Comparing LED Lighting To HPS Lamps For Plug Production

In the second of a two-part series, research at Purdue University is determining how LEDs, providing light of different wavelengths, compare to traditional high-pressure sodium lamps.

by **WESLEY C. RANDALL** and **ROBERTO G. LOPEZ**

IN the October issue of *Greenhouse Grower*, we reviewed lighting in vegetative propagation. In this second article, we discuss the use of light-emitting diodes (LEDs) as greenhouse supplemental lighting sources for plug production of annual bedding plants.

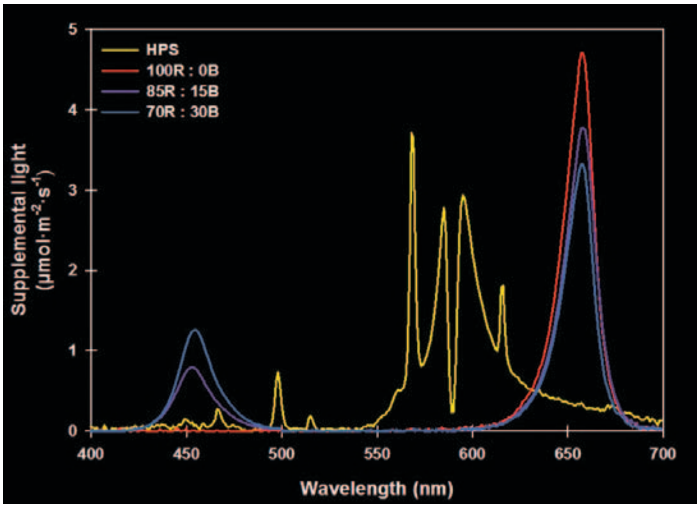
In northern latitudes, plug production occurs in late winter and early spring to meet spring and summer bedding plant sale dates. However, this is also when the ambient outdoor daily light integral (DLI) is seasonally low. Recent research at Purdue University and Michigan State University indicates a DLI of between 10 to 12 mol·m^{-2}·d^{-1} is required to produce high-quality young plants (see flowers.hort.purdue.edu for more information). However, the only way to increase the DLI in a greenhouse to those levels is through the use of supplemental lighting.

Plug producers who use supplemental lighting from high intensity discharge (HID) lamps such as high-pressure sodium lamps (HPS) are able to reduce production time and produce more uniform and high-quality plugs that are compact, sturdy and fully rooted. Additionally, plants flower faster when they are provided with higher DLIs during the young plant stage.

For these and other reasons, growers rely on HPS lamps to provide supplemental lighting (also known as photosynthetic or assimilation lighting) to their crops. However, light-emitting diodes (LEDs) have the potential to offer higher energy efficiencies, a longer lifetime and precise wavelength specificity that can eliminate wavelength emissions that are not used for photosynthesis.

Light-emitting diodes have been used in research for many years, but high-intensity LEDs for plant growth applications are relatively new to the commercial market. Because of their versatility and claimed high efficiency, interest in using LEDs for commercial greenhouse production is on the rise and is evident from by the influx of LED products in the marketplace. However, to our knowledge, few if any published studies investigating the use of LEDs as supplemental light sources for greenhouse plug production are available to growers. Therefore, our goal was to determine how plugs of ten bedding plant species grown under LEDs producing specific combinations of wavelengths would compare to those grown under traditional HPS lamps.

Figure 1: Light Quality Output of HPS and LEDs



Spectral composition of supplemental light with an intensity of 100 µmol·m^{-2}·s^{-1} produced from high-pressure sodium (HPS) lamps or light-emitting diodes (LEDs) with (%) 100:0, 85:15, or 70:30 red:blue light ratios.

