

Precision and location of measurements critical for climate control and energy efficiency

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Published in the Grower 58(11), 2003, p. 46-48

Greenhouse climate control is as good or as bad as its underlying measurements. This article is about correctly measuring temperature, humidity and outdoor conditions. This requires using the right type of sensor, keeping it clean, applying maintenance and calibration when needed, and placing the sensor in the right location. Incorrect measurements can cost a lot of money due to loss of production, waste of energy or disease infection.

Correct measuring is important

A grower can set the computer to control the temperature very accurately at 21.5 °C (for instance), but if the measurements are inaccurate, he may get 19 °C or 23 °C instead. Deviations of 1-2 °C are very common, and larger faults happen too. Possible causes are: poor quality sensor, incorrect position of the sensor, the sensor is exposed to sun, heating or wind, or is covered by a layer of dirt, or the fan in the measuring box is not working. Inaccurate measurements can trigger unnecessarily heating which is a waste of energy. Every 1 °C higher temperature costs about 5% more energy. Moreover, plant performance and yield are affected even by a 1 °C deviation in average temperature. Plant growth, flowering, fruit set, and fruit ripening can be too slow and you loose production, or can be too fast and the plants loose their balance. Both cost money.

Also the humidity measurement can easily go wrong, and its impact is equally important. A small measuring fault can easily cause 10-20% deviation in relative humidity (RH). This can be the difference between a good climate and too humid. It can make that the vents are not opened or the heating is not activated when they should. This can lead very quickly to grey mould (*Botrytis*) infection.

Measuring box

The temperature and humidity sensors must be protected from direct sunshine and from excessive turbulence and wind. Therefore they are placed in a so-called measuring station or measuring box. Very large greenhouses are split up in compartments, with their own heating, venting and control system, and also their own measuring box. The control of the whole greenhouse (compartment) depends on the measurements, so the measuring box must be put on a place that is representative for the greenhouse. It should not be directly above a heating pipe, or exactly in the stream of a fan, or very close to the vents. Also be aware of cold spots and gradients in the greenhouse.

Horizontal temperature gradients

In most greenhouses the temperature and humidity are not equally distributed. There can be horizontal gradients, for instance it can be warmer near the north wall, or cooler on the wind side. If a greenhouse is built on a slope, the temperature will be higher at the top than at the bottom. Also it can be warmer along an un-insulated heat transfer duct. If there is a consistent horizontal temperature gradient, it can be seen in the plants, especially in young plants. Obviously plants on warmer places are taller and are further in development (flowering) than plants on colder places.

Horizontal temperature gradients cost money, and ideally they should be resolved. This can be done by adjusting heating pipes, insulating a cold wall, or shading the south wall. Some growers install fans to even out the temperature and humidity. If the gradients cannot be resolved, it is even important that the measuring box is placed on a representative location.

Vertical gradients

There are vertical gradients too, e.g. in winter it will be warmer near the ground where the heating pipes are, and colder near the roof. The vertical gradients cannot be resolved easily, and only at high costs, e.g. installing a thermal screen. Even better is to install a grow-pipe. This is a small heating pipe that can be lifted, so it 'grows' when the crop grows. A grow pipe often uses water of a lower temp, e.g. water from the condenser. Installing fans can break the vertical gradients a little bit, but not very well in a mature crop.

Because of the vertical gradients in temperature and humidity, it is very important to place the measuring box at a specific height. It is often recommended to place it near the plant heads but still between the plants. Do not forget to move it up when the plants grow.

Wet-bulb and dry-bulb measurements

There is a range of sensors available for measuring temperature and humidity. Some are electronic sensors, that can be very good. Be aware that very cheap sensors can be less accurate, or more prone to problems.

The most accurate way of measuring temperature and humidity is using a set of two temperature sensors: one measures the dry-bulb temperature and the other the wet-bulb temperature. A small fan draws an air flow along the two sensors at a speed of about 2 meter per second. The wet-bulb sensor is covered by a wet wick. When water evaporates from the wick, it cools down the sensor, so that this sensor measures a lower temperature. The difference between dry-bulb temperature and wet-bulb temperature is an accurate measure for air humidity. A difference in temperature of 1 °C equals nearly 10% in relative humidity. Obviously the two temperature sensors must be of very good quality and must be identical; otherwise they will give a very inaccurate humidity reading. The computer can present the measurements as relative air humidity or as vapour pressure or vapour pressure deficit.

If the wet wick is removed, both sensors measure the same temperature, and the relative humidity reading must be 100%. It is good to remove the wet wick now and then, to check if the two temperature sensors are still identical. If not, they have to be recalibrated or replaced. This system requires some maintenance. Follow the instructions for keeping the wet-bulb sensor wet, and for keeping the fan in good order.

Other sensors

Greenhouse climate control also requires measurements of light/radiation, wind speed, wind direction and rain fall. Some systems use additional sensors e.g. a plant temperature meter. Light meters and radiation meters come in many different types, and several different units are being used. Unfortunately, good meters are expensive, and quite often we see cheaper types installed. This can be workable for the grower, but the readings are often not reliable enough for comparison with other data. The light/radiation meter should never be placed inside the greenhouse. This would result in highly variable readings that are completely unsuitable for climate control. So the sensor should be placed outside, and it should never be shaded (this can happen especially at low sun altitudes, e.g. in the winter). So it should be placed above or far away from structures and obstacles, including the wind speed meter.

Equally the wind speed and wind direction meters must be unobstructed. The rain meter should be placed on a slight slant, so that water can run off. All meters must be checked, cleaned, serviced and calibrated now and then; follow the guidelines of the manufacturers. Good quality measurements are essential for good climate control.