GROWERTALKS

Features

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The Gist on Mist

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Vapor pressure deficit (VPD) isn't a new concept, but it's beginning to become more widely implemented in commercial greenhouses. The VPD concept was developed in the 1970s by Bob Oglevee (Oglevee Greenhouses in Connellsville, Pennsylvania) as a tool to improve mist control systems in propagation. Bob was aware of the challenge of applying the right amount of mist to unrooted cuttings, so he developed a relatively simple method to predict evapotranspiration based on the greenhouse climate. This tool allows the mist system to dynamically change throughout the day and night to compensate for the continual fluctuation in humidity, temperature and sunlight in a greenhouse.

Today, mist propagation systems are still primarily controlled by time clocks. These are called static systems because they don't automatically adjust to the changing greenhouse environment. As a result, growers must be continually adjusting their time clock settings as the weather changes. Since growers are busy people, they don't always make the appropriate adjustments throughout the day. In most cases, this results in excess water being applied to the cuttings since it's safer to err towards applying excess water than allowing the cuttings to dry out and immediately die.

As our industry becomes more aware of environmental impacts and more concerned about sustainability issues, water management becomes more of a focus. Excess water application has several negative side-effects—such as wasted fertilizer in the leachate, increased disease incidence, and increased algae growth on the growing media and walkways. The solutions for these problems are costly, but these issues can be mostly avoided with proper water management. VPD is a tool that can help.

What's VPD?

VPD is a concept that states the primary driving force for evapotranspiration (water loss from wet leaves) is the difference between the water vapor pressure in the leaf and the water vapor pressure in the air (Figure 1). Water vapor pressure isn't a term that's familiar to most growers, but it's relatively simple to understand. Water vapor pressure represents the potential for water to evaporate from a leaf and is mathematically calculated from temperature and humidity measurements.

VPD increases when environmental conditions cause a rise in leaf temperature or a decline in air temperature and/or air humidity. Leaf temperatures are most likely to rise when solar radiation increases or when cuttings start to dry out on the propagation bench. Air temperatures and air humidity are most likely to decrease when outside air is brought into the greenhouse and the humid, warm greenhouse air is exhausted out through the vents. These are obviously the conditions when mist frequency must increase to compensate for the higher rate of evapotranspiration, thus VPD control can allow the mist system to adjust dynamically.

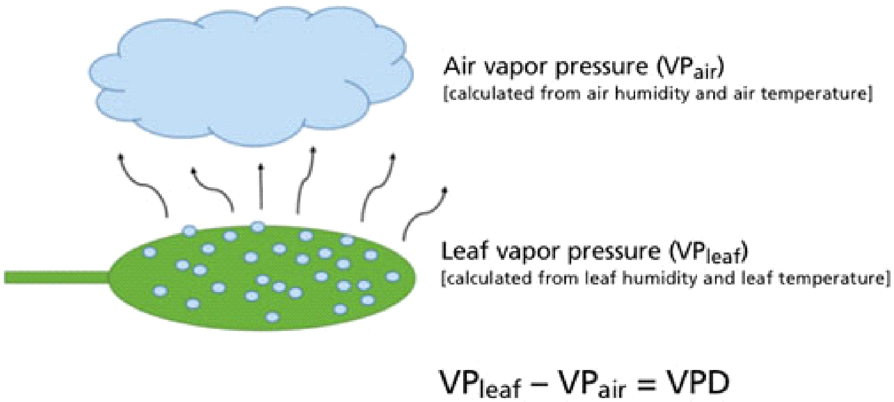

Figure 1. Vapor pressure deficit (VPD) is calculated by subtracting the water vapor pressure of the air from the water vapor pressure of the leaf. Water vapor pressure is calculated based on the temperature and humidity of the water in the air or leaf. See Sidebar 1 for the specific equations

How do mist systems utilize VPD?

VPD measurements are recorded every minute by the mist control system. The system can be a greenhouse climate control system, such as Argus, or a boom control system, such as GTI. These measurements are accumulated until a threshold number is reached and a mist event is triggered (Figure 2). In time clock systems, the grower has a recipe, either in their head or on paper, that has the estimated time settings for each day in propagation. In VPD control systems, the grower must similarly put together a recipe of VPD threshold numbers for each day in propagation, since the mist requirements for cuttings decrease with each passing day on the propagation bench. Thus, the VPD threshold increases each day in propagation, resulting in more time between mist events as the cuttings mature.

