THE THEORY OF MIST PROPAGATION

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Mist propagation is a form of automated syringing which has proven itself in both experimental and commercial use. A number of plants are now being propagated from cuttings which formerly were grafted, and plants which are easy-to-root can be propagated in a shorter time. Also the time in which a cutting can be taken and successfully rooted has been extended by the use of mist. Although timing is still very important, it is not quite as critical as it is for other types of propagation practices.

The question may now be asked, if mist is really automated syringing, why is there such a difference in the results obtained with mist as compared to the standard double glass technique? Why is it, for example, that with *Prunus serrulata* 87% rooting is obtained in 32 days under mist where as only 37% is realized under double glass, or similarly with *Cornus florida rubra,* 96% rooting is obtained under mist compared with 22% under double glass?

To find the answers to these questions, we started by studying the environment under the two conditions — mist and double glass. First we measured temperature. Using very fine thermocouples and a Minneapolis Honeywell multiple recording potentiometer we continuously recorded leaf, air, and rooting medium temperatures. The results from a typical 24 hour period are shown in Figure 1. It can be seen that the leaf tissue temperature under double glass was consistantly higher. This was particularly true during the day, when there was as much as a 30° F. difference. On the average, during a 24 hour period, the leaf tissue temperature was 11° F. higher under double glass. This large and consistant difference in temperature can affect a cutting in many ways.

First, let us consider water relations. As you know leaves contain thousands of pores which are essential for the exchange of carbon dioxide and oxygen. These pores also provide an outlet for the loss of water vapor. Whether or not the loss of water vapor (transpiration) is beneficial to a plant is problematical. In an intact plant the loss of water from the leaves is compensated by water taken up by the roots. But the propagator, as his first step in preparation of a cutting, is to severe the shoot from its water supply. Now, the loss of water vapor becomes a very serious problem, since if it is not reduced, the cutting will wilt and die.

Of all the differences noticed between mist and double glass propagation, perhaps the most pronounced is the ability of the cuttings to maintain turgidity, even when extremely soft cuttings are used. The ability to maintain turgidity under mist is not explained by the presence of more water vapor in the air. In fact the vapor pressure under the two conditions is approximately the same. However, the difference in leaf temperature as described above can cause the difference. Using the data given in Figure 1 we can calculate on a theoretical basis the tendency of a leaf to lose water. In Table 1 you can see with the 11° F differential in temperature between mist and double glass that the vapor pressure gradient under double glass is over twice that under mist. In other words cuttings under double glass can potentially lose twice as much water as a cutting under mist.

Experimental results bear out the theoretical conclusions. Figure 2 shows a comparison of fresh and dry weights under mist with those under double glass. Fresh weight under mist increases significantly as does dry weight. But under double glass the cuttings actually lose fresh and dry weight. Under mist an average cutting gained 4.14 grams of water during the propagating period while an average cutting under double glass lost 1.88 grams of water.

A second way a large temperature differential can affect a cutting is by speeding up respiration or food utilization. Within the normal range of temperatures used for growing plants, a 10° F. increase in temperature will double the rate of respiration. Therefore, cuttings under double glass are using the products of photosynthesis at twice the rate of the cuttings under mist. This in itself is a serious problem since the soft cuttings, which are ideal for mist propagation, contain low carbohydrate reserves. But the problem is greatly magnified by another environmental difference between mist and double glass. This is the difference in light intensity.

The confined air space under double glass acts as a heat trap. If not heavily shaded, the air and tissue temperatures of the cuttings

Table 1. A Comparison of Vapor Pressure in Leaves Under Mist and Double Glass

	Mist	Double Glass
Leaf temperature	75°F	86°F
Vapor pressure within leaf (mm Hg)	23.76	31.82
Vapor pressure of surrounding air (mm Hg)	17.50	17.50
Vapor pressure gradient (mm Hg)	6.26	14.32

reach a point where the cuttings are killed or are severely "burned." But as a consequence of the shading, the average light intensity under double glass was 240 foot candles. In contrast under mist, where no shade was used, the average light intensity was 7000 foot candles.

