Misting is a technique of minimizing plant moisture loss while rooting cuttings by controlled periodic wetting of the foliage. Though constant operation of the mist has been used successfully with some plants, results are generally better with intermittent misting. Constant misting is wasteful of water, it leaches plant nutrients from the leaves (particularly with plants with succulent leaves) and the excess water draining into the soil reduces soil temperatures, thus restricting root development.

The on-off interval for misting depends upon how quickly water dries from the leaves. Essentially, the mist should be turned on whenever the plant leaves become dry and should remain on only long enough to wet all leaf surfaces. Since cuttings can easily die if they are allowed to become dry and are exposed to bright sunlight for even a short period, it is very important that the leaves be kept wet at all times when the sun is shining on them. Over-misting is generally considered to be less detrimental than over-watering.

Prior to the general adoption of mist propagation, rooting was attempted by maintaining high relative humidities in the rooting area and restricting sunlight by partial shading when sunlight became intense. The use of partial shading, however, reduces the rate of photosynthesis, indirectly restricting the rate of root development. This, obviously, is undesirable.

Misting reduces leaf transpiration in two ways. First, it causes a reduction of leaf temperature due to evaporative cooling as the water on the leaf evaporates. Second, it maintains high humidity conditions at the leaf surface. The cooling is reported to be as much as 10 to 15°F as compared to leaves not misted. These cooling effects are considered to be so effective that it is generally recommended that misted propagating beds be placed in direct full sunlight.

The development of disease under misting is not, as might be suspected, a serious problem. Powdery mildew development, in fact, is reported to be restricted by misting. Apparently mildew spores do not germinate under water and misting actually serves to hold this particular disease in check.

**Mist Propagation Bench**

The most common arrangement for mist propagation is to place the propagation area on a bench as shown in Figure 1. Since the bed will be kept wet constantly, the bed bottom and sides should be of a material highly resistant to water. Corrugated cement asbestos, which is a common bench material, is highly satisfactory for this purpose. The bench bottom should be covered with a freely draining material, such as gravel or crushed stone, to a depth of 1 inch. The size of the aggregate should be about 1/4 inch. The gravel should then be covered with 2 to 3 inches of sand.

If flats are used for holding the rooted cuttings, the flats are placed on the sand. If the cuttings are to be rooted directly in the bench, the rooting media (for example, a mixture of 3 parts...
sand and 1 part peat) should be placed to a depth of about 2 inches on top of the sand. Since the mist application tends to lower soil temperatures, which in turn restricts root development, best results are obtained when the soil media is warmed. For most plants, a temperature of 75°F is considered optimum. To achieve such temperatures, electric heating cable can be placed in the sand slightly above the gravel layer. Standard soil electric heating cable units are available in lengths of 30, 60 and 120 feet. Thermostat controls are also available which permit setting the soil temperature at whatever level is desired for the specific plant species being rooted.

When the greenhouse is heated with steam or hot water, some soil warming can also be provided by placing one or more heating pipes below the bench. If this arrangement is used, the piping below the bench should be separately controlled so that heat can be added even when greenhouse space heating is not required.

Other features of benches, such as required supporting framework, bench dimensions, and construction features, are discussed in detail in Extension publication AEN-13, "Greenhouse Benches."

Piping Arrangement

The mist nozzles are normally placed on the end of a vertical riser from a distribution pipe placed on or below the propagating bed, as shown in Figure 2. Such an arrangement avoids dripping from the nozzles when the water is turned off, and the riser does not interfere with the uniformity of the mist pattern. If the nozzles are placed on a pipe running above the bed, the nozzles should preferably be placed on the bottom of the pipe so that droplet collection on the distribution pipe is minimal. Dripping from the...
nozzles is still somewhat of a problem with this arrangement due to water draining from the pipe when the water is turned off.

The distribution pipe size depends upon the water discharged by the nozzles and the number of nozzles installed along the length of the pipe. Most mist nozzles discharge from 4 to 15 gallons of water per hour. A 1 inch line will distribute water to 50 of the higher 15 G.P.H. capacity nozzles without significant pressure loss, a 3/4 inch line to 25 nozzles, and a 1/2 inch line to 8 nozzles. Approximately four times as many of the 4 gallon per minute nozzles could be placed on each of these lines.

The risers should normally be made of 1/2 inch diameter pipe. Depending upon nozzle type, the nozzles require a minimum water pressure of 20 to 40 psi for effective distribution over the bed. Pressures as high as 120 psi can be used with some mist nozzles. If the water main pressure in the greenhouse is below the required pressure, a booster pump should be placed in the water line to obtain the required pressure.

Since all of the nozzles have rather small orifices and openings, a filter or strainer should be placed in the line to remove solids which could plug the nozzles.

The control valve is generally an electrically operated solenoid valve which turns the water on and off in response to a control signal. The different controls which can be used are discussed later in this article.

Types of Mist Propagation Nozzles

Two basic types of nozzles are used in mist propagation systems:

1. Oil-burner type nozzles, which are of the whirling action type.

2. Deflection nozzles, where a small stream of water impacts against a small flat plate. Typical nozzles are shown in Figure 3.

