BY DAVID KUACK

Making LEDs Easier to Choose and Use

U.S. researchers are working cooperatively to determine which LEDs are best suited for greenhouse propagation, production and flowering.

Photo courtesy of Roberto Lopez

Purdue University researchers found propagation of vegetative cuttings (geranium, New Guinea impatiens and petunia) was similar under LEDs and high-pressure sodium lamps.

Two acronyms—LEDs and PGRs—are the two topics Erik Runkle, associate professor and floriculture extension specialist at Michigan State University, said he gets questions about most frequently. LEDs or light-emitting diodes have the potential to be used with both low-intensity (photoperiod control) and high-intensity (photosynthetic) applications. And LED lighting is a technology that an increasing number of greenhouse growers are looking at for photoperiod control and improving plant growth.

For low-intensity applications, Erik said the light is used to affect the flowering of plants that are sensitive to daylength. He said the light intensity needed for photoperiod control is about 1 to 2 micromoles per square meter per second.

High-intensity light applications are used primarily to increase growth. Erik said the light intensity for increasing photosynthetic growth is typically 50 to 60 micromoles per square meter per second and can be two to three times higher for tomato production.

"Photosynthetic light is used to increase biomass," he said. "High-intensity lighting can be used to regulate photoperiod, but it would be an expensive way to do it because most plants don't need that much light to initiate flowering. However, some growers do two-for-one, delivering a long day and photosynthetic light by using high-intensity light."

Erik is working with researchers at Purdue University, Rutgers University, University of Arizona and Orbitec (Orbital Technologies Corp.) on a USDA-supported project that's examining the effect LEDs can have on different phases of the ornamental and vegetable plant production, including seed germination, seedling growth, vegetative propagation, impact on flowering and increased photosynthesis. Another part of the project is focused on best management practices and guidelines for testing and selecting LED lights.

Bulb replacement

Erik is focusing on photoperiodic lighting looking at developing LEDs with a light spectrum that's effective at regulating flowering to replace incandescent and even fluorescent lamps. Federal energy legislation passed in 2007 will phase out the production of incandescent bulbs by next year. Erik said incandescent bulbs only convert approximately 8% to 10% of energy into light and on average last about 1,000 hours.

"The two major reasons for growers to consider LEDs for photoperiod lighting is they are about eight times more efficient than incandescent bulbs," he said. "The other reason is longevity of the LEDs. Conservative estimates for LEDs are 20,000 hours to as many as 50,000 hours. That's 20 to 50 times the lifespan of an average incandescent bulb. Considering how long these lamps are used for photoperiodic night interruption, in a northern climate like Michigan, a grower might not have to replace an LED lamp for at least 30 to 40 years."

The low-intensity applications that Erik is studying are typically replacing incandescent or compact fluorescent bulb fixtures that are spaced 5 to 8 ft. apart.

"Instead of 60-, 100- or even 150-watt incandescent bulbs, LEDs can replace these at the same spacing," he said. "We are currently working with a Philips 18-watt LED bulb that is meant to be a drop-in replacement for an incandescent or compact fluorescent. If a grower was previously using 60-watt incandescents and was going to replace them with 18-watt LEDs, he would be able to space out the LED bulbs to achieve the desired intensity."

Not all light is the same

One of the reasons that Erik initiated the LED research was his concern for growers not knowing the difference between various light sources.

"We wanted to avoid having growers going out and buying the cheapest light fixtures thinking light is light," he said. "It is red and far red light that regulates flowering. My concern is if a grower purchased a lot of white light LEDs that contain no or very little red and far red light. Use of some LEDs could result in no or very little photoperiodic response. We're most concerned that growers get the response—flower promotion or >>>

flower inhibition—they are trying to achieve and not something that is substandard. Other issues include energy efficiency and the durability of the lamps."

Erik said most growers don't have the capability of making the measurements to ensure lamps are delivering the light wavelengths needed for a flowering response.

