Understanding Fog Technology

Thomas R. Mee
Mee Industries Inc., 4443 N. Rowland Ave., El Monte, California 91731

Historically, many methods have been used in the attempt to retain moisture in unrooted cuttings. These have included sprinkling, misting, intermittent mist, and more recently micromist and fog. It has long been recognized that large droplets get the rooting medium too wet and soggy and that intermittent application of a fine mist is superior to sprinkling. Intermittent misting works fine for some applications, but it is difficult to control and sometimes results in an environment that is either too wet or too dry. Fog technology can solve those problems, but few people understand that the application of fog technology in propagation is entirely different from that of intermittent misting.

First, it's important to understand the difference between fog, micromist, mist, and sprinklers (rain size drops). The difference to the grower boils down to how wet things get, specifically plants and the growing medium. Big drops hold much more water than tiny droplets, so on a drop-by-drop basis a big drop will get anything it collides with much wetter than a small droplet. But what happens if we apply the same volume of water to an equivalent greenhouse area—in one case with rain or mist size droplets, in another case with fog size droplets? The answer is that all of the rain and mist drops will fall to the ground, and all of the fog drops will stay airborne. With micromist some droplets will fall and some will stay airborne. Sprinklers produce rain-sized drops, low-pressure misters produce mist-sized drops, and high pressure foggers produce fog and micromist. There are also products on the market, called foggers by the manufacturers, that propel low-pressure mist across a greenhouse with high velocity fans.

At low relative humidity, some water will evaporate from any drops that are airborne. With low pressure sprinklers and misters operating in a greenhouse environment, typically about 3% of the water will evaporate. With micromist, if the humidity is less than 50%, typically all of the water will evaporate while the droplets are airborne—if the humidity is 80% or more, then as much as half of the volume of micromist water will reach the ground before evaporating. Fan blown misters have some fall out even in low humidity environments and at high humidity virtually all of the water will fall to the ground. With true fog, if the humidity is less than 100%, all of the water will evaporate while airborne. At 100% humidity, fog droplets will not evaporate, but will still remain airborne. As a rule of thumb, in a greenhouse environment, all droplets smaller than 40 microns will stay airborne, droplets larger than 40 microns tend to settle onto the growing surface, especially if the humidity is high.

The above information leads to one rather obvious conclusion: if you want to irrigate, use misters or sprinklers; if you want to raise the humidity or do evaporative cooling, fog or micromist is better for the job.

FOG TECHNOLOGY

True fog is made by atomizers that produce an array of droplets ranging in size from about 2 to 40 µm in diameter. By comparison a human hair is about 100 µm in diameter. Micron is an expression meaning micrometer, or one millionth of a meter. The most useful measure of fog or micromist is volume median diameter. The volume median diameter of a typical fog is about 15 μm. This means that half of the volume of water in the fog is contained in droplets that are larger than 15 μm, and half is in droplets that are smaller than 15 μm.

The best atomizers used in micromist systems will produce an array of droplets ranging in size from about 2 to 100 μm in diameter. The volume median diameter of such a micromist is about 40 μm, so that half of the volume of water is in droplets larger than 40 μm.

It should be noted that most manufacturers today claim that their devices produce 10-μm droplets. While this might be technically correct, it is a useless statement unless the entire drop size spectrum is investigated. For example, in the micromist system discussed above only about 2% of the volume of water is in droplets 10 μm and smaller. This makes the 10-micrometer claim true, but meaningless.

What is the meaning of drop size? At 50% relative humidity and lower, a 100-micron droplet will evaporate in the 20 sec it takes to settle the 8 to 10 ft typically available in a greenhouse. But, at the higher humidity typical of a propagation area, all droplets larger than about 50 μm will reach the growing bench before evaporating.

PROPAGATING WITH FOG

True fog can be used to create a zero-transpiration environment without overwetting the growing medium. This is because fog drops will not settle and irrigate the medium. When micromist is used for propagation it must be cycled off long enough to allow excess water to drain and evaporate from the growing medium. While the drying time is much less than is necessary for heavy mist, it is still long enough to allow some water to transpire through the stomata.

When fog is used for propagation the usual practice is to keep a light fog around the plants at all times. This foggy atmosphere will be at 100% RH, but that in itself is not enough to guarantee zero transpiration loss. This is because when solar energy is absorbed by a leaf, the temperature of the leaf surface is raised above that of the surrounding atmosphere. This raises the vapor pressure of the plant water, so that some water would transpire and evaporate even in a 100% RH environment.