The whirling nozzles use small slots within the internal body of the nozzle to break up the water and to generate small droplets which then pass through an orifice and outward away from the nozzle. Since the slots are quite small, these nozzles are particularly susceptible to plugging. The whirling nozzles specifically made for mist propagation discharge the water through an angle of 160°. They are recommended for use at pressures from 25 to 100 psi. In studies conducted by the authors, the water discharge of whirling nozzles varied from 3.46 to 7.70 gallons per hour as the water pressure was varied from 25 to 60 psi. The relationship between the water pressure and discharge for several nozzles is shown in Figure 4. The whirling nozzles provided relatively uniform distribution of water over the bench at all pressures with only slightly better performance at the higher pressures.

The deflection type nozzles have larger orifices than the whirling nozzles and hence have somewhat less tendency to be plugged by solid particles in the water. Since they are simpler in construction, they are also generally a little less expensive than the whirling nozzles. The uniformity of water distribution over the bed area with deflection nozzles is quite variable and for a given nozzle could either improve or become worse as the pressure increases. You can check the uniformity of distribution by placing water cups over the bed area and observing the water collected after a given period of operation. The gap between the face of the orifice and the deflection plate and the centering of the plate over the orifice can be adjusted for most deflection type nozzles. Adjustment is recommended whenever uniformity of distribution differs by

Figure 3. Three types of mist propagation nozzles. A. Deflection type with adjustable plate gap. B. Whirling type, 160° spray angle. C. Deflection type with brass spring wire baffle.
more than 50%. The output of the deflection nozzles is generally higher than the whirling nozzles, varying between 4.18 and 15.34 gallons per hour for the nozzles tested.

**Nozzle Position**

The nozzles should be spaced so that there are no dry areas on the bed and yet the overlap is minimal. If excessive overlap occurs, excessive wetting may result with subsequent unnecessary leaching of nutrients, water wastage, and reduction in soil temperature. Most nozzle manufacturers recommend the nozzle spacing which they feel provides the best results. The most common recommended spacing is 3 to 4 feet. In tests by the authors, the best misting performance was obtained with deflection type nozzles operated at 40 psi and spaced 4 feet apart.

The nozzles are normally placed about 18 inches above the plant bed surface. Some manufacturers may, however, recommend somewhat lower heights.

**Controls for Misting Systems**

Most mist propagation systems are controlled with time clocks. Two clocks are required. One is a 24 hour clock to turn the system on during the daylight hours and off at night. A cycle timer is then used to control the duration of the “on” cycle and the interval between mist cycles. The clock used should be such that both of these intervals can be adjusted to correspond to the growing and environmental requirements. During bright warm summer days, the optimum number of mist cycles can be as many as 20 per hour. Each “on” period should be as short as possible, but sufficiently long to fully wet all leaf surfaces.

A number of greenhouse equipment suppliers provide time clocks with the capability to provide such adjustments.

The disadvantage of clock type controls is that they must be set for bright sunlight conditions so that the plants do not become dry during periods of maximum stress. When set in such a manner, they over-water whenever the sun is less intense, when clouds reduce the solar radiation entering the house, or when the drying rate is reduced due to a reduction in air temperature. For this reason several different types of automatic controls have been developed. One is a pivoting beam which has a piece of screen on one end of the beam and a counterweight on the other. The unit is placed in the misted area so that when water collects on the screen, the additional weight rotates that end of the beam down. A switch connected to the beam then shuts the water off. When the misting stops, the water on the screen dries, thus reducing the weight on that end of the beam. When adequate water has evaporated, the beam rotates in the opposite direction, activating the switch and turning the mist back on. By adjusting the position of the counterbalance weight, the drying interval and mist time can be controlled within reasonable limits.

A second type of control system is one in which the water completes an electric circuit between two electrodes, activating a control circuit. These electronic type controls
are sold commercially in Europe but are not common in the United States. Their advantage is that they do not involve any moving parts and are therefore not as subject to variation due to wind, insects, or dirt accumulation and pivot friction.

Regardless of the type of control used, it should permit a gradual reduction in the frequency of misting as plants become rooted. Such control enables the grower to harden the plants to the water stresses involved with normal watering practices before he removes them from the mist propagation area.

Since even short periods of dryness with new cuttings can be fatal, over-wetting is not considered to be as detrimental as under-wetting. For this reason, the solenoid valve used in the water distribution line should be one which is normally open (that is, open when no current is provided to the control). Then if an electric power failure occurs, the mist will operate continuously, keeping the plants wet throughout the electric power failure. This is, of course, dependent upon having a water supply system which maintains line pressure during periods of electric power failure.

Summary

Mist propagation of plant cutting is a widely accepted practice. For best results, the mist should be operated intermittently. The on-off interval for misting should be such that all cuttings are kept constantly wet. The propagation area is generally placed on a bench for convenience.

Ideally, the total propagating area should be uniformly wetted. In practice this is difficult, if not impossible, to achieve due to various nozzle characteristics. However, extreme variations in water distribution should be avoided. Both whirling and deflection type nozzles can give good results when operated at water pressures between 25 and 60 psi on four foot wide benches. For deflection type nozzles, obtaining the best uniformity of water distribution may require adjustments of the gap between the deflection plate and the nozzle orifice and the position of the plate over the orifice.

Some form of automatic control is essential to prevent excessive use of water and detrimental growth effects due to overwatering which would occur with continuous misting. Since as many as 20 on-off cycles may be necessary per hour, manual control is impractical. The most common control is the electric time clock; however, devices which sense and actuate as a result of the drying rate would be preferable. Two such devices are available: a counter-balanced, rotating beam with a switch, and an electronic artificial leaf where wetting actuates an electronic circuit.