnum wrighti.* Terminal application did not result in significantly less root development than one of the basal treatments for 5 species: *Euonymus, alatus compactus, Juniperus chinensis ketleeri, Juniperus horizontalis douglasi, Pachysandra terminalis,* and *Rhododendron catawbiense grandiflorum.* Results for other species were either inconclusive due to poor rooting or there were no differences between treatments.

The terminal treatment was noticeably ineffective on *Acer palmatum disectum* (Japanese red maple). This may have been due to the heavy waxy bloom on that species. Terminal treatments resulted in minor chlorosis on *Rhododendrons* species. No chlorosis was observed on any basal treatment. Chlorosis was one of the side effects noted in preliminary work when NAA was used as a terminal treatment. It should be noted that the low values for many of the basal treatments do not indicate lack of roots but rather lack of root elongation. This may have been the result of inhibitory levels of auxin in tissue at the site of root initiation. This phenonemon was not observed in terminal treatments in these experiments.

It is apparent that terminal treatments are feasible and perhaps could be used on a practical basis provided optimum concentrations were determined. It may be found that different concentrations are required for each species. Terminal applications have resulted in modified root orientation on some species, notably on *Ilex* where the greatest number of experiments have been carried out. There have been no lasting inhibitory effects on terminal or axillary buds from terminal treatments. The application of auxin to terminal buds and leaves may be a useful tool in studying auxin movement in relation to the environment. It may also have a practical application in treating scions during grafting to facilitate more rapid union of the scion to the stock.

EFFECT OF METHOD OF APPLICATION OF GROWTH REGULATORS ON CODED ROOT LENGTH OF CUTTINGS OF WOODY ORNAMENTAL PLANTS

Species	Terminal Dip 1% IBA + 500 ppm NAA	Basal Dip 0.2% IBA + 500 ppm NAA	Basal Dust 0.3% (Talc)
Acer palmatum disectum	7.0 NA	29.5 NA	7.0 NA
Euonymus alatus compactus	517.0 A	505.0 A	158.6 B
Juniperus chinensis Ketleeri	42.0 A	11.0 B	55.6 A
Juniperus horizontalis couglasi	88.6 A	73.7 A	75.3 A

Junipurous hoirzontalis plumosa	115.0 A	45.0 B	123.0 A
Pachysandra terminalis	239.3 A	260.0 A	121.3 B
Picea glauca conica	64.6 NA	20.6 NA	20.6 NA
Rhododendron 'Dr. Dresselhuys'	218.3 A	26.6 B	23.3 B
Rhododendron catawbiense grandiflorum	52.8 A	54.0 A	36.2 B
Viburum carlesi compactum	149.0 A	203.6 B	40.2 C
Viburnum plicatum tomantosum	20.0 A*	20.0 A*	20.0 A*
Virburnum wrighti	385.3 A	260.6 B	159.3 C

NA = no analysis made due to the small number of cuttings which rooted
Numbers with the same letter on the same line are not significantly different from each other (P 05)

* In this species only root numbers are listed, not coded values

LITERATURE CITED

1 Hildreth, A C and Mitchell, J W 1939 Spraying is a new method of applying root promoting substances Flor Rev p 14

2 Leopold, A C and Guernsey, E S 1953 Auxin polarity in the coleus plant. Bot. Gaz 115 147-154

3 Mitchell, J W and Marth, P. C 1947 Growth Regulators for garden, field and orchard University of Chicago Press

4 Stoutemeyer, V T and O Rourke F. L 1945 Rooting cuttings from plants sprayed with growth regulating substances Proc Amer Soc Hort Sci 46 407-411

5 Went, F W and White, R 1939 Experiments on the transport of auxin Bot Gaz. 100. 465-484.

HUGH STEAVENSON: Our next speaker is one of our very loyal members, Al Lowenfels.

VARIOUS TYPES AND STRENGTHS OF HORMONES FROM U. S. A., ENGLAND AND HOLLAND

ALBERT LOWENFELS
White Plains, New York

I planned to bring containers of Hormones that are sold commercially and say a few words about my experiences with them. But then I felt that few words on the whole subject of root promoting substances would be of interest.

Hormones for plant growth are comparatively new. Baileys Nursery Manual, 22nd adition—a wonderful book in

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1. Hildreth, A. C. and Mitchell, J. W. 1939. Spraying is a new method of applying root promoting substances. Flor. Rev. p. 14.
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I planned to bring containers of Hormones that are sold commercially and say a few words about my experiences with them. But then I felt that few words on the whole subject of root promoting substances would be of interest.

Hormones for plant growth are comparatively new. Baileys Nursery Manual, 22nd adition—a wonderful book in many ways published in 1919 says nothing about hormones. Neither does the article signed by B. M. Watson in Baileys Encyclopedia mention Hormones. Laurie and an assistant Professor named Chadwick in Modern Nursery mention Potassium permangenate and Sucrose as rooting aids. Their book was published in 1931. Also slight attention is given to acetic acid, Manganese sulphate and Manganese dioxide.

Hottes in How to Grow Plants (1940) cites the work that Boyce Thompson Institute did in this field since 1924, mentioning Dr. Hitchcock and Zimmerman, who defined a hormone as a substance produced in one part of the body usually ductless glands and is then transferred to another part where it has a specific physiological effect. Hormones change adolescent children unto adults and when the Hormones dissapear from the body old age is brought on. Hottes continues telling how in 1910 a Danish botanist proved that some of these same substances will also have an important effect on plants. (In fact I once read someplace that if you dipped the bases of cuttings in the urine of a pregnant woman, rooting would be improved). At first Boyce Thompson experimented with gases but finally Professor Kogel of Holland found a crystalaline substance in urine known as Indoleacetic Acid and experiments showed that this and other substances would be of great help. Kains and McQestern in 1942 tell how a man named Fitting used Hormones for plants in 1910. They tell how Hitchcock in 1933 reported the effect of carbon monoxide on initiating roots and was the first to use a chemical substance on an organ of a plant. Boyce Thompson investigation found 32 possible root promoting substances. Then this institute gave a license to Merck and Co to market a powder which was called Hormodin A.

Sheats of England wrote a detailed and supposedly authoritative book on Propagation in 1948. Oddly enough Sheats found no use for Hormones. Sheats stated that Hormone treated cutting made more and better roots—but when planted outside—that after 6 months the untreated plants were more advanced than the treated ones. He concluded 'It is safe to say that up to date no real commercial advantage has yet been gained by the use of substances for the production of plants by cuttings'. And in his detailed instructions on how to propagate hundreds of species I haven't found one that mentions hormones.

We of course know that hormones DO help many plants form roots, in fact I do not see how we could propagate many subjects without them and so far I know hormone treated cuttings do as well—and often better than plants rooted without them. Now a few words about the Hormones I brought along. I propagate all my material myself including transplanting into bands or peat pots so my words are entirely the result of my own observations.

I did not bring Hormodin—or Rootone along for I felt you are all familiar with them. Seradix is an English product (and I believe it is used in Canada). It comes in three strengths and I feel that it is similar to Hormodin. Rootagen comes in two strengths for soft and harder cuttings. I didn't have much success with either.

Hormoroot is made by an individual in Jersey. It comes in various strengths including some very strong. I found it quite good. Hormex comes from the West Coast in various strengths. One thing I like about Hormex—the Talcum powder seems finer and so clings better. Incidentally in a 1939 report Hitchcock and Zimmerman stated that an ingredient of controlled talc, soluble in chloroform was found to be active when used on tomato plants. At that time they also reported that the principal action of the hormone occurse within a short time, probably in many cases within 24 hours. I have been using Hormex for the past two years and find it quite satisfactory.

Jiffy Grow, a liquid with an alcohol base I have just started to use this past season and am therefor unable to report conclusive results. This is also my 1st year with Proliferol. Rhizopan I bought when I visited the marvelous nursery area at Boskoop Holland. Unfortunately I cannot read Dutch so I'm not sure what strength I received in my one can for it comes in various strentghs so I hardly knew what I was doing with it. Chloromone is a green liquid. Altho commended by one prominent Jersey member, I didn't find it too satisfactory. And the price of $3.00 for a small container seems too high for general commercial use.

I have often wondered how long hormones in powder would remain effective. Fortunately Dr. Hitchcock of Boyce Thompson is still alive and so I wrote him. He answered," Altho there is scant information about the lasting properties of commercial preparations, our results, (not all published) indicate that the low concentrations are effective for 1-2 years and the higher concentration powders for longer periods, up to 5 years. No doubt the concentrations have varied in commercial preparations but at the time we tested some of these powders it was evident that the most effective range in milligrams of indolebutyric acid per gram of fine talc were respectively 2, 5 and 8 Mg/g. Dr. Hitchcock also sent me some of the papers of the investigations around 1940 which I brought along. Please do not take them they are the only ones I have. Boyce Thompson issues a catalog of all their publications—they are at Yonkers New York.

I keep records of what I do—and have some of them along too in case any member cares to discuss this subject.

My conclusions are that Hormodin deserves the #1 spot. The directions in each package tell which one of the three strengths to use on a wide variety of subjects—and I believe that generally propagators have found it most satisfactory.

The past two years I have also used Hormex—and this too has worked well—and there is one benefit—it not only has the three regular strengths—the same as Hormodin—but also is sold in higher concentrations for harder to root subjects. I think that Hormex costs less than other powders. I have a circular that shows their prices.

I think I should mention that Eastman, Rochester, N.Y. sells basic chemicals for making your own hormone liquid mixtures. I inquired about this a few years back but felt that trying to work out the right method of mixing and using their chemicals was beyond me. However undoubtedly in this august gathering there probably are some who use the Eastman chemicals or might be interested in finding out about them.

HUGH STEAVENSON: Our next speaker, as can be seen from the program, is Bob Fleming.

PHYSIOLOGICAL AND ANATOMICAL EFFECTS OF GIBBERELLIC ACID ON PLANT CUTTINGS

ROBERT A. FLEMING
Horticultural Experimental Station
Vineland Station, Ontario, Canada

INTRODUCTION

Gibberellic acid has been tested in various experiments by many researchers with the purpose of determining its usefulness in the field of horticulture. Much has been discovered with respect to the effects on the above-ground parts of plants. Little information was available in 1957 on the direct effect on root promotion as in the case of cuttings or root growth as it is affected by treatments with gibberellic acid. For this reason the following study was carried out. It was conceivable, as in some ways gibberellic acid duplicated the response of plants to treatment with known auxins or plant hormones, that the material might also favorably affect root induction in plant cuttings. The effects of the known auxins were well established, toxicity levels were known, and the inhibiting effect on root growth was known. Little information was available at the time concerning this phase of research using gibberellic acid. From literature available it was evident that gibberellic acid has a low toxicity rating. Responses have been evident on plants with as little as one ppm up to and beyond 1000 ppm with no indication of injury with the exception that, at the high concentrations plant response, where evident, was more pronounced than at lower concentrations.

While much of the literature pertaining to increased growth after treatment with gibberellic acid, showed a decrease in per cent dry weight of roots in relation to top, there is no indication that inhibition has been the cause. Where the three regular strengths—the same as Hormodin—but also is sold in higher concentrations for harder to root subjects. I think that Hormex costs less than other powders. I have a circular that shows their prices.

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While much of the literature pertaining to increased growth after treatment with gibberellic acid, showed a decrease in per cent dry weight of roots in relation to top, there is no indication that inhibition has been the cause. Where there is a definite increase in total plant dry weight, weight of roots is greater than in the check plots.

DISCUSSION AND RESULTS

In the treatment of softwood Forsythia and Ligustrum cuttings with Gibberellic Acid, no beneficial results were found. At no time did Gibberellic acid treatment equal or exceed the percentage rooting of the control cuttings with either species used. Indolebutyric acid with ligustrum cuttings gave a better percentage rooting at all but the highest concentration used (120 ppm in solution) at which strength cuttings were permanently injured, many dying, the remainder failing to root. Injury was also noted at the 40 ppm level, in solution, using Gibberellic acid. Of interest is the fact that given further time in the propagating bench, treated lots of the 10 and 20 ppm Gibberellic acid in solution eventually rooted to 90-100 per cent. Of the two lots tested in this way with Ligustrum at 10 ppm Gibberellic acid in solution the extra time required for maximum rooting was 30 days; at 20 ppm in solution — 25 days. Normal maximum rooting for control and Indolebutyric acid treatments 40 and 80 ppm, of the same lots was 27 days and 44 days respectively. A similar result was obtained in two lots of Forsythia. At the 10 ppm Gibberellic acid in solution 44 days were required for maximum rooting (85%) as opposed to 17 days for the controls and Indolebutyric acid treatments. At the 20 ppm Gibberellic acid in solution (Indolebutyric acid 80 ppm) the control rooted 100% in 21 days. Both Gibberellic acid and Indolebutyric acid treatments required an additional 21 days for 100% rooting. In this instance injury to the base of the cutting was obvious in the Indolebutyric acid treatment, rooting generally taking place at the node immediately above the injured portion.

In Forsythia 80 ppm Indolebutyric acid in solution appeared to be the critical point. In the replicate lot of cuttings injury was such that rooting failed to take place completely. At 120 ppm IBA in solution all cuttings were dead or beyond recovery.

At the lowest concentrations used 10 ppm Gibberellic acid in solution and Indolebutyric acid 40 ppm in solution, maximum rooting was obtained in all instances including the control. In the second set of cuttings using the same concentrations Gibberellic acid treated cuttings had failed to root entirely at the time Indolebutyric acid cuttings had attained maximum rooting, but on resetting Gibberellic acid treated cuttings rooted to 85% in an additional 27 days.

At no time was the typical response to Gibberellic acid treatment apparent on cuttings of Ligustrum regardless of concentration used. In contrast to this semi-dormant hardwood cuttings of Ligustrum set December 13, 1957 after treatment with 40 ppm Gibberellic acid in solution for 24 hours showed the characteristic elongation of new shoots within seven days and showed marked elongation within two weeks, but failed to root completely. Softwood Forsythia cuttings failed to show the elongation response at the lowest concentration used (10 ppm in solution of Gibberellic acid) but showed moderate elongation over controls at the 20 ppm concentration and marked elongation at the 40 ppm concentration.

Where the elongation occurred in softwood cuttings rooting was decreased to a marked degree although up to the 20 ppm concentration rooting was carried out to a satisfactory level (85%) after resetting (44 days as opposed to 17 days for the control and Indolebutyric acid treatments).

Hardwood cuttings of Forsythia taken in February 1957 and treated with a 10 ppm solution of Gibberellic acid for 24 hours showed marked elongation of shoots within 7 days — formed a good callus pad at the base of the cuttings and in 41 days had begun to develop a few roots. Indolebutyric acid treatment at 40 ppm in solution gave 100% rooting in the same period, while controls had produced little callus and only a very few roots.

Talc treatments using Gibberellic acid and Indolebutyric acid in concentrations equal to those used in solution, failed to show any significant differences between treatments. This may be due possibly in part to the natural activity of talc and to the fact that concentrations of root inducing substances in talc are usually much higher than those used in this experiment. Rooting was consistently good in all talc treatments. Generally Gibberellic acid treatments at the higher concentrations (20 and 40 ppm in talc) had not reached maximum rooting at the time of removal of Indolebutyric acid and control treatments, but maximum rooting which was generally lower than IBA and control treatments (75-85% as opposed to 95-100%) was obtained within 7-10 days of other treatments.

At no concentration in talc was there any response in shoot elongation to Gibberellic acid treatment.

Microscopic examination of sections of fresh material taken at time of removal from the propagating bench showed no irregularities as to cell formation or arrangement. Primordia were evident on Gibberellic acid treatment lots as well as the control and IBA treatments. Root primordia appeared normal as compared with controls and IBA treatment though possibly not as well developed.

Microscopic photographs of various treatments were taken of cross sectional and longitudinal sections of the rooted portion of stems of both Forsythia and Ligustrum. No apparent differences were visible between one treatment and another. Callus was no more abundant with one treatment than with another with the exception of hardwood cuttings, as already mentioned in which case callus was quite evident on Gibberellic acid treatment while root development is much less than in IBA treatment.

Production of new roots is the most important factor in the ultimate establishment of a cutting provided the cutting itself will remain in a healthy functioning condition during the root initiation period. A count of primary roots produced, that is those originating directly from the stem was made, and an average taken from five cuttings.

In no case, using talc as the carrier was Gibberellic acid superior in number of primary roots produced than either Indolebutyric acid or talc alone. The average of totals of all talc treatments shows Indolebutyric acid as good as or better than other treatments in both Forsythia and Ligustrum while Gibberellic acid treatment average is lowest in both species.

In solution treatments using Ligustrum, in one case Gibberellic acid treatment at the 40 ppm level did give more primordia produced but the average was not consistent, as the replicate showed Indolebutyric acid with the higher level of primordia produced. In Forsythia in the treatments using 80 ppm IBA and 20 ppm Gibberellic acid, Indolebutyric acid treatments produced many more primary roots than either check or Gibberellic acid treatment. In average of total primary roots produced, Indolebutyric acid treatments in the case of Forsythia show much larger figures than either check or Gibberellic acid treatment.

SUMMARY AND CONCLUSIONS

Treatment of softwood cuttings with Gibberellic acid as relatively dilute concentrations (10-20-40 ppm) failed to produce a rooting response as compared with controls or dilute concentrations of Indolebutyric acid (40-80-120 ppm).

Forsythia cuttings were slightly injured at the 40 ppm concentration in solution of Gibberellic acid and the 80 ppm solution Indolebutyric acid. 120 ppm concentration of Indolebutyric acid was highly injurious to both Forsythia and Ligustrum.

The elongation of shoots, normally associated with Gibberellic acid treatment was not evident in any treatment of Ligustrum. At the lowest concentration (10 ppm) Forsythia showed no respose. At the higher concentrations 20 and 40 ppm, elongation of the growing point was evident and most pronounced at the highest concentration.

