BY ERIK RUNKLE

Red Light and Plant Growth

When you hear the term "red light," what do you think of? Stopping at a traffic light? A certain district in Amsterdam? Light from LEDs? Red light can convey caution or danger or stopping at intersections, but for plants red light is highly effective at regulating growth and development. Within the photosynthetically active waveband (400 to 700 nm), sunlight emits roughly similar amounts of blue, green and red light. With conventional electric lamps, the proportion of light is somewhat similar, ranging from 24 percent for cool-white fluorescent to 40 percent for high-pressure sodium (HPS) lamps.

With arrays of light-emitting diodes (LEDs), the proportion of red light can range from 0 to 100 percent. Many commercial LED fixtures developed for plant growth applications emit a large proportion of red light, with 75 to 85 percent of the light spectrum commonly emitted in the red region.

The primary reasons why LED fixtures emit a lot of red are 1) red LEDs are among the most efficient at converting electricity into photosynthetic photons, 2) chlorophyll strongly absorbs red light, thus it is effective at photosynthesis, and 3) red LEDs are relatively inexpensive. Let's take a brief look at how red light influences plant growth and development.

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The "brightness" of red. The luminous efficiency curve illustrates our visual perception of the brightness of different colors of light under well-lit conditions. At the same intensity, green and yellow light appear bright to us while red appears dim. A common type of red LED has an emission peak at 660 nm, which has a relative visual efficiency of less than 10 percent.

Red light on photosynthesis. The relative quantum efficiency curve (Figure 1) generated by Keith McCree more than 40 years ago quantifies the efficiency of different colors of light at stimulating photosynthesis on an instantaneous basis. Although this curve is sometimes over-interpreted, it does show that red light is at least as effective as other colors of light at promoting plant growth. Therefore, while red light isn't the most efficient color for general illumination for people, it is among the best colors of light to stimulate plant growth.

Red light on extension growth. Many plants grown under only red light, such as plants grown indoors under only red LEDs, have a stretched, elongated appearance; the leaves are thin and large and plants become tall. In most cases, plants grown under only red light do not have desirable growth characteristics. However, when a relatively small amount of blue light is added to red light, extension growth of plants is inhibited. Therefore, plants grown indoors with 80 to 90 percent red light and 10 to 20 percent blue light are quite compact, with smaller leaves and shorter stems. In greenhouses, plants receive the wide solar spectrum and so the color of light provided by supplemental lighting has much less impact on extension growth.

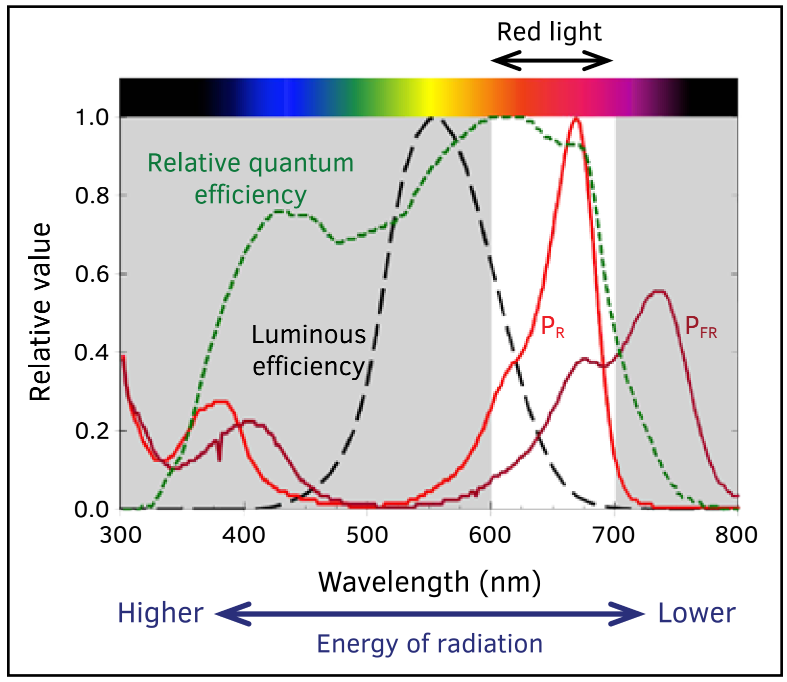

Figure 1. Red light is usually defined as radiation with wavelengths between 600 and 700 nm. Although red light has a low luminous efficiency, meaning that the light appears relatively dim to people, it has a high relative quantum efficiency and is highly absorbed by the red-absorbing (P_R) form of phytochrome. Therefore, at least with LEDs, red light is often the primary waveband used for photosynthetic and photoperiodic lighting.

As discussed in previous articles, the amount of red light relative to the amount of far-red radiation (R:FR) also has a pronounced effect on leaf expansion and stem elongation. As far-red is added to red light, the R:FR decreases and extension growth increases. High-pressure sodium and fluorescent lamps emit a high R:FR while sunlight and incandescent lamps emit a low R:FR. In greenhouses, extension growth can be slightly inhibited using lamps with a low R:FR, or no far red as is the case for many LEDs. Indoors, the absence of far red in a light spectrum results in compact growth.

Red light on flowering. The pigment phytochrome mediates flowering of plants with a photoperiodic flowering response. Generally, plants are very sensitive to low intensities of red light; during the night, 1 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of red light can inhibit flowering of short-day plants and promote flowering of some long-day plants because of phytochrome's sensitivity to red light (Figure 1). The addition of far-red radiation to red light, in roughly similar quantities, is effective to stimulating flowering of a wide range of long-day plants. Therefore, lamps designed to regulate flowering of plants always emit red light and in some cases, also far red. gpn