The processes of respiration and photosynthesis under mist and double glass are compared in Table 2. In this experiment with *Cornus florida* the percentage rooting in 21 days was 96% under mist and 22% under double glass. In the mist bed, with an average temperaure of 75° F and a light intensity of 7000 foot candles, the rate of photosynthesis was equivalent to 6.93 mg of CO_2 taken up each hour by each square centimeter of leaf area. The cuttings under double glass exposed to 80° F. and 240 foot candles of light were ac-

Table 2. Comparison of Rooting, Photosynthesis and Respiration Under Mist and Double Glass

	Mist	Double Glass
Percent Rooting (*Cornus florida*)	96%	22%
Average Leaf Temperature	75°F	86°F
Respiration (mg CO_2/hr/cm^2)	---	5.26
Photosynthesis (mg Co_2/hr/cm^2)	6.93	---
Increase in carbohydrates (mg per cutting)	138.0	17.2

tually respiring rather than manufacturing carbohydrates. The rate of respiration was equivalent to 5.26 mg of CO_2 given off every hour by each square centimeter of leaf. The cuttings under double glass were utilizing carbohydrates almost as fast as they were being manufactured under mist. As a result the cuttings under mist gained 138 mg of carbohydrate per cutting while under double glass there was an increase of only 17.2 mg per cutting. The increase was 8 times greater under mist. The rooting potential of a cutting, and particularly a soft-wood cutting, is very closely related to its carbohydrates supply and the substances which can be synthesized from this starting material. A cutting under mist with 8 times more carbohydrates will have a much better chance of rooting than a cutting under double glass.

The reasons, therefore, that cuttings under mist root better than cuttings under double glass can be attributed to a few main factors. One, the reduced leaf temperature under mist reduces the transpiration rate without the necessity of having a confined air space. The reduced leaf temperature is probably due to a combination of cooling by the water itself, if it is indeed at a lower temperature, and by the evaporation of the water from the leaf surfaces during the "off mist" periods.