Preparing Plugs For The Study

After seeding and germination at a commercial grower, begonia, celosia, impatiens, marigold, pansy, petunia, salvia, snapdragon, vinca and zonal geranium seedlings were received at Purdue University in 288-cell plug trays filled with a soilless substrate. Plug trays were then placed under one of four supplemental light treatments that provided 100 µmol·m^{-2}·s^{-1} of supplemental light from LEDs (Philips GreenPower LED research module) consisting of varying red:blue light ratios (%; 100:0, 85:15, and 70:30) or HPS lamps (150-watt) for 16

Figure 2: Impatiens ‘Dazzler Blue Pearl’

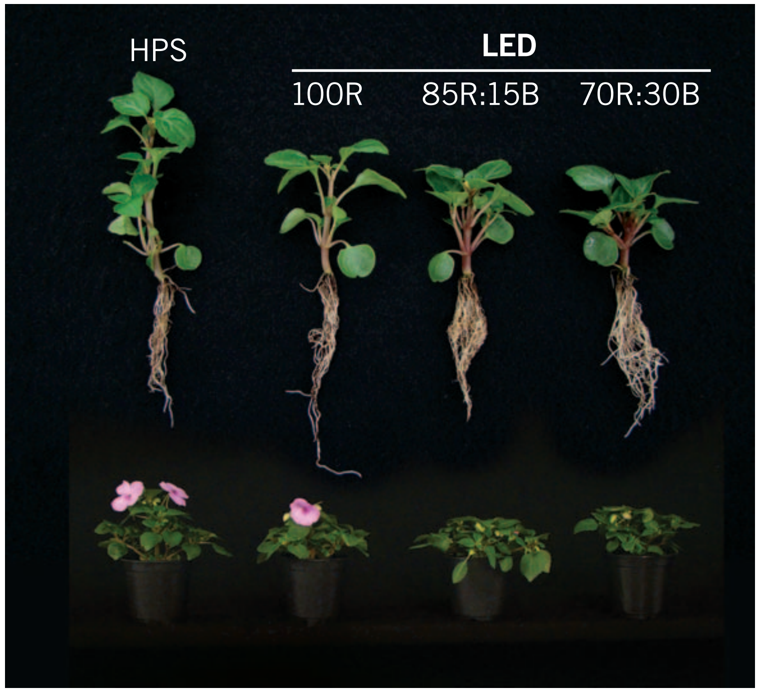


Figure 2. **Seedlings and flowering plants of *Impatiens* ‘Dazzler Blue Pearl’ propagated under 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of supplemental light from high-pressure sodium lamps (HPS) or light-emitting diodes (LEDs) varying in red:blue light ratios and finished in a common growing environment.**

hours. The 16-hour photoperiod consisted of solar radiation and supplemental lighting. The spectral distribution of supplemental light from the HPS lamps and LED lights is shown in Figure 1. Plugs were grown for 28 days with a constant 70°F day and night temperature set point and irrigated with 100 ppm N from a balanced fertilizer (Jack’s 16–2–15 LX Plug Formula for High Alkalinity Water).

In order to determine if there were any carryover effects from the supplemental light treatments, seedlings were transplanted into 4-inch containers with a soilless substrate and moved to a common finishing environment at 70°F. The plants were then provided with a 16-hour photoperiod (sunlight plus supplemental lighting from HPS lamps) to achieve a target daily light integral (DLI) of approximately 10 to 12 $mol \cdot m^{-2} \cdot d^{-1}$. Plants were irrigated as necessary with 200 ppm N (3:1 mixture of Everris 15–2.2–12.5 and 21–2.2–16.6 NPK, respectively).

