BY ERIK RUNKLE

LED Lighting Applications for Plants

I first wrote about light-emitting diodes (LEDs) in this column in 2009, and although much of what I wrote then is still true today, some things have substantially changed for the better. In particular, fixtures being commercially produced today emit much more light and are more efficient at converting electricity into photons for plant growth and development.

At the same time, the cost to purchase and deliver each mole of photons has decreased. Therefore, I think we're on the cusp of a surge in the commercial implementation of LEDs for plant growth and flowering applications.

There are numerous applications for LEDs on plants, but here I discuss the four most common. For all applications, the costs to purchase, install and operate LEDs are usually the most important factors when considering whether to invest in this technology. Therefore, growers and entrepreneurs are encouraged to perform a thorough economic analysis, such as determining the return on investment or internal rate of return. Some LED companies can help you with this, but be sure all of the inputs (for example, hours of operation per year, electricity price and assumptions for an alternative conventional lighting solution) are appropriate for your operation.

MICHIGAN STATE UNIVERSITY EXTENSION
FLORICULTURE TEAM

Erik Runkle is professor and floriculture Extension specialist in the department of horticulture at Michigan State University. He can be reached at runkleer@msu.edu.

Photoperiodic LED lighting is the delivery of a very low light intensity (typically 1 to 2 $\mu mol \cdot m^{-2} \cdot s^{-1}$) to accelerate flowering of long-day plants and inhibit flowering of short-day plants. Screw-in LED bulbs primarily emit red light and, in some cases, also far-red light. These horticultural lamps replace the common incandescent bulb and, although they are substantially more expensive, they consume only 10 to 15 percent the amount of electricity and can last 25 times longer. With this application, lights only operate at night and for a maximum of four to six hours per day.

Overhead LED supplemental lighting is the delivery of a moderate intensity of light (usually 50–75 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for ornamentals, 100–200 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for high-wire vegetable crops) to increase plant growth, which can elicit faster rooting, thicker stems, greater branching, and more flowers and fruit. When used on ornamentals, the LEDs usually operate only during the winter and early spring, when the daily light integral is low (<10 $mol \cdot m^{-2} \cdot d^{-1}$). They operate for more months of the year when used on high-wire vegetable crops because fruit production usually increases with more light. Most LED fixtures emit a high percentage (70 to 90 percent) of red light, with the remaining consisting of blue, white and sometimes far-red light.

Intra- or inter-canopy LED supplemental lighting is the delivery of a moderate intensity of light inside the canopy of tall-growing (high-wire) crops such as tomato (Figure 1). Because

Figure 1. Intra-canopy LED lighting is used on tall-growing crops such as tomato to deliver light deep inside a shaded canopy.

LEDs emit little radiant heat, they can be placed next to plant leaves, and sometimes fruit, without scorching them, as could occur with conventional lamps. This application provides light to a region substantially shaded by leaves above, increasing fruit yield and potentially increasing fruit quality, depending on the placement and intensity of the LEDs. These fixtures usually emit only red or red with a small percentage of blue light.

LED sole-source lighting is the delivery of light to an indoor controlled environment (such as in a warehouse or container) in which the only light available to plants is from the LEDs. This application excites me the most about LEDs because one can take full advantage of the ability to create a light spectrum to elicit specific growth responses. The intensity typically delivered is 150 to 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and fixtures operate up to 18 or 20 hours a day. As with other LED applications, red is the primary light emitted from commercial fixtures and the percentage of blue and far red (and sometimes other colors) can be manipulated to influence plant characteristics including leaf size, stem length and early or late flowering. gpn