Fogging Systems: Selection, Installation and Operation©

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Fog is an alternative evaporative cooling method to the fan and pad system. Fog is also used for germination and propagation. Its advantages include more uniform cooling throughout the greenhouse, higher efficiency, and lower maintenance costs. For propagation, a high relative humidity can be maintained without saturating the growing medium.

WHAT IS FOG?

Fog particles are generally considered to be less than 50 microns (0.002 inches) in diameter. The particle size typically used in high-pressure, greenhouse-fog systems is about 10 microns. Mist, on the other hand, is particles from 50 to 100 microns. As a comparison, human hair is about 0.004 inches in diameter that equals 100 microns. Breaking 1 gal of water into 50-micron droplets will produce about 68 billion droplets of fog.

Injected into the air these tiny water droplets remain suspended until they are evaporated. The smallest particles vaporize almost instantaneously. The larger droplets are carried by air currents, gradually becoming smaller until they are vaporized. Mist size particles are much heavier and take much longer to evaporate. These are more likely to fall out and wet the plant surface or saturate the growing medium. If they don't evaporate before nighttime, the potential for disease increases.

HOW FOG WORKS FOR COOLING

Evaporative cooling uses the heat from the air to change the water droplets into vapor. In this process, large amounts of heat are required. The resultant air is therefore cooler and more humid, an advantage to plant growth.

One of the principles of physics states that cool air can take up less water than warm air until saturation is reached. For each gallon of water that is evaporated, over 9400 Btu of heat are absorbed. If the solar load per hour is 100 Btu/ft^2 in the greenhouse, it will require per hour about 0.1 lb fog/ft^2 to maintain temperature. Ventilation air is then used to carry the warm, moist air out of the greenhouse. This is replaced by drier outside air.

The potential for cooling is measured by the difference between the dry bulb temperature, measured with a standard thermometer and the wet bulb temperature, measured with a wet sock over the end of a similar thermometer. A sling psychrometer or battery powered hygrometer are low cost instruments to get these measurements.

Theoretically the air can be cooled to the wet bulb temperature but because of inefficiencies, the temperature will be 2 to 3 ºF higher. Although evaporative cooling is most effective in the Southwest where the air is dry and the difference between dry bulb and wet bulb is near 40 ºF on a summer day, it can also be quite effective across the rest of the U.S.A. In most other sections of the country including the humid Southeast, there is a potential for 10 to 20 ºF cooling below ambient during the warmest part of the day when the stress on the plants is the greatest.

HOW FOG WORKS FOR PROPAGATION

The humidity in the air affects the evapotranspiration rate from the leaf surfaces. To get good propagation, a balance between humidity and transpiration is needed to allow water and nutrient uptake without excess dehydration. In a crop with a dense foliage canopy and without much air movement, a boundary layer of moisture approaching saturation develops around the plants. If the growing medium is also saturated, there is a potential for problems from fungi, moss, grey mold, and fungus gnats.

On the other hand, when the air temperature is high and leaf temperature increases, water loss can exceed the ability of the plant to take up moisture and stress can build up within the plant. The use of fog at this time can reduce the air temperature and increase the humidity within the plant canopy without saturating the plant medium. With more oxygen in the root zone, faster rooting occurs. Once the root system is established, the relative humidity can be reduced.

Experience is usually the best approach to determining the proper humidity level. The following can be used as a guideline for relative humidity:

Establishment phase	60% to 80%
Rapid growth phase	55% to 70%
Hardening phase	45% to 50%

Another advantage to the fog system is that foliar feeding, insecticides, and fungicides can be applied automatically with a fog system. This saves time and gives a uniform application.

FOG SYSTEMS

Several methods are used to produce fog. A typical system uses a high-pressure pump, distribution piping, and nozzles that break the water stream into very fine droplets. Piston pumps are needed to develop the 800 to 1200 psi pressure to get the 10- to 20-micron size droplets. Most systems available from irrigation equipment suppliers and labeled as fog systems operate on 50 to 60 psi irrigation water and create a droplet size larger than 50 microns. They are really mist systems.

Copper, stainless steel, and re-enforced flexible hose are used for piping. Diameter is frequently 1/4 or 3/8 inch as water supply required per nozzle is only 1 to 2 gal/h. Distribution piping for cooling is placed above the air intake louvers or vents and a few lines of pipe are placed above the crop. For propagation, lines of pipe are evenly spaced above the crop.

Plastic, ceramic, and stainless steel are used for nozzles. Nozzles should have anti-drip check valves to prevent dripping after the system shuts off. An integral strainer will keep the nozzle from clogging.

The greatest problem associated with fogging systems is nozzle clogging from chemical and particulate matter. Calcium deposits can coat the inside of the pipe and nozzles reducing flow. Water treatment or the use of rainwater or bottled water can solve this problem. Several levels of filtration of particulate matter should be installed. The final filter should have a one or two mesh.

Fog can also be produced by a system using a high-speed fan with water channeled to the tip of the blades. The shearing action as the water exits the blades produces a fine fog. The fan distributes the fog above the crop canopy. This system has the advantage of less clogging as no nozzles are used but some growers have had to remove the system because of the high noise level.

Water at household pressure, injected through a nozzle into a stream of compressed air will also produce a fine fog. Each nozzle requires both a water and air supply. Different flow rates and droplet sizes can be achieved by adjusting the water and air pressure. Distribution can be through ducts, HAF fans, or nozzles evenly space over the crop.

Mist systems can be controlled with time clocks, a mechanical sensor, or humidistat. The time clocks operate so that the mist is turned on for several seconds every few minutes. The mechanical sensor is usually a screen placed in the plant canopy that collects moisture and turns off a solenoid valve when it gets heavy. The humidistat is a switch that senses the humidity level of the air.

Fog systems frequently operate with a controller or computer that measures vapor pressure deficit (VPD). The difference between saturation water vapor pressure and ambient water vapor pressure is the VPD and represents the evapotranspirational demand of the surrounding atmosphere as well as the proximity to the dew point. Due to the fact that relative humidity varies with temperature, it is better to manage propagation with VPD. By maintaining the VPD below one, water stress within the plant can be keep at an acceptable level.

The following are some manufacturers of fogging systems:

Atomizing Systems, Inc.
1 Hollywood Ave. Bldg #1
Hohokus NJ 07423-1433
Phone: 888/COLDFOG

Jaybird Mfg. Inc.
2595B Clyde Ave
State College PA 16801
Phone: 888/889-4407

Mee Industries, Inc.
204 W. Pomona Ave.
Monrovia CA 91016
Phone: 800/732-5364

MicroCool
1229 Gene Autry Trail
Palm Springs CA 92264
Phone: 800/322-4364

MicroMist Systems
32032 Dunlop Blvd.
Yucaipa CA 92099
Phone: 909/795-7600

Zwart Systems
Box 235
Grimsby Ont Canada
Phone: 905/643-4156