Morton's Soil Drench C to insure prevention of disease. Rooted cuttings are potted in 2¼″ peat pots.

In our program we take great measures in preventing disease problems. The following precautionary measures are taken:

1. Disinfecting all tools with Chlorox 1:4 with water.
2. Spraying copper napthanate solution on all exposed wood surfaces.
3. Washing concrete floors of the propagation house daily.
4. Washing cutting benches with Chlorox solution daily.
5. Personal cleanliness of each employee.
6. Periodic drenching of cuttings, and liners with Morton's Soil drench C to prevent contamination.

MODERATOR COGGESHALL:

Our next speaker will be Dr. Harold B. Tukey, Jr., Department of Floriculture and Ornamental Horticulture, Cornell University, who will speak to us on the Leaching of Nutrients from Cuttings and Its Effect on Subsequent Growth. Dr. Tukey!

DR. HAROLD B. TUKEY, JR.: Thank you, Mr. Chairman, Members of the Society, and Guests: It is a great pleasure to be with you at your annual meeting. In spite of the snow, let me tell you I would rather be here than in the northern part of New York, so I thank you for the excuse to come.

LEACHING OF METABOLITES FROM ABOVE-GROUND PLANT PARTS, WITH SPECIAL REFERENCE TO CUTTINGS USED FOR PROPAGATION

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That leaves and other above-ground plant parts, including fruits and stems, may absorb water and nutrients, is now well established. The cuticle layer of foliage, once thought to be continuous and impermeable to the passage of nutrients, has now been found to be discontinuous, with numerous cracks and projections which allow the passage of nutrients in aqueous solutions. That these same plant parts may also give up or lose materials into their external environment is less well understood and appreciated. And yet for at least 150 years there have been reports of this phenomenon, indicating that metabolites, both organic and inorganic, could be leached from foliage by aqueous solutions (2). Despite the considerable experimental evidence and speculation which followed these early reports, the concept of leaching was not fully appreciated. Full and adequate proof was seemingly provided by the use of radioisotopes which conclusively demonstrated that labeled materials, absorbed by plants, could be leached by water, including rain and mist (6,11). The magnitude and diversity of these losses make them important in many aspects of plant science, including plant propagation.

The term "leaching" is herein defined as the removal of materials from plants by aqueous solutions. No distinction is made between either the source and form of the materials or the mechanism of removal, only that the materials were derived from the plant.

In order to better understand the phenomenon of leaching as it pertains to plant propagation, it is necessary to review the experimental work done on the subject. This is particularly true, as the results of our preliminary experiments have indicated that the results obtained with other crops are directly applicable to the propagation methods and materials with which we are familiar. In our experiments, young seedlings and rooted cuttings of a number of plant species were grown in either aerated nutrient solution cultures or in a soil medium to which in some cases, radioisotopes of several nutrients were added and were absorbed by the plants as they grew. The plants, both radioactive and nonradioactive, were leached by exposure to an atomized mist spray of distilled water for periods of up to 24 hours. The leachates were passed through ion-exchange resins which absorbed the charged leached metabolites. The resins were later eluted with appropriate chemicals and the eluates were analyzed for radioactivity and for nonradioactive nutrients. Organic metabolites were analyzed qualitatively by chromatographic techniques.

Using these techniques, the phenomenon of leaching was investigated. The first experiments investigated the general occurrence of leaching in nature, using a number of diverse plant species. From these studies and others reported in the literature, leaching is apparently wide spread in nature, with losses now reported from over 115 species. These plants include representatives of deciduous forest and shade trees, coniferous forest trees, deciduous tree fruits, small fruits and grapes, tropical and sub-tropical fruits, vegetable crops, grains, grasses, and forage crops, woody ornamentals, greenhouse and herbacous ornamentals, plantation crops, and tropicals and conservatory plants. From each and every plant studied, metabolites could be leached, and in fact, we know of no plant yet studied which cannot be leached (10).

Now of course there are differences in the ease in degree of leaching of metabolites from various plants, as presented in Table 1. This

Table 1. Loss of Inorganic Nutrients from Young Plants by Leaching With Distilled Water for 24 Hours.

Species	Nutrient			
	Ca	Mg	P	K
	(percent leached)			
Acalyphia wilkensiana	31.1	27.1	20.0	12.7
Chrysanthemum morifolium	10.7	8.1	2.2	1.7
Cucurbita pepo	10.7	19.5	2.5	16.5
Eranthemum nervosum	8.4	7.1	5.1	3.4
Kohleria tubiflora	5.0	6.1	6.0	3.4
Peperomia obtusifolia	2.5	5.0	1.0	1.0
Phaseolus vulgaris	14.1	22.6	4.3	10.1
Pisum sativum	2.4	11.0	0.9	0.4
Ruellia spp.	7.9	9.8	8.8	4.2

table compares the losses by leaching of calcium, magnesium, phosphorus, potassium from a representative sampling of plant species including commercial floriculture crops, vegetable crops, and herbaceo ornamentals. Some species are more susceptible to leaching of these nutrients than are others. For example, squash, bean, and *Acalypha* are more susceptible to the leaching of these nutrients than are *Peperomia* and pea. The other species ranked somewhere in between this range.