Both species responded by increased shoot growth when hardwood cuttings were used.

Due to the varied response of plants to treatment with Gibberellic acid it can be stated only that Forsythia 'Spring Glory and Ligustrum ovalifolium are not beneficially affected as to rooting response by treatment with Gibberellic acid. This information supports previous work by Marth, and would lead to a generalization that treatment of plant cuttings with Gibberellic acid has no effect on the rooting ability of the cutting and in some instances may show definite inhibition.

HUGH STEAVENSON: Our next speaker doesn't need any introduction. Bill Snyder has been mixing up some hormone formulations that may become as popular as the Gibson. At Rutgers he is known as synergism Snyder.

HORMONE-FUNGICIDE COMBINATIONS IN ROOTING

WILLIAM E. SNYDER
Department of Horticulture and Forestry
Rutgers, the State University
New Brunswick, N. J.

The propagator's search for chemicals to improve the rooting of stem cuttings has been directed primarily along two lines: first, chemicals which increase the rooting response itself; and second, chemicals which reduce the incidence of disease in the propagation bench.

With the discovery, in the mid-1930's, of the stimulating effect of indoleacetic acid and related compounds on rooting, it was hoped that successful rooting of all stem cuttings would be relatively easy. Such a naive idea, however, was soon expelled for, as was soon learned, the cuttings of many plants remained difficult to root even when treated with these chemicals.

There are numerous factors which contribute to a possibility of disease in the propagation bench. The use of soft, succulent plant tissue, the frequent presence of systemic diseases within the stock plant, the everpresent spores of fungi on the plant, in the air and the medium, the use of warm, humid conditions which are equally suitable for growth of both fungi and roots, and even the dipping or soaking methods frequently used to apply root-inducing chemicals to the cuttings — all of these pose a potential threat to successful rooting of cuttings.

It was only logical that investigations would be made involving the incorporation of a fungicide with the root-inducing chemical treatment.

In 1941, Grace (5, 6) and Grace and Farrar (7) added nutritive salts and an organic disinfectant, ethyl mercuric bromide, to the talc containing indolebutyric acid. Their data show that the disinfectant resulted in an increased rooting response with some plants (*Coleus, Chrysanthemum* and *Deutzia*), no effect with some plants (*Symphiocarpus, Lonicera* and *Taxus*), but with an increased mortality of at least one plant (*Weigela*).

Geranium and carnation cuttings are especially susceptible to fungus diseases. White (15) has shown that ferbam (ferric dimethyldithiocarbamate), sold as Fermate, Chromate, Ferberk, etc., used either alone or in combination with a root-inducing chemical not only significantly reduced the cutting and in some instances may show definite inhibition.

HUGH STEAVENSON: Our next speaker doesn't need any introduction. Bill Snyder has been mixing up some hormone formulations that may become as popular as the Gibson. At Rutgers he is known as synergism Snyder.

HORMONE-FUNGICIDE COMBINATIONS IN ROOTING

WILLIAM E. SNYDER
Department of Horticulture and Forestry
Rutgers, the State University
New Brunswick, N. J.

The propagator's search for chemicals to improve the rooting of stem cuttings has been directed primarily along two lines: first, chemicals which increase the rooting response itself; and second, chemicals which reduce the incidence of disease in the propagation bench.

With the discovery, in the mid-1930's, of the stimulating effect of indoleacetic acid and related compounds on rooting, it was hoped that successful rooting of all stem cuttings would be relatively easy. Such a naive idea, however, was soon expelled for, as was soon learned, the cuttings of many plants remained difficult to root even when treated with these chemicals.

There are numerous factors which contribute to a possibility of disease in the propagation bench. The use of soft, succulent plant tissue, the frequent presence of systemic diseases within the stock plant, the everpresent spores of fungi on the plant, in the air and the medium, the use of warm, humid conditions which are equally suitable for growth of both fungi and roots, and even the dipping or soaking methods frequently used to apply root-inducing chemicals to the cuttings — all of these pose a potential threat to successful rooting of cuttings.

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Geranium and carnation cuttings are especially susceptible to fungus diseases. White (15) has shown that ferbam (ferric dimethyldithiocarbamate), sold as Fermate, Chromate, Ferberk, etc., used either alone or in combination with a root-inducing chemical not only significantly reduced the number of dead or rooted cuttings, but also increased the percentage of healthy cuttings which rooted. Other workers have also reported beneficial effects of adding ferbam to the chemical treatment, for example: *Chamaecyparis Lawsonian Allumi* by Newton and Lines (12) ; *Taxus cuspidata* and *Viburnum tomentosum* by Snyder (13) ; carnation by Murakishi and Hendrix (10) ; and cyprus, tamarix, sequoia and English holly by Newton (11).

In a study of control of *Phomopsis* canker in gardenia, Davis (2) placed disease-free cuttings in *Phomopsis*-infested sand which had been mixed with ferbam at rates of ¼ to 2 pounds of dry powder per 100 pounds of sand. The cuttings remained free from *Phomopsis,* however, the higher concentrations of ferbam gave a slight, temporary retardation of root elongation.

Probably the most spectacular results with ferbam have been reported by Tinley with the rubber plant (*Hevea brasiliensis*) (14). Treatments with indolebutyric and naphthaleneacetic acids were not effective in stimulating rooting. Mixtures containing 75% ferbam and 25% talc, however, increased the rooting of one clone (BRIM 501) from 10 to 70% and of another clone (PB 86) from 78 to 100%. Other fungicides tested, including zeram, parzate and manzate, were less effective than ferbam.

Two closely related mercuric materials used as seed disinfectants (Ceresan and Semesan) were reported to be detrimental to rooting by Newton and Lines (12).

Dichlone (2,3-dichloro-1,4-naphthoquinone), sold as Phygon, was treated by Doran on cuttings of a wide range of ornamental plants (3). Cuttings treated with a root-inducing chemical and dichlone rooted better than untreated cuttings and, with a number of the plants tested, a combination of the growth regulant and fungicide gave superior results to treatments consisting of either of the materials used alone. A beneficial effect of dichlone has also been reported for cacao cuttings by Alvin and Durante (1) and Mora (9) and for olive cuttings by Hartmann (8).

Thiram (tetramethyl thiuram disulfide), sold as Arasan, Tersan and Thylate, has also been used effectively with *Chamaecyparis Lawsoniana Allumi* (12), carnation (10), and cyprus, tamarix, sequioa and English holly (11). At Rutgers, we have been using a mixture consisting of equal parts of thiram (75% active) and Hormodin No. 3 with algin as a suspension agent. Rooting of a wide range of florist and nursery crops has been equal to or superior to the use of powdered root-inducing treatments. Our cuttings have been remarkedly free of disease and rotting.

Captan (n-trichloromethylmercapto-4-cyclohexene-1, 2-dicarboximide), sold as Captan and Orthocide 58-W, mixed in the rooting medium at a rate of 100 to 150 grams per cubic meter or added to a powder containing 1% indolebutyric acid has been reported to improve the rooting of geranium cuttings (4).

The most extensive tests with fungicides in combination with root-inducing chemicals have been made at the Boskoop Experiment Station. The reports of these tests are contained in the Yearbooks for 1961 to 1965 in several articles prepared by Van Doesburg, Van Elk and Ravensberg (16-30). Cuttings of approximately seventy-five species or varieties of ornamental plants have been treated with growth regulators and fungicides both alone and in combination. The two fungicides used were captan and ferbam.

In these tests, conifer cuttings were soaked for 24 hours in the hormone solution and then dipped or dusted with the fungicides diluted with talc. Other cuttings were dipped or dusted with talc mixtures containing both the growth regulator and the fungicide. When used as a dusting on the base of the cuttings, the concentration of captan was 25% and of ferbam, 40%. Concentrations of 5% captan and 4 to 5% ferbam were used for dipping.

Although the rooting percentages and root ratings for some of the species show variation from year to year, in general, the combinations of growth regulator and fungicides have given comparable or better results compared with treatments of the growth regulator alone.

Based on the data presented in this series of reports, the following plants have shown the greatest response to the combination treatments:

Cornus alba sibirica
Laburnum Watereri vossii
Lonicera brownii fuchsioides
Rhododendron: 'America', 'Pink Pearl' and 'Van Weerden Poelman'
Chamaecyparis Lawsoniana: 'Naberi' and 'Stewartii'
C. nootkatensis: *glauca* and *pendula*
C. obtusa: *filicoides, lycopodioides* and *tetrangana aurea*
Juniperus chinensis: Ketelerri, Pfitzeriana, Pfitzeriana aurea and 'Skyrocket'
J. virginiana: Canaertii, Hillii and *pyramidiformis* Hillii
Tsuga canadensis pendula
T. chinensis

In a recent communication, Dr. D. Dorsman, Director of the Boskoop Experiment Station stated: "At the moment we only advise captan dust (dipping) powder for conifer cutings. The spraying powder seems too strong. Also with ferbam the number of rooted cuttings is not enlarged on long term."

The Hormo-Root series of commercial products now contain 15% thirma (tetramethyl thiuram disulfide), however at this time neither the Hormodin nor the Rootone series have incorporated a fungicide.

What, then, is the status of mixtures containing fungicides and growth regulants for rooting cuttings?

1. Most of the currently available fungicides have been tested. Dichlone, captan, thiram, and ferbam have generally been superior to other fungicides.
2. Although the use of these fungicides in combination with root-inducing chemicals have given somewhat variable responses, many species root as well as or better than when treated with only a root-inducing chemical.
3. Use of high concentration of the fungicides is often deleterious.
4. With some species, treatment with the fungicide alone apparently results in the stimulation of rooting. Results with combinations suggest that there may be a synergistic effect in some plants.
5. The use of a fungicide in the powder treatment cannot take the place of good cultural practices, such as the use of disease-free stock, sterilization of the cutting knife and the medium, and careful maintenance of the propagation structure and environment.

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A LIST OF FUNGICIDES WHICH HAVE BEEN USED IN COMBINATION WITH ROOT-INDUCING CHEMICALS

1. *CAPTAN* (n-trichloromethylmercapto-4-cyclohexene-1, 2-dicarboximide)
   Sold as: Captan
   Orthocide 58-W
2. *DICHLONE* (2,3-dichloro-1,4-naphthoquinone)
   Sold as: Phygon
3. *FERBAM* (ferric dimethyldithiocarbamate)
   Sold as: Fermate
   Karbam-black
   Chromate
   Niagara-carbamate
   Ferberk
4. *THIRAM* (tetramethyl thiuram disulfide)
   Sold as: Arasan
   Tersan
   Thylate
   Spotrete
5. *ZERAM* (zinc dimethyldithiocarbamate)
   Sold as: Zerlate
   Karbam-white

6. *ZINEB* (zinc ethylene bizdithiocarbamate)
Sold as: Parzate
Dithane Z 78
7. ... (tetrachloroquinone)
Sold as: Spergon
8. . (closely related mercury compounds)
Sold as: Ceresan
Semesan

MODERATOR STEAVENSON: Do we have any questions for the four previous speaker?

FLOYD FITTS: Mr. McGuire, isn't Carbowax 400 a solid at room temperature?

JOHN MCGUIRE: No, the higher numbers are solid, this one is a liquid at room temperature.

MODERATOR STEAVENSON: Our next speaker is Walter Peffer, one of our old and faithful members, who I believe attended the first meeting of the Society.

GROWING RHODODENDRONS WITH THE AID OF MERCURY VAPOR LIGHTS

WALTER PEFFER
Level Green Nursery, Trafford, Pa.
Eastern Shore Nursery of Va., Inc. Keller, Va.

During the past five years I have experimented with various methods and systems for growing Rhododendrons in the greenhouse with the aid of artificial light.

In October 1965 I purchased a newly developed 100 watt Westinghouse Viscount Mercury Vapor Light, no. 890D569G33, for experimental purposes. The Mercury Vapor Light, according to the electromagnetic spectrum consists of 20% ultra violet rays from bactercidal of 2.500 angstrom units through the erythemal and black light to 3,800 angstroms. These rays do not produce energy. The remaining 80% of light which is energized are the visible rays of 3 800 to 5,800 angstroms. From this information it can be concluded that the mercury light contains more natural sunlight than any other artificial device. Infrared rays are present in small quanities.

Mercury Vapor Lights of higher intensity are also available, for example, Westinghouse no. 890D569G43 175 watt and no. 890D569G53 250 watt.

The plastic shield which is included with the lamp was discarded and an aluminum cone shaped shield was fabricated. This shield was placed in proximity to the rafters of the greenhouse in order to give a uniform distribution of light.

A ¼″ rope was fastened to the fixture, drawn through a pulley which was anchored in the apex of the greenhouse, and then taken down a rafter to a holding device at the side of the

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A ¼″ rope was fastened to the fixture, drawn through a pulley which was anchored in the apex of the greenhouse, and then taken down a rafter to a holding device at the side of the house. By raising and lowering the rope, the lamp can be set at different positions. Light meter readings were taken at various settings to determine the most effective concentration of light at bench level heights.

Directly under the light, 4½′ from the plants to the base of the light 35 foot-candles of light were observed. From this point horizontal readings were taken in one foot intervals to a distance of eight feet (half the with of the greenhouse) where 15 foot-candles were observed.

Approximately 1000 Rhododendrons were grown with the aid of the Mercury lamp. Varieties grown were; Roseum Elegans, Catabiense Grandiflora, Everestianum, Album Novum Nova Zembla, and America. The reds were slower to respond than the other varieties.

In the first week of September 1965 and in 1966 some Rhododendrons cuttings were propagated in the usual manner and others placed under the Mercury lamps. The plants in the latter group not only rooted faster but also had heavier root structure.

Rooted Rhododendrons were transplanted in the greenhouse the first week of December and the lights were in operation from 8 P.M. to 5 A.M.; the lights are controlled by a poultry house timer.

Three weeks after transplanting activity was noted in the leaf buds, especially in the twelve foot circle directly under the light. One week later the remaining plants in the sixteen foot diameter began to grow. Two weeks later there was noted plant growth at the ends of the benches where 8 foot-candles of power were recorded.

In summarization the advantages of the Mercury Vapor light are:

1. Simple and safe installation. The hazzard of possible shock through use of wires required in fluorescent and incandescent lights is eliminated.
2. Single lights can be mounted to cover 16′ width and 24′ centers between lights for the length of the greenhouse.
3. Economical; 100 watts can produce the same results as 1200 watts used in combination of fluorescent and incandescent lighting.
4. Plants seem to have more bud breaks, better color, and normal elongation.
5. Airbourne bacteria is destroyed by the low light wave.

In order to arrive at a true evaluation experiments are now in progress using various types of lights, including the Mercury light.

I have in my possession an Electromagnetic Spectrum chart which shows complete graphs and colors of all types of lights and will be happy to discuss any technical details with any one interested at the close of this afternoon's session.

HUGH STEAVENSON: You've heard your next speaker before and he was so good he was asked to come back again this year. Dr. Harrison Flint.

TESTING LANDSCAPE PLANTS FOR HARDINESS IN VERMONT'S CLIMATIC ZONES[1]

HARRISON L. FLINT[2]
Department of Plant and Soil Science
University of Vermont

This program was started in 1962, shortly after I arrived at the University of Vermont. At that time it was apparent that one of Vermont's greatest horticultural needs was more accurate information on the hardiness of some of the better landscape plants. A testing program started at the University of Vermont ten years earlier had been carried on actively for three years, and then had lain dormant because of a personnel change.

For such a program to be of value to the majority of people in the state, it was necessary to test not only at the University of Vermont (in the Lake Champlain Valley) but in other parts of the state as well, since Vermont includes a range of average annual minimum temperatures from -10 to -15° F. in the southeastern corner, to -30 to -35°F. in the northeastern corner.

Fortunately, quite a number of species had been observed previouly in Vermont, due to the efforts of local nurserymen and other people willing to experiment with new plants. Additional information was available from arboreta in other areas having a climate at least roughly similar to that of Vermont, including the Arboretum of the Canada Department of Agriculture in Ottawa, the Montreal Botanical Garden, the George Landis Arboretum, and the University of Minnesota Landscape Arboretum. Information from such sources narrowed the selection of test species and enabled us to include species whose hardiness was most in doubt.

Cooperators were selected by invitation, to insure a good sampling from the hardiness zones in question. In the spring of 1963, the first plants were distributed. From the beginning of the program until July 1, 1966, approximately 2800 individual plants were distributed for trial. These represented 157 taxa, and were distributed to a total of 43 cooperators. A list of taxa, including the number of cooperators testing each and the number of plants under test, is available from the author.

Most of the plants distributed were propagated at the research greenhouses of the University of Vermont and were grown outdoors in pots to a size where they could be planted in final location. During this time they were over-wintered

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[1] University of Vermont Agricultural Experiment Station Journal Article No 174
[2] Present address Arnold Arboretum, Jamaica Plain, Massachusetts

in a frost-free greenhouse to eliminate any possibility of winter damage before distribution. Most were distributed when they were well-established in a one-half or one-gallon size pot. Plants were distributed in late spring to allow them nearly a full season in which to grow and become established before the first winter. Since many cooperators did not have nursery facilities it would not have been practical to use smaller plants.

Each winter a checklist of available plants was sent to the cooperators, who then checked those they were interested in testing. Distribution lists were prepared from the responses. In this way, once the cooperators were selected, the entire program was kept on a voluntary basis. Cooperators were not asked to prepare written reports. Instead, University personnel made observations annually at the time new plants were distributed.

One of the secondary benefits of this kind of work is that those engaged in the field work have an opportunity to observe existing landscape plantings in the hardiness zones in question. The comments below are based more upon observations of existing plantings then upon results of the tests in this program. Obviously, a program so young cannot have had enough time to furnish much reliable information. Most of the results will be be seen in following years. Hardiness zones designations following each plant description are those currently recommended in Vermont[1], and are subject to revision as the range of useful hardiness of some is extended into colder areas.

