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MODERATOR HESS: Our next speaker is unquestionably one of the greatest innovators in the nursery industry, whether it be to create a complete mist system we have come to know as the "Phytotecktor" or ways of advertising the sale of a nursery. Harvey has made a tremendous contribution to our Society and also is a recipient of the Society's Award of Merit. Harvey will talk to us about the mechanics of misting.

MIST SYSTEMS AND THEIR CONTROLS

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The first requirement of a mist system is that it distribute the water as evenly as possible over the bed area. There are several reasons for this requirement. The next speakers will discuss some of the reasons for not wanting too much water in any one spot — such as leaching of nutrients from the cuttings, water-logging of the rooting medium, etc. One reason they may not bother to mention is that the cuttings will dry out and die in any spot that does not get enough water.

Even reasonably good distribution of the water is difficult to arrange. Really uniform distribution is practically impossible. There are so many different things that must be taken into account — water pressure, nozzle spacing, nozzle height over the cuttings, type and capacity of nozzle, air movement, and a long list of other things. The difficulty is complicated by the fact that nozzles throw circular patterns of water. There is no way to arrange them so they just cover a square. There will always be a lot of overlap of the circular patterns so that the overlapped areas get more water than the rest. If the misting time is reduced to decrease the amount of water in those parts of the bed, other parts will not get enough water.

The best that can be done is a compromise. One must try various combinations of nozzles, spacing, water pressure, size of beds, etc. until the best compromise is reached. Then all these conditions *must* remain constant. Changing only one thing may throw the whole arrangement out of adjustment.

Air movement, wind in other words, can completely upset the most carefully designed mist system. For that reason I think it best to do mist propagation inside a nearly airtight structure of some kind so that the mist can be distributed in reasonably still air even on a windy day. It is easier and cheaper to arrange a tight structure than it is to design an outdoor mist system that will give even distribution no matter what the direction and velocity of the wind is.

Mist nozzles should be dependable and reasonably free from trouble. In the early days of mist propagation it was thought necessary to use low capacity nozzles so as to avoid putting too much water on the cuttings. Such low capacity nozzles gave endless trouble because of a poor distribution pattern in the first place and because the many tiny water passages in them stopped up so easily.

As soon as someone thought of intermittent mist and it was recognized that high capacity nozzles could be turned on and off by a timer and solenoid valves so that they ran only a small part of the time the trouble was largely eliminated. The best modern practice uses fairly high capacity nozzles throwing a fine spray rather than a mist. The small droplets in the spray can be made to give a much more even distribution of the water than mist can do. These large nozzles are controlled by suitable equipment so that they run only a very small part of the time.

We may have as many as six or seven hundred running at once at various times of the year, yet it is unusual for more than two or three nozzles to become clogged in a whole year.

The deflection type of nozzle is the one where the water comes out a simple hole as a straight jet of water which then hits a target above and bounces off in a flat circular pattern. The Florida 550 is an example of this type. It is, in my opinion, the only sensible *type* to use. The simple construction and the large water passages in such nozzles make it very unlikely that they can become clogged.

However, they are not trouble free. The distribution patterns of such nozzles do change radically in time because of wear and sometimes because of deposits from the water although that is usually not a serious problem with properly designed and operated deflection type nozzles.

The jet of water rushing through the hole in the nozzle tip wears the inside of the hole rapidly if the tip is made of brass or some other soft metal. Hardened stainless steel is much more resistant to this wear and tungsten carbide still more so, but also much more expensive. Once the hole in the tip wears and the jet of water is no longer precisely round the distribution pattern of the nozzle becomes quite poor.

The jet of water also wears the face of the target to a very rough surfaces — sometimes actually drills a shallow hole in it. This causes a very bad pattern. With targets of soft metal it is necessary to re-surface the face of the target after every 30 to 60 day period of use.

We have completely eliminated this trouble by surfacing each target with a small, highly polished disc of sapphire. Sapphire is the second hardest natural material known. It stays flat and perfectly smooth after long use — forever as far as I know. The tiny sapphire disc is cemented to the end of the target with a special heat curing epoxy cement. The sapphires are cheap and the operation is fairly easy.

All our nozzles now have hardened stainless steel tips and sapphire targets. Most of them can be used for long periods without any attention. That explains why we have only 2 or 3 fail in a year out of six or seven hundred we use.

The stainless steel tips are not perfect and do sometimes cause some irregularity of pattern. Tungsten carbide tips would be better but are quite expensive. I think if I were going to stay in the business, I would convert all the old nozzle tips so that the jet of water came out through a hole in a little sapphire. Such sapphires are cheap since they are made by the millions for watch jewels.

A good mist control system should take into account every condition that is causing water to evaporate from the cuttings—sunlight. temperature, and air movement. The easiest way for a control system to do that is for it to measure the evaporation directly rather than to measure any one or all of the conditions causing the water to evaporate. The system should then replace just exactly the amount of water that has evaporated — no more and no less. No less because the cuttings would dry out and die in that case. Several other speakers will explain why the control should put no more water on the cuttings than necessary — no more than just enough to replace that which has evaporated, just enough to keep the cuttings barely wet. This is important if best results are to be obtained with difficult plants or with plants that root slowly and must stay under mist a long time.