Not only are there differences among species but also there are differences in the leachability of cultivars of the same species, and even leaves of the same plant. These differences are apparently related to the internal conditions of the plant and the physical properties of the leaf. Leaves with a smooth, waxy leaf surface, such as pea and *Peperomia,* which are wetted with difficulty, are less subject to the leaching acion of aqueous soluions. However, the leaves of squash and bean which are relatively large, flat-surfaced, pubescent, and wetted with ease are more easily leached. Similarly, leaves of many ornamental tropicals are easily wetted and easily leached.

Table I also shows differences in the leachability of individual metabolites from the same species. For example, losses of magnesium from pea were high, although losses of the other nutrients from this species were low in comparison to the other species studied. A greater amount of potassium and phosphorus was leached from *Kohleria* than from chrysanthemum, but in the case of calcium and magnesium, the situation was reversed.

Thus, the leaching phenomenon appears specific for each species and for certain materials. Differences between leachability of inorganic nutrients are seemingly related to their functions and involvement in plant metabolic processes. For example, phosphorus, is not easily leached from actively growing plants where it conceivably would be utilized rapidly and converted into unleachable forms; whereas calcium and potassium may exist in the so called "free space" areas of leaves, and thus more likely to be leached.

However, regardless of the specificity of plants and nutrients to leaching, each and every plant so far studied has been found capable of nutrient loss by leaching to some degree at least. Several species studied are tropical plants with a thick cuticle and a smooth waxy leaf surface, characteristics which might make them less susceptible to leaching. However, nutrients are leached from even these naturally protected leaves.

Since leaching is such a wide spread natural phenomenon, it is of interest to determine the nature of the metabolites leached from plants. In the case of inorganic nutrients, all the major essential nutrient elements can be leached, and in addition those minor elements which have been studied can be leached.

Typical quantitative losses from young leaves are presented in Table I. The quantity of loss depends upon the nutrient and upon many internal and external variables. However, in general, potassium and sodium are leached with relative ease. Calcium, magnesium, and sulfur are leached with moderate ease, and phosphorus, chlorine, iron, and zinc are leached with difficulty. Losses by leaching by 24 hours may be as high as 80 to 90% of the potassium content, 50 to 60% of the calcium content of mature leaves which are more susceptible to leaching than are younger leaves. Losses of iron, phosphorus, and zinc from young leaves in 24 hours may be less than 1% of the nutrient content of the foliage. It has been calculated that from an acre of crop plants during 18 to 24 hours of rainfall, 62 pounds of ash constituents, 39 pounds of phosphoric acid equivalent, and 5 pounds of CaO are leached (See 11). Dalbro (3), has reported losses from apple foliage of 25 to 30 pounds of potassium, 10½ pounds of calcium and 9 pounds of sodium per acre in one year. Thus, large quantities of essential nutrients can be leached, even from young actively growing plants.

Large amounts of nutrients are also leached from cuttings under mist. Sharp (8) and his co-workers in Florida, using peach, grape, and blueberry cuttings, reported a 16 percent decrease in the nitrogen content, a 23 percent decrease of phosphorus, and a 43 percent decrease of the potassium content of the cuttings after 30 days of constant mist. They also showed that the mineral content of peach foliage was decreased to a greater degree by constant than by intermittent mist.

In addition to inorganic materials, large amounts of organic materials, principally carbohydrates can be leached from leaves. Dalbro (3) reported losses of 800 pounds of carbohydrates per acre from apple foliage per year. From young bean leaves 6 percent of the dry weight

Table 2. Metabolites Leached From Plant Foliage

Inorganic	Carbohydrates	Amino Acids	Organic Acids
calcium	fructose	alanine	aconitic
chlorine	galactans	arginine	adipic
iron	glucose	asparagine	ascorbic
magnesium	lactose	aspartic acid	citric
manganese	pectic substances	b-alanine	fumaric
nitrogen	raffinose	cysteine	glutaric
phosphorus	sucrose	g-aminobutyric	glycolic
potassium	sugar alcohols	glutamic acid	lactic
silica compounds		glutamine	maleic
sodium		glycine	malic
strontium		histidine	malonic
sulfur		hydroxproline	pyruvic
zinc		isoleucine	succinic
		leucine	tartaric
		lysine	acidic glycosides
		methionine	
		phenylalanine	
		proline	
		serine	
		threonine	
		tryptophan	
		tyrosine	
		valine	

was leached 24 hours in the form of sugars (11). The carbohydrates identified in the leachates from leaves include free sugars, polysaccharides, and sugar alcohols. In addition, large numbers of essential amino acids are leached from foliage. In fact, of the soluble amino acids in plant foliage, we have found 21 in the leachates from leaves (10).