SLIDE PRESENTATION:

1. *Pyracantha* 'Kazan' When I first arrived in Vermont, the last plant I expected ever to have use for again was *Pyracantha.* Then I made a visit to Gardenside Nurseries at Shelburne, Vermont, south of Burlington, and found a plant of *Pyracantha* 'Kazan' that was considerably taller and wider than I am. Some of the staff of the Arnold Arboretum had thought for some time that this cultivar might be hardier than most. We propagated it and distributed more than two hundred plants to Vermont nurseries. To date it has done well in almost every location. Zone 4B. Other cultivars of *Pyracantha* have not been tested. Perhaps some of these will be found equally useful.

2. *Euonymus alata* is known to be exteremely hardy and is a fine shrub for fall and winter interest. Zone 4A. The point here is that the compact form, *Euonymus alata* 'Compacta', is considerably less hardy than the species. In central Vermont (Zone 4A[1]), this plant is killed back every year — in some years nearly to the ground.

3. *Elsholtzia stauntonii* is killed to the ground every winter in Vermont but this doesn't keep it from being a useful

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[1] U S D A Plant Hardiness Zone Map

and interesting plant. A member of the mist family. Elsholtzia has the fragrant foliage that one would expect, and the happy habit of waiting until September to flower. Because of winter damage it remains a low shrub — not a disadvantage today. Zone 4B.

4. *Prunus* 'Hally Jolivette' is one of the best and hardiest flowering cherries. While this plant is not as showy as some of the Japanese flowering cerries, it holds its flowers much longer. When the first flowers to open have passed, there are still unopened flower buds on the plant. In Burlington, the plant is reasonably showy for 2 to 3 weeks. Zone 5A.

5. *Viburnum fragrans* is both a surprise and a puzzle. This plant has long been considered none-too-hardy in parts of southern New England and it is especially prone to late spring frosts because it flowers so early. But it has been growing and flowering very well in Shelburne, Vermont. It has now been distributed to many other parts of the state and will bear watching further as time goes on. Apparently one important factor in its success is that it must be planted in perfectly drained soil. Zone 5A.

Viburnum species known to be fully hardy in Vermont include: *V. acerifolium, V. alnifolium, V. cassinoides, V. dentatum, V. lantana, V. lentago, V. opulus, V. prunifolium* and *V. trilobum.* Others hardy in all but the coldest parts are: *V. burkwoodii, V. carlesii,* and *V. sieboldii.* More than 40 species and varieties of *Viburnum* are currently under test at the University of Vermont.

6. *Rhododendron calendulaceum* and some of its hybrids are proving hardy in central Vermont. Zone 4 B.

Other azaleas that are hardy in the coldest parts of Vermont include three natives: *Rhododendron canadense,* Rhodora, *Rhododendron roseum,* Roseshell Azaleas or Mountain Pink, and *Rhododendron viscosum,* the Swamp Azalea. Others that are hardy in all but the very coldest parts of the state include *Rhododendron japonicum* and *Rhododendron nudiflorum.* Still others that have proved useful in the mildest parts of Vermont include *Rhododendron kosterianum, Rhododendron vaseyi* and *Rhododendron schlippenbachii,* although the latter frequently loses its flower buds to spring frosts even in the warmer parts of the state.

7. *Pyrus calleryana* 'Bradford' has been very successful in the Champlain Valley thus far, although the oldest plants observed are between 10 and 15 years old. It appears that this may be just as fine a small shade tree in Vermont as it has been reported to be farther south. Zone 5A.

8. *Acer ginnala* is one of the hardiest small trees. It often takes a few years to begin to assume its interesting roundheaded shape, but when it does, it is outstanding. Both its form and the red color of its fruits are quite variable among individual plants, but all that we've seen have good scarlet fall foliage. It would probably be useful to select outstanding

variant forms and propagate them vegetatively — this maple is easily propagated by cuttings. Zone 3 B and colder.

9. *Castanea mollissima*, the Chinese chestnut, has been a topic of conversation among plantsmen in recent years, since it and its hybrids are expected to be the source of future edible chestnuts in this country. Growing seasons in Vermont are seldom long enough to allow nuts to mature. However, this does not detract from the ornamental value of the tree, and we may see it used more in the warmer parts of the state. Zone 5 B.

10. *Cladrastis lutea*. This American native has been tried very little in northern New England but has been perfectly hardy for 15 years in Burlington, Vermont, and is a welcome addition to the list of shade trees for northern areas. Zone 5A.

11. *Magnolia soulangiana* is doing very well in the Champlain Valley in areas having good air drainage. Remember that the Champlain Valley is prime apple-growing country, and not especially prone to late spring frosts. Zone 5A.

12. *Phellodendron amurense* is native to the Amur River border region between Manchuria and Siberia, where temperatures fall far lower than in northern New England. Once established, this tree is successful, but vigorous young plants can be injured by early fall freezes. Zones 3B.

13. *Syringa amurensis japonica*, the Japanese Tree Lilac, is one of the finest small ornamental trees and has done well for many years in even the coldest parts of Vermont. Zone 4A.

14. *Sorbus alnifolia*, the Korean Mountain Ash, is considered by some to be the finest species of *Sorbus* available. It has an interesting broad pyramidal habit, long lasting red-orange fruits and good orange fall foliage color, and seems to be highly resistant to borer attack. The limits of its hardiness have not been too well known but it is growing well in Ottawa, Canada, and is currently under test in western Vermont. Zone 4B.

15. *Pinus nigra*, the Austrian Pine, is one of the finest evergreen trees in Vermont. It is especially useful for windbreaks or large-scale hedgerows and may find more use in highway planting, along with the native Red Pine, *Pinus resinosa*. Zone 4A.

16. *Mahonia aquifolium*, the Oregon Hollygrape, has been very successful in certain parts of Vermont, especially where it is protected by reliable snow cover. It has been observed in quite a few spots in the south-eastern and east-central parts of the state and is now under test and so far doing well in the Champlain Valley. Zone 5A.

17. *Pieris floribunda*, the Mountain Andromeda, seems to be perfectly hardy in much of Vermont. Zone 4 B. The Japanese Andromeda, *Pieris japonica*, has not been successful.

18. *Rhododendron catawbiense* is perhaps the hardiest species of large-flowered *Rhododendron* and has been observed doing reasonably well even in areas frequently experiencing

35 degrees below zero. Zone 4A. Exposure is important for many rhododendrons in many areas, but it becomes especially important on the fringes of the useful hardiness ranges. Other species of *Rhododendron* doing well in the warmer parts of the state are *R. mucronulatum* and *R. smirnowii.*

19. *Rhododendron maximum,* the *Rosebay Rhododendron* is native to Vermont and is found in one colony as far north as Troy, just a few miles from the Canadian border. It grows under a partial forest canopy, however, and when brought out into cultivation sometimes winterburns severely in exposed spots. If placed in protected spots, it does well in cultivation, but is not outstanding as an ornamental. Zone 4A.

HUGH STEAVENSON: Thank you Dr. Flint for that beautiful and informative talk. Unfortunately the next speaker shown on your program, Mr. Maurice Wilsey, could not be with us. But we have what I like to think of as a second generation Harvey Templeton, Mr. Werner Rexer.

AQUA-VAPOR CONTROL

WERNER REXER
LaSalle, Ontario, Canada

Based on the principal of contraction and expansion of a special type of cordage, is the new misting and watering device, known as the Aqua-Vapor Control. The cordage in the wet stage, is approximately two percent shorter as compared when dry. (See Figure 1.) The control is equipped with a subminiature microswitch of one ounce release force rated at a maximum of 5 amperes and 250 volts. It has a life expectancy of over ten million on-off operations and is completely enclosed in a waterproof housing. A plunger connected to the cordage actuates the microswitch through a diaphragm. (See Figure 2.). The total travel required is five one thousandths of a inch. The contraction and expansion of the cordage is one eighth of an inch when changing from a wet to a dry condition. This allows for variation caused by heat or cold, and makes the unit self adjustable. The control is hooked up directly to the curent of any type and to a solenoid valve, or a motor and pump. In the latter case, a relay is necessary.

The adjustments are made by placing the control in various locations from the mist nozzle, it is designed to range from 5 to 30 seconds on at any one time. The off or drying period is the same as that of the cuttings; in hot, dry surroundings with high light intensity it may operate as many as 40 times an hour, or as little as once every two or three hours on a rainy cool day, or at night. Further adjustments can be made by covering part or all but one of the holes of the perforated tube. This extends both the on and the drying period. One hole must remain open to receive the mist.

For hardening off, all the holes on top and the side away

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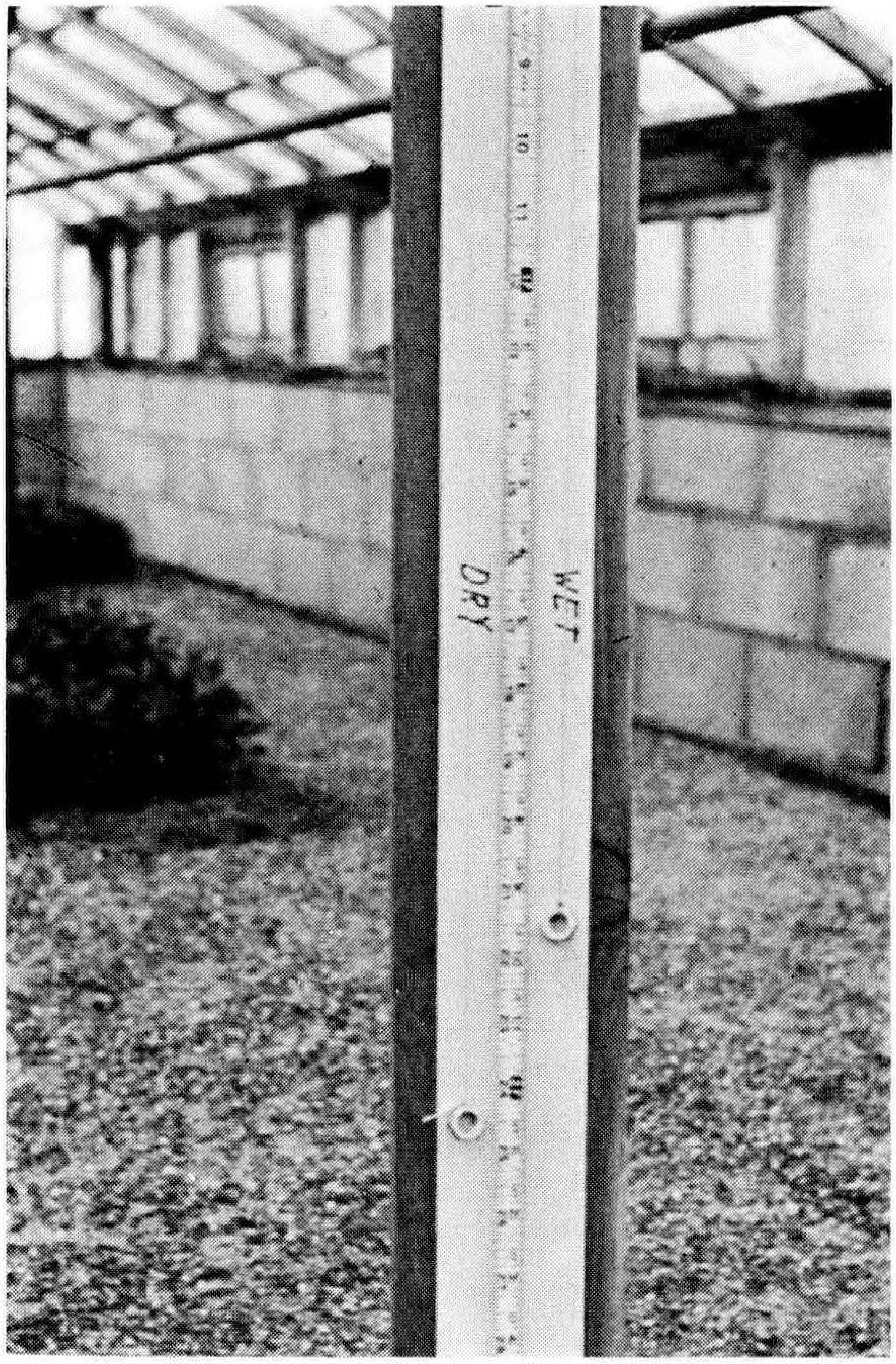


Figure 1. A demonstration of the effect of moisture on special cordage used in the aqua-vapor control.

from the mist nozzle are covered. The holes facing the mist nozzle are left open and this will greatly extend the period between mistings.

An additional sleeve, still in the developmental stage, will cover all of the holes of the perforated tube in such a way that it will be dustproof but will allow moisture to penetrate. Then the control unit can be buried at various depths in the soil for automatic irrigation.

I have considered every angle in the design, and construction of this control, so it can be used for every type of misting and irrigation. It also is designed many times stronger and safer than necessary. It has been under test since April 1966 and even the most primitively constructed unit has yet to fail. Theoretically it has a life expectancy of well over one hundred years when used continuously. The only maintenance required is when dirty water is used or when heavy deposits of minerals cover the cordage. This, however, should be of no concern since the on and off periods will slowly extend, which would be noticeable a month in advance of failure. The deposits can be removed by dipping the control into a dry cleaning fluid or by sending it to the dry cleaner.

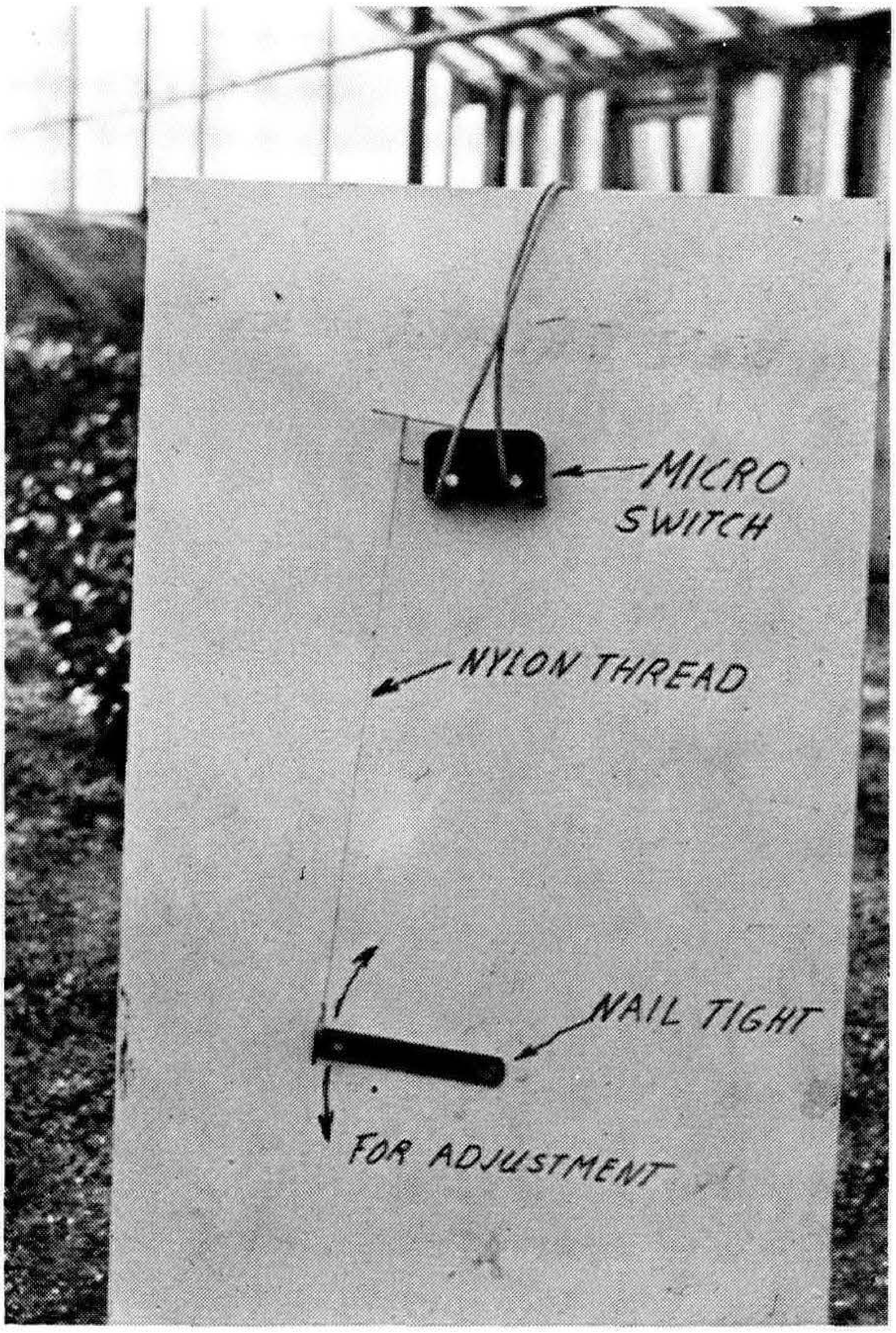


Figure 2. Principles of operation of aqua-vapor control.

