Evaluating Greenhouse Supplemental Lighting For Young And Finished Plant Production

Researchers at Purdue and Michigan State University compare young and finished plant production under LED toplighting and HPS lamps to determine which source is most effective.

by **JOSHUA CRAVER** and **ROBERTO LOPEZ**

IN NORTHERN latitudes, young bedding plant producers are faced with the challenge of low ambient light levels during winter and early spring when peak production generally occurs. While a photosynthetic daily light integral (DLI) of 10 to 12 $mol·m^{-2}·d^{-1}$ has been recommended for the production of high-quality young plants, the DLI during these months of the year can fall as low as 1 to 5 $mol·m^{-2}·d^{-1}$.

These low DLIs can ultimately lead to production issues such as delays, inconsistent and excessive extension growth, and poor performance after transplant. Thus, it is important to supply young plants with ample photosynthetic light during production to ensure that a high-quality and consistent product is produced.

The most common way to overcome light-limiting conditions is by providing supplemental lighting to the crop. High-intensity discharge (HID) lamps, such as high-pressure sodium (HPS) lamps, are the current industry standard for the provision of supplemental lighting. However, with the development of new lighting technologies, some drawbacks to the utilization of these older lamps include their electrical inefficiency, production of radiant heat, and relatively short bulb lifespan, which is influenced by the number of times the lamps are turned on and off. While additional photosynthetic light is provided to the crop, operating costs can be high from these various shortcomings.

Light-emitting diode (LED) technology has been at the forefront of advancements in lighting for controlled environment applications. For those who may not be familiar, LEDs are solid-state semiconductor devices that are capable of producing light within a very narrow spectrum. While this form of lighting has become an alternative to traditional lighting sources in greenhouse production for many reasons, one of the most notable relates to energy consumption. For any commercial grower, reducing energy consumption while also maintaining or improving the value of a crop is obviously of significant interest.

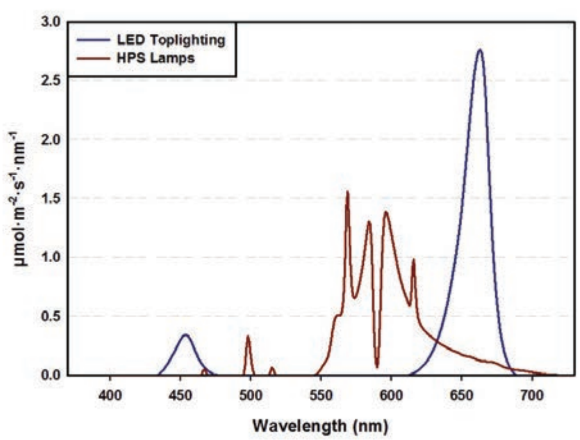

Figure 1. **Spectral quality delivered from either light-emitting diode (LED) toplighting or high-pressure sodium (HPS) lamps at a photosynthetic photon flux (from 400 to 700 nm) of 70 $μmol·m^{-2}·s^{-1}$ at canopy level.**

Previous Research Showed The Limitations of LED Technology

Up until recently, LED technology has had limited application to enhance greenhouse production through supplemental lighting. One of the primary issues involved the density of fixtures necessary to provide a meaningful supplement to the ambient light. In a November 2013 *Greenhouse Grower* article (read the article at goo.gl/3XG4dp) written by Wesley Randall and Roberto Lopez, the authors discussed that while LEDs were suitable for supplemental lighting of bedding plant plugs, the arrays themselves caused excessive shading. Therefore, ambient light from the sun was reduced, resulting in a somewhat counterproductive and limiting solution for supplemental lighting.

Several new high-intensity supplemental LED arrays are now on the market. These LED arrays are designed to provide an output similar to or higher than that from a typical 400-watt HID fixture and in a more energy-efficient manner.

Comparison Of LED Toplighting And HPS Lamps

With the introduction of high-intensity LED arrays, our objective was to evalu-

Figure 2. **Annual bedding plant plugs grown under supplemental lighting provided by either high-pressure sodium lamps (left) or light-emitting diode toplighting (right).**

ate the use of LED toplighting as an alternative to traditional HPS lamps in the greenhouse for supplemental lighting applications. Specifically, we wanted to look at the production of both young plants, as well as finishing plant material under these two supplemental light sources, to determine if there were any differences or benefits to using one over the other for various annual bedding plant species.

We conducted the experiment at Galema's Greenhouse, a commercial wholesale producer of young and finished plants located in West Lafayette, IN. While this setting did present limitations, such as temperature set point control and fertilization options, the opportunity to evaluate supplemental lighting sources in a commercial production scenario was desirable.

Figure 3. **Finishing of annual bedding plants under supplemental lighting provided by either high-pressure sodium lamps or light-emitting diode toplighting.**

The seven species evaluated for this study included French marigold 'Bonanza Deep Orange,' *Gerbera* 'Terracotta,' New Guinea Impatiens 'Divine Blue Pearl, ornamental millet 'Jester,' pepper 'Hot Long Red Thin Cayenne,' *Petunia* 'Single Dreams White,' and *Zinnia* 'Zahara Fire.' Seeds were sown into 128cell trays and placed under a 16-hour photoperiod using one of three supplemental lighting treatments:

1) 70 $\mu mol \cdot m^{-2} \cdot s^{-1}$ provided by HPS lamps (600-watt);

2) 70 $\mu mol \cdot m^{-2} \cdot s^{-1}$ provided by LED toplighting (Philips 200-watt GreenPower LED toplighting modules; deep red/blue); or

3) no supplemental lighting (ambient).