There are also large quantities of organic acids present in the leachates from leaves, organic acids which play an important part in the growth processes of plants.

The metabolites leached from the foliage of plants are summarized in Table 2. The losses of a diversity of such metabolically important materials as inorganic nutrients, carbohydrates, amino acids, and organic acids greatly increases the significance and importance of the leaching phenomenon. Leaching affects the quality, yield, and nutritional value of commercial food crops. This is particularly well illustrated in tropical regions where crops during a rainy season may be inferior to those during the dry season, due in part to leaching of metabolites by rain. In addition, during the process of plant growth and development, loss of any of these important metabolic materials, particularly at a critical time will greatly influence the subsequent behavior of the plant.

It should be re-emphasized that the results obtained with intact plants are directly applicable to cuttings of plants propagated beneath mist, both quantitatively and qualitatively.

The variations in leachability which exist between plants and even between two individual leaves of the same plant indicate that there are many factors involved and which influence the process. A list of factors which have been investigated is presented in Table 3. A greater amount of nutrient loss occurs from older leaves than from younger leaves. Young leaves, although they appear delicate and fragile are less susceptible to leaching than are more mature leaves, which may lose a majority of the nutrient content in 24 hours of leaching. Losses are influenced by the type and nature of the plant, the

Table 3. Factors Affecting the Leachability of Metabolites

Internal	External
Type and Nature of Plant	Leaching solution
Metabolite Being Leached	Light-Darkness
Leaf Characteristics	Temperatures
a). wettability	Duration of Leaching Period
b). waxiness	Intensity and Amount of Rain
c). cuticle	Injury (disease, insect, mechanical, climatic, nutritional)
d). pubescence	
e). hydathodes	
Physiological Age of Leaf	Dew
Plant Nutrient Status	
Physiological Disorders	Nutrition in Root Medium

metabolite leached, and leaf characteristics as mentioned earlier in this paper.

Losses are also increased when there is an adequate supply of nutrients to the leaf and within the plant than when the plant is nutritionally deficient. For example, losses of nutrients over a several day leaching period may total 3 to 8 times the amount of the nutrient initially in the plant, indicating a very effective replenishment mechanism in plants, by which leached nutrients are replaced by nutrients from other parts of the plant. This is well illustrated in autoradiograms resulting from the uptake and distribution in several plants of radioactive materials which were leached from cucumber leaves. This illustrates the recycling principle of nutrients in nature in which nutrients are absorbed by the roots, are translocated in the stems to the leaves and are leached to the soil beneath by rain and dew, and there are reabsorbed by roots of the same or a different plant. This is apparently an important process in nature and certain plants receive a considerable proportion of their nutrition *through this means. This process also occurs to a lesser degree to* nutrients and plants in a mist propagation bench.

Losses of metabolites are increased when the plant is injured, as by disease, insect attack, physiological disorders, mechanical means, chemicals, adverse temperatures, and nutritional and moisture deficiencies. It should be pointed out that some horticultural practices injure plants intentionally, such as pruning, some propagation procedures, and applications of herbicides.

Light has little influence upon the leaching of most mineral nutrients, but losses of carbohydrates, phosphorus, and sulfur are greater in the light than in the dark. An increase in temperature increases the losses of calcium, potassium, and magnesium, but the effect of temperature is minimized in the case of carbohydrates, phosphorus, and sulfur.

Of special interest in regards to mist propagation is the fact that a light mist falling over a long period of time is more effective in leaching nutrients than is a brief but heavy rain shower. Wetting and re-wetting the foliage of plants makes them more susceptible to leaching than would the same amount of water applied as a continuous drench. In addition, salts in the leaching solution such as sodium and potassium increase the nutrient loss by leaching, but calcium seems to inhibit leaching.

Plant propagators utilizing mist propagation techniques have all recognized that nutrients can be leached from cuttings by the mist. Evans (4) reported losses of nutrients from *Cacao* propagated under mist. Sweet and Carlson (9) noted the appearance of deficiency symptoms in leafy cuttings rooted under mist. Later, Long *et al* (6) using radioisotopes, were able to effectively demonstrate that nutrients could be leached from cuttings. Losses of phosphorus from cuttings of sweet potato, bean, and poinsettia varied from 2 to 12½% of the nutrient in the leaf during two 4-hour leaching periods. This was in comparison to only trace losses from intact plants. Langhans (5) and

Ang (1) have also showed loss of phosphorus from herbaceous crops under mist.