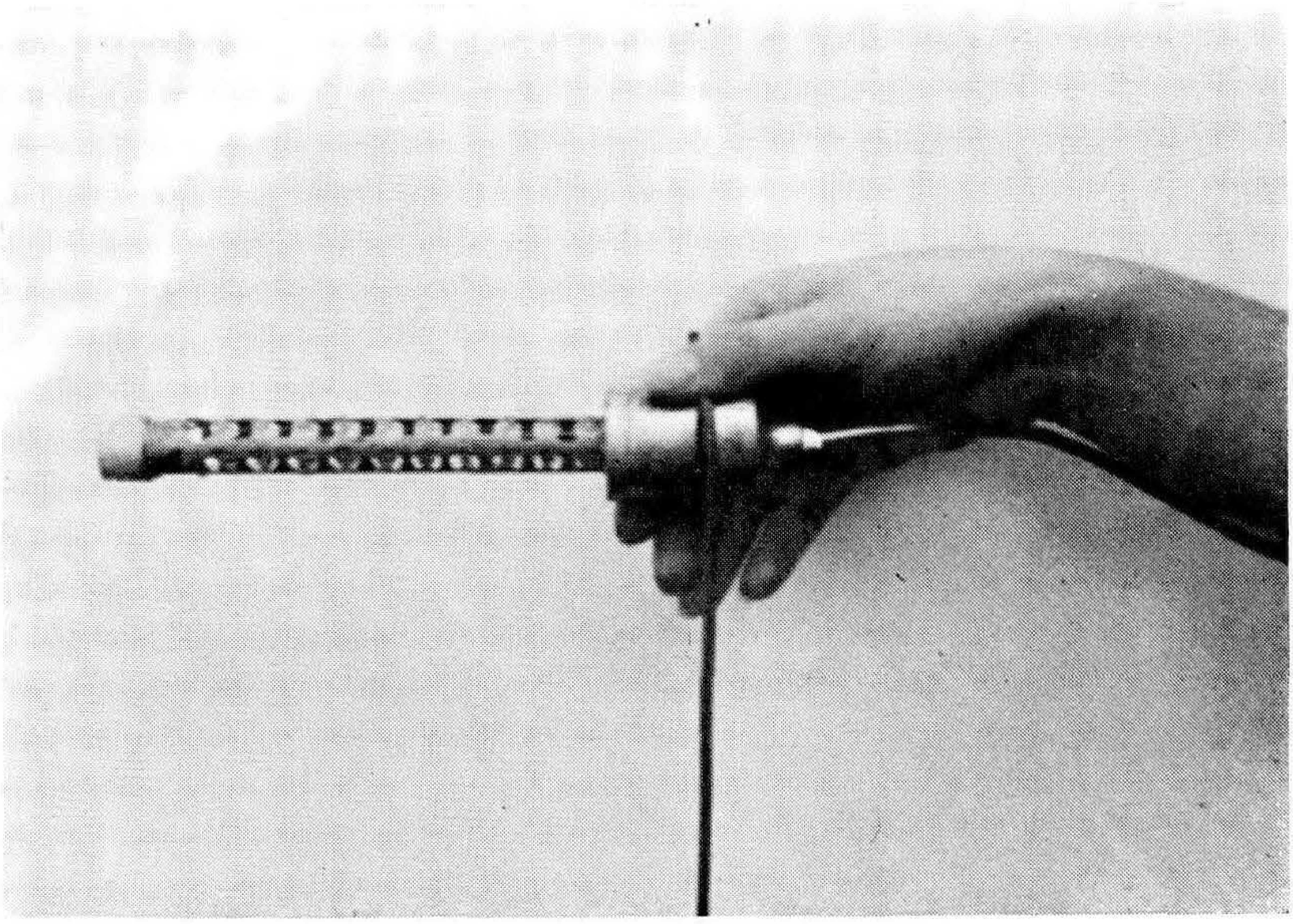


Figure 3. A finished model of the aqua-vapor control.

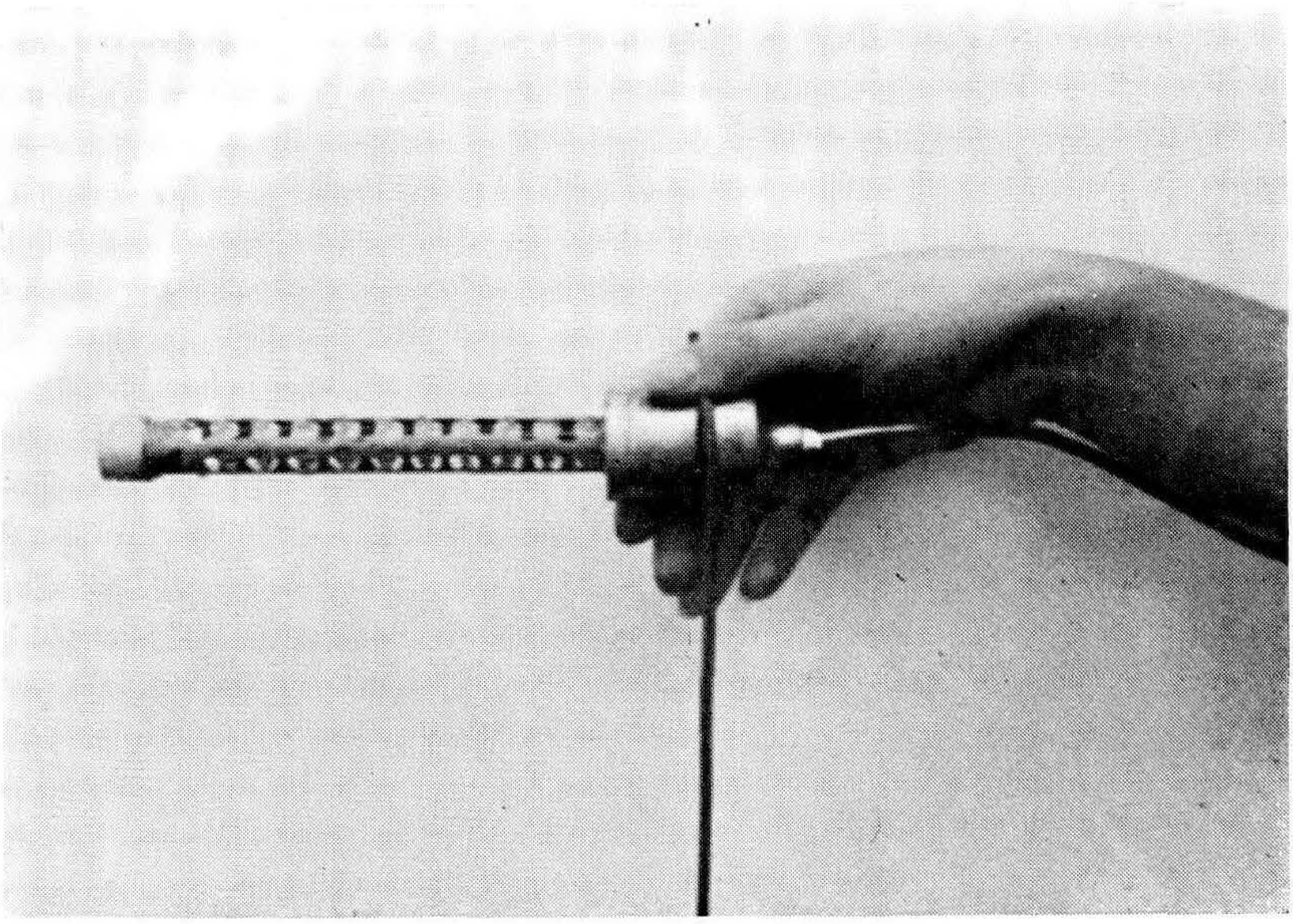
STU NELSON: Our next subject is one which stimulated much discussion last year — DMSO. To lead off the discussion this afternoon is Dr. Len Stoltz.

EFFECT OF DIMETHYLSULFOXIDE(DMSO) AND TOBACCO SMOKE EXTRACT (TSE) ON ROOT INITIATION

LEONARD P. STOLTZ
Department of Horticulture
University of Kentucky
Lexington, Kentucky

While working in Dr. Hess' lab I discovered that tobacco smoke blown into a piece of filter paper had a strong root initiating effect on mung beans which are used in the rooting bioassay developed by Hess (1). Later tobacco smoke extract which had been prepared by collecting the smoke in a cold trap from machines which automatically smoke the cigarettes was purchased and used. On the average 50 cigarettes yields 1 gram of tar.

In order to obtain an indication of the strength of the root initiation effect one gram of TSE was dissolved in 10 ml of methyl alcohol. A serial dilution was prapared by reducing to one-half the amount of TSE for seven dilutions; the last dilution contained 1/128 as much as the first. Twenty lambda of each extract was spotted on filter paper and tested using Hess' mung bean rooting bioassay. In this case 1 on



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When TSE is chromatographed in different solvents the active fraction moves to the same area of the chromatogram as does Hess' cofactor 4. Because of this and its physiological activities the two are considered to be the same or very similar in chemical make up.

TSE also promotes the growth of oat mesocotyl sections using the methods of Nitsch and Nitsch (2). The material which promotes oat mesocotyl section occurs at Rf 0.4 to 0.5 while the fraction which promotes root initiation occurs at Rf 0.8 to 0.95.

Because of the striking root and growth promotive effects of TSE I was curious as to whether this material might be of value in the propagation of difficult-to-root cuttings. Preliminary tests using TSE alone showed no striking effect on the rooting of coleus, chryanthemum or hibiscus.

Dimethylsulfoxide (DMSO) is reportedly effective in aiding the movement of various materials across plant and especially animal tissues. The failure of TSE in the preliminary tests to influence rooting could have been the result of its inability to cross membranes and move to its site of action. Therefore DMSO alone and in combination with auxins and TSE were tested on the rooting of mung bean particularly a difficult-to-root Chrysanthemum variety Mrs. Roy.[1] DMSO at

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[1] The author expresses his gratitude to Yoder Bros., Inc., Barberton, Ohio who furnished the the Chrysanthemum cuttings, varieties Mrs Roy and Bright Golden Anne used in these studies

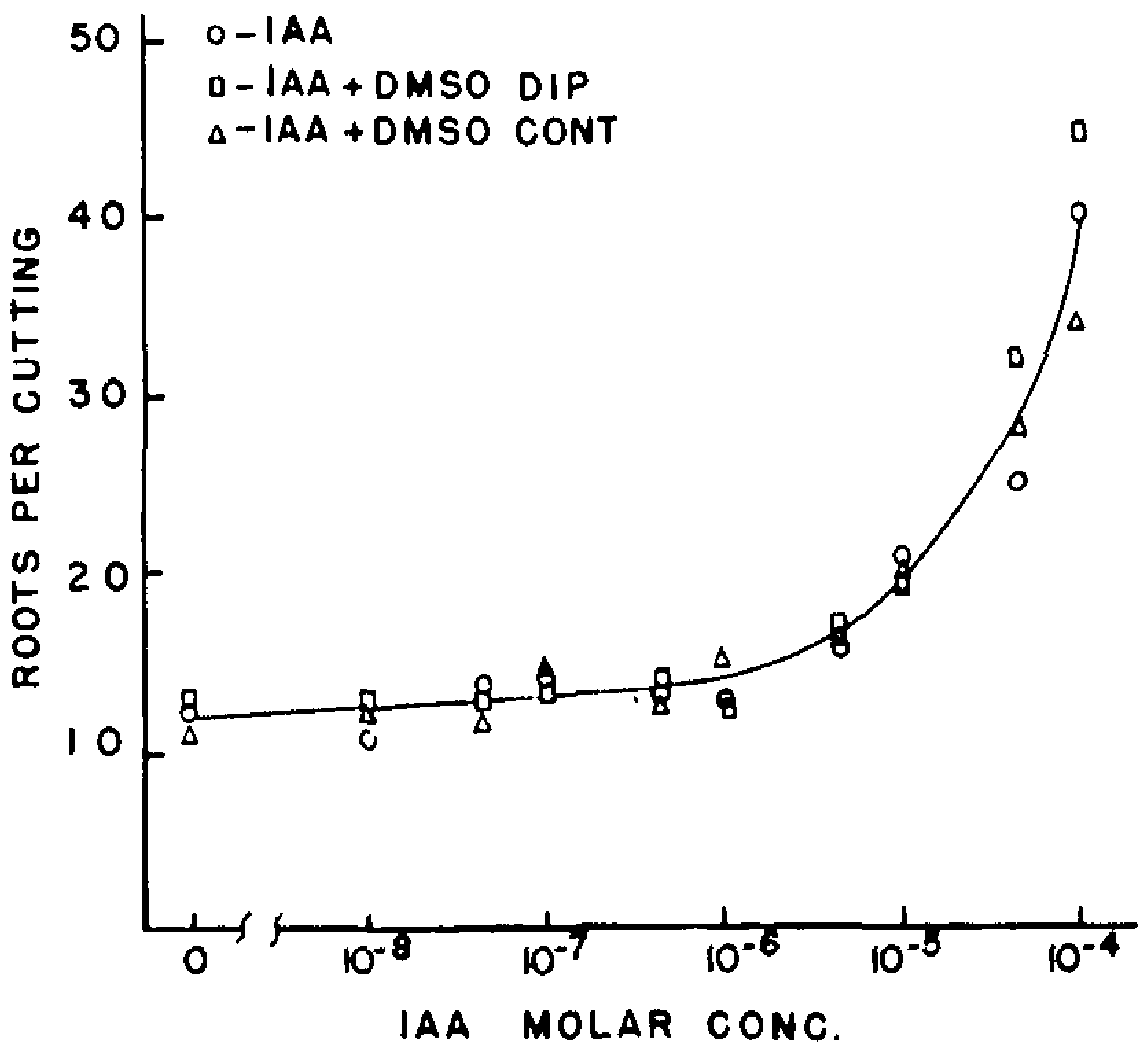

Figure 1 Root initiation of mung beans when treated with several concentrations of IAA. O-IAA supplied alone, O-IAA plus, 5% DMSO as a dip treatment and O-IAA and 50 ppm DMSO supplied continuously to the cuttings.

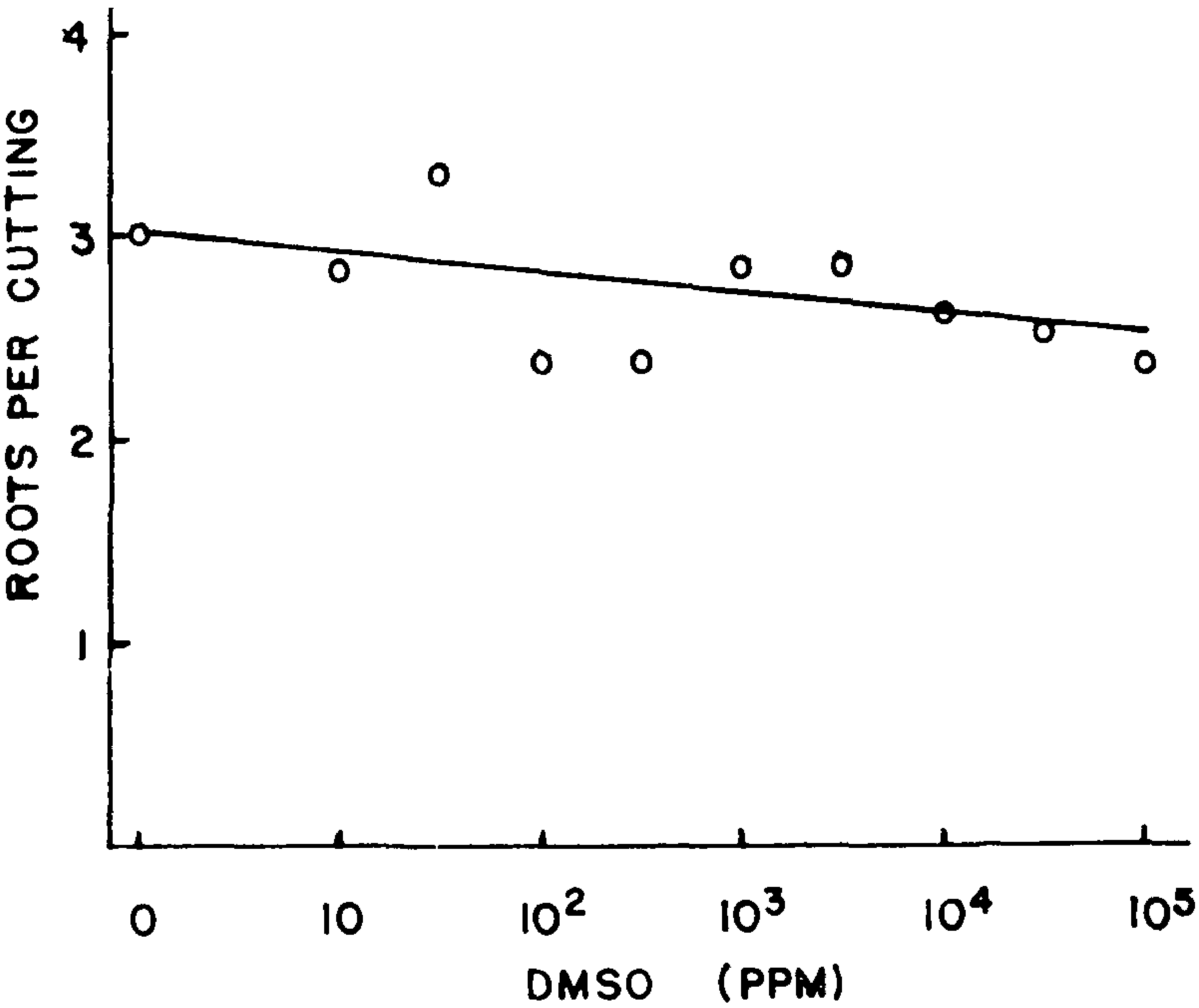

Figure 2 Root initiation response of Chrysanthemum variety Mrs Roy as a result of dipping the basal ends of the cuttings into several concentrations of DMSO

1000 ppm and above was toxic when supplied continuously to mung beans but no deleterious effects were observed up to 100,000 ppm (10%) when the cuttings were dipped into it and transferred to vials of water for rooting.

Indoleacetic acid with and without DMSO was first tested on mung bean seedlings to determine if the DMSO promoted the effects of IAA. No promotive effect was found. The results are presented graphically in Figure 1.

In the next series of tests only the difficult-to-root Chrysanthemum variety Mrs. Roy was used. In the first test the base of the cuttings were dipped in DMSO and the cuttings were stuck in a mist propagation bed for rooting. DMSO at 10, 10^2, 10^3, 10^4 and 10^5 ppm was used. There was a slight depression of roots per cutting as the concentration of DMSO increased. See Figure 2.

