BY ERIK RUNKLE

Including Far Red in an LED Lighting Spectrum

Far red (FR) is a one of the radiation (or light) wavebands that regulates plant growth and development. Many people consider FR as radiation with wavelengths between 700 and 800 nm, although 700 to 750 nm is, by far, the most active. By definition, FR is just outside the photosynthetically active radiation (PAR) waveband, but it can directly and indirectly increase growth. In addition, it can accelerate flowering of some crops, especially long-day plants, which are those that flower when the nights are short.

As we learn more about the effects of FR on plants, growers sometimes wonder, is it beneficial to include FR in a light-emitting diode (LED) spectrum? Not surprisingly, the answer is, it depends on the application and crop.

In the May 2016 issue of GPN, I wrote about the effects of FR on plant growth and flowering (https://bit.ly/2YkxHCO). Briefly, leaf size and stem length increase as the intensity of FR increases, although the magnitude depends on the crop and other characteristics of the light environment. Including FR in a lighting spectrum can increase the surface area of a plant, enabling it to capture more light and (indirectly) increase growth. In addition, photons between 700 nm and approximately 720 nm can be energetic enough to stimulate photosynthesis and thus (directly) increase growth.

FR IN SUPPLEMENTAL LIGHTING

For every 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of photosynthetic light (400 to 700 nm) from the sun, there is also 1 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of FR. In fact, the sun emits similar intensities of red and FR light, so there is usually plenty of FR inside a greenhouse. Therefore, there is generally limited value of including FR in supplemental lighting.

An exception can be when the solar daily light integral (DLI) inside a greenhouse is very low, such as less than 5 $mol \cdot m^{-2} \cdot d^{-1}$. Under these conditions, supplemental lighting is especially effective at increasing plant growth, and delivering at least some FR can be useful. In a few instances (such as for tomato), FR can also accelerate flowering.

FR IN INDOOR LIGHTING

There are more compelling reasons to include FR in sole-source lighting, when there is no sunlight and thus, no background FR. Plants grown indoors under blue and red LEDs (a common indoor lighting spectrum) can have small leaves and short stems. While this can be desirable for some crops, larger leaves can be desired for other crops.

We have learned that blue light (and to a smaller extent, total light intensity) can influence the effects of FR. When the intensity of blue light is high, adding FR only slightly increases extension growth. Therefore, the utility of including FR in an indoor lighting spectrum is greater under lower intensities of blue light. One compelling reason to deliver at least some FR light indoors is to induce early flowering of young plants, especially long-day plants.

> "As the DLI increases, the utility of FR in photoperiodic lighting diminishes."

FR IN PHOTOPERIODIC LIGHTING

Over the past 20+ years, we have learned a lot about the role of FR in the flowering process of ornamental annuals and herbaceous perennials. The established paradigm is that FR has practically no influence on flowering of day-neutral or short-day plants. In contrast, when the DLI is low, the delivery of red and FR light during long nights (low-intensity photoperiodic lighting) can accelerate flowering of at least some species. As the DLI increases, the utility of FR in photoperiodic lighting diminishes. Therefore, lamps that emit both red and FR are recommended to induce flowering of a range of long-day plants during the winter and early spring.

DELIVERING FR FROM LEDS

FR can be delivered by FR LEDs, which usually have a peak emission of around 730 nm. This is a very effective peak to promote both extension growth and early flowering of some crops. FR is also delivered by warm-white LEDs; about one eighth of the total photon output is in the FR region. Put another way, with the delivery of 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of photosynthetic light, warm-white LEDs also emit 12 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of FR. (In comparison, cool-white LEDs emit about 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of FR.) The energy efficiency (efficacy) of FR LEDs is very high, which is a compelling reason to consider including FR LEDs in a lighting fixture. gpn

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