Which Light Sensor Should I Use?

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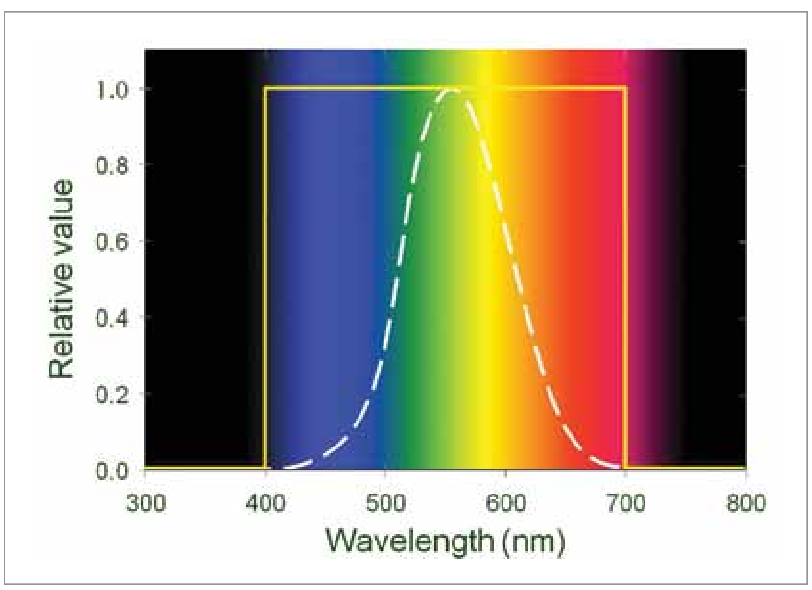
Light intensity can be measured at any point in time (an instantaneous value) or it can be measured frequently over a period of time and integrated (a cumulative value). Instantaneous measurements are useful for determining when to close retractable curtains, apply whitewash or operate mist in a propagation greenhouse. This article focuses on the different units of instantaneous light intensity and how each is measured.

Footcandles. As the term implies, a footcandle can be defined as the intensity of light cast from one candle at a distance of one foot. This measurement unit is based on the human eye's sensitivity to light, which is greatest under green light, more specifically at a wavelength of about 555 nm (Figure 1). The sensitivity of our eyes to light is not uniform across the visible spectrum; we cannot see deep blue or deep red light as well as green light and thus, those light intensities appear dimmer. Therefore, footcandles are specifically for people and are not an appropriate measurement unit for plants.

Footcandle meters are the least expensive to purchase, beginning at around $30. A limitation of footcandle meters is that their reading under electric lights can be erroneous, especially when the light contains a large amount of blue or red light, such as from LEDs. Lux meters are similar to footcandle meters, where 1 footcandle = 10.8 lux for all light sources.

Figure 1. Perception of light by humans (dashed white line) is different from the light waveband effective for photosynthesis in plants (solid yellow line). Therefore, for plant applications, a quantum meter provides a more meaningful value than a footcandle meter, especially under electric light.



Photosynthetic photons. The amount of light available for photosynthesis is defined as the light intensity within the waveband of 400 to 700 nm. This waveband is sometimes called the photosynthetic photon flux, or PPF, and includes blue, green, yellow, orange and red light — and colors in between — and considers these colors equally. In other words, a blue light particle (a photon) of light is considered to have the same effect on photosynthesis as a green or red photon of light. This unit of measurement is the number of photons per square meter per second, or $\mu mol \cdot m^{-2} \cdot s^{-1}$. Sometimes just called "micromoles," this is the most appropriate measurement system when relating light intensity to plant growth.

A quantum sensor measures the amount of photosynthetic light and sends the reading to a data acquisition device, such as an environmental control computer or a data logger. A quantum meter measures the light and then displays the output value directly. Two leaders in the manufacturing of quantum sensors are LI-COR and Kipp & Zonen, which sell for around $400. Less expensive but good alternatives are manufactured by Apogee Instruments, which sells a quantum sensor for around $140 and a quantum meter for around $330.

Watts. A third way to measure light intensity is based on its power. This is sometimes called "radiant flux", which refers to the amount of energy per unit of time, and the unit is watts or watts per square meter ($W \cdot m^{-2}$). Watts are used to measure energy consumption or output, such as with light bulbs, hair dryers and microwave ovens. Similarly, we can measure the amount of energy emitted from a source, such as a bulb or from sunlight, at a particular distance.

A radiometer is a device that measures the power of a light source, and a pyranometer can be used to measure the total amount of short-wave radiation. Short-wave radiation includes photosynthetic light, as well as energy from UV and near infra-red (IR) light. Plants and people experience IR light as heat. Therefore, readings by a radiometer are sometimes the most useful to determine when to close (and then open again) greenhouse shade curtains. The companies already mentioned manufacture pyranometers for greenhouse applications and they begin at around $170.

Under sunlight, any type of light sensor can be used because conversions can be made among units. Conversions of light units, for sunlight only, are:

$1\ \mu mol \cdot m^{-2} \cdot s^{-1} = 5.0$ footcandles $= 54$ lux $= 0.51\ W \cdot m^{-2}$.

These conversions change significantly under filtered light or electric light, in which case using the appropriate sensor becomes more important. This is especially true with LEDs, since any conversion factor would depend on the color(s) of the LEDs. Much more information about light sensors and conversion factors can be found at http://www.apogeeinstruments.com/faq_solar.htm g

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