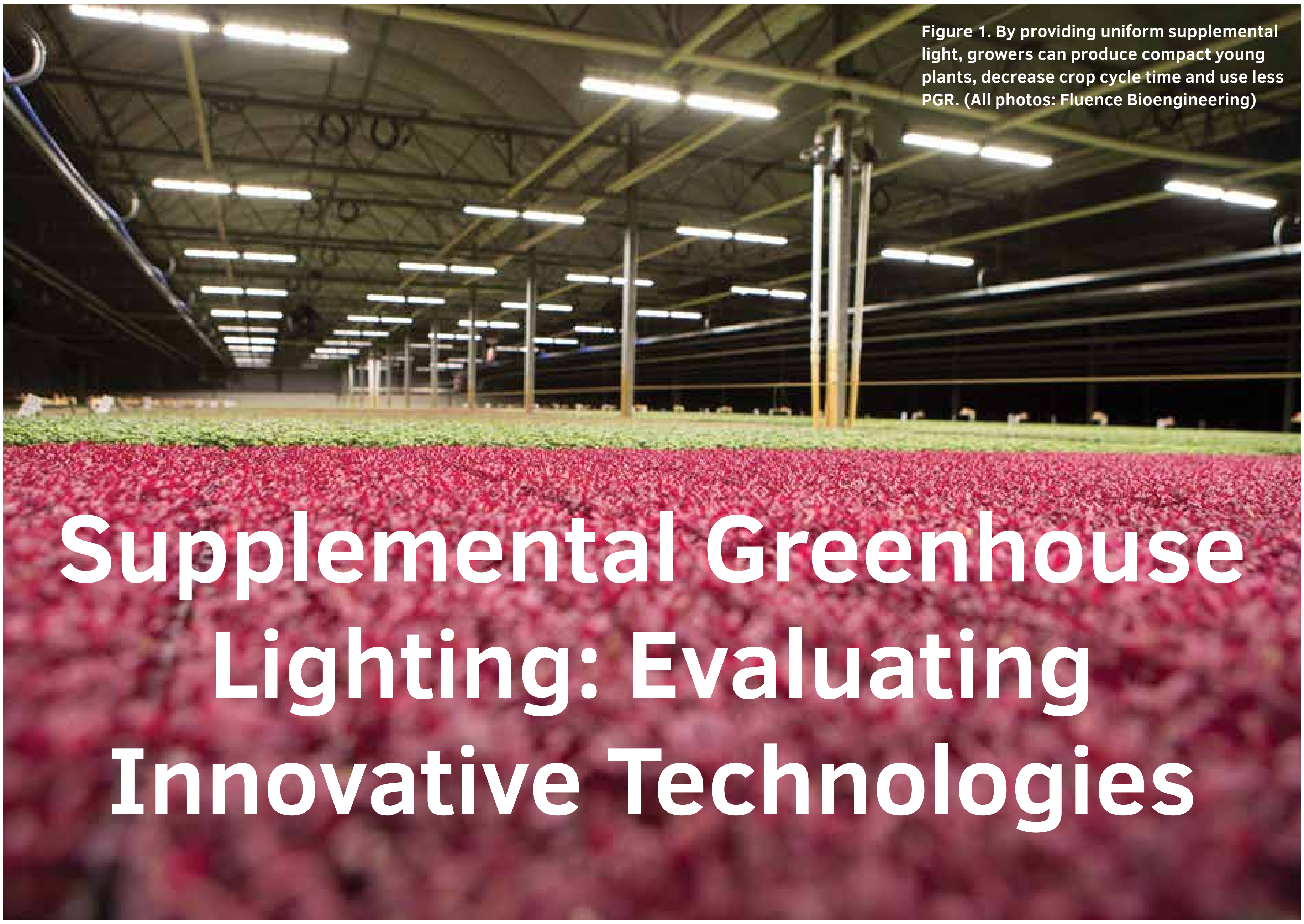

Figure 1. By providing uniform supplemental light, growers can produce compact young plants, decrease crop cycle time and use less PGR. (All photos: Fluence Bioengineering)

Supplemental Greenhouse Lighting: Evaluating Innovative Technologies

Reducing crop cycle time, improving quality and reducing the number of PGR applications are just three of the major benefits you can expect by implementing supplemental lighting into your operation.