Since a confined air space is not necessary with mist, shading or

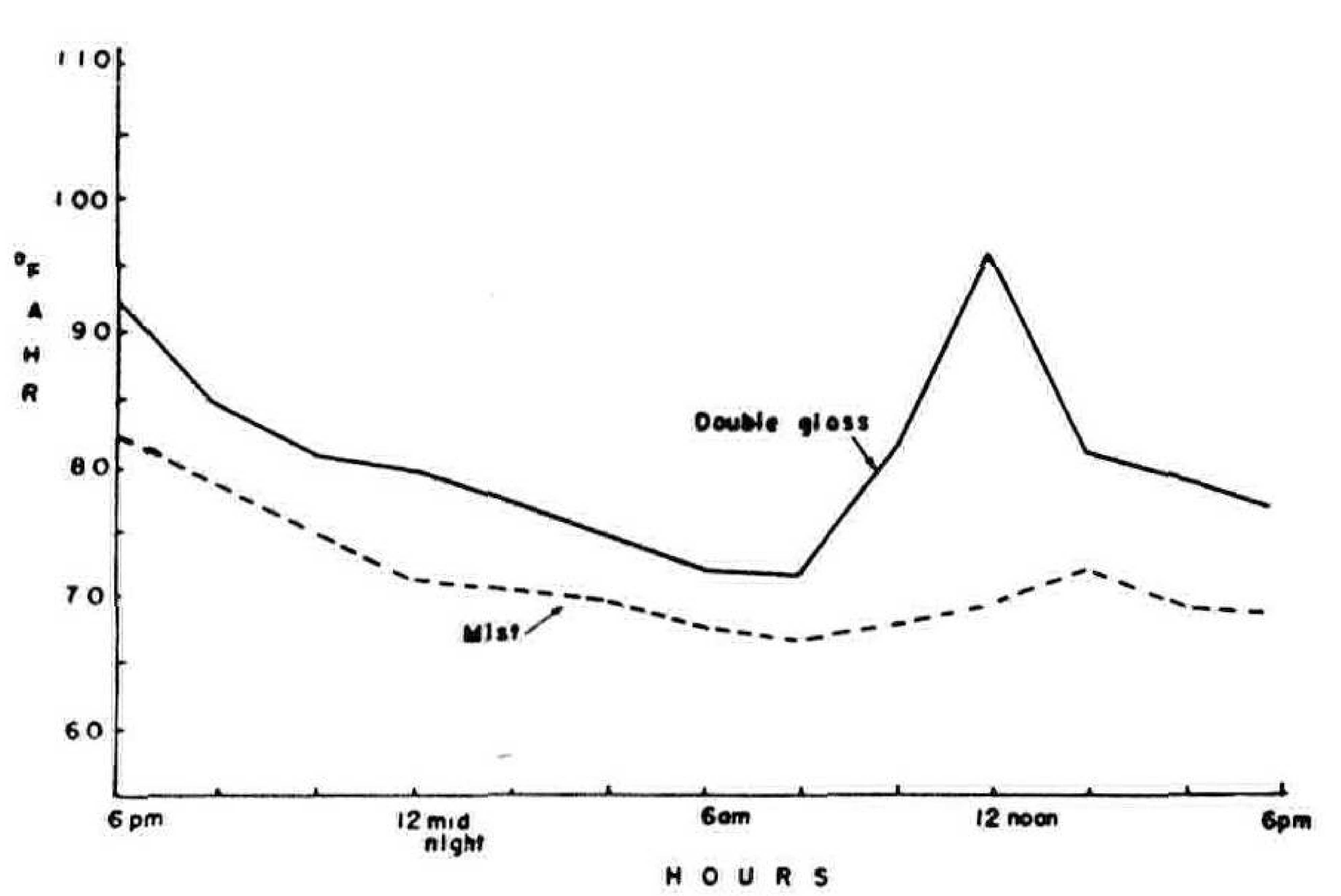

FIG. 1. Leaf tissue temperature under mist and under double glass during a 24 hour period

at least heavy shading is not required. Therefore, much higher light intensities can be used.

The combination of high light intensity and reduced tissue temperature results in situation where the products of photosynthesis can actually accumulate and be utilized in the process of root initiation. Cuttings under the low light, high temperature environment of double glass actually utilize carbohydrates at rate greater than they are manufactured during most of the propagating period.