It is difficult to assess directly the effect of leaching upon the subsequent behavior of cuttings as it is almost impossible to receive the beneficial effect of mist and prevent leaching at the same time. One indirect method of assessing the effects of leaching is to attempt to replace the leached metabolites by application of nutrients through the mist system. Morton (7) has been working on this problem using chrysanthemum and poinsettia cuttings. Initially, cuttings of chrysanthemums contain 5 percent nitrogen, 5 percent potassium and 0.5 percent phosphorus. After being exposed to intermittent mist for 28 days, control plants showed a considerable depletion of all three nutrients. Applications of urea through the mist system maintained the nitrogen content of the foliage but, of course, the phosphorus and potassium content were still low. When a complete, all-soluble fertilizer material was applied through the mist, levels of nitrogen and phosphorus were maintained, but potassium which is the most readily leachable nutrient of any, was still at a considerably lower concentration than that present initially in the cuttings. Very similar results were obtained with poinsettia where it was shown that applications of a complete nutrient solution such as Half-Hoagland solution and a complete fertilizer through the mist seemed to counteract the loss of nitrogen and phosphorus, but did not counteract the losses of potassium.

The influence of such applications of nutrients through the mist was appreciable upon the subsequent behavior of the cuttings. Cuttings which received a complete fertilizer applied through the mist as compared to control plants were 30 percent taller had a greater dry weight, a more luxuriant root development, and a greener color at the end of the mist period. There was no effect upon time of rooting. Cuttings which received nutrients through the mist eventually produced more growth, blossomed earlier and were of considerably greater vitality than control plants which were leached of nutrients during the propagation period.

These results suggest that applications of nutrients through the mist successfully replenished the materials leached from the cuttings, except in the case of the readily-leachable potassium. However, these are preliminary results and are not presented as recommendations. As pointed out earlier, plants are very specific in regards to the leaching phenomenon and recommendations must be worked out for each plant and each nutrient. Of course, in many propagation establishments and with particular crops it is already a common practice to add nutrients through the mist lines in an effort to replace leached nutrients.

Nutrient loss may not always be harmful to plants. Experimentally, plants grown in nutrient solutions may accumulate toxic concentrations of salts, but survive if syringed daily. In this sense leaching becomes important as an ecological factor in plant adaptation and distribution. The effect of rainfall and mist on plant distribution and development has always been thought of in terms of moisture requirements and tolerances. Perhaps rainfall and mist may play an equally important role in conditioning the plant to fit its environment through leaching (10).

This may also be the case in some of the responses in terms of rooting that one observes using mist propagation techniques. An analogy might be made in the comparison of a large man and a small man. The large man may be able to do certain things better, such as playing football and lifting heavy loads. On the other hand, the small man may be able to run faster and jump higher. And yet, both men may be able to do some things equally well, such as thinking, speaking and writing. Similarly, with certain plants, loss of a particular nutrient may be *harmful* when a plant is at a *critical time of development* such as loss of phosphorus prior to rooting or fruit set. On the other hand, loss of nutrients at another stage of the plant development *may have no harmful effects and may even be beneficial.*

The leaching phenomenon is a relatively old but poorly understood concept in plant production which has been sadly neglected. *Research has shown what an important role it may play in the behavior* of plants. The leaf now assumes an even broader role beyond the classical concepts of transpiration and photosynthesis — a dynamic role of uptake and loss of water and metabolites from plants, helping to adjust a plant to its environment and influencing its growth and development.

BIOGRAPHY

1. Ang, Jan-Kee The effect of mist on the uptake and leaching of potassium and phosphorus by *Chrysanthemum morifolium* and *Dianthus caryophyllus* cuttings. M. S. thesis. Cornell University. 1958.
2. Arens, K Die kutikulare Exkretion des Laubblattes. Jahrb. wiss. Botan. 80:248-300. 1934.
3. Dalbro, S. Leaching of nutrients from apple foliage. Proc. XIV Intern. Hort. Cong. 770-778. 1955.
4. Evans, H. Investigations on the propagation of cacao Trop. Agr. 28:147-203. 1951.
5. Langhans, R. W. *Some effects of intermittent foliar water applications on the physiology of plants and the growth of greenhouse roses.* Ph.D. thesis. Cornell University. 1958.
6. Long, W. G., D. V. Sweet, and H. B. Tukey. The loss of nutrients from plant *foliage by leaching as indicated by radioisotopes. Sci. 123:1039-1040. 1956.*
7. Morton, W. M.S. thesis, Cornell University. In preparation.
8. Sharpe, R. H. Mist propagation studies with emphasis on mineral content of foliage Proc. Florida State Hort. Soc. 68:345-347. 1955.
9. Sweet, D. V. and R. E. Carlson. Rooting of cuttings in air-cooled mist chambers. Mich. State Agr. Expt. Sta. Quart. Bul. 38:258-267. 1955.
10. Tukey, H. B., Jr. and J. V. Morgan. The occurrence of leaching from aboveground plant parts and the nature of the material leached. Proc. XVI Intern. Hort. Cong. (In press).
11. Tukey, H. B., Jr., H. B. Tukey and S. H Wittwer Loss of nutrients by foliar leaching as determined by radioisotopes. Proc. Am. Soc Hort. Sci. 71:496-506. 1958.