However, when plants are placed in a fog environment another phenomenon takes place that prevents transpiration loss. Although the fog droplets do not settle significantly, they do migrate and bump into both the upper and lower leaf surfaces. This means that after a short time in a fog environment a plant will be coated with a very thin layer of fog water. Under these circumstances when solar energy tends to increase the leaf temperature it is the fog water, rather than plant water, that evaporates and cools the leaf.

The properties of fog make it very useful for plant propagation. Because fog does not settle, the growing medium can be kept light and fluffy and oxygen rich. This cannot be accomplished with mist, and is very difficult to accomplish with micromist. Only true fog can create a healthy, zero-transpiration environment. The zero-transpiration environment created by fog greatly enhances the chance of rooting hard-to-root varieties. Fog is also useful for starting plants in plug trays, whether from seed or from tissue culture. Fog will not saturate the plug tray, and will maintain a healthy environment for seed germination and for tender tissue-culture plants just out of the test tube.

FOG MAKING SYSTEMS

There are three basic types of atomizers used in fog and micromist systems today: air atomizers, direct-pressure swirl jet atomizers, and impaction-pin atomizers (See Fig. 1 and 2 for examples of the latter two). Air-atomizing devices use the shearing force of an air jet to atomize water. The two types of direct-pressure atomizing devices use high pressure and the velocity of water through a small orifice to accomplish the atomizing.

Air-atomizing fog systems have the advantage of being cheaper to make for small systems requiring only 2 or 3 atomizers. Air atomizers are not practical for large systems because the energy requirements are typically 20 times that needed for an equivalent direct-pressure system. A 3000 ft^3 greenhouse would typically use 1 horsepower for a direct-pressure verses 20 horsepower for an equivalent air system. The water flow through an air atomizer can be varied, but high flow rates produce larger droplets. Caution should be used when evaluating an air system, because the specifications usually list maximum flow and minimum droplet size without making it clear that the two do not go together. A good air atomizer can produce true fog-size droplets, but at water flow rates that are ½ to ¼ that of a direct-pressure fog nozzle, and energy requirements twenty-times as high. Another disadvantage of air atomization is that air compressors designed for shop use are not meant to run continuously as is required in an air fog system. The continuous running greatly shortens the life expectancy of the compressor and increases maintenance costs.

Swirl jet nozzles are considerably cheaper to make than impaction-pin nozzles, but produce micromist rather than true fog. Swirl jet nozzles are less efficient than impaction-pin nozzles because of energy loss caused by friction in the swirl chamber. A swirl jet nozzle with an equivalent orifice size operating at the same

