Review of Instrumentation to Control the Greenhouse Environment

Chieri Kubota
School of Plant Sciences
The University of Arizona
Tucson, AZ 85721-0036
Email: ckubota@ag.arizona.edu

"Measurement of environmental conditions accurately" is a basic key technique to understand your crop performance in greenhouse. Technology development of instrumentation (sensing, recording, and controlling) has contributed to expanding what we can do in controlled environment agriculture. Use of computers in agricultural (horticultural) instrumentation developed rapidly in the 1980s and we can now purchase small button-size sensors that can store weeks of recorded data to download to your computer in a spreadsheet format! Such technology development simplifies measurement of microenvironments and plant interactions, permitting greater understanding. However sensors and recording devices became so 'user-friendly' that they permit practically everyone to use such sensors by only following the short users' manual. One caution emphasized in this lecture is that sensor use and recording became so easy that one can easily make mistakes in their use without knowing that the data obtained has little value or needs careful interpretation, resulting from such inappropriate use.

Air temperature:
Temperature measurement seems so easy, but as you learn sensor characteristics, you will know that accurate temperature measurement is one of the most difficult tasks in greenhouse controlled environment. Air temperature measurement is often challenging especially under high radiation conditions. This is because radiation increases the sensor temperature, which is the temperature the sensor gives us, while what we want to know is the air temperature, not the sensor temperature. Therefore, aspirating the sensor is 'must' to accurately measure air temperature, as aspiration brings the sensor temperature close to air temperature. The air velocity recommended for accurate measurements is 3 m/s (10 feet/s or 7 miles/h), especially if the sensor size (diameter) is greater than 2 mm. The most commonly used air temperature sensor in the greenhouse is either thermocouple type or thermistor.

Relative humidity and VPD:
There are many relative humidity sensors that do not record accurate values. Sensors used in humid environments (like inside the greenhouse) need to be re-calibrated every year or two to maintain the accuracy. As most humidity sensor readings are influenced by the temperature, aspiration must be done for accurate readings. Vapor pressure saturation deficit (VPD) is a better indicator to understand potential transpiration. VPD of the air can be computed from air temperature and RH using a psychrometric chart.

Light intensity:
Two light intensity units are often used in greenhouse crop production. One is a quantum unit ($\mu mol/m^2/s$ or $mmol/m^2/day$) and the other is an energy unit (W/m^2 or $MJ/m^2/day$). Quantum sensor is generally for measuring photosynthetic photon flux (PPF), the photons (400-700 nm) usable for photosynthesis received on a horizontal surface (unit: $\mu mol/m^2/s$). Energy sensor is

generally used for quantifying much broader solar radiation (300 – 2500 nm) and is called a pyranometer. Both types of sensors are easy to use, but need calibration once in several years and need to be maintained without dust accumulating on the sensor surface, especially if placed outside the greenhouse.

CO_2 concentration:
CO_2 concentration measurement is often ignored despite the fact that CO_2 is a critical factor for plant photosynthesis. This is because we humans do not have a sensing capability for CO_2 gas. In a cold winter morning, when greenhouse vents are tightly closed, we often see very low CO_2 concentration due to the photosynthesis of the plants in greenhouse. Therefore having a capability to at least monitor CO_2 is always important for plant production. Most commonly used sensor for CO_2 is an infrared gas analyzer (IRGA). Various types of IRGAs are available nowadays at a reasonable price. Such models are usually equipped with a single sample cell without a reference cell. Models equipped with both sample and reference cells are generally more accurate and stable (therefore more expensive). Sensors that measure by diffusion of ambient gas to the sample cell have slower response times than the one with an internal pump to send the air to the cell. For controlling CO_2 inside a small volume of air (i.e., growth chamber), it is recommended to select a sensor that has a quick response.

Greenhouse environmental controllers:
There are various types of controllers available so that you can activate heaters, vents, irrigation, CO_2 enrichment, cooling systems, etc. based on the information recorded by the sensors in greenhouse. The price for these controllers varies depending on its capacity such as input and output channels, data storage capacity, alert capacity, as well as flexibility in programming logic.

Observation and record keeping:
No matter what capability of measurement and control of greenhouse environments the growers have, evaluating the recorded data to find if they make sense relative to what the growers observe in the greenhouse is critical. Instrumentation is a tool for growers to understand the past and current status of greenhouse environments and to develop near and long term strategies in crop management and resource saving. A key to success is not to maximize the instrumentation capacity but to effectively use available instrumentation in greenhouse crop production.

Useful information website:

NCERA-101 Plant Growth Chamber Handbook:
http://ncr101.montana.edu/Growth_Chamber_Handbook/Plant_Growth_Chamber_Handbook.htm