The auxin and rooting cofactor activities of extracts of the basal portions of the Chrysanthemum cuttings used in the next 3 tests were determined. The auxin activity was about the same for each group of cuttings of Mrs. Roy used and showed little difference from the easy-to-root variety, Bright Golden Anne, which was assayed to determine if auxin content alone could account for the reduced rooting response of Mrs. Roy.

The second test was undertaken to determine if 10% DMSO used as a carrier for indolebutyric acid (IBA) would increase the rooting response of Mrs. Roy cuttings. Concentrations of 100, 500, 1000 and 2000 ppm IBA were used. The number of roots per cutting increased as the concentration of IBA increased but DMSO had no enhancing effect and is considered to have had a slight inhibitory effect. See Figure 3. The rooting cofactor activity of the basal stem portion of Mrs. Roy cuttings was low compared to that in the easy-to-root variety but the leaves of Mrs. Roy showed greater amounts of cofactor 4 than the leaves of Bright Golden Anne. Thus in the stem area where rooting occurs there is a lesser concentration of rooting cofactor 4.

In the third test the basal ½" of cuttings of Mrs. Roy were dipped in 50% alcoholic solution solutions of TSE with and without 10% DMSO. Some increase in rooting occurred as the concentration of TSE increased but this amounted to on-

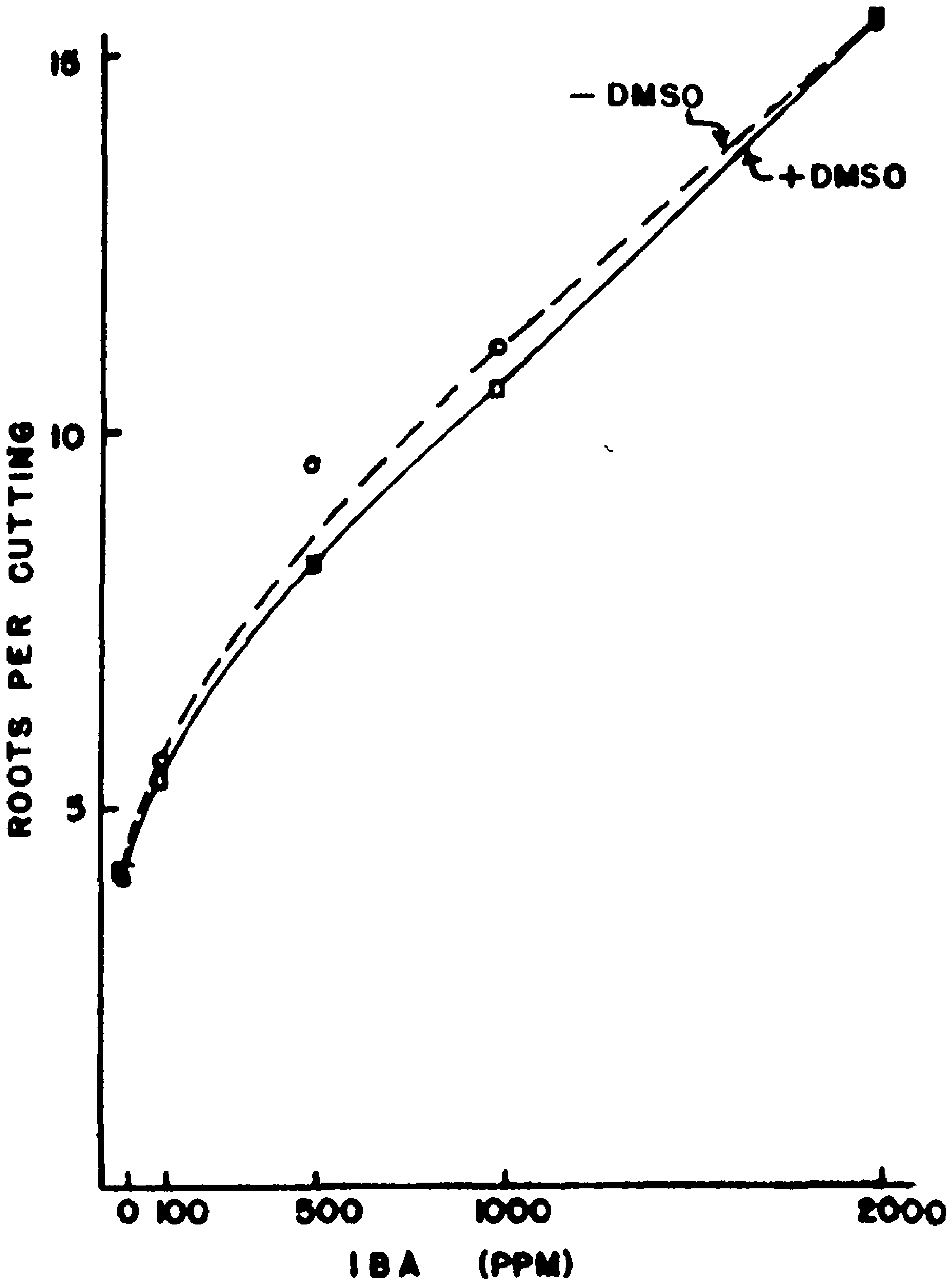

Figure 3. Root initiation of Chrysanthemum variety Mrs. Roy when treated with several concentrations of IBA alone and IBA plus 10% DMSO.

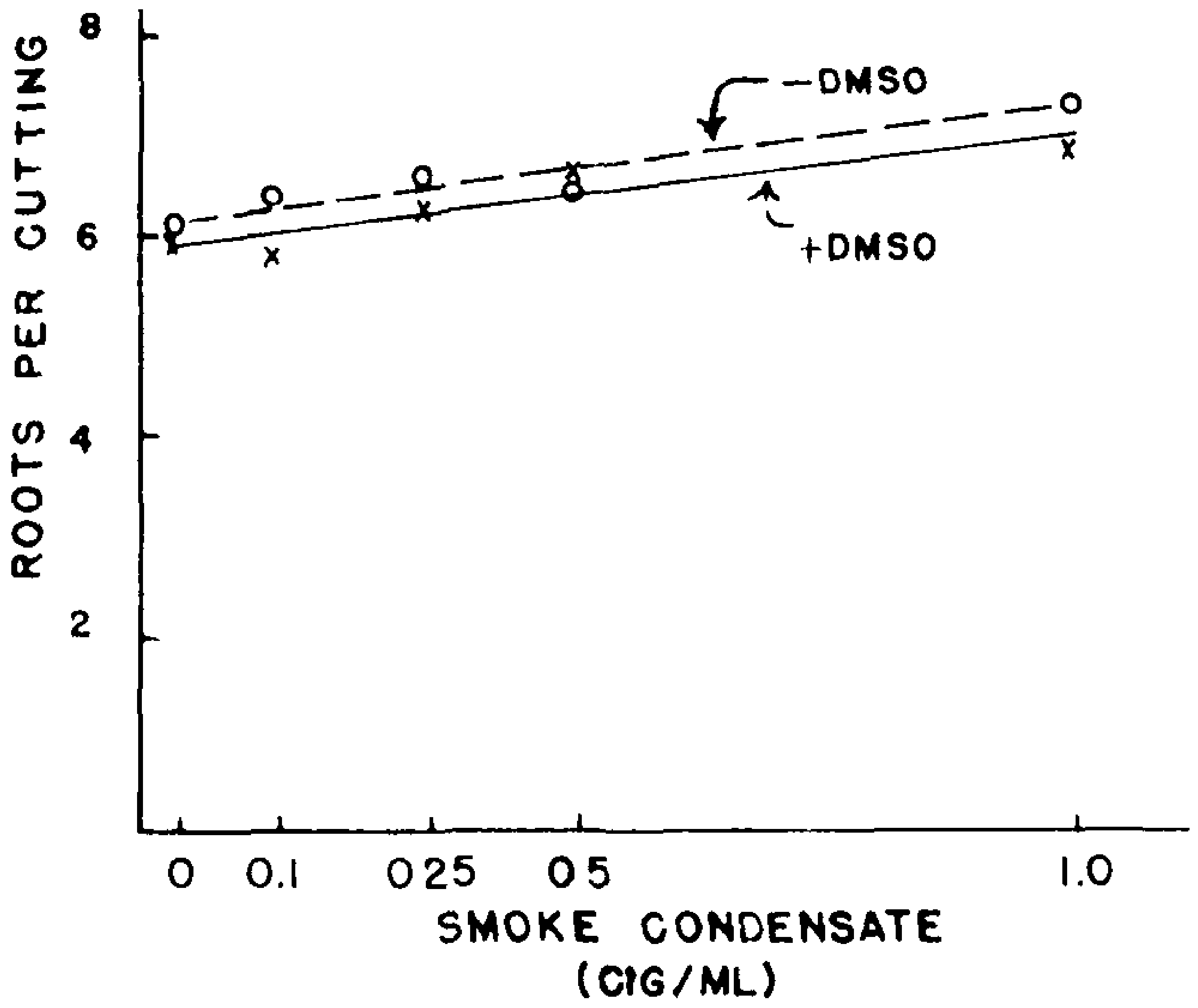

Figure 4 Root initiation of Chrysanthemum variety Mrs Roy when treated with several concentrations of tobacco smoke condensate alone and with 10% DMSO

ly one root per cutting at the highest concentration used. See Figure 4. DMSO appeared to be slightly inhibitory. The cofactor 4 concentration in the stem tissue of Mrs. Roy cuttings was only slightly less than that in the Bright Golden Anne. As previously noted the auxin contents of these two varieties were also about equal in each test. In this case the Mrs. Roy and Bright Golden Anne each had about the same relative amounts of cofactors and auxin yet Bright Golden Anne had an average of 27 roots per cutting while Mrs. Roy had only 7 roots per cutting. This indicates that some factor other than auxin and cofactors is limiting in the cuttings of Mrs. Roy. This became more clear when the results of the fourth test were completed. The rooting cofactor activity of the basal stems of this group of Mrs. Roy cuttings was the lowest of all. Therefore one would assume that if cofactor 4 was the limiting factor these cuttings would exhibit the lowest rooting and be more likely to respond to applied cofactor 4.

In the fourth test the cuttings were allowed to take up TSE with and without 1000 ppm DMSO for 14 hours before being stuck in the mist bed. No promotion by TSE with or without DMSO occurred and the higher concentrations used gave reduced rooting. The interesting fact noted in this case was that rather than having the lowest rooting response, as might be predicted from the cofactor and auxin bioassays, the untreated cuttings in this group averaged 13 roots per cutting. The mum rooting tests were run in March, April, May and

June respectively. Since daylength was increasing during this time it is assumed that carbohydrate content would also be increasing. Stoltz and Hess (3,4) have shown a direct relationship between both cofactor 4 and carbohydrates in the rooting of girdled Hibiscus cuttings. It is proposed that in the tests reported here the rooting of Mrs. Roy cuttings was related to the carbohydrate content more so than to the cofactor or auxin content. However the number of roots per cutting of Mrs. Roy is still considerably less than that of the easy-to-root variety Bright Golden Anne and some factor other than carbohydrates, auxin and rooting cofactors is involved in its reduced root initiation response.

The conclusions drawn from the tests reported here are as follows:

1. DMSO causes a slight inhibition of root initiation in cuttings of mung bean and Chrysanthemum variety Mrs. Roy.
2. TSE causes pronounced root initiation in cuttings of mung bean but fails to give any response when applied to cuttings of Chrysanthemum variety Mrs. Roy.
3. Some factor(s) other than auxin, rooting cofactors and carbohydrates appear to be responsible for the reduced root initiation in Chrysanthemum variety Mrs. Roy.

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HUGH STEAVENSON: Thank you very much for that very interesting research report. Our next speaker is Dr. Booker Whatley.

THE EFFECTS OF NUTRIENT SOLUTION, FOLIAR SPRAY, 3-INDOLEBUTYRIC ACID AND DIMETHYL SULFOXIDE (DMSO) ON ROOTING OF HIBISCUS SYRIACUS

BOOKER T. WHATLEY, STANLEY O. THOMPSON
AND GEORGE WILLIAMS, JR.
Southern University
Baton Rouge, Louisiana [1,2,3,4]

Growing plants in nutrient solutions or aggregates moistened with nutrient solutions is by no means a recent development. In 1699 Woodward (6,9) grew plants in media such as spring rain, river, and distilled water to which he added garden soil. He observed a positive correlation between growth of plants and the amount of soil in the various media. These crude experiments represented the beginning of attempts by scientists to determine the nutrient requirements of plants. Very little additional study was reported in this field until Sachs, Knop, and Nobbe from 1859 to 1865 developed the general procedure for growing plants in aqueous culture solution. Knop later proposed a solution that has been widely used in the study of plant nutrition. Nutrient solutions have been proposed by Shive, Hoagland and many others (3,6,8). These studies provided experimental verification for the early theories that plants were made up of chemical elements secured from water, soil and air (5).

We have employed solution culture or hydroponics to study the effects of various factors on rooting of *Hibiscus Syriacus*. Bailey (2) described this plant as being nearly or quite glabrous, an erect-growing shrub ten to twenty feet in height, which is hardy in the northern states. The plant is grown for its summer and autumn bell-shaped flowers.

Dimethyl sulfoxide (DMSO) is presently being intensively investigated in both zoology and botany. Great interest has been shown in the possible use of this solvent in medicine and agriculture. DMSO, made from a by-product of the paper manufacturing industry, was synthesized in Germany in 1867 (1); however, no use was found for it until 10 or 15 years ago. Currently it is principally used as a solvent in the production of synthetic fibers. It is a good solvent for many organic chemicals and inorganic salts which it apparently has the capacity to transport in plants and animals. This characteristic seem to suggest that DMSO may act as a vehicle to carry substances "piggy-back" to desired sites in plants (4).

The growth retardants B995 and CCC containing DMSO were administered as a spray by Seiuchetti and Born (7) to

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[1] This work was supported in part by a grant from the Society of the Sigma Xi and RESA Research Fund

[2] The authors express their appreciation to Dr Barton R Farthing, Professor and Head, Department of Experimental Statistics, Louisiana State University, for his advice and assistance regarding the experimental design and statistical analysis

[3] The authors express gratitude to Dr Robert J Herschler, Crown Zellerbach Corporation, Camas, Washington for the supply of DMSO and the concentrated foliar spray

[4] Appreciation is expressed to Mr Simuel W Austin, Assistant Professor of Photography, Southern University, for photographic assistance

the aerial parts of *Datura tatula*. Inhibitory effects on height, growth, and alkaloid content were greater in those plants receiving the combined treatment of DMSO and retardant than in those treated with retardant alone. Phytotoxicity was noted in the plants treated with CCC alone, and with CCC combined with DMSO.

MATERIALS AND METHODS

A 2 x 4 factorial experimental design replicated five times with one cutting per one gallon glass jar per treatment for each replication was employed in this study.

Softwood cuttings eight inches in length and ten to twelve mm in diameter at the base were inserted in the solutions to a depth of four inches. Four different treatments were applied prior to placing the plant material in two types of rooting media: continuously aerated distilled water and Hoagland solution, each containing five ml of a saturated captan solution. The treatments were:

01 Control

02 Foliar spray which consisted of:
1.5 parts NAA
50.0 parts DMSO
30.0 parts Acetone
10.0 parts Glycerine
10.0 parts Triton X100
Five ml of this emulsifiable concentrate was diluted in water to 100 ml. The stock plant was sprayed with this solution the afternoon of 20 September and morning of 21 September 1966 and all cuttings were taken 30 September 1966.

03 Fifteen minute soaking in a solution containing 1000 ppm IBA and 0.5% DMSO.

04 Thirty minute soaking in a solution containing 1000 ppm IBA and 0.5% DMSO.

The data were obtained by counting the number of roots formed on each cutting during a 45 day period. An analysis of variance and orthogonal comparisons were used to determine differences among treatments.

RESULTS AND DISCUSSION

There were highly significant differences among the four treatments. No significant difference was found between Hoagland solution and distilled water. However, there was a significant interaction between types of solution and treatments (Table 1). Examination of the orthogonal comparisons and the treatment means (Table 2 & 3) shows that the main difference among treatments was due to the large number of roots resulting from treatment three. The interaction was between types of solutions and treatments two and three. With treatment two, distilled water was the better solution, while with treatment three Hoagland solution was superior.

The result obtained with treatment four, thirty minutes soaking in 1000 ppm IBA and 0.5% DMSO solution, was no different from that obtained with the control. For this treatment phytotoxicity was noted from the complete defoliation of the cuttings. If DMSO has the capacity to transport substances in plant tissues these substances may reach toxic or inhibitory levels if exposure is for an extended period.

TABLE 1 ANALYSIS OF VARIANCE

Source of Variation	d/f	SS	MS	F
Total	39	18,670		
Replications	4	1,306		
Treatment A (1,2,3,4)	3	8,758	2,919	15.12**
Treatment B (5,6)	1	130	130	1
Treatment A X B	3	3,064	1,021	5.29**
Error	28	5,412	193	

TABLE 2 ORTHOGONAL COMPARISON

Treatments	d/f	M.S.	F
1 vs 2, 3, 4	1	1,470.00	7.62**
2 vs 3, 4	1	843.75	4.37*
3 vs 4	1	6,444.05	33.39**
Error	28	193	

TABLE 3 TABLE OF MEANS

Treatment Solution	01	02	03	04	Average
Hoagland	9.0	3.4	57.2	11.2	20.2
Distilled Water	14.0	32.6	37.2	11.4	23.8
Average	11.5	18.0	47.2	11.3	22.0

Treatment three, fifteen minutes soaking in a solution of 1000 ppm IBA and 0.5% DMSO, was significantly better than treament two, foliar spray. The foliar spray was applied ten days prior to taking the cutting and it is conceivable that some of the root-inducing effect was lost during that period. The reason why treatment two is most effective in distilled water and treatment three is most effective in Hoagland solution is not suggested by the data.