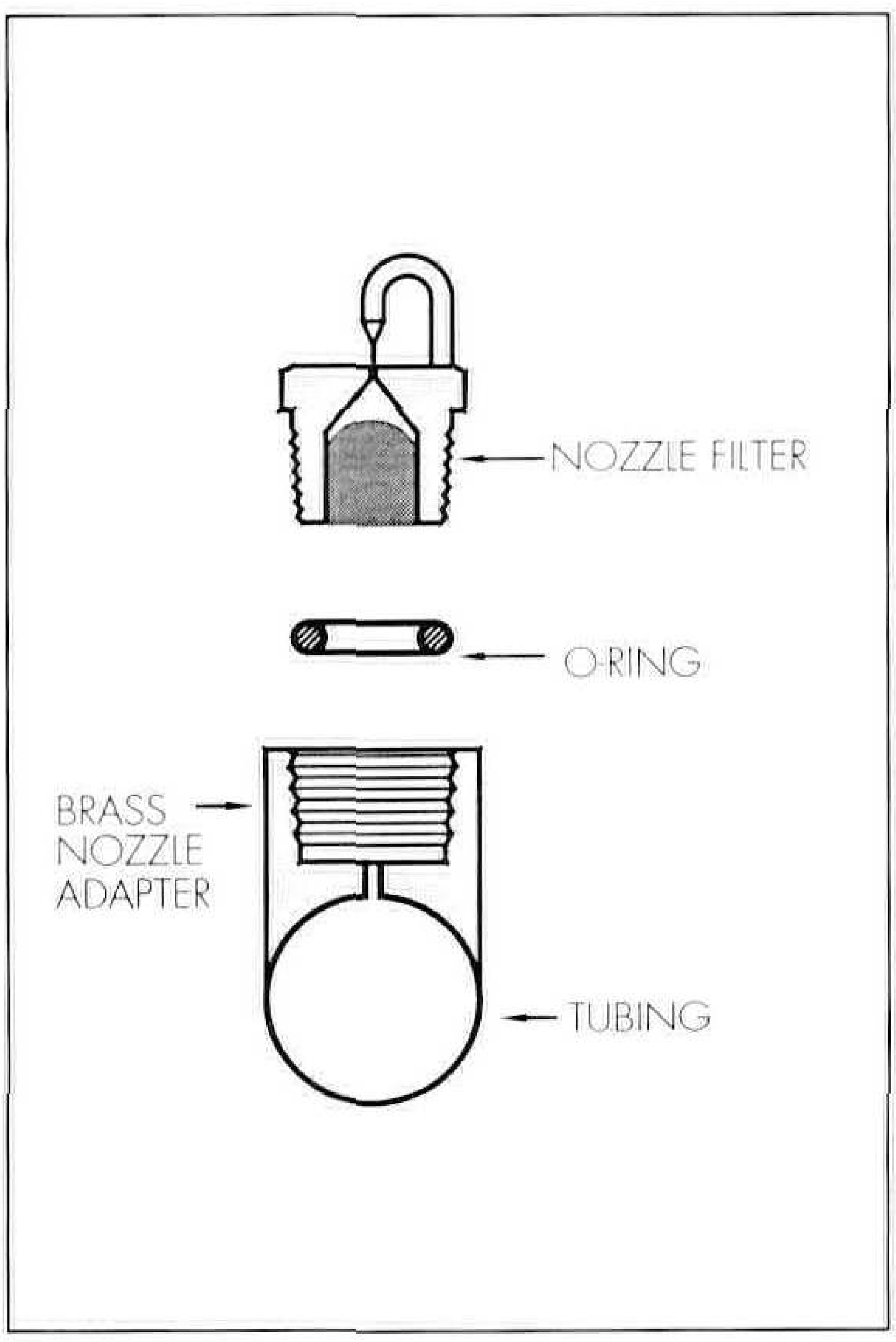

Figure 1. Impaction pin nozzle.