MODERATOR COGGESHALL: At this time would the four previous speakers on this morning program please come up on the stage?

Just one word before we ask these gentlemen a question or series of questions. When you stand, please give your name loud enough so it can be heard down front, so the question can be attached to somebody, shall I say. At this time we will entertain questions.

MR. MARTIN VAN HOF: I would like to start off with Jim Wells. He told us wounding was almost essential. Well, I almost agree with him, but with the common arborvitae he said he had better results by wounding than not wounding. With me, it is just the opposite way.

When we take pyramidalis cuttings, the cuttings from the bottom branches will root more readily than tip or leader cuttings. We treat both with No. 3 Hormodin powder. In due time, with difficulty, they will root and will be just as heavy as the others. We surely do get them 90 per cent.

Wounding of rhododendron—when we came over yesterday we were talking with one another about rhododendron. There are people who just cut the outer bark either with a sharp knife or with a glass cutter and get better results than with heavy wounding.

Now I want to ask Dr. Tukey about leaching under mist propagation. Does the same thing hold true with evergreens?

DR. TUKEY: What was the question?

MR. VAN HOF: I mean the feeding with urea or something.

DR. TUKEY: I can tell you better about leaching from evergreens than I can about feeding urea, applying this nutrient through the mist, because we haven't done this yet. *Taxus* and juniper are now being run. We can perhaps let you know at a later time. Certainly, leaching does occur from evergreen cuttings. Surprisingly, it can occur in greater amounts than from some of the herbaceous plants. As a general rule, the losses from the herbaceous plants such as chrysanthemum and poinsettia are greater than they are from the woody plants. The taxus seems to be less susceptible to leaching than juniper. Juniper leaches two to three times as much as taxus in our experience. What response this has or what effect this has on subsequent growth, I don't know. Certainly, you can get nice deficient cuttings and have poor color under certain conditions.

DR. KENNETH REISCH: In relation to the wounding of *Ilex*. Jim, we reported at last year's meeting that wounding did not give as good results as cuttings treated with growth substance or with no treatment. This was one under mist, whereas the others were not. We did not get a beneficial effect from wounding *Ilex opaca*.

MODERATOR COGGESHALL: Another question?

MR. CASE HOOGENDOORN: I have a question here for Dr. Waxman or Dr. Snyder. We were trying to root Juniper San Jose, which seems to be rather difficult. We didn't have any luck in the sand, so we tried it in sand and perlite and they rooted very well. The only thing, after they started to root some of them started to turn yellow and then they died. What happened then? I want to tell you one more thing — it was not because the medium was too wet. You don't have to tell me that.

DR. WAXMAN: Maybe it was too dry.

MR. HOOGENDOORN: The only thing I can tell you, when they finally rooted there was at least 15 per cent. Then we picked them up and planted them. After that we didn't have any more losses. Was it that peat that might have had an effect on the rooting?

DR. WAXMAN: Was it sand and perlite when you got the yellow?

MR. HOOGENDOORN: No, peat and perlite.

DR. WAXMAN: I know Charlie once mentioned about injuries in connection with the perlite. Is that a possibility?

DR. CHARLES HESS: I picked this up from Ohio. I don't think those injuries were from the straight perlite.

MODERATOR COGGESHALL: Any other comment?

MR. JACK HILL: I have one for Dr. Tukey. Will you describe the mechanics of the system which you have found most effective in getting this fertilizer or these various nutrient solutions into your mist system, recognizing the highly corrosive effect of most of the nitrogen fertilizers.

DR. TUKEY: Perhaps we haven't been in this business long enough to run into corrosion problems, but as yet we haven't had them. I expect we will. We have done this on an experimental basis, just two or three benches are all that we can use. We use all soluble material, such as those that are plentiful on the market and inject them with an ordinary pump system into the lines, rather than using the proportional injection system you find for automatically watering. As a rule these put on too much material and you get injury to the foliage. So we have to cut this down by gauging and use of solenoid to cut in the pump so the nutrients solution is injected into the lines rather than the water solution.