SUMMARY

A 2 x 4 factorial experimental design replicated five times with one cutting per one gallon glass jar per treatment per replication in continuously aerated Hoagland solution and distilled water was employed to study the effects of nutrient solution, foliar spray, 3-indolebutyric acid and DMSO on rooting of *Hibiscus syriacus*. Highly significant differences were found among the four treatments. Treatment two, foliar spray; and treatment three, fifteen minutes soaking in 1000 ppm IBA and 0.5% DMSO solution were significantly better than treatment one, the control; and treatment four, thirty minutes soaking in 1000 ppm IBA and 0.5% DMSO solution. Treatment three was significantly better than treatment two. There were no differences found between Hoagland solution and distilled water. A highly significant interaction was found between treatment two and treatment three with type of solution.

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HUGH STEAVENSON: We have several minutes for questions.

JAMES WELLS: I just wanted to comment on an effect of Captan which has not been mentioned. When we first tested this I did so on a batch of cuttings taken after Christmas. The variety was *Rhododendron roseum* and I treated the batch of cuttings with 1% IBA and half of the batch was treated with 1% IBA plus 5% Captan. There was a marked inhibition of top growth on the cutting in the bench while they were rooting where they had been treated with Captan. This was of real value because this variety naturally makes early growth in the bench and certainly cuttings put in that late are very subject to growth in the bench at that time of the year. After the cuttings were moved on there was no further inhibitory effect on the development of the cuttings.

HUGH STEAVENSON: I would like to ask Dr. Stoltz or Dr. Whatley if there is any possibility that DMSO will be used commercially.

LEN STOLTZ: Based on the work I have done I would say probably not with the materials we have tried so far. Also there is some concern with its danger. So many people who have worked with DMSO have had an impairment of vision, usually when relatively high amounts are absorbed.

BOOKER WHATLEY: There is some indication from the limited number of tests we have conducted that you may be able to use a lower concentration of auxin when supplied in combination with DMSO.

VINCE BAILEY: I would like to ask Mr. McGuire about the terminal application of hormones. Was any of the terminal tissue removed before application?

JOHN MCGUIRE: Nothing was taken off the terminal portion of the cuttings.

RALPH SHUGERT: Has anyone used Captan and an auxin on pfitzer cuttings?

JOERG LEISS: We have made up a powder consisting of IBA, NAA, Captan, and Ferbam and it gave us good results.

The following session, moderated by Mr. Roy Nordine, was the first presentation of plant material worthy of introduction to the trade.

ROY NORDINE: The plant material described this afternoon from arboreta will be available at your request for propagation-seeds, cuttings, or whatever it happens to be. Nurseries, of course, are allowed to sell their plant material. (Editor's Note: The following plant material was presented.)

CERCIS "OKLAHOMA"

Cercis "Oklahoma" was discovered in Spring 1964 in the "Arbuckle Mountains" of Oklahoma. The flowers are a rich wine red over the entire bloom. The leaves are almost round, heavy textured with a glossy sheen that appear to be waxed. The leaves are closely spaced creating a neat appearance throughout the growing season. The trees start blooming at one year and bloom heavily at an early age. This tree seems to grow more compact and will probably not grow as large as the *Cercis canadensis.*

The "Oklahoma" Redbud is thought to be a natural hybrid between *Cercis reniformis* and *Cercis canadensis* having some characteristics of each. The best method of propagation treated with 1% IBA plus 5% Captan. There was a marked inhibition of top growth on the cutting in the bench while they were rooting where they had been treated with Captan. This was of real value because this variety naturally makes early growth in the bench and certainly cuttings put in that late are very subject to growth in the bench at that time of the year. After the cuttings were moved on there was no further inhibitory effect on the development of the cuttings.

HUGH STEAVENSON: I would like to ask Dr. Stoltz or Dr. Whatley if there is any possibility that DMSO will be used commercially.

LEN STOLTZ: Based on the work I have done I would say probably not with the materials we have tried so far. Also there is some concern with its danger. So many people who have worked with DMSO have had an impairment of vision, usually when relatively high amounts are absorbed.

BOOKER WHATLEY: There is some indication from the limited number of tests we have conducted that you may be able to use a lower concentration of auxin when supplied in combination with DMSO.

VINCE BAILEY: I would like to ask Mr. McGuire about the terminal application of hormones. Was any of the terminal tissue removed before application?

JOHN MCGUIRE: Nothing was taken off the terminal portion of the cuttings.

RALPH SHUGERT: Has anyone used Captan and an auxin on pfitzer cuttings?

JOERG LEISS: We have made up a powder consisting of IBA, NAA, Captan, and Ferbam and it gave us good results.

The following session, moderated by Mr. Roy Nordine, was the first presentation of plant material worthy of introduction to the trade.

ROY NORDINE: The plant material described this afternoon from arboreta will be available at your request for propagation-seeds, cuttings, or whatever it happens to be. Nurseries, of course, are allowed to sell their plant material. (Editor's Note: The following plant material was presented.)

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The "Oklahoma" Redbud is thought to be a natural hybrid between *Cercis reniformis* and *Cercis canadensis* having some characteristics of each. The best method of propagation is by T-bud in late summer. In our area, late July to early August is the best period. It can be grafted on started understock in the greenhouse with a side graft as with evergreens. The grafts are quite slow to produce a planting size tree. The name Cercis "Oklahoma" has been registered with the Arnold Arboretum.

The following plants were described by Harrison Flint, The Arnold Arboretum, Harvard University, Jamaica Plain, Mass.

Indigofera incarnata alba. There is nothing really new about this plant, but it has been overlooked. It was first obtained by the Arnold Arboretum in 1885 from Veitch and Sons, Chelsea, England, and after 80 years it still is not found in nurseries in this country. *Indigofera incarnata alba,* like *Indigofera kirilowii,* is a good plant for stabilizing slopes, one of our best ground covers for bank use. It is a little lower than *I. kirilowii,* however, seldom exceeding 18 inches in height and has white flowers.

Propagation: Division of underground stems, or softwood cuttings in June or July.

Hamamelis 'Arnold Promise'. This hybrid witch hazel originated as a seedling in the Arnold Arboretum in 1928 and was named in 1963. It is a hybrid of *H. mollis* and *H. japonica,* and is outstanding for its large brilliant yellow flowers, borne in clusters of three, appearing in Boston in early March. In some years it has good reddish-orange fall foliage.

Propagation: Softwood cuttings in June. Hold rooted cut-cuttings over winter without disturbing their roots, if possible.

Rhododendron 'Smoky Mountaineer'. This cultivar was selected from a group of *Rhododendron calendulaceum* seedlings in the Arnold Arboretum in 1941. Its flowers are similar to those or *R. calendulaceum* in size and shape but their uniform, strong red-orange color does not fade in the sun. A more detailed information sheet is available from the Arnold Arboretum.

Propagation: Softwood cuttings in early summer.

The following plans were described by Roy Nordine, The Morton Arboretum, Lisle, Illinois.

White Ash — *Fraxinus americana*

A large tree native over the eastern half of the United States and adjacent Canada. Frequently confused with Green Ash. White Ash develops early into a uniformly branched and very shapely tree, oval in shape. Fall color is usually a deep purple, sometimes yellow and purple. Propagate by seeds sown either in fall or spring or budded on any ash seedling in late summer. Hardy in Zone 4.

Dwarf European Cranberry, *Viburnum opulus compactum*

A dwarf form of the European High Bush Cranberry. Mature height not known, 12-year old plants are 4 feet high.

A fine, rounded shrub with branches from the ground. Flowers and fruits annually at an early age. Propagates by summer cuttings from June 15 to early August. Hardy to Zone 4.

Yellow Japanese Barberry — *Berberis Thunbergi aurea*

A Japanese Barberry with fine, clean bright yellow foliage that tolerates full sun with very little burning. Mature height somewhat less than the types species. Propagates by summer cuttings from June 15 to early August. Zone 4.

Bottle Brush Buckeye — *Aesculus parviflora*

A shrubby species native to the Southeast. Mature height in our collection is 6 feet and wider than high where room permits. Large, bold foliage, white spiked flowers in late June and excellent yellow fall color. Fine rounded shrubs with branches from the ground under all types of shady locations. Propagates by layers made in early June. Summer cuttings from June 15 to July 15 and seeds that must be sown as soon as ripe in late September. Zone 5.

Dwarf European Fly Honeysuckle — *Lonicera xylosteum nana*

This dwarf shrub develops very quickly into a plant under 4 feet, but much wider. An excellent foliage plant with large deep green leaves. Flowers are cream or pale yellow; fruit has not been noticed. Propagate by greenwood cuttings from June 15 to August 1. Zone 4.

Canby Pachistima — *Pachistima Canbyi*

In our extensive collection of gounds covers, this plant is the finest. It has all the qualities necessary for a perfect plant. Small, graceful branches and stems on a plant less than a foot high, dark green small narrow evergreen leaves that never brown. It will perform well in sun to the deepest of shade. Propagates easily by cuttings taken after the spring flush has hardened until late in the winter. Summer cuttings root in less time. Zone 4.

(Zones are for the USDA Zone Map)

The following plants were described by Rod Bailey.

Philadelphus "Miniature Snowflake" — This plant is a sport of Philadelphus "Minnesota Snowflake". The flowers are double and very fragrant. The foliage is dark green and resistant to many of the leaf diseases that attack most Philadelphus species. It is a dense growing dwarf shrub attaining a height of about 30 inches.

Potentilla tridentata — Wineleaf Cinquefoil. This plant is a native of Minnesota and will withstand temperature of 40° below zero. The foliage is a dark shiny green and remains evergreen even at 40°. The ultimate height of the plant is about six inches and produces an abundance of delicate white flowers in mid-summer. It can be used as a ground cover or as a dwarf border shrub and works very nicely in rock gardens.

FRIDAY EVENING SESSION

December 9, 1966

PLANT PROPAGATORS' QUESTION BOX

RALPH SHUGERT: I would like more information on the modification of temperature with the freezing and thawing of water under polyethylene structures. Isn't this heat from freezing lost too quickly to be of value? Are there any temperature data? What about 3-5days of 10° F.? Would it help here?

DICK VANDERBILT: I think you can get about 10 days of useful heat between 5 and 0° F. This seems to be what it did. You can take the penalty out of the first deep freeze and if you continue to get low temperatures the rest of the winter you are just going to stay cool. But at the five days at near zero temperatures the water in the canal will be just like a frost in October. In the other houses the cans will be frozen up completely.

RALPH SHUGERT: If potted evergreens showing fall discoloration are placed in unheated greenhouses covered with opaque plastic—will the "greening up" process in spring be hastened or retarded compared to clear poly shaded 25% by white latex paint?

KNOX HENRY: Our experience has been that the opaque plastic or white plastic has a tendency to retard the greening up process in the Spring. Our procedure is to cover with white plastic and then about the middle of March we remove the white plastic and replace it with clear plastic and allow a temperature build up which brings on the green color.

JAKE TINGA: I don't like the plant material to get discolored in the first place. I am trying to preserve October green until April. Once it is discolored, I don't think you can effectively green it up except by new growth.

TOM PINNEY: I disagree. It can be done by using clear plastic. We have done it 6 or 7 years in a row. Take an Arborvitae which will typically discolor in the Fall. We put them under plastic in November and December and they are nice and green by March.

KNOX HENRY: I want to be sure I made myself clear. If we put evergreens with winter coloration in clear plastic houses and in the white plastic houses, the greening process is retarded in the white plastic houses as compared to the clear plastic.

RALPH SHUGERT: Has anyone used P.V.C. plastic from Japan on overwintering houses and for how long?

KNOX HENRY: We have used a little of it. It is quite satisfactory. To us it gives the same net result that a colorless plastic or white plastic depending upon whether you use a colorless P.V.C. or a white P.V.C. We have experimented a little with a green tinted P.V.C. The results were identical with using regular polyethylene. The only problem was that the cost was not identical. The P.V.C. is a great deal more expensive for us.

ANDY ADAMS: We would prefer to use fiberglas to P.V.C. for two reasons. You have no guarantee how long P.V.C. will last and we know a piece of fiberglas will give 10, 15, or 20 years service. Also on long runs with wide bar spacing the expansion (of P.V.C.) on 100°F. days is great enough to pull the nails.

JOHN KNAPP: I visited a fellow who had quite a range this summer and he had P.V.C., plastic, glass, polyethylene, and his comment was no more P.V.C. for any house. There were large holes in his P.V.C. houses. He said he had a high wind and the P.V.C. disintegrated. The polyethylene was not damaged.

KNOX HENRY: I think most of you will recognize that we should remember that there are a great number of manufacturers of P.V.C. and consequently there are as great a number or variety of quality. The P.V.C. we used came with a written guarantee for 10 years. We had to do a lot of looking before we found it. If anyone is interested, I would suggest you compare the cost with fiberglas, which I agree is a better product and second, make sure the quality of the P.V.C. is good and try and find someone who is already using it first.

BRUCE BRIGGS: We have used P.V.C. for two years. We used it because it is the clearest plastic and lets the most light through. If you don't need all the light then use polyethylene.

RALPH SHUGERT: Are there any results of the rooting cofactor work that can now be applied to the rooting of difficult-to-root cuttings?

LEN STOLTZ: At the present there are no directly applicable results, but there will be in the future.

RALPH SHUGERT: How does the esterification of DMSO with IBA increase the effectiveness of IBA?

CHARLEY HESS: If an ester does form between the DMSO and the IBA, the combination may be more soluble and be better able to enter the plant tissues.

RALPH SHUGERT: What is an ester?

CHARLEY HESS: It is the combination of an acid and an alcohol. Our gracious hosts, the Newport Nurserymen, will show you how it is done.

RALPH SHUGERT: Would it be possible to apply the hormones to the tip of a cutting by a spray?

JOHN MCGUIRE: We have used sprays and they are as equally effective as dipping the tips in the solution as I described in my paper. We did not recommend it with the higher numbered carbowaxes because it interfered with gaseous exchange and caused chlorosis of the foliage. With low numbered carbowax it worked all right.

RALPH SHUGERT: What is Cutstart?

PETE VERMEULEN: We really don't know. It is made by Vitamine Institute in Hollywood, California. Dr. Thompson will not release the formula. Charley has worked with it.

CHARLEY HESS: It contains thiamine, or Vitamin B1 and naphthaleneacetic acid or its derivatives. It may also have some other auxins. We do not know the concentrations of the auxins of the various strengths of Cutstart.

HARVEY GREY: You can mix IBA in talc by using a ball mill or by first dissolving it in alcohol and then mixing the alcohol solution and the talc together and then evaporate off the alcohol. Charley, did you feel the two techniques will give different results?

CHARLEY HESS: The alcohol technique probably gives the most uniform results. The things that you have to watch out for is that you do not add too much alcohol in relation to the amount of talc being used. As the alcohol evaporates, the mixture should be occasionally stirred to keep it uniform. However, the most effective method to get a root promoting substance into a cutting is as a concentrated dip. The hormone is already in solution, so it goes directly into the cutting. When you use talc, you have to rely either on the moisture of the medium or moisture on the surface of the cutting to dissolve the hormone before it gets in.

RALPH SHUGERT: Tom Pinney, would you describe your method of adding Captan to the quick dip solution which Dr. Snyder spoke about in his presentation?

TOM PINNEY: We use a quick dip just as Charley has mentioned and I like to vote for this because we think it is the best way. Starting with the 10,000 ppm or the 1% concentrate, using carbowax, (⅔ carbowax and ⅓ water) we then make our dilutions, say to a 1000 ppm or 0.1%, we will then add to each 100 cc of the final solution ¼ teaspoon of 50% wettable Captan. If you made up 400 cc you would use one teaspoon of Captan. We add the Captan last because we want to be sure everything else is in solution. The Captan will not dissolve, it is a suspension.

ZO WARNER: Why not dip the whole cutting in Captan when you bring it in and then treat it with the concentrated dip?

CARMINE RAGONESE: I find that a total dip in Captan inhibits bud development.

JIM WELLS: For those of us who like to stick with powdes, there is a reasonable substitute for the quick dip. That is any powder that is made up from the potassium salt of the indolebutyric acid is immediately water soluble and we think it has a much more rapid and complete penetration of the cuttings.

DICK VANDERBILT: Where do you get the potassium salt?

JIM WELLS: We bought ours a number of years ago from May and Baker in Dagenhan, Essex, England.

BILL CURTIS: Why not use Chlorox to clean up your cuttings?

CARMINE RAGONESE: The New Jersey Chapter of the Rhododendron Society experienced difficulty in rooting deciduous azeleas. They used a 5% mix of Chlorox and quick dipped the entire cutting in the solution. The results were astounding, there was no fungus and no problem from inhibited bud break.

RALPH SHUGERT: Has anyone used traumatic acid to increase the rooting of cuttings or to increase the formation of callus when grafting?

CHARLEY HESS: Traumatic acid is known as a wound hormone, and is synthesized by tissues which have been wounded. It is not active as a root promoting substance and I suggested it might be tried in grafting. I have received a letter from Holland and they have tried it a number of times without success.

RALPH SHUGERT: Has anyone used hormones as an aid in grafting?

ARIE RADDER: At one time we used Chloromone on juniperus and it helped considerably.

JOHN ROLLER: We also use it on juniper grafts such as *J. canareti* and *J. virginiana glauca* and it helps considerably.

CASE HOOGENDOORN: Do you get equal callus formation on stock and on the scion?

JOHN ROLLER: We paint both stock and scion. Actually the scion is dipped and inserted into the union while the scion is still wet.

RALPH SHUGERT: What strength of Chloromone?

JOHN ROLLER: We use full strength.

GERRY VERKADE: Is there any Boron in Chloromone?