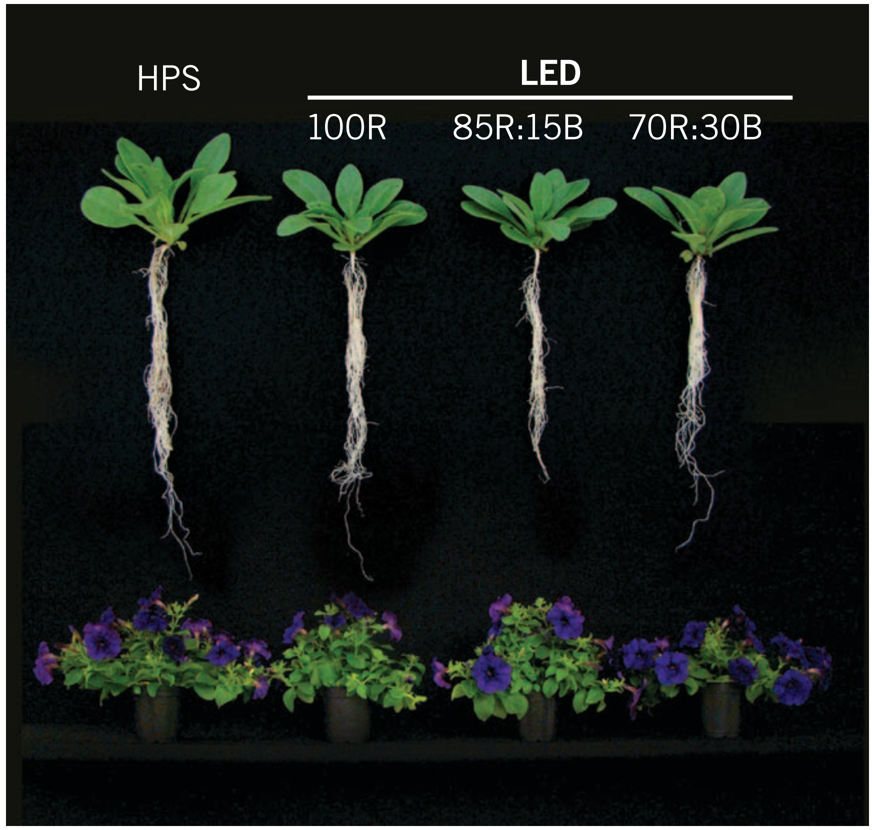
Plug Quality Was Better Under LED Lighting Than HPS Lamps

Our first objective in this study was to determine if light from LEDs of varying wavelengths would affect plug growth and quality when compared to plugs grown under HPS lamps. After 28 days under the various supplemental light treatments, plug quality of snapdragon, begonia, vinca, impatiens, petunia and marigold was statistically higher under the 85:15 red:blue LEDs. Although there were differences between species, plugs were generally more compact, sturdier and greener, and had thicker stems and higher dry mass than those grown under HPS lamps. For salvia and zonal geranium, plug quality was highest under the 70:30 red:blue LEDs. Pansy plants under the 100:0 red:blue LEDs were generally more compact and had thicker stems and higher dry mass than those grown under the HPS lamps. Celosia was the only species displaying highest plug quality under HPS lamps. This could be attributed to the heat provided by the HPS lamps, as celosia is a cold-sensitive species.

In addition to the effects on plug quality, we wanted to compare plants propagated under the described light treatments during the finish stage. We observed few differences in the quality of finished plants during the plug stage for the different light sources that were provided.

Under our experimental conditions, we provided 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of supplemental light for 16 hours. Under a typical commercial scenario, the supplemental lamps would not have run on sunny days for the entire 16-hour photoperiod and a more moderate supplemental light intensity of 55 to 70

Figure 3: Petunia 'Plush Blue'



Seedlings and flowering plants of *Petunia* 'Plush Blue' propagated under 100 μmol·m^{-2}·s^{-1} of supplemental light from high-pressure sodium lamps (HPS) or light-emitting diodes (LEDs) varying in red:blue light ratios and finished in a common growing environment.

μmol·m^{-2}·s^{-1} would have been provided.

Although LEDs do not produce radiant heat with the emitted light, heat is created as electricity flows across the diode itself. Passively cooled LED fixtures use a heat sink to draw heat off the back of the diode and do not require additional electricity. A heat sink has its own drawbacks because it increases the size of the fixture and can cause excessive shading, as in the case of our study.

LEDs Are Suitable For Supplemental Lighting Of Plugs

As a result of this study, we believe LEDs have the potential to be a suitable alternative supplemental light source for use during plug production. The majority of the species tested in this study responded positively to supplemental lighting with both red and blue light. Therefore, our preliminary results indicate that a light ratio of 85:15 red:blue could be a good combination for greenhouse supplemental lighting of bedding plant plugs. However, it is also important to remember that although blue LEDs have a higher electrical conversion efficiency compared to red LEDs, blue light is a higher-energy light, which can increase the energy consumption. Therefore, further research is necessary to determine if lower amounts of blue light can yield positive plant responses.