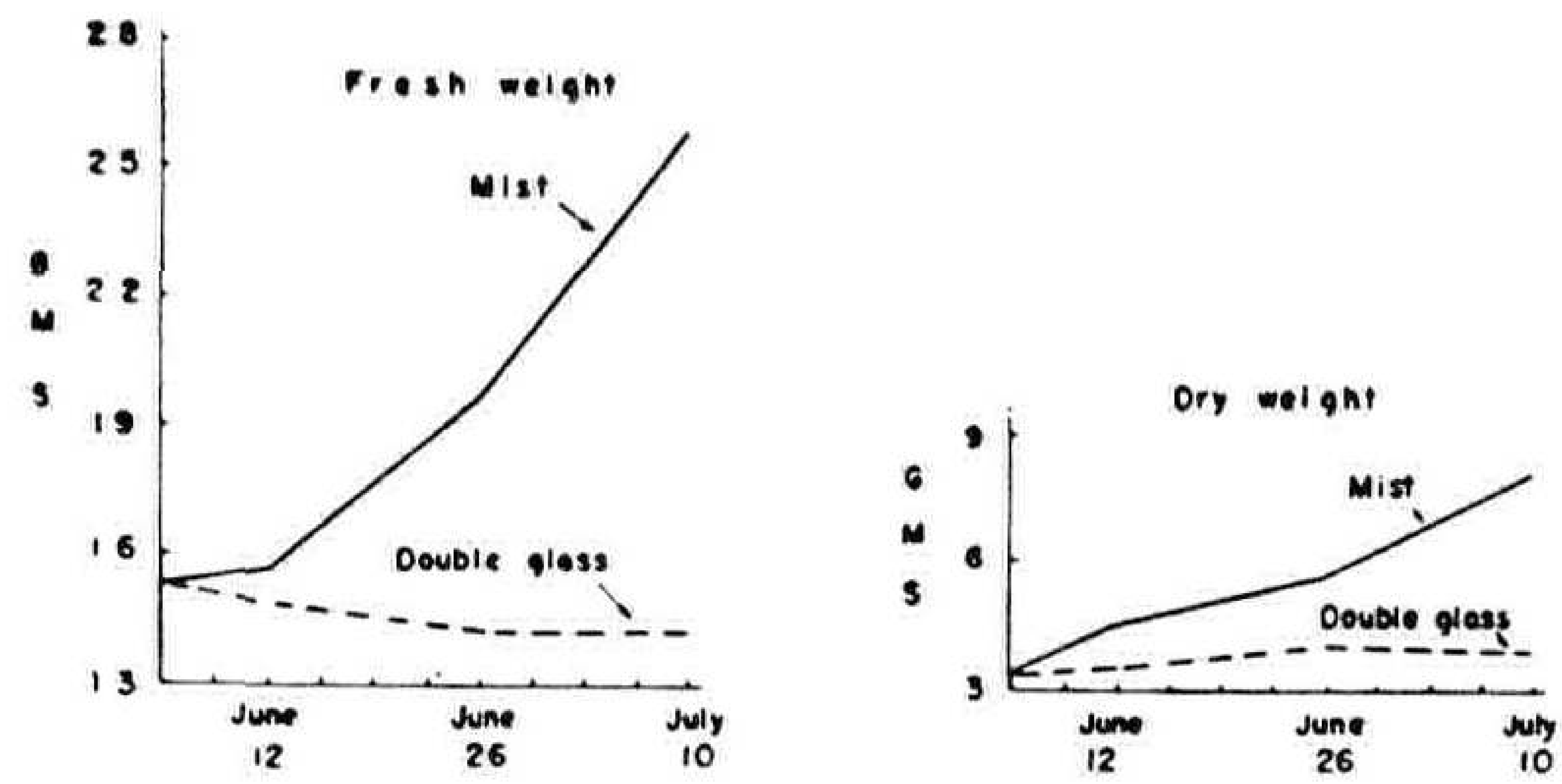

FIG. 2. Comparison of fresh and dry weight of cuttings under mist and double glass

	Gain in fresh weight	Gain in dryweight	Water increase x loss
Mist	8.85 gm	4.17 gm	4.14 gm
Double glass	- 1.22 gm	0.66 gm	- 1.88 gm

MODERATOR HARTMANN: Thank you, Charles, for a most enlightening discussion. I think we can see now that the better results we have been obtaining with mist is not just a matter of good luck, but it is based on sound physiological principles, which are not difficult to understand.

We will now hear from Mr. Peter Mordigan, of Mordigan's Evergreen Nurseries, Sylmar, California, who will discuss the Economics of Mist Propagation. Mr. Mordigan.

THE ECONOMICS OF MIST PROPAGATION

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The increased use of mist propagation throughout the country has necessitated that progressive propagating nurseries experiment and energetically use their findings for the sole purpose of a more efficient operation. The cost of production has become such a serious problem that thoughtful propagators should stop and analyze their particular situation. There are those who are already satisfied with their results. However, there are many who are interested in new methods of propagation. Perhaps this discussion on "The Economics of Mist Propagation" will give hope and comfort to the new adventurer and give reassurance to the "Old Timer" that he is on the right track. To best illustrate this, a quick analysis of our own operation, should throw a new light on the subject.