"Growers can measure the light intensity from LEDs as well as other lamp types by using a quantum meter," he said. "These meters, which cost $200 to $300, measure photosynthetically active radiation in the 400 to 700 nanometer wavelengths."

A quantum meter measures light in units of micromoles per square meter per second. Visible light, which is light that's observed with the human eye, covers the wavelengths between 380 and 770 nanometers. This is why it's not recommended to use a footcandle meter or a lux meter to characterize the amount of light available for plant growth or photoperiod responses.

"Most lights used in horticulture applications emit a range of wavelengths, which when combined look close to white light," Erik said. "LEDs are quite different because their spectrum is very narrow and the light wavelengths most often used [red, far red and blue] are the ones that humans see the poorest. For example, when we look at a blue LED it looks dim, but if you measure the photons coming out of it with a quantum meter, it can be fairly bright even though we do not perceive it as being bright."

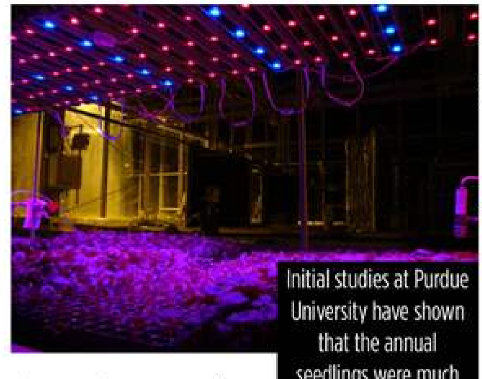

Photo courtesy of Roberto Lopez

Initial studies at Purdue University have shown that the annual seedlings were much more compact, had increased stem caliper, chlorophyll content and dry mass when they were grown under LEDs compared to high-pressure sodium lamps.

LEDs can produce white light using different strategies. For example, white light can be produced by combining red, blue and green LEDs or by coating the emission site with particular phosphors that change the light color.

Lighting during propagation

Roberto Lopez, associate professor and floriculture extension specialist at Purdue University, has done studies with high-intensity photosynthetic lighting on the propagation of vegetative cuttings (liners) and seedlings (plugs) of bedding plants. Cutting propagation studies included geraniums, New Guinea impatiens and petunias rooted under high-pressure sodium (HPS) and LED lights.

"There were no differences in rooting for cuttings under high-pressure sodium or a combination of red and blue LED lights," Roberto said. "Basically, we got the same growth regardless of the lights used. We have published the study results in the April 2013 issue of *HortScience*."

(http://hortsci.ashspublications.org/content/48/4/428.abstract)

Purdue doctoral candidate Chris Currey, who conducted the vegetative cutting research with Roberto, found that growers should provide a daily light integral (DLI) of 10 to >>>

12 moles per square meter per day of light for rooting cuttings.

"In most greenhouses during peak propagation [January and February] there is nowhere near that light level," Roberto said. "For growers who monitor the light level in their greenhouses, it's usually 6 to 8 moles. In northern latitudes the DLI can be as low as 1 to 2 moles during extended periods of cloudy weather. It's difficult to achieve a DLI of 10 to 12 moles in the middle of the winter without supplemental light."

While the results with cuttings and light sources were similar, Roberto said he's encouraged by the initial results he and grad student Wesley Randall have seen with seedlings (plugs) using Philips Lighting red and blue LEDs.

"We looked at the top 10 selling bedding plants," he said. "We found that the seedlings were much more compact, had increased stem caliper [thickness], chlorophyll content and dry mass when they were grown under LEDs compared to HPS lamps. Overall, the plugs were generally of higher quality under LEDs than under HPS lamps. The results look very promising and we are going to do more research work this fall."

Photo courtesy of A.J. Both

Because LED lights don't give off as much heat as high pressure sodium lamps, it's possible to interlight with LEDs in order to increase the photosynthetic rates and/or enhance the flower quality of crops like cut roses.

Roberto said one of the studies will involve fine-tuning the red and blue light combinations in multi-layer production in growth chambers and in the greenhouse.