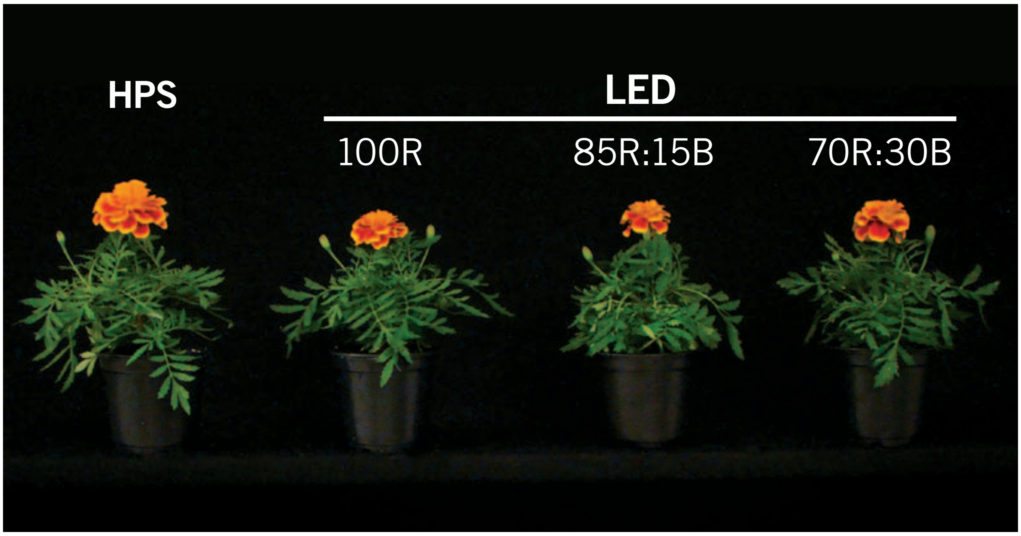
Additional Research Results On LEDs Is In Progress

Currently, we are investigating the use of commercially available LEDs that are passively cooled and that do not cause significant shading of sunlight in the greenhouse to provide supplemental lighting to plugs. In this study, we are comparing the quality of plugs produced under no supplemental lighting (DLI of approximately 4 to 5 $mol \cdot m^{-2} \cdot d^{-1}$) or supplemental lighting from LEDs and HPS lamps.

Additionally, we are investigating the use of sole-source red and blue LEDs in multilayered production in a highly controlled growth room to produce plugs. Our goal is to compare the quality of plugs produced under sole-source LED lighting to those produced in the greenhouse with natural sunlight and supplemental lighting from LEDs under a similar DLI.

We recommend that greenhouse growers do their homework before purchasing any supplemental lighting system and they fully understand the pros and cons of passively and actively cooled LEDs. Additionally, growers should conduct their own studies to determine if supplemental lighting is necessary for their operations and crops. **GG**

Figure 4: Impatiens ‘Dazzler Blue Pearl’



Seedlings and flowering plants of ‘Bonanza Flame’ marigold propagated under 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of supplemental light from high-pressure sodium lamps (HPS) or light-emitting diodes (LEDs) varying in red:blue light ratios and finished in a common growing environment.

Wesley C. Randall (**wrandal@purdue.edu**) is a graduate student and Roberto G. Lopez (**rglopez@purdue.edu**) is an associate professor and Extension specialist at Purdue University. The authors would like to thank Ball Horticultural Co. for seeds, Heartland Growers for sowing, Everris and Jack’s for fertilizer, Fafard for substrate, Philips Lighting and Hort Americas LLC for LED lights and technical assistance. Thanks to the USDA Specialty Crop Research Initiative Grant (2010-51181-21369) and Phillips Lighting for financially supporting this research.