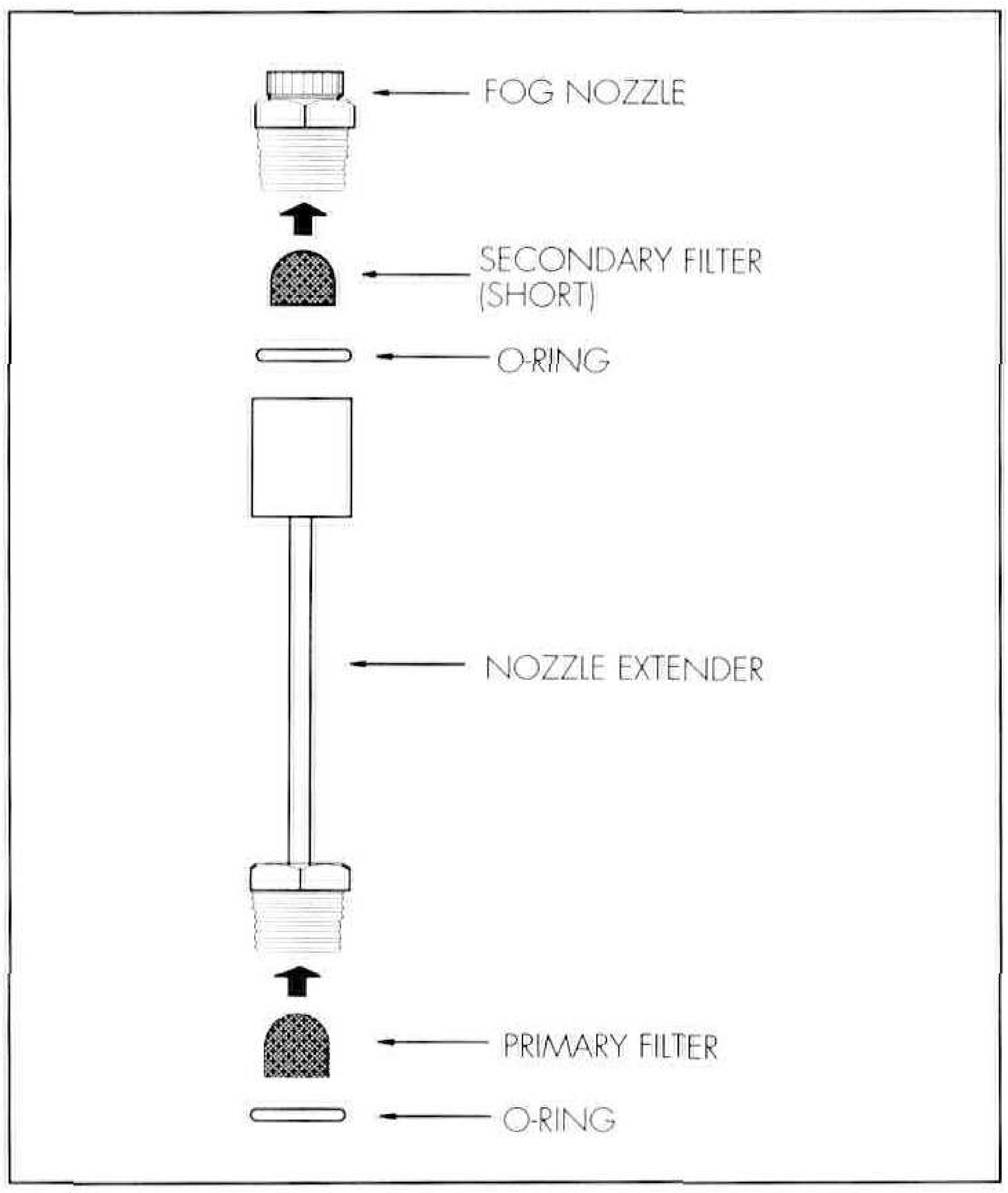

Figure 2. Swirl jet nozzle and extender.

pressure as an impaction pin nozzle, will produce droplets that are approximately 2½ times larger than the impaction pin, with a flow rate that is approximately ½ that of the impaction pin. To get an equivalent drop size and flow rate would require that the swirl jet operate at about 6 times the pressure of the pin nozzle. This would require 6 times the power and considerably more costly pumps and plumbing. Impaction-pin fog systems are the most efficient at producing true fog droplets. To make a true fog, air atomization requires 20 times the energy and swirl jets six times the energy of an impaction-pin system. In addition, the swirl jet system would have to operate at about 6000 psi, and would require much more costly pumps and equipment. Direct-pressure, impaction-pin fog systems typically operate at 1,000 psi, a compromise between equipment costs and small droplet size. These systems are cost effective and practical for use in large areas. Higher pressure would produce finer fog, but would also greatly increase the equipment and operating costs.

SUMMARY

All three basic types of fog systems have advantages and disadvantages. Air atomization systems are best suited for small applications that require only two or three atomizing nozzles. Air systems are impractical for large areas because they become too costly.

Micromist systems are less costly to make than true fog systems and, therefore, might have a cost advantage in applications where the relative humidity does not need to exceed 75% or where wetting is not a problem.

True fog systems are capable of producing droplets that are small enough to stay suspended in the air under all greenhouse conditions. True fog systems offer a tremendous advantage in high-humidity areas where maximum evaporative cooling is required. True fog also offers advantages in propagation situations where zero transpiration loss is desired and where too much wetting would cause problems.

There are a number of fog system manufacturers in the market today. It is impossible to evaluate them by reading sales literature or by listening to sales spiels—all claim to be the best. The best way to make an evaluation is to talk to a grower who has experience using a particular system or, preferably, has experience with more than one manufacturer. There is definitely a difference in quality between systems that seem to be equivalent. Lower cost is not necessarily the most economic purchase. Pay attention to the vendor's ability and reputation for after-sale customer service. All systems need maintenance. Most important, pay close attention to the vendor's knowledge of water chemistry and ability to handle water quality problems. All systems on the market today are subject to nozzle clogging problems and all nurseries have different problems associated with water quality. The vendor's ability to analyze and take care of water quality problems will save many maintenance headaches in the future. When interviewing a grower ask about maintenance costs as well as up-front costs.

The use of fog technology and zero-transpiration environments for propagation is still relatively new to the grower, but it has produced some spectacular results, especially in the propagation of hard-to-root plants.