CHARLEY HESS: Not to my knowledge. It is included in Jiffy Grow.

DAVID BAKKERS: We tried a grafting paste from Germany which is supposed to contain a hormone. It did a nice job as a grafting wax but I could see no difference from normal wax.

CHARLEY HESS: I should say that there have been numerous trials with growth substances and grafting. The reports are varied and some report benefits, others no effect. It varies with plant species, time of application, and condition of the stock and scion.

RALPH SHUGERT: What is the best hormone for Kalmia cuttings?

AL FORDHAMS: 1000 ppm each of IBA and NAA.

RALPH SHUGERT: Has anyone had success rooting *Acer griseum* cuttings?

VOICE: Yes, by taking very soft cuttings from young plants.

RALPH SHUGERT: Can *Robinia psuedo tortuosa* be grafted on *Gleditsia triacanthos inermis?*

JOE MCDANIEL: No.

RALPH SHUGERT: Has anyone observed witches broom or a mutation on *Cedrus atlantica glauca* or *Sciadopitys verticillata?*

AL FORDHAM: We have found one on the Cedar of Lebanon but not on *Cedrus atlantica glauca* or *Sciadopidys.*

CASE HOOGENDOORN: What understock do you use for *Cedrus atlantica glauca pendula?*

HANS HESS: We graft them in December on *Cedrus deodora* with good success.

CASE HOOGENDOORN: Ours seem to take and even start to grow, but then we lose two thirds of them.

GERRY VERKADE: Get them out of the sweat box, Case. What size stock do you use?

CASE HOOGENDOORN: We use two year old seedlings, pot them up and grow them one year in the pot. Then we graft them.

GERRY VERKADE: That's your mistake. Put some seed in this winter and graft them next fall, on those little tiny stocks and you will have no problem.

RALPH SHUGERT: How do you propagate *Rhus cotinus* Royal Purple?

PETE VERMEULEN: We make them from soft wood cuttings. We top the long shoots so we can get the short shoots, 4-6 inches long, all up and down the stem. This in our area is early June. They are treated with the Germain formula I mentioned the other day. They are inserted in a medium of 50% peat and 50% perlite and under intermittent mist outside.

RALPH SHUGERT: How do you keep birch seed?

TOM PINNEY, JR.: We have to keep birch seed over from year to year because we can not always count on a crop. We store it in plastic bags in 35°F. storage. The viability will drop and by the third year it is pretty well down, and the resulting seedlings will be very weak.

RALPH SHUGERT: What is the pre-germination treatment for *Taxodium distichum?*

HUGH STEAVENSON: You can fall seed it after you collect it or give it 60 days at 41°F. But fall seeding after it is collected will give you good germination in the spring.

PETE VERMEULEN: How do you treat *Davidia* seed so that the 4 or 5 seedlings in the nut germinates instead of just one?

AL FORDHAM: We put them in a polyethylene bag together with a medium of damp sand and peat moss and we watch them. When the radicles have emerged we put them in cold storage for 3 months after which we get a very complete germination in about 4 or 5 days. The seed is planted about ½ inch deep in flats.

RALPH SHUGERT: I am confused on this question of bottom heat. Some say yes, others not. Bill Curtis, for example, used 85°F. to root *Magnolia grandiflora.* What is the right answer?

BILL CURTIS: We used to have problems with magnolias. But I remember the advice from Alabama was to burn them up. So I use real strong bottom heat—85 to 90°F. and get excellent results. I could not do without it. However, you must watch the water and not allow the flats to dry out.

STU NELSON: I guess I better defend myself. There are exceptions to every rule and anybody can pick examples where something is going to work. But when you speak in general, I feel you do not need bottom heat. Sure on shy rooting rhododendrons it will work. But in general the literature, and I think most of you people will admit that most of the things you grow don't need bottom heat. As you increase the efficiency of the propagation system it becomes less necessary as does hormone. If you try to push the cutting too hard, you go flat on your face.

HARVEY GRAY: I think bottom heat is a tool and as such it must be used properly. For example, I think it is very beneficial for outdoor mist particularly if the water temperature is low, from a deep well for example.

LESLIE HANCOCK: With all due respect to Stu, I think a man who can challenge a 150 years of experience has a lot of courage. You have to understand the physiology of the plant to know to what extent bottom heat is important. We do know that heat stimulates cell activity. If cell activity takes place at the top of the cutting, it will grow instead of rooting. If you heat from below, the top will stay dormant until the roots are formed. You will have more cell stimulation where you have more heat, and when you want to put roots on a vegetative shoot, why of course it is best to stimulate the lower portion of the cutting.

MARTIN VAN HOF: I can take both sides of the question. You don't need bottom heat if your timing is right and you are not in a hurry. But if you want to prolong your season, because you know we are not always on time, then you should use bottom heat.

STU NELSON: I just would like to say that bottom heat like hormones are not going to put roots on cuttings that are not going to root. Rooting is a race for survival and all things being equal the cutting will eventually root or it will die. In some cases bottom heat will speed up rooting, I don't think there is any doubt about this. Bottom heat will speed up rooting but bottom heat is not necessary for rooting.

RALPH SHUGERT: Now for some questions on cost accounting. Mr. Wells, your rule of thumb of direct labor costs as a percent of total production costs was apparently arrived at prior to 1960. Have your indirect cost risen at the same rate as your labor costs so this relationship still applies today?

JIM WELLS: Yes, they appear to have done so. I don't think its going to last, our labor costs are going to jump ahead.

Ralph Shugert: I believe everyone's operation is a little different. Therefore, wouldn't it be correct to assume that it is necessary for every operation to determine its own total labor percentage as well as its own direct labor percentage?

Jim Wells: Yes. I tried to show the method which we used. The important thing here is that anyone can determine the ratio that exists now by looking at his balance sheets between his labor costs and all other costs. Whatever this ratio you can determine it. At the time I worked it out, the ratio was exactly half. You may be half, you may be ⅔ or you may be ⅓, if you are automated you may be ¼. The whole of the talk was to clear the air of all the multitude of details which is likely to clutter up our thinking in trying to establish a system that will work. The nursery business is a very difficult one in which to set up cost accounting.

Hugh Steavenson: We have used the Wells' formula in our operation and I find it very valuable. It is just as valid now as when he first worked it out. Jim has made many contributions to the Society and I feel this is one of the finest.

Ray Blue: Presently at Koster we can not use Jim's formula as stated because of change in the machinery and labor situation. The basic breakdown today is based on deciduous tall material, decidous low material, evergreen tall, evergreen spreading and rhododendrons. Then we have an operational cost. So a plant will be given a number that will fall in this range and then the operation will be given a letter. So that B-6 may be digging rhododendrons. We can go back and pull out an operational cost. I feel that cost accounting is time well spent, no matter what is the size of operation.

Knox Henry: I was trained as an accountant before I came into this business and in the last few months we have installed a computerized bookkeeping system. We are not solely a nursery. We are doing some nursery production as well as nursery retail sales, greenhouse operations and a large bedding plant operation. Our situation is not unique, a lot of you have similar operations where you would be classified as having more than one department. The relationship between the direct labor cost at any one time on a certain crop does have a definite bearing on the ultimate cost on that item as Mr. Wells has poited out. I agree with him wholeheartedly. If anyone is interested, after we have had some experience with the system, I will be glad to describe the automated operation. you are operating.

Vince Bailey: The American Association of Nurserymen through the Horticultural Research Institute has done considerable work setting up a bookkeeping system whereby you can determine your costs of plant material, labor, etc. and I agree this system is important no matter what size unit you are operating.

RALPH SHUGERT: Has any other material been grown other than rhododendron under the mercury vapor lamp?

WALT PEFFER: Last year the only thing I grew was rhododendron but at the present time I am growing viburnum, some azaleas and a few hollies. Although good growing conditions will not develop until later in the season, these items at the present time are looking very good.

RALPH SHUGERT: What do you think about using a sodium light for growing in the greenhouse?

WALT PEFFER: I do not know of any case where a sodium lamp has been used but I would not be in favor of it because the sodium light consists of 87% infrared. It does not contain much light useful to the plant.

HANS HESS: What is the cost of the mercury vapor lamp?

WALT PEFFER: The cost of the lamp is approximately $35.00. It is the G-33 for the 100 watt lamp. The transformer is included in the lamp.

ED HUME: Don't the mercury vapor lamps contain a lot of ultra violet light in the range of 3000 A which is inhibitory to plant growth?

WALT PEFFER: The output of the mercury vapor lamp I recommended is only 15% in the ultra violet and is not inhibitory.

VOICE: Are the mercury vapor lamps operated continuously?

WALT PEFFER: No, they are operated from 8 o'clock in the evening to 5 o'clock in the morning. This is not a predetermined factor, but the low cost of operating the light allows me to run it all night. Do not use the mercury vapor light as a intermittent light or for flash lighting because it will damage the transformer.

RALPH SHUGERT: Will your aqua-vapor control work up to 100% humidity?

VERNER REXER: Yes.

RALPH SHUGERT: Is the aqua-vapor control commercially available?

VERNER REXER: I expect it will be on the market in January or February in 1967. The cost should be in the range of $35.00 to $40.00.

(Editor's Note: Mr. Bruce Briggs showed slides of his air propagation technique at the end of the Question Box.)

SATURDAY MORNING SESSION

December 10, 1966

The Saturday morning session began with the annual business meeting at 8:30 a.m. in the Colonial Room. The minutes of the meeting are recorded at the beginning of the business and technical sessions of the Eastern Region section of the Proceedings. After the business session a nutrition symposium was conducted. Dr. Kenneth W. Reisch served as moderator.

STU NELSON: We have a very interesting panel on nutrition this morning. The moderator for our closing session is Dr. Ken Reisch from Ohio State University.

KEN REISCH: I would like to introduce the first subject, Vegetative Propagation as Affected by Nutrition — a review by Dr. Jim Kelley.

VEGETATIVE PROPAGATION AS AFFECTED BY NUTRITION — A REVIEW

JAMES D. KELLEY
Department of Horticulture
University of Kentucky
Lexington, Ky.

Considerable emphasis has been placed upon studying the factors that influence the rooting of cuttings, the goal being to maintain an environment that will result in the greatest percentage of rooted cuttings in the least amount of time. Information that has been obtained has resulted in a manipulation of temperature with the addition of heat, moisture by misting, day length by shading or using additional light, application of growth regulators and others.

At the same time, little attention has been focused on factors influencing the stock plant from which the cutting is taken and how temperature, light intensity, nutrition, photoperiod, hormones treatment, moisture, and other factors might influence rooting of the subsequent cuttings.

We often think of a cutting as the beginning of a new plant, but it is really the continuation of an existing plant and what the cutting will or will not do is to some degree influenced by the environment conditions under which it developed as the shoot or stem on a stock plant.

Evidence that nutrition of the stock plant was a factor influencing root initiation and development of cuttings taken from such plants was first presented by Kraus and Kraybill in 1918 (9). They demonstrated that the carbohydrate—nitrogen ratio of tomato stems played a major role in rooting. They placed pieces of tomato stems 1 to 4 inches long and without leaves on filter paper moistened with distilled water and covered them with a bell jar. The following results were observed: yellowish stems high in carbohydrates and low in total nitrogen produced many roots and weak shoots; greenish stems containing starch and fairly high in total nitrogen produced roots and shoots and green, succulent stems without starch, low in carbohydrates and high in total nitrogen all decayed without root or shoot production.

Experiments by Schrader in 1924 (17), Starring in 1924 (19), and Garner (4), in 1944 demonstrated that a high ratio of carbohydrates to nitrogen favored rooting in tomatoes and grapes. Sarring (19) found that firmness of stems could often be used as an index of carbohydrate content. Stems low in carbohydrate are soft and flexible in contrast to those high in carbohydrates which are firm and stiff.

Knight (8) in 1926 was the first to attempt to classify cuttings according to their internal conditions. He recognized three types of stem cuttings on the mother plant: (1) leader in active growth; (2) laterals in active growth, and laterals with the terminal bud formed. He noted that firm cuttings which had ceased growth were much superior to actively growing shoots and attributed better rooting to a higher carbohydrate content.

Haun (5) grew stock plants of geranium at three levels of nitrogen, phosphorus, and potassium. He found that nitrogen nutrition of the stock plant had a greater effect on the rooting response than did phosphorous or potassium. Low and medium levels of nitrogen resulted in a higher percentage of rooted cuttings than the high level.

In work with *Ilex crenata* 'Hetzi', Kelley (7) has shown a possible carbohydrate-nitrogen relationship (Table 1. Cuttings from stock plants receiving a relatively low nitrogen application produced the greatest total root length and largest number of secondary roots while stock plants grown under high nitrogen conditions produced the least number of primary and secondary roots.

Table 1. Effect of nitrogen nutrition of stock plants on rooting of *Ilex crenata* 'Hetzi'.

Grams of N per 1 gal H_2O	Total roots per cutting	Total root length per cutting	Secondary roots per cutting	Length of primary roots
		cm		cm
0.7	4.6	8.0	17.1	1.7
2.8	5.9	7.3	12.1	1.2
10.0	4.2	3.6	5.0	0.9

Ryan (15) recently reported that seedling stock of *Eucalyptus ficifolia* fertilized with nitrogen resulted in a reduction of successful grafts. Seedling stock with a leaf nitrogen content of 1.2 percent resulted in 100 percent successful grafts while plants with 4.1 percent leaf nitrogen gave only 13 percent successful grafts. Pregirdled scion wood also resulted in a greater percentage of successful grafts.

Pridham (13), after work with *Liqustrum ovalifolium*, concluded that the rooting of cuttings and subsequent growth of the young plant depended primarily upon the maturity and treatment of the parent.

Other investigators (2,3,11,12,18,23) have generally concluded that factors contributing to a high carbohydrate content of the stock plant favored the rooting of cuttings. The nutrition of the cutting material is of very great importance and recognized by many. This is shown by attempts to induce a high carbohydrate-nitrogen ratio in stock plants by ringing, notching, and root restriction.

Cultural factors that contribute to a favorable ratio are growing the plants in full sun, applying limited amounts of nitrogen, controlling moisture, root pruning, and other procedures that will generally restrict growth of the stock plant.

Two micronutrients, boron and zinc, have been shown to influence rootings. Samish (16) found that after fertilization of grapes with zinc, the tryptophan content of the cuttings increased and rooting was improved. Since tryptophan is a precursor of the naturally occurring auxin, indole-acetic acid, he attributed the results to a possible increase in indole-acetic acid. Beneficial results from zinc applications to stock plants have been noted in South Africa in the propagation of Marianna plum by hardwood cuttings.

Boron was first shown to play a role in rooting by Hemberg (6). He showed that when hypocotyls of *Phaseolus vulgaris*, without cotyledons, were placed in tap water or in extracts of dry leaves in distilled water they rooted but in distilled water they did not, due to the absence of boron.

Boron nutrition has also been shown to influnce rooting of chrysantheums. Tackett (21) found that chrysanthemum cuttings containing a leaf content of less than 35 ppm boron rooted poorly (Table 2).

Albert and Wilson (1) found that boron was necessary for root tip elongation in tomatoes and concluded that when boron was not available to the root the early stages of cell development were influenced within 24 hours.

Little information is available concerning the effect of other micronutrients on rooting; however, they should not be overlooked. Likewise, the information for nitrogen in incomplete, which means that much will have to be done before we know how stock plants should be handled for production of cuttings with maximum rootability.

The internal condition of the cutting is of great import-

Table 2 Effect of boron nutrition of stock plants on rooting of chrysanthemums

Boron in nutrient solution	Boron content of leaves	Total length of roots per cutting	Number of roots per cutting
ppm	ppm	cm	
.001	5.8	2.0	1.6
.01	11.4	2.5	1.8
.10	45.2	8.2	4.8
1.00	92.9	5.1	4.2
2.50	123.9	4.1	4.4

ance as shown by the foregoing references. To date the researcher has not characterized the internal conditions that favor rooting to a degree to be applicable to the plant propagator. Until more is known about the factors which combine to modify these internal conditions, propagators will continue to be frustrated with seasonal and year-to-year variations in rooting due to a lack of knowledge of how environment influences stock plant and its effect on rootability of cuttings.

It is important to remember that nutrition is only one factor that is related to rooting, but is interrelated with other factors in influencing successful plant propagation.

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KEN REISCH: The next paper is prepared by two gentlemen. Dr. Meyer is now at the University of Illinois. Dr. Tukey will present the paper.

NUTRIENT APPLICATIONS DURING THE DORMANT SEASON

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Spring is not the only time for nutrient applications to nursery plants, and it may not even be the best time. However, nursery plants in temperate regions grow rapidly during the spring and early summer. It is only natural to suppose that nutrient applications during this period would be most beneficial, and spring applications are common nursery practice.

However, many workers have shown that nutrients applied to woody plants during the spring and summer often produced no additional growth the year they were applied, but rather were absorbed and stored within the plants. The year following the nutrient applications, important growth differences were noted. Thus, the spring growth of woody plants is dependent to a large extent upon nutrient reserves

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However, many workers have shown that nutrients applied to woody plants during the spring and summer often produced no additional growth the year they were applied, but rather were absorbed and stored within the plants. The year following the nutrient applications, important growth differences were noted. Thus, the spring growth of woody plants is dependent to a large extent upon nutrient reserves accumulated in the plants prior to the spring flush (4), that is, during the dormant season. Thus, it becomes obvious that nutrients applied during the dormant season might be effective in promoting a greater amount of spring growth. However, the first question which must be answered is "Do the roots of dormant plants grow during the winter?", for after all, it is growing roots which absorb nutrients.

Therefore, 3 to 4-year-old plants of *Taxus media* 'Hicksii' and *Forsythia intermedia* 'Spring Glory' were grown in a soil peat: perlite medium in 1-qt. plastic containers. After the plants were completely dormant in the Fall, they were placed in a greenhouse in root environment chambers which controlled the root temperature at 35, 40 and 45°F, and the root growth was measured.

