Light Quality Defined

Light can be a complicated topic for growers. Read on to understand more about the fundamental dimensions of light.

By Erik Runkle

While it seems like a simple phenomenon, light is a deceivingly complex topic with plants. There are three fundamental dimensions of light: light duration, light quantity and light quality. Light duration is the photoperiod, or the number of continuous hours of light in each 24-hour period. Photoperiod regulates flowering in many greenhouse crops, and that is why we have photoperiodic response categories such as short-day plants and long-day plants. Photoperiod is easy to understand because we are simply concerned with the number of light hours and the number of darkness hours each day.

Light quantity is the number of light particles (called photons) capable of performing photosynthesis. Light quantity is more complex because it can be measured in two ways: the instantaneous amount of light (light intensity) and the cumulative amount of light delivered each day (daily light integral). Light quantity can be measured in different units, including foot-candles, lux, Watts, $\mu mol \cdot m^{-2} \cdot s^{-1}$ and $mol \cdot m^{-2} \cdot d^{-1}$. The latter two units are preferred when growing plants because they quantify the capacity of plants to perform photosynthesis (on an instantaneous and daily basis, respectively).

Light particles have different amounts of energy. The amount of energy of each light particle is determined by its wavelength. The relative number of light particles at each wavelength describes the third dimension of light, light quality. In other words, light quality refers to the spectral distribution of light, or the relative number of photons of blue, green, red, far red and other portions of the light spectrum emitted from a light source. Some of these portions are visible whereas others are not.

Understanding Nanometers

The wavelength of light is usually measured in nanometers (nm, which is one billionth of a meter). Blue light is generally considered to be the portion of light that has a wavelength between 400 and 500 nm. Blue light, green light (500-600 nm) and red light (600-700 nm) comprise the spectrum of light primarily used for photosynthesis (400-700 nm). Approximately half of the sun's energy falls within the photosynthetic waveband. The remaining amount of energy has shorter wavelengths (such as UV light) or longer wavelengths (such as far red light and infra-red radiation).

The proportion of red light relative to the amount of far red light (the red to far red ratio) influences stem elongation, particularly in full-sun crops. Lamps that emit large amounts of far red relative to red light (such as incandescent lamps) promote stem elongation. In addition, plants are effective filters of red light but transmit or reflect most far-red light. Therefore, in an environment shaded by plants (such as underneath hanging baskets), the red to far red ratio decreases and stem extension of crops below is promoted.

Measuring Quality

Sophisticated devices called spectroradiometers measure light quality and are expensive to purchase (often $4,000 or more). However, greenhouse growers usually don't need to measure light quality because it is relatively fixed for each light source unless a grower is interested in the light quality under a plant canopy.

The distribution of light and the red to far red ratio for the most common light sources are summarized in Figure 1 below. These values can be useful to predict the impact of different light sources on plant growth. The large amount of far-red light emitted from incandescent lamps and their low lamp efficiency (radiant yield) illustrates some undesirable attributes. The widespread use of high-pressure sodium lamps for supplemental greenhouse lighting is primarily because they have the highest radiant yield. GPN

Light Distribution

Light source	Light distribution percentage				Red to far red ratio	Radiant yield (percent)
	Blue	Green	Red	Far red		
Cool-white fluorescent lamp	21	52	24	2	10.7	22-27
High-pressure sodium lamp	5	51	38	6	6	29-31*
Incandescent lamp	2	13	34	52	0.7	6-7
Metal halide lamp	18	49	25	8	3	20-21
Sun (direct sun and sky)	23	26	26	25	1	43

*values are for 400-Watt lamps; 600- or 1,000-Watt lamps may be more efficient.

Figure 1. The percentage distribution of light within the photosynthetic waveband (blue, green and red) plus far red, the red to far red ratio and the radiant yield, which refers to percentage of energy that is in the form of photosynthetic light.

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