Figure 1. **Light is a dynamic part of the production environment, and measuring the light intensity in your facility will tell you what your crops are experiencing.**

Photos courtesy of Christopher Currey.

Greenhouse Toolkit Series:

How to Measure Greenhouse Light

In part three of this five-part series about the tools you need to keep track of your greenhouse environment, learn how to effectively use quantum sensors to monitor how much light your plants need for optimal growth.

By Christopher Currey, Roberto Lopez, Brian Krug, W. Garrett Owen, and Brian Whipker

Light is one of the most important aspects to plant growth and development. The quantity of light our crops receive is proportional to their growth and, of interest to commercial greenhouse producers, quality and/or yield. However, it can sometimes be a factor that is overlooked or taken for granted in production. Are our crops receiving adequate light to promote good growth and development? Are we providing too much light and wasting electricity by operating our lights when it is not required? The only way these questions can be answered is to measure the light in your greenhouse (Figure 1).

Quantifying Light in the Greenhouse

Before we discuss how to measure light, we need to discuss what types of units are used to measure light. There are several, but they are not all created equal with respect to plants. The foot-candle (fc) and lux (lx) are both types of photometric units of light measurement. While these units, especially fc, are some of the most commonly used for measuring light, they are biased toward measuring light that is visable to the human eye and biased for people, not plants. Sometimes light is measured in radiometric units, watts per square meter ($W \cdot m^{-2}$).

Quantum light measurements measure the amount of photosynthetically active radiation, or PAR, which is the light between 400 and 700 nanometers (nm). The light within this range is most effective for photosynthesis,

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This article is the third in a five-part series. Visit **GreenhouseGrower.com** to read about monitoring plants and substrate temperatures with infrared thermometers and keeping track of pH and EC. Next up in the series: Adding Carbon Dioxide to Your Greenhouse.

Figure 2. **The quantum sensor on this daily light integral meter is covered in a plastic bag to keep excessive moisture from mist off the sensor. However, notice the fog and condensation building up inside the bag, ultimately reducing the accuracy of these measurements.**

which is why we use units that quantify the light used for plant growth and not the human eye. There are two different ways to measure quantum light: instantaneously or cumulatively. Light is quantified as micromoles per square meter per second ($\mu mol \cdot m^{-2} \cdot s^{-1}$) when measuring light instantaneously. Alternatively, when quantifying the amount of light over the course of a day, light is quantified as mole per square meter per day ($mol \cdot m^{-2} \cdot d^{-1}$).

Figure 3. **Note that the sensor on the quantum meter is right at the canopy level of these rooted poinsettia cuttings. Placing quantum sensors at the plant canopy will get the most accurate measurements of the light the plants are growing under.**

Which is better — measuring instantaneous light intensity or daily light integral (DLI)? There is a place for both of these measurements. Instantaneous light measurements are good for making day-to-day lighting decisions such as deciding when supplemental lights should be turned off due to adequate ambient sunlight, when retractable shade should be drawn across the crop due to excessive light intensities, or when evaluating the uniformity of supplemental lighting. Alternatively, DLI is useful for making seasonal lighting decisions, such as when the use of supplemental lighting should start or stop, or when permanent shade should be put up or taken down.

Using Quantum Meters to Measure Light

While some of you may have a foot-candle meter, a quantum meter is an instrument used to measure light in quantum units. Quantum meters are comprised of a quantum sensor to measure light connected to the unit with a display to show values. When selecting a quantum meter, determine what uses(s) you have in mind, so you can purchase an instrument that will fill your needs.

What Type of Unit Should I Buy?

One of the first things you will have to determine is if you want to have a unit where the quantum sensors are directly

attached to the meter or a unit where the sensors are separate from the meter. The primary benefit of having a unit where the sensor is attached directly to the display is that it is the most compact. If you plan on carrying your quantum meter around, these models are the most convenient. The other types of meters have the quantum sensors attached by a cable, which allows the sensors to be placed anywhere as you hold on to the display unit. With these types of quantum meters, you can also purchase models that have multiple sensors connected to a bar. These line quantum sensors can provide a more accurate light measurement because the intensity is based on multiple independent readings.

What Type of Sensors Will Work Best?

Next, let's focus on the sensors themselves. What types of light do you plan on measuring in your greenhouse? If you are focused on measuring sunlight or traditional electric lighting (i.e., high-pressure sodium lamps), nearly all of the quantum sensors on the market will work fine for your needs. However, if you plan on using your quantum sensors to measure narrow wavelength light from sources like light-emitting diodes (LEDs), you will need to make sure that the quantum sensors are designed to measure this type of light; narrow-spectrum light is more challenging to measure and, therefore, requires a more sophisticated sensor to get accurate measurements.

Best Management Practices for Effective Use of Quantum Sensors

Now that you know what light you want to measure and have selected the right tool for the job, there are a few best management practices to getting the best light measurements. First, make sure the surface of your sensor is clean of dust, debris, and residues (Figure 2). You can simply wash off the sensor surface with some deionized water and a soft cloth before use. Next, place the sensor at plant height (Figure 3) to get the most accurate reading. If you are using a light meter with a different setting for sun or electric light, be sure that you are selecting the correct setting for the light you are measuring, as there are different correction factors that are used for sun and electric light to get the correct final measurement.

If you are trying to get a measurement of the average light (instantaneous or DLI) over an area, you will need to measure at multiple locations throughout the area. How many different locations? Well, the more the better. However, only you will be able to solve the cost-benefit analysis of the number of measurements versus the time and effort.

Measuring the cumulative light over the course of the day (i.e., DLI), will require a slightly different approach than measuring instantaneous light intensity. Many of the same best-management practices apply, with respect to selecting and operating sensors. The difference is going to be in the unit taking the measurement. Some handheld quantum meters have a function that allows the meter to log measurements periodically throughout the day to measure DLI. Alternatively, quantum sensors can be tied into greenhouse computer systems or built into data loggers that can calculate DLI; this latter option will be discussed in a subsequent article.

Use It — Don't Lose It!

With the tools to measure light, you will know what your crops are actually receiving, and it will provide you with the opportunity to make informed management decisions. What are you going to do once you start measuring light? Record your measurements, along with your observations of how plants are responding to light. After a few seasons, you can use the data you have collected to better predict how light changes during production, and you will be able to stay ahead of your crops' needs. **GG**

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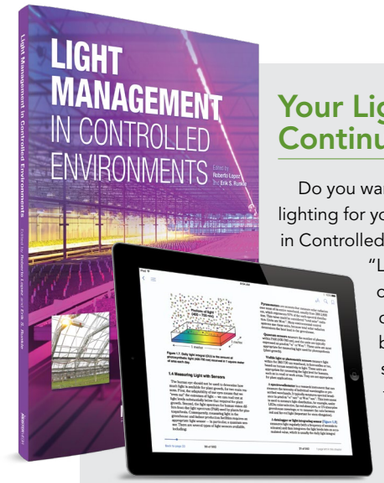

Your Lighting Knowledge Continues Here

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"Light Management in Controlled Environments" is available through Amazon in Kindle format or in print format. Go to **GreenhouseGrower.com/Lighting** to purchase.