"In the greenhouse there is the light spectrum from the sun and from the LEDs," he said. "We would like to compare greenhouse production versus the LEDs as the sole source of photosynthetic light. We would also focus on the species [geranium, impatiens, marigold and petunia] that benefited the most from receiving the LED light."

Roberto said heat-loving species like vinca and celosia didn't perform as well in the greenhouse under LEDs as they did under HPS lamps. He attributed the difference to a temperature-related issue since HPS lamps give off more heat than LEDs.

Measuring LED performance

A.J. Both, an agricultural engineer at Rutgers University, said his part of the research project will address the challenges growers and consumers face when looking at LED lighting.

"There are many companies with products on the market today and they all have claims about lifespan, light quality and benefits," A.J. said. "It's very difficult to verify these claims independently. So every manufacturer can pretty much claim what it wants. There is no real standard or baseline that we can relate these statements to and say this makes sense or no, this is too outlandish to even consider."

A.J. is working to design an experimental setup in a controlled environment where measurements would be made of electricity >>>

consumption, light output, light intensity and light spectral qualities.

"We would develop a testing procedure to compare manufacturers' products," he said. "We would then come up with some guidelines that would be provided to the industry. This would then enable both manufacturers and greenhouse growers to make comparisons between the lighting systems that are available."

Making comparisons easier

A.J. said the testing design that he's developing will allow manufacturers and growers to bring in light systems on which specific tests can be conducted related to energy consumption and other performance parameters. The tests will enable A.J. to evaluate the entire product.

"It's not going to be feasible to test every single unit that is available," he said. "We are not like *Consumer Reports* that can do testing on a large scale and publish a lot of data. We will be selective in the number of systems that we will evaluate. We probably won't test more than a couple dozen lights per year. We're not planning to be in the business of running a commercial testing lab.

"We will trial a limited number of lamps because the tests will require some time and some consideration as to what environmental conditions we want to test the lights under and the type of measurements we need to take. Initially, it will take more time and then as we get used to the testing procedures it will go more quickly."

Combining research results

A.J. said combining the information he collects with the findings of plant scientists like Roberto and Erik should provide growers with specific crop information.

"Determining which LED lighting is best for a particular crop is part of what the other project researchers are doing," he said. "They are looking at it more from a quality aspect. What light wavelengths to provide, where to locate the lights in the crop canopy, what duration, and things like that. I'm looking at it from the standpoint of what type of lights need to be evaluated to make it clear to growers what choices they have and what system might be better for them depending on their application."

Making the right choice

Both Roberto and Erik advise growers to do their homework when it comes to LED lights.

"LEDs are a very promising technology," Erik said. "They will enable us to do things with plants that we haven't been able to do with other light sources. I am also cautious that growers don't spend a lot of money without thinking about the economics. I want to make sure growers think through the investment and whether it is economical. There are some situations where LEDs have a clear advantage. Then there are cases where you run the numbers and LEDs are not competitive at this point in time. It's like any other business investment; growers have to run the numbers. It's not a question of if, it's a question of when."

Roberto advises growers to talk to other who are already using LEDs to find out how they're performing.

"There are a lot of LEDs on the market and some are not lasting very long because they weren't designed for use in a greenhouse," Roberto said. "Growers should look at light-fixture quality and company reputation. Many of the claims that are being made are not true in terms of energy savings. In terms of the design, the life of the diode is dependent on the temperature so if they are not properly cooled then their lifespan decreases quite a bit.

"I'd tell growers to consider the costs and to go with the lighting system that is the most economical. The energy efficiency is going to depend on the LEDs and there are a lot of claims out there that they are more efficient. Until more work is done, I would continue using high pressure sodium lamps at least for the propagation of vegetative bedding plant cuttings based on our research results." **GT**

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Some of the information presented in this article first appeared in the Hort Americas September 2012 Newsletter, www.hortamericas.com.

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