The control system should "fail safe." By that I mean that if anything goes wrong, the control should either put on more water or turn the water on and leave it on. That way the cuttings are safe in spite of the failure of the control. The excessive water is not good for the cuttings but it will at least keep them alive until the failure is noticed and corrected. If anything goes wrong the control should *not* do the opposite; that is, put on less water or leave the water off. That way all the cuttings would be lost on a hot summer day possibly long before the failure was noticed.

Now as to the relative merits of the different mist control systems:

Time clocks are, of course, the simplest. They are also the least accurate. Unless re-set continually they can be right for only one set of weather conditions or for only one time of day. Even if one stood by and re-adjusted the time clock with each change of weather, it would still not be good enough — because even that would be no better than the best judgment of the human operator. Good control systems can be much better than human judgment.

As far as reasonable principle goes, one of the simplest systems is one of the best. That is the little balancing device known generally as the Geiger control, the one where the water accumulates on a square of screen and tips over a mercury switch. Actually, it was developed in England a good while before Geiger got it. In principle it is right because it does measure directly the evaporation of the water. In practice, it is imperfect principally because it does not "fail safe." Contamination of the screen by deposits from the water causes it to put less water, not more as it should do to be safe. A large bug on the screen would keep the water turned off and kill the cuttings. Wind will interfere with its action too.

Another kind of control measures light intensity, adds it up over a period of time, and puts on water according to the accumulated quantity of light. It is measuring solar energy which is only one of the things causing evaporation of water. In principle it neglects the other causes entirely. Therefore, it cannot be really precise. The fact that it works fairly well, and it does work fairly well, is a little surprising. Its success can only be explained by a meteorological probability; that is, the probability that strong sunlight will be accompanied by higher temperature and generally by more air movement. Were it not for this usually-to-be-depended-upon coincidence, it would not work nearly as well.

In principle the Electronic Leaf is good since it does meassure evaporation directly and it does "fail safe" if the proper electronic circuit is used. In practice, it has given nearly everyone trouble — principally for two reasons — neither one a very good reason. One general cause of complaint is that impure water contaminates the "leaf" and interferes with its action. A pair of sensing elements (the "leaves") each one used on alternate days and each cleaned before use would stop that complaint. Two minutes a day should do it.

The other cause of complaint was simply due to lack of experience with the device. Almost no one was willing to attach a recorder to the electronic leaf so that they could see what it was doing. If they did not know what it was doing, how were they to learn how to make it do what they wanted it to do? Attach a recorder to it so you will know what it is doing, then give yourself a little time to get used to running it and your troubles are over. May I say that we have had at least one operating 24 hours a day every day in the year for over 12 years? Now it is no more trouble to set one up and adjust it than it is to make a good martini!

I have two suggestions for the future. First, if impure water really is a valid objection to the use of the Electronic Leaf, I suggest a relay actuated by a change in capacitance. The sensing element or "leaf" would then be a condenser constructed so that its capacitance would change depending on whether or not it was wet. If of small size or otherwise properly constructed, the conductance of the water which wet it would not be of importance. Therefore, the impurity of the water would not matter. You understand that the present Electronic Leaf is actuated by a change in resistance of the film of water on the surface of the "leaf." Therefore, an impurity in the water *might* interfere with proper action if it *did* change the conductance of the water to a great degree.

My other suggestion is as pure in principle as pure can be. It measures the amount of water by measuring the hydrogen atoms in it. Therefore, the quality of the water has nothing to do with it. If it is water — H_2O — two hydrogen atoms and one oxygen atom, the device will measure it. Of course, in this case the water must not be contaminated with some other source of hydrogen such as a hydrocarbon (alcohol or sugar, for example). But then, I don't suppose any of you intend to spray your cuttings with beer!

Seriously, the quantity of water *can* be measured "atomically" by measuring the number of hydrogen atoms in it. It can be done this way: A polonium-beryllium source is used to provide a stream of fast neutrons. Such fast neutrons are scattered and de-energized (that is, slowed down) by hydrogen atoms, the amount of scattering and de-energizing being in proportion to the amount of hydrogen atoms present. Some of the neutrons are returned, by the scattering, to a silver foil detector sufficiently de-energized so that they can be captured by the silver. The silver foil in turn emits beta rays which are counted by a Geiger counter. This in turn can be made to turn the mist off and on. It is not easy though!

Such a scheme does have advantages. The purity of the water does not matter. Nor does the physical state of the water matter. The device will measure the quantity equally well in either the solid, liquid, or vapor phase. The device will average the quantity of water over a considerable radius — say about 12 inches. It does not matter where the water is. It can be inside the cutting, on the surface of the cutting, or as a vapor in the air. Thus turgidity of the cutting, surface wetness, and relative humidity of the air can all be measured and corrected by one device at one time.

THE MILLENNIUM IS HERE!

MIST FROM A CUTTING'S VIEWPOINT

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When softwood cuttings of plants such as *Prunus serrulata* were placed under intermittent mist or under conventional double glass, superior results were obtained under the mist as shown in Table I. Some of the reasons for better results under mist can be found by studying the micro environment and tissue temperatures under mist and double glass.

The vapor pressure or relative humidity under the two conditions is approximately the same when the mist is off, near