Managing Humidity in the Greenhouse

By growing dry, moving the air and warming the plants before dehumidifying your greenhouse, you can save money and improve crop quality.

By Dean Peterson

Too much humidity in a greenhouse is trouble. Splashing from condensate dripping from the ceiling can spread diseases. Water puddles on the greenhouse floor promote algae growth, are insect breeding grounds, and a safety hazard for workers.

Humidity that is too high interferes with plant transpiration. It also causes condensate droplets on the ceiling and walls which reflect light. "This reduces the amount of light transmission into the greenhouse for plant growth," says Peter Ling, associate professor in Ohio State University's Department of Food, Agriculture and Biological Engineering. Ling is based at the Ohio Agricultural and Research Development Center at Wooster, Ohio.

Too little humidity also can stress plants by accelerating transpiration to more than what the roots can take up and translocate. The solution to these and other humidity concerns is a program of systematic humidity management, Ling says.

KNOWING WHAT YOU'RE DEALING WITH

Relative humidity is the amount of water in the air compared to the total amount of water the air can hold. Warm air has more water-holding capacity than cool air so temperature has a big impact on relative humidity. Air with a relative humidity of 80 percent at 68° F will have a 56 percent relative humidity at 79° F.

Dew point is the temperature at which the relative humidity reaches 100 percent. If a surface in contact with the air is at the dew point or below, condensation will occur.

Vapor pressure deficit (VPD) is the difference between the amount of moisture (water vapor) in the air and how much moisture (water vapor) the air can hold when saturated.

VPD in the greenhouse can be thought of as the difference between the amount of moisture in the air and how much moisture is on the leaf surface.

"VPD is the driver of transpiration," Ling says. "Transpiration affects water translocation, nutrient uptake and photosynthesis. When the vapor pressure deficit is too high, drought stress can occur because the transpiration rate exceeds the rate water can translocate from the roots to the leaves."

VPD is measured in kilopascals (kPa) which is the pressure of 1,000 newtons of force per square meter of surface. One thousand newtons is about equivalent to 225 pounds. VPD is calculated using temperature and relative humidity. A general VPD range for a greenhouse is from 0.45 kPa to 1.25 kPa.

The higher the VPD, the drier it is in the greenhouse. The lower the VPD, the more moisture is present. At the upper limit of the VPD range, the crop may not be able to keep up with transpiration demand. At the lower limit, disease and fungal growth are concerns.

"Each crop has a different, optimal VPD range," Ling says. The optimal VPD for a crop can change with every growth stage.

TAKING CONTROL

The starting point for humidity management is to "grow dry" or have a dry greenhouse. "Grow dry is the least energy intensive method for managing humidity," Ling says.

Grow dry means precise watering to provide just enough water to meet the plants' needs without leaching. Proper timing of watering is also important. "Don't water right before sunset," Ling says. "That water overnight could be a problem. At sunrise, you want to decrease the humidity, raise the VPD and get the plants ready for transpiration and photosynthesis."

Draining condensate, considering condensing surfaces and eliminating condensate collection points are also part of growing dry.

Draining condensate prevents light reflection off droplets and provides more light for plant growth. Surfactant products are available for problem surfaces. "Do not leave too many wrinkles when installing roofing," Ling says. The wrinkles become collection points for condensate from any water film on the roof.

Circulating air, either horizontally vertically or both, can help keep humidity evenly distributed. Vertical air movement up from the floor is effective for seedlings on grated tables. Ceiling fans and horizontal air flow is best for taller plants and a denser canopy.

Warming plants with some of the new technologies in heat piping can also help ensure a dry house. "We want water to spend a minimal amount of time on the plants," Ling says. Water that stays on the leaves too long can cause fungal growth or condensate to drip on the floor.

"If these practices don't get your relative humidity down to where it needs to be, look at dehumidification," Ling says. "Dehumidification is the most energy intensive way to remove humidity from the greenhouse."

A heat and vent system that purges high humidity air and replaces it with dry air from outside is the most common dehumidification method. The system can be either a heat-and-vent or a heat-mix-vent operation. "A heat-mix-vent system is

recommended," Ling says. "It gives more time for mixing air so more moisture is purged."

A heat and vent system's efficiency is affected by the outdoor temperature and humidity. Air drawn in that is colder than the set point must be reheated and that takes energy. Air drawn in that's more humid than the greenhouse also requires more energy.

A heat and vent system is typically about 20 percent of a greenhouse's energy bill, but can range about five percent to 30 percent.

A heat exchanger can make a heat and vent system more efficient by recovering some of the heat lost through venting. A heat exchanger is an air-to-air system that lowers energy use in direct proportion to the exchanger's efficiency. Heat exchangers for greenhouse use are typically about 40 percent efficient.

Adding a heat exchanger typically saves five to 15 percent on the total energy bill. With these numbers, a heat exchanger will pay for itself in three to nine years.

However, in summer conditions, even as far north as 53 degrees' north latitude — where much of the research has been done, heat exchangers become less efficient than heat and vent systems.

Consider the air exchange rate before adding a heat exchanger. Exchange rates equal to or less than 1.2

changes per hour are not adequate. "Identify an exchanger of sufficient capacity for your greenhouse," Ling says. A greenhouse may require several exchangers. The air exchange rate is the total volume of air that moves through the greenhouse in one hour.

Mechanical and chemical dehumidifiers are ventless dehumidifiers that do not exchange air with the outdoors. "They are a closed greenhouse," Ling says, and no added CO_2 is lost.

Ventless dehumidifiers offer the advantages of recovering water for greenhouse use and recovering latent heat when water vapor is condensed. Ventless dehumidifiers have lower power requirements and an energy efficiency of greater than 100 percent.

Mechanical dehumidifiers use either a heat pump or a refrigeration system to create a cooling cycle to collect moisture from the air and condense it. This is followed by a reheating cycle to reheat the air.

Removing moisture rather than venting warm air lowers heating costs. Latent heat captured through condensation also provides supplemental heat.

Low outdoor humidities and warm outdoor temperatures reduce the savings from a mechanical dehumidifier. The advantage of latent heat recovery is lost when greenhouses must be cooled.

Chemical dehumidifiers use a hygroscopic solution, typically a saturated salt, as desiccant to dry the air. A chemical dehumidifier absorbs moisture better, has a lower temperature of regeneration and a low cost. They also recover latent heat and have been found to save about 10 percent of the energy used in a heat and vent system.

Chemical dehumidifiers are not as efficient as heat and vent systems when the outside air has a low humidity and medium to low temperature. Some units also require a boiler.

All dehumidification systems are affected by the amount of plant material and excess water in the greenhouse. The air leakage rate and the air exchange rate are also factors. "Modern greenhouses tend to have less air leakage and hold higher humidities," Ling says.

Much of the research on dehumidification was done at higher latitudes and mostly during the heating season. At latitudes of less than 45 degrees north, there will be less benefit from mechanical and chemical dehumidification.

"Efficient, humidity management requires a systematic approach," Ling says. "Grow dry, circulate air and warm plants all effectively reduce greenhouse humidity. If you must use dehumidification, pick a system that fits your climate." ❖

Dean Peterson is a freelance writer based in St. Johns, Michigan. He can be reached at dpeterson060@gmail.com.