It goes on as a rule three times a day, this nutrient mist, for about one or two-hour periods. At other times we have used a nutrient mist during the entire misting period and the results have been no different, so we have cut down on the amount of nutrition.

As yet. we haven't had the problem of corrosion so I can't answer it. Certainly it would be a problem to the commercial nursery.

MR. HILL: Just to make sure, I understand you are applying a diluted fertilizer for a 2-3 hour period.

DR. TUKEY: We are applying it as an intermittent mist of ten seconds every two and a half or three minutes for three or four hour periods.

MR. JOHN MAHLSTEDE: A question for the California delegate. You mentioned that you keep track of the number of cuttings your girls make. I am wondering what ranges in numbers and the respective wages paid for a number of cuttings per hour as piece work.

MR. KUBO: Shall I tell them, George? Well, you put me on the spot, John. As I have said, the reason for the use of the boxes was to keep count of our cutting girls. The purpose for it is not to increase the speed of the faster ones but to increase the ones that are slow. That is the purpose, and as far as the amount of cuttings we make a day, of course, depends on the variety. It varies from 2,000 to 6,000 depending on the item. Like any of the junipers we cut approximately 3,000 in a day's time. As far as the wages we pay, I think I will skip that.

MODERATOR COGGESHALL: Another question?

MR. VINCENT BAILEY: I have another question on economics. Somebody mentioned the light-activated mist switch. Can anyone tell me approximately what this switch costs? That sort of appealed to me. I have never used one.

DR. WAXMAN: When we first published this description from Connecticut, we stated that for the single bench or single line system it would cost about $60 if you put it together yourself. There is a company that produces these now, and I think they sell for about $120.

MODERATOR COGGESHALL: Another question?

MR. JIM WELLS: I want to ask for some more data on this Morton Soil Drench C. Mr. Kubo mentioned that he used it a number of times. First of all, you damp your cuttings down or wash them with ordinary water.

MR. KUBO: Yes.

MR. WELLS: Then you dip them in Morton Soil Drench C. and submerge them for ten mnutes. They are under complete cover.

MR. KUBO: Right.

MR. WELLS: They come out and are on the wire racks where they drain, to be made into cuttings. When they are made, they are drenched again.

MR. KUBO: I think you got a little confused there. We first wash the cuttings with ordinary water. then a continuous mist is applied until the cutting operation. The women take the cutting wood, sit at the cutting bench and make their cuttings and they bundle them for ease in handling in applying hormones. When the basket or the wire bottom box is filled, then they apply the Morton Soil Drench. After the cuttings are taken out of the dip, then they are drained and the sticking operation takes place.

MR. WELLS: They are treated with hormones?

MR. KUBO: After they are drained.

MR. WELLS: They are still moist or will they have dried?

MR. KUBO: They are still moist.

MR. WELLS: Then you stick them and then apply Morton's Soil Drench?

MR. KUBO: Yes. I have been asked why we use Morton's Soil Drench so many times. As I have mentioned, our program is based on prevention more than control. Therefore, whenever there is a human element involved we go ahead and apply Morton Soil Drench just to insure no contamination. It is just used as insurance. Once we find contamination takes place, rather than trying to treat it, we dump the whole planting.

MR. HILL: Why don't you dip the workers?

MR. WELLS: The Shell material which you are now using is what?

MR. KUBO: It is known as SD 345. I have talked to one of the Shell representatives and he said in the near future it will be out for sale and it will be under the name of Shell 345. It is still in the experimental stage and is still not for sale.

MODERATOR COGGESHALL: A question right here.

MR. RALPH SHUGERT: While you are up, would you explain briefly your greenhouse sterilization procedure?

MR. KUBO: The copper naphthenate we mentioned is 8 per cent and is diluted one to four. The number of times we apply copper naphthenate is after each crop. In the lining houses, if the liner takes two months to produce, as it comes out we copper naphthenate. The recommendation is once every six months, but we find rather than try to keep time, it will be a lot easier to go in and apply it after each crop.

MR. MERTON CONGDON: Mr. Kubo, I was quite amazed at the amount of free water and drench you use on these cuttings. Some years ago in the early days of the Society here, we had some lengthy discussions on the effect of free water when you take the cuttings and the effect on the rooting. We have found, at least in our nursery ,there is a definite effect on the rooting capacity of the cutting by the use of too much free water. Do you not find any material that is affected so far as the rooting?

MR. KUBO: The conifers are affected. We keep away from continuous misting. One thing to consider is the area we are located in. In Sacramento the relative humidity goes down as far as ten per cent, so it is necessary to keep your cutting wood as moist as possible to prevent dessication. I think we have more heat damage than over-irrigation or over-watering.