The results in Figure 1 with *Taxus* show that there was no measurable root growth at 35°F. However, when the root temperature was increased to 40 and 45°F., there was a considerable increase in the root growth even though the tops of the plants remained completely dormant. In addition, the root growth of plants receiving nutrient applications was much

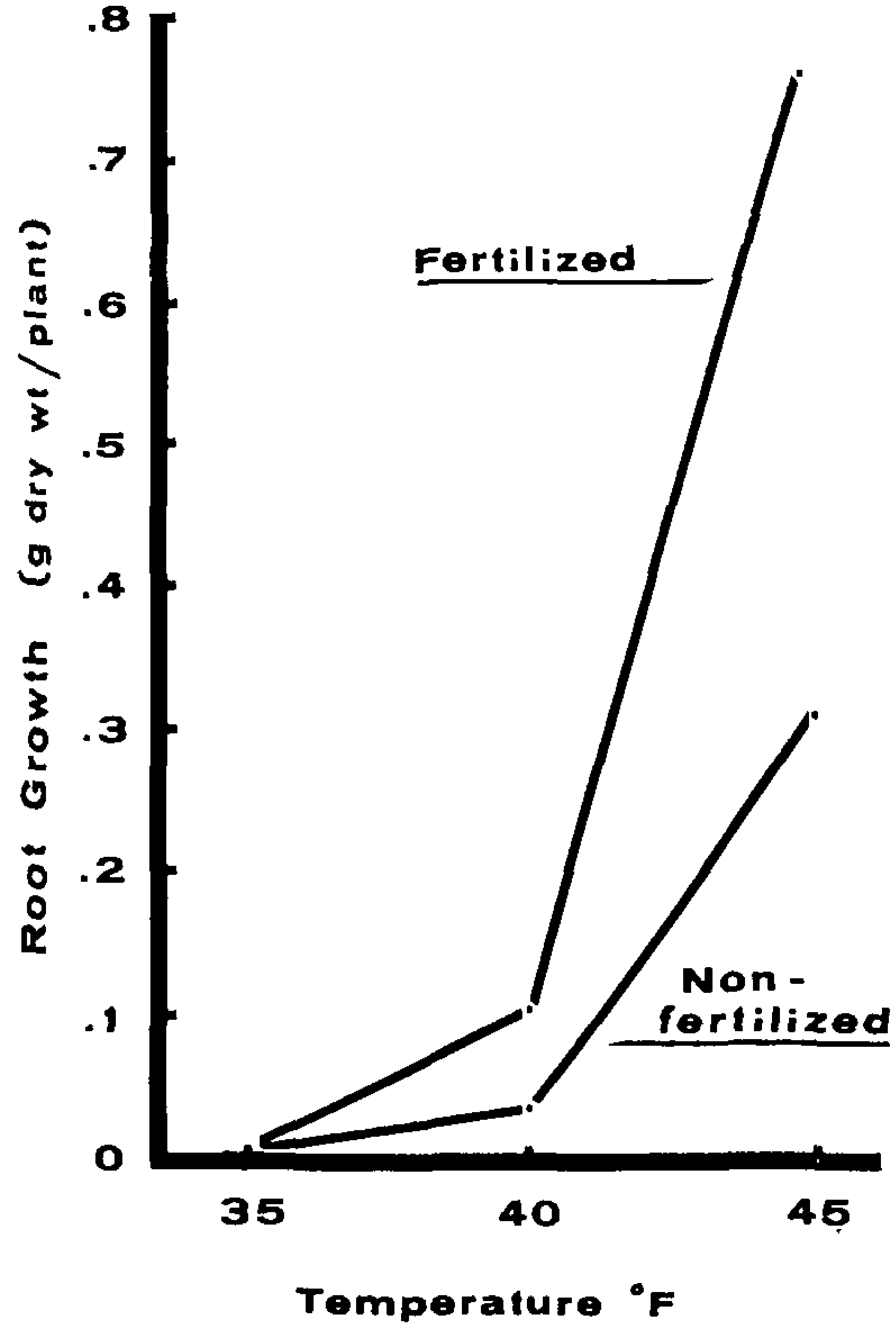

Figure 1 Influence of root temperature and fertilizer application on the root growth of *Taxus media* plants during the dormant season From Meyer and Tukey (5).

greater than that of plants receiving no nutrients. *Forsythia* behaved similarly.

Root growth of plants during the dormant season is now reported in more than 45 species, including fruit trees, shade and forest trees, and ornamental plants. Such growth is usually at a slower rate during the winter than during the summer, but as long as the soil remains unfrozen, root growth will continue.

The next question to ask is if these growing roots can absorb nutrients from the soil and are the absorbed nutrients translocated into the above-ground parts and stored. Accordingly, nutrients were applied to the roots of young *Taxus* plants growing in containers late in the growing season. Nitrogen was applied as NH_4NO_3, phosphorus as KH_2PO_4, and potasium as K_2SO_4 and KH_2PO_4. The nitrogen, phosphorus, and potassium content of the stems and needles was measured in April, while the plants were still dormant, and the results of these analyses are shown in Table 1. As the amount of nitrogen applied to the roots was increased from 0 to 135 milligrams per plant, the concentration of nitrogen in the dormant stems increased from 1.54 to 2.37 percent dry weight. Similar results were obtained with phosphorus and potassium in that increased application rates to the roots increased the dormant season nutrient content in the plants.

In another experiment, Smith (7) reported that radioactive phosphorus was quickly absorbed by the roots of dormant fruit seedlings and was translocated into the dormant stems accumulating in the regions of the buds.

Table 1. Influence of root applications of N, P, and K the previous season on the nutrient content of dormant *Taxus* plants, on the following spring growth, and on the mineral content of new growth.[1]

Treatment	Dormant nutrient content (% dry wt)	Spring growth (g fresh wt)	Mineral content of new growth
Nitrogen (mg)			
0	1.54	19.67	1.49
45	1.95	29.57	1.67
90	2.18	36.50	1.69
135	2.37	38.19	1.77
Phosphorus (mg)			
0	0.157	26.52	0.206
175	0.193	31.46	0.258
350	0.209	34.97	0.266
Potassium (mg)			
0	0.63	30.83	1.04
90	0.78	31.92	1.34
180	0.82	30.20	1.41

[1] From Meyer and Tukey (4).

These results effectively demonstrate that roots growing during the dormant season can effectively absorb nutrients during this period and that the nutrients are translocated into the above-ground parts in preparation for spring growth.

The next question to be answered is, "Are nutrients which are absorbed in the dormant season effective in producing growth the following spring"? The results in Table 1 show that as the nitrogen concentration increased from 1.54 to 2.37 percent, the spring growth almost doubled from 20 grams fresh weight per plant to more than 38 grams. Similarly, phosphorus applications caused an increase from 26.5 grams to 35 grams. New growth was not only stem length, but also an increase in the number of lateral shoots which developed.

Potassium applications did not increase the amount of spring growth of *Taxus*, but in *Forsythia* they did have an influence upon winter injury. *Forsythia* plants which did not receive high concentrations of potassium suffered considerably from winter injury, whereas those which did receive potassium applications suffered no damage. This emphasizes the importance of potassium in the total development of the plant, and it emphasizes the importance of a correct nutrient balance in plants for winter survival.

It is also interesting to note in Table 1 that the nutrient concentration of the new spring growth was increased substantially by nutrient applications the previous season, thus inflencing the potential future growth of the plants.

The results of these experiments and those reported in the literature (1,2,3,6,7,8) demonstrate that fall applications of nutrients are successful in that (a) roots of many woody plants continue to grow in unfrozen soil throughout the winter and do not become dormant like the above-ground parts, (b) these growing roots absorb nutrients efficiently, (c) the nutrients are translocated into the dormant above-ground parts, and (d) are used in making increased growth the following spring.

Fall nutrient applications offer several advantages over more conventional spring applications. For example, soils in spring are wet and cold and may not exceed 35 to 40° in the root zone until the spring flush of growth is well underway. Under such cool soil temperature conditions, the activity of soil microorganisms is inhibited and nutrient availability is reduced. In addition, root uptake of nutrients is also inhibited by cool soil temperatures. Therefore, when woody plants are making their most rapid growth of the year, and when nutrient requirements are at their highest, nutrients may not be available nor be absorbed until too late for that season's growth. And even in the best of years, there is only a critical period of a few days during which nutrients must be applied, carried into the root zone, absorbed, and translocated into the growing regions. Such precise timing of spring applications is often impossible with the pressure of other spring work and land which is too wet to work.

In the fall, it is a very different situation. Cold air temperatures and cultural practices induce dormancy in the tops of woody plants. However, soil temperatures in the root zone remain warm for a considerable period after the tops are dormant. In Ithaca, soil temperatures at the 4-inch depth may exceed 40-45° until well after Christmas, allowing more than 6 weeks after plants are fully dormant during which nutrients can be applied safely and absorbed by the plants. The fall season is often a more convenient time for field work, and fall nutrient applications can be combined with fall herbicides treatments. Fall nutrient applications made after plants are fully dormant will avoid any risk of winter injury, and in fact, there is good evidence that winter hardiness is improved by such applications.

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Ken Reisch: Last but not least, certainly, is a subject that is receiving a lot of attention now, particularly in other parts of the country and other industries, is fertilizer injection systems. To present this is Dick Bosley, Mentor, Ohio.

A FERTILIZER INJECTION SYSTEM

RICHARD W. BOSLEY
Director Bosley Products
Mentor, Ohio

INTRODUCTION

In recent years there have been rapid gains of knowledge in the fields of growing plants under stress. The coming of age of container growing has caused us to question many of our previous values and to investigate areas and industries, that seem quite foreign to us, for the answers. Some of the areas in question we have discussed at this meeting, such as winter protection. Others, such as the medium requirements brought about by the short soil columns in cans, is causing quite a stir in the wood processing industries as they see a large potential market for their wood by-products. In California, redwood sawdust has gone from a material which the mills were glad to see you haul away to a rather high priced item of short supply today because Dr. O. A. Matkin, of Soil and Plant Laboratory, Inc. developed its use as a soil amendment. Another area which is still undergoing a revolution is that of plant nutrition and how to supply it. It has become increasingly obvious that if you are to compete in the field of container growing with the California nurserymen, then you must produce the plant in the shortest possible time. One of the requirements to achieve this is to try to maintain an optimum fertility level at all times. The level that you consider optimum may well change from week to week as the season develop but the goal does not.

In searching for a means of doing this we were very dependent upon Dr. Fred Peterson, of the Soil and Plant Laboratory, Inc., who with the assistance of Mr. Ed Kott, of the Milton Roy Company, developed the electrical component type proportioning system, previously utilized exclusively in industrial process control applications. I will try to illustrate and explain the operational characteristics of the system and show what advantages it has.

SYSTEM GOALS

Prior to our installation of the injection system our method for fertilizing container stock, after that which was incorporated in the initial medium, was to top dress. There were a number of problems with this method though; high labor costs and the very slow reaction time after getting the results of soil tests from the laboratory, were the most serious objections. During our very short growing season we cannot afford to have the plants below optimum fertility for the period of days it takes to apply fertilizer by hand. Slow release fertilizers could be used but they again require a lot of labor to apply and you loose control of the fertility program as soon as you put it on. It seemed obvious that we had to come to a constant feed through the irrigation system as the plants need for fertilizer was related to it's water use.

Some of the equipment requirements for constant feed through the irrigation were: 1) Dependable operation, 2) Ease of Ratio Adjustment, 3) Automatic Maintenance of Constant Ratio, 4) Optional Accessories, 5) Engineering Service, and 6) Economy. To go in to some of these points in greater detail — The pump had to be *dependable,* designed to handle very corrosive chemicals, and had to be able to pass some solids without damage. It had to be ruggedly constructed for industrial-type service to give long life and reliable operation without costly maintenance.

The system had to have ease of ratio adjustment. The *strength* of solution delivered to the plants had to be adjustable over a wide range by simply turning a micrometer control on the pump. No premixing of various fertilizer solution strengths could be tolerated to the labor factor and the possibility of errors.

It might be desireable to have *accessories available* for the basic fertilizer system such as conductivity monitering equipment on the main irrigation line to shut the equipment down so as to protect against overfertilization; automatic low flow cut off; solution tank low-level alarm system; and anti siphon devices between the pump and the main line.

The automatic maintenance of a constant fertilizer-to-water ratio, once the pump is set, is required to be automatically and accurately maintained over the entire flow range for which the system is designed.

It is important that the manufacturer of the injector have an engineering interest in developing its hardware for fertilizer applications.

Even though the cost must be evaluated on the basis of the useful life of a system rather than upon the initial cost, the total cost still had to be within reach of our industry members.

3 SUB SYSTEMS FLOW SENSING

There are three sub systems into which the components that we arrived at can be divided. The first sub system is the flow sensing. Two methods are currently being used. Where the water supply is free of sediment or suspended material such as fine sand, water meters, equiped with an electrical pulse generator can be used. These devices produce an electrical pulse signal with frequency proportionate to flow. If the water is not clear, flow must be sensed by a differential pressure producing device. This device, in the case of our system, consists of a plate with a two inch hole in it inserted in the three inch main line. As the water rushes through the smaller hole it produces higher pressure on the pump side and lower pressure on the irrigation side of the orifice plate. Small tubes transmit these signals to the telemetering equipment. The system has a flow rate range-ability of 10:1 with a precision of plus or minus 2%. In our system this means that the equipment will start injecting fertilizer at a flow as low as 15 G.P.M. and keep injecting the same proportion of fertilizer per gallon up to a flow of 150 G.P.M., Range ability as high as 25:1 can be had but at a much greater cost. Flow sensors are available in sizes to accommodate ½" pipe up to and including 48" pipe, with flow rates from 20 G.P.M. (gallons per minute) to thousands of G.P.M.

TELEMETERING

The second subsystem is the telemetering or transmitting equipment. Once a physical signal of a measurable type is developed by the flow sensor, this signal must be interpreted. The telemeter causes the injection pump to work more or less on a 15 second cycle depending on the flow through the main line. Within the telemetering box is a device that automatically turns the equipment on when it senses a flow rate over 15 G.P.M. and off when it drops below that figure. This is very useful to us as the equipment is remote from the water pump controls and clocks.

PUMP

The third subsystem is the pump, which was selected to meet requirements with respect to capacity, type, and materials of construction. Our pump is a duplex type; that is, there are two independent sides to the pump, one for nitrogen and the other for potassium, each of which has the ability, when set at 100% to pump, under continuous operation, 18 gallons per hour of fertilizer. Each head is individually adjustable, with a micrometer device, from 0 to 100%. The fertilizer concentrations in the solution tanks remain the same all year and soil test reports simply indicate a new setting for each of the micrometer adjustments. If we have several days of rain which lower the fertility level in the containers by leaching, this equipment allows us to bring the fertility level back to normal by simply putting on a ½" of additional water, as soon as it stops raining with both vernier adjustments set at 100% and then returning them to'their previous settings. Special applications, such as iron, are easy to make by simply removing one of the lines from the solution tank and switching it to a special tank. This equipment can also be adapted to apply concentrate sulfuric acid, to overcome a bicarbonate content in poor water, if this is needed.

The solution tanks are 80 gallons each capacity. We dump 400# of ammonium nitrate into one tank and 100# of Murate of Potash in the other. A rather normal setting would be 20% on the nitrogen and 40% on the Potassium. One filling of the Nitrogen tank will feed about 150,000 gallons of line irrigation water. The Ammonium Nitrate is 33% and the Muriate of Potash 60%.

The system costs between $2-4,000.00 dollars, depending on how fancy it is, and has an expected life of ten years. On the credit side should be listed the return one must expect from increased productivity and the savings one must expect from reduced labor and increased efficiency of application of fertilizer materials. We feel that to start a container growing nursery today, one of the first items you would need would be a fork lift and the second would be a good injection system. The manufacturer of this equipment is the Milton Roy Company, Philadelphia, Pa.

KEN REISCH: We will now have some time for questions.

HENRY KNOX: Very briefly, we have a large greenhouse operation and find the Ferto-jet from California very satisfactory. It is a strictly mechanical apparatus with the exception of the electricity required for the motor driving the pump. It is a double action piston. With our system it is set up to a ratio 1 to 100, one part fertilizer to 100 parts water. This does necessitate adjustment of the amount of fertilizer put into your concentrate tank. It will operate at a complete range from a hose which will take about ½ gallon per minute to the maximum capacity of the line. We use a high pressure water pump which increases our water pressure to 150 p.s.i. and we found other injectors would not function at these high pressures. This system has worked well for us over the past 4 years with little maintenance. The cost for us in Canada was $525, including duty.

KEN REISCH: Thank you Mr. Henry. The florist industry has been using this system successfully for years.

BEN DAVIS: I would like to ask Dr. Tukey what kind of fertilizer he used on the fall applications.

HAROLD TUKEY: We used ammonium nitrate, potassium dihydrogen phosphate, and also potassium sulfate.

BEN DAVIS: What about using a commercial grade of fertilizer?

HAROLD TUKEY: I see no reason why you could not.

CASE HOOGENDOORN: Do you consider the best time to fertilize nursery stock, November?

HAROLD TUKEY: In Ithaca we usually say the latter part of October, November, early of part of December for our weather.

VOICE: In what tissues is the fertilizer stored after it is taken up in the fall.

HAROLD TUKEY: Most of this material supplied accumulates just behind the buds. With the first break in the weather it moves in rather quickly.

JOHN ROLLER: What happens during warm periods, say in January, with this food stored right behind the bud? Does that increase the danger of winter damage?

Harold Tukey: Whether there is more or a quicker break from fall fertilized plants is a question. I don't think that fall application makes a plant any more susceptible to winter injury. In fact just the opposite, fall applications seem to make a plant more winter hardy. But, if you get an unusual season and things begin to break in winter, definitely they will get clipped.