The spectral distribution of the two supplemental lighting sources is shown in Figure 1, and the experimental set-up for each of the supplemental lighting treatments is shown in Figure 2. The plugs were grown at a constant 73°F air temperature and irrigated with a water-soluble fertilizer providing 100 ppm nitrogen (N). Data was collected two weeks (marigold/millet), three weeks (pepper/petunia/zinnia), four weeks (impatiens), or five weeks (gerbera) after germination.

In addition to evaluating the effects of the light source on plug production, we also wanted to determine how finished plant material would perform under these three treatments in a separate greenhouse. Specifically, we wanted to see how changing or maintaining the supplemental lighting source during the young and finished plant stage might affect critical production variables such as time to flower. To test this objective, plugs from each treatment were transplanted into 4½ inch containers and placed under one of the three lighting treatments described above (Figure 3). For this finishing environment, plants were grown under a 65°F/59°F day/night temperature set point and irrigated with a water-soluble fertilizer (20-10-20) providing 200 ppm N. Data was collected on these plants once the first flower was completely reflexed or on a predetermined date (millet and pepper).

Plug Quality Similar Under LED Toplighting And HPS Lamps

Generally, plug quality between the two supplemental light sources was not significantly different (Figure 4). Specifically, there was almost no difference between plugs grown under HPS lamps or LED toplighting for measurements such as stem length, stem caliper, root dry mass, or shoot dry mass. However, significant differences were observed when comparing plugs grown under supplemental lighting (provided by either HPS lamps or LED toplighting) to those grown under ambient light.

Generally, plugs grown under supplemental lighting were marketable sooner, had thicker stems, greater mass, and were all-around higher in quality. Thus, these results reaffirm that while the source of the supplemental light doesn't appear to have much impact on plug quality, the additional 70 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (supplemental DLI of 4 $mol \cdot m^{-2} \cdot d^{-1}$) of light was highly beneficial.

Similar results were observed regarding the finished plant stage under these same supplemental lighting treatments. Generally, while the results were not always significant, plants flowered earlier and had greater dry mass under supple-

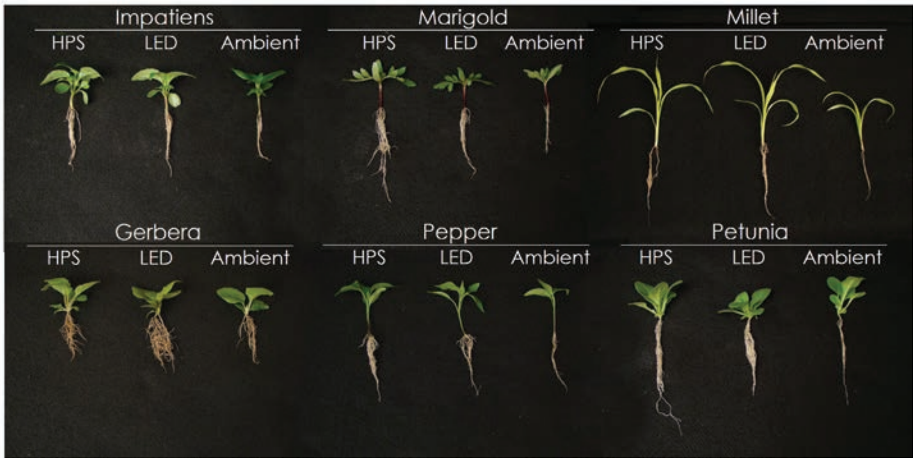

Figure 4. **Impatiens, marigold, millet, gerbera, pepper, and petunia plugs grown under one of three supplemental lighting treatments: 1) 70 μmol·m^{-2}·s^{-1} provided by high-pressure sodium (HPS) lamps; 2) 70 μmol·m^{-2}·s^{-1} provided by light-emitting diode (LED) toplighting; or 3) no supplemental lighting (ambient).**

mental lighting with negligible differences between those produced under HPS lamps and those under LED toplighting. However, ornamental millet finished under HPS lamps had a higher dry mass than those plants finished under LED toplighting, but it is unclear as to whether this increase in dry mass was due to the different spectra or the radiant heat emitted from the HPS lamps.

Factors to Consider Before Choosing Your Supplemental Lighting Source

We conclude from this study that LED toplighting may be used as an equivalent supplemental light source to HPS lamps for the greenhouse production of bedding plant plugs and finishing plant material.

While plant quality, growth, and development were similar under both light sources we investigated, there are still some important facts to consider prior to deciding on which fixtures an operation should utilize. Some of these variables include the potential for energy savings, rebates or tax credits, price of the fixtures, how many months out of the year the fixtures will be used, lifespan of the fixtures, and radiant heat output. Additionally, it is important to note that electronic ballast and double-ended HPS lamp fixtures are much more energy efficient than older technologies. **GG**

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