MODERATOR COGGESHALL: Another question?

MR. ALBERT LOWENFELS: With respect to applying fertilizer through a mist system, many of us use city water. Would you recommend, therefore, that we turn off our mist and give them a little dose of some fertilizer or not? Use that in place of misting for a period?

MR. TUKEY: There are available commercially certain injection systems which can inject directly into a water line. The only problem with this, as I mentioned before, is that you put on too many nutrients. This is mostly designed to go on root systems. If you inject with commercial injection systems, which are now available. the nutrient accumulation on the whole is too great. So definitely, you have to go to some modification of this, whether it is injecting at only certain times at infrequent intervals or a separate system altogether which comes in automatically and substitutes. We couldn't inject directly into the water system we have. That is why we use a separate system. It definitely is a technological problem.

MR. LOWENFELS: Wouldn't it be a good idea to take a sprinkling can and go over your cutting bed?

DR. TUKEY: You always think toward the way things were before the mist propagation, and of course, good propagators try to use the mist propagation. I don't know why it couldn't be done. This is a labor problem, of course. Most of us don't like to do it. We would rather do it automatically and hook it up automatically.

MR. RICHARD JAYNES: I would like to ask Dr. Tukey — I wonder particularly under conditions of the intermittent mist where you have high evaporation whether there are times when you get an accumulation, particularly of some of the salts that occur in city water, rather than actual loss.

DR. TUKEY: This you can see in the literature, of course, in the case of calcium. You can get an accumulation of calcium. In some water systems there is enough calcium to replace that which is lost. Certainly, if you cut down on the amount of water you can get an accumulation of these salts on the foliage, even so much they will burn very definitely. This is rather easily taken care of by a little additional water, as a rule. So here you have to judge. You can't have your cake and eat it, too. You have leaching going on with more water and you also have beneficial effects. You can't prevent leaching and have the mist. The same with the accumulation of materials, but additional water will take it off.

MR. JACK HILL: I have a question for Ed Kubo. Ed, have you ever been able to determine any rooting inhibition of your cuttings that is traced to the application of Panogen? I raise this question because we seem to have been able to clearly associate reluctance to root with the use of Panogen. Therefore, we have discontinued it on particular varieties. We were heretofore using it much as you do.

MR. KUBO: Jack, on that qustion we have found some damage, not damage but a little stunting of the plants if we use too much of the Panogen or the Morton Soil Drench C. However, we have found that the setback is not great enough to give up the Panogen. As far as the root injury, we have found none whatsoever.

MR. HILL: Was this stunting effective as a result of your application of Panogen to the unrooted cuttings or rather to the drenching of liners?

MR. KUBO: Both, because last year I found out when one of the Shell experimental men came over and we were testing the Morton Soil Drench, one with untreated conditions and one by using the SD 345. We have found both the SD 345 and the Panogen or Morton Soil Drench C have some effect. The higher the dosage the more the stunting.

MR. PETER VERMEULEN: Mr. Kubo, in your greenhouse sterilization, is copper naphthenate the only sterilizer you use?

MR. KUBO: As far as for root exposure, that is all. As far as the washing of the benches and of our tools, we use Cholorox, and for sterilization of soil we use steam and, of course for your bulk soil in the container we use methyl bromide and just stock piling.

MR. VERMEULEN: The copper naphthenate is applied to the surfaces of the greenhouse? What is your carrier? You mentioned diluting 1 to 4. Is that right?

MR. KUBO: Eight per cent, on with thinner.

MR. VERMEULEN: How do you apply it?

MR. KUBO: As a spray. We put the solution in the Hudson tank and spray it on. We find it just as effective as if you were to paint it with a brush.

MR. GEORGE HOYSIC: Have you used anything like plastic spray to prevent any leaching of the material on your plants. Has leaching had anything to do with changing the hardiness of plants?

DR. TUKEY: Let me answer the first question about preventing leaching. We have not done it, but it has been brought to our attention. One of the rubber companies in the southeast area was interested in bringing in plants into production earlier. Here they would have a problem; since carbohydrates, sugars, are important, they are interested in preventing the loss of these. They tried preventing the loss by a plastic coating and they were able to bring the plant into production of latex two or three years earlier. Here is an extreme example of where it works. Whether it would be effective in our own systems I couldn't say. We have no evidence directly on leaching and its effect on hardiness. However, there is some evidence that application or use of foliar sprays before the dormant season will increase hardiness, particularly some of the nitrogen compounds. Whether this has any effect on increasing hardiness as they are taken out of the mist propagation bench is only theoretical. We have no evidence. I think theorectically it would. This is not good enough; you have to have evidence.