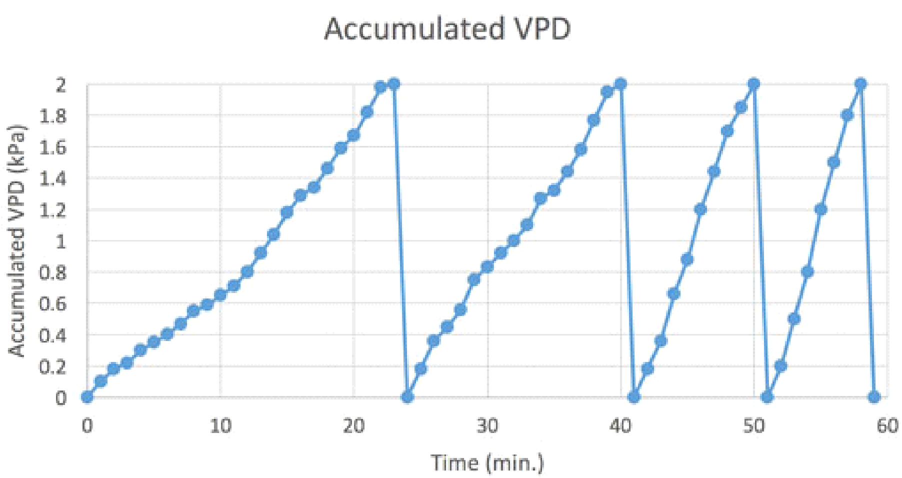

Figure 2. VPD is calculated each minute and that value is accumulated. Once this value reaches a threshold setting, a mist event occurs. In this example, four mist events occur over one hour. The amount of time between mist events is decreasing because the environment is becoming warmer and/or drier, thus VPD is accumulating at a faster rate. This explains how VPD dynamically changes the mist program as the greenhouse climate changes.

Limitations & pitfalls

Automation allows a good grower to do a better job and to use their time more efficiently. Automation doesn't turn a bad grower into a good grower. Thus, VPD control allows propagators to worry less about the mist system and it frees them up to do other essential tasks. VPD control doesn't replace the need for skilled personnel; in fact, it likely increases the need for intelligent and experienced growers that can get the most out of the system.

VPD does not perfectly predict evapotranspiration, so growers can't simply set up a VPD recipe and walk away. Good growers will appreciate what a VPD system can do for them, but it's a mistake to think that VPD is a cure-all solution for everything that ails them in propagation.

VPD … Not just for mist anymore

VPD can be used for more than just controlling mist events in propagation. VPD can also be used for controlling irrigation systems. This concept has been used for irrigating hanging baskets. Large containers are more forgiving than smaller containers and there's no reason why VPD recipes couldn't be easily adapted to control valves on hanging basket lines. There's much need for additional research to be done in this area.

Current research

At Clemson University, we're currently creating new models to predict water use in propagation. Our initial findings suggest that VPD isn't the best way to control mist systems, although it may be the easiest solution to implement. We've observed that solar radiation is the single most important environmental factor that influences evapotranspiration, followed by wind speed. This means that we can more accurately predict the need for a mist event if we have solar radiation and wind speed measurements. These measurements are more difficult to make than air temperature and humidity measurements, so new ideas and technology will be necessary to take the next step in mist control.

For now, VPD is still a useful concept to pursue and to consider investing in.

SIDEBAR 1
Calculating VPD

Three measurements are required to calculate VPD:
1) Leaf temperature; 2) air temperature; and 3) relative humidity. (Leaf temperature is difficult to measure, so Sidebar 2 addresses the most common methods for estimating leaf temperatures.) Once you have these three
measurements, you'll use the following three equations to calculate VPD:

Equation #1
Calculating leaf water vapor pressure (VPleaf):

VPleaf = 2.716 (19.017-(5327/(LeafTemp+273.15)))

LeafTemp is in degrees Celsius. This calculation assumes that the relative humidity of the leaf is always 100%.

Equation #2
Calculating air water vapor pressure (VPair):

VPair = 2.716 (19.017-(5327/(AirTemp+273.15))) x relative humidity

Relative humidity of the greenhouse air is expressed as a fraction, e.g., 50% = 0.50. AirTemp is in degrees Celsius.

Equation #3
Calculating vapor pressure deficit (VPD)

VPleaf – VPair = VPD

The units of pressure for these equations are in kiloPascals. Some VPD systems use millibar (mbar). Simply multiply kPa by 10 to get mbar.

SIDEBAR 2
Estimating Leaf Temperature

Leaf temperatures are easily measured with an infrared temperature gun; however, this isn't practical to do on a continuous basis in the greenhouse. So there are two other options:

Option #1: Artificial leaf
Many commercial VPD systems utilize an "artificial leaf" as part of a weather station located in the greenhouse. The artificial leaf is simply a metal rod that sticks out of the weather station and the temperature of this rod is measured inside the weather station. Sometimes the sensor is painted green (which doesn't make it more leaf-like). As you can imagine, a piece of metal isn't going to be the same temperature as a transpiring leaf.

As an example, a green car in the parking lot is going to get a lot hotter on a sunny day than the leaves in the trees in that same parking lot. So artificial leaves aren't particularly accurate; however, they do somewhat compensate for the effect of solar radiation on evapotranspiration.

Growers know that sunny weather requires more mist in propagation. An artificial leaf will increase in temperature as solar radiation increases. This results in a higher water vapor pressure of the leaf, which in turn creates a higher VPD condition. The result is that mist will be turned on more frequently.

The bottom line is that the mister will adjust better on sunny days with an artificial leaf despite the limited accuracy of the measurement.

Option #2: Assume the leaf is the same temperature as the air
One can simply substitute an air temperature measurement in Equation #1 (Sidebar 1) for the leaf

temperature measurement. For the most part, leaf temperatures are similar to air temperatures, so this is a reasonable assumption. This also means that you can make VPD calculations with only two measurements: air temperature and relative humidity. This method doesn't compensate for the effect of solar radiation on evapotranspiration, but its ease of use makes VPD measurements more accessible to many growers. **GT**

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