MR. ROBERT De WILDE: This morning I gathered from Dr. Snyder's talk and from Mr. Wells that plants which would benefit from wounding are those plants with which you would remove a barrier between the inner cortex where the root primordium is initiated and the epidermis. I gathered also there was mention of a wounding hormone which is produced and I spoke briefly to Dr. Hess during our break. He mentioned there is a rooting hormone which has been isolated. I would like to know a little bit more about this wounding hormone. Has it been synthesized? Has it been used as a root promoting substance in itself?

PRESIDENT SYNDER: I would like to speak very briefly about the first statement you made, Bob. If there is any mechanical barrier in the stem, then certainly the removal of that by wounding should enchance the rooting, but we do get benefits from wounding when we do not have the mechanical barrier there. If we have it, it should help but we get help when we don't have the mechanical barrier.

I will let Charlie take the wounding.

DR. CHARLES HESS: The wound hormone is called traumatic acid and it is commercially available from chemical supply houses. We have tried it on the mung bean rooting test, and it is effective.

One thing we would like to try and we have never had a chance to do it yet, is to see if the application of traumatic acid would have any beneficial effect on graft union formation. Has anyone given this a try?

QUESTION: What concentration?

DR. HESS: It would be fairly dilute, around 10 p.p.m.

MR. DeWILDE: That is what I had in mind, in grafting, if this substance could be used.

DR. HESS: So far the application of auxins to the graft union has not given good results, but this might be another possibility.

MR. BENJAMIN: In the third stage you mentioned auxins and you also mentioned inhibitors. Are you here associating the presence of these inhibitors with rooting at all?

DR. WAXMAN: That is a very good question. That is why I told you in the beginning I was sticking my neck out. Inhibitors are *associated with inhibiting growth of cells, but we haven't tied this up* too definitely. The work Charlie has been doing with mung bean shows portions of these inhibitors have decreased the rooting of the mung bean. Is that right?

DR. HESS: Yes.

DR. WAXMAN: Whether these inhibitors are the same ones Charlie is using, and if they increase at that time of the year, is still unanswered.

MR. JOHN MAHLSTEDE: At a conference last spring in Hershey, there were a lot of states looking with fear at the various injection systems that are being connected to the water line. They are worried about the water drop and poor check valves resulting in nutrients siphoning back into the main water supply line and causing some contamination. I think a lot of growers that are using these systems might be looking into the references on it, because I think it might be a problem in the months ahead.

MODERATOR COGGESHALL: At this time I would like to thank the panel for starting the program off this morning with a very, very good discussion. Thank you very much.

PRESIDENT SNYDER: We will resume in this room at 1:30.

(The session recessed at 12:30 o'clock.)

RECESSED

THURSDAY AFTERNOON SESSION

December 6, 1962

The second session convened at 1:45 o'clock, President Snyder presiding.

PRESIDENT SNYDER: This afternoon's session is a Panel Discussion on Cultural Aspects of Plant Propagation. The moderator is Fred C. Galle, Ida Cason Galloway Gardens, Pine Mountain, Georgia.

MODERATOR GALLE: We are a little bit behind, so our first panelist will talk on Chemicals and Soil Amendments — Dr. J. B. Gartner, Department of Horticulture, University of Illinois, Urbana, Illinois.

CHEMICALS AND SOIL AMENDMENTS

J. B. Gartner
Department of Horticulture
University of Illinois

First of all, when John Mahlstede asked me to appear, I told him I would be happy to. I thought I would have a message I could present, but the more I think about it the more I wonder why I am up here. There are probably two good reasons why I accepted. One was the fact that at Universities we don't get the opportunity to travel at will, and it gave me the opportunity of attending the Society Meeting, which I am happy to do. Another reason is that we were conducing some experiments pertaining to chemicals and soil amendments. I will discuss these later.

First of all, I would like to go back and review some of the older materials that have been used as aids in transplanting.

Wax Emulsions

In 1937, Dr. Miller of Michigan State University developed a wax emulsion that proved successful in reducing transpiration when applied to nursery stock. This material was placed on the market and sold under the trade name of Dow Wax. For a number of years, this material was used by nurserymen in transplanting nursery stock.

Plastics became popular during the war and in 1948, while at Michigan State University, O'Rourke, Hamner and myself became interested in some of the new plastics. One of these new plastics looked very promising as an aid to transplanting since it was nontoxic, transparent and dried at room temperature. The plastic is a polyvinylchloride resin which at the time was named Geon 31X. Today this material is sold as Transplant Coat, Wiltpruf, and many other trade names. When we first started testing this material, we tried it on cut Christmas greens and cut Christmas trees. We had excellent results with this experiment and was able to reduce the dry-