BY JOSH GEROVAC

Fall is a wonderful time of year for ornamental greenhouse growers. The busy spring/summer season is over, your garden chrysanthemum/fall crops are mostly shipped out, and if you grow poinsettias your greenhouse is starting to look a lot like Christmas. One drawback to this time of year is the days are getting shorter, which means the average ambient light intensity reaching your crops will continue to decrease until the winter solstice.

Spring plug and liner production starts shortly after poinsettias ship out and, depending on the location of your operation, ambient light levels can be well below the threshold where high-quality young plants can be produced. The benefits of using supplemental lighting for greenhouse production have been well documented by grower testimonials and academic research conducted over the last 20 years (Figure 1). However, aside from labor costs, electricity is normally the second most expensive indirect cost for greenhouse operations.

Technology has been advancing over this time, and growers now have multiple energy efficient options to choose from when selecting a supplemental light source. This article will discuss multiple considerations that growers will face when evaluating light sources for supplemental lighting, including but not limited to: light intensity, spectrum, energy efficiency, light distribution and fixture lifespan.

HIGH-PRESSURE SODIUM FIXTURES

The most common horticulture lighting system is high-intensity discharge, mainly high-pressure sodium (HPS) fixtures. Their popularity as a horticulture lighting system can be attributed to the fact that they produce high intensities of photosynthetically active radiation (PAR) with most of the light emitted being in the 565 to 700 nm range, which are effective wavebands to drive photosynthesis (If you need a refresher on horticulture lighting metrics visit www.fluence.science/science/par-ppf-ppfd-dli).

However, HPS fixtures were not designed specifically to grow plants (they were designed to light roadways and parking garages). One drawback to using HPS fixtures for horticulture lighting is the large amount of radiant heat that is produced by the fixture. The surface temperature of HPS bulbs can reach temperatures above 800° F which necessitates adequate distances between the plant canopy and the fixture to avoid damage to plant tissue. This is why many growers have previously installed 400- or 600-watt HPS fixtures for supplemental lighting in propagation areas equipped with rolling benches and low trusses.

Lower wattage fixtures emit less radiant heat, but these fixtures also produce less light and are not very efficient at converting electricity into PAR. The unit used to quantify fixture efficiency (or efficacy) is μmol/J (which is the amount of PAR produced by a fixture pet input watt of electricity). Most single ended 400-, 600- or 1,000-watt fixtures have an energy efficiency around 1.1 μmol/J, and can get up around 1.3 μmol/J when electronic ballasts are used instead of magnetic. However, the advent of double ended HPS technology has significantly improved the efficacy of HPS fixtures as they are now capable of achieving efficacies around 1.7 μmol/J.

LED TECHNOLOGY

If you have been following the emergence of LED technology over the last decade you have likely noticed several advances in technology. When I finished graduate school in 2014 the most efficient LED-based horticulture lighting systems were about as efficient as double-ended HPS fixtures. The long lifespan (L70 ≥ 50,000 hours) compared to that of an HPS bulb intrigued a few growers to switch to LEDs early on. However, the relatively high cost of LED-based horticulture lighting systems compared to HPS fixtures while achieving similar energy efficiencies caused fewer growers to switch from HPS to LED technology.

LED chip manufacturers have significantly improved the efficacy of diodes available to horticulture lighting manufacturers which has enabled them to significantly improve photon efficacies that greatly surpass HPS fixtures. Some LED-based horticulture lighting systems are now capable of achieving photon efficacies 45 percent greater than double ended HPS fixtures and while the improved efficacy of individual diodes has improved the efficiency of LED-based horticulture lighting, it is just one variable responsible for the improvement over HPS technology.

Figure 2. The spectrum (i.e., color) of light emitted from a horticulture lighting solution has a significant impact on both energy efficiency and overall plant growth and development. While red and blue light is more energy efficient to produce, a broad spectrum will target more photoreceptors for improved cultivation and improve visual acuity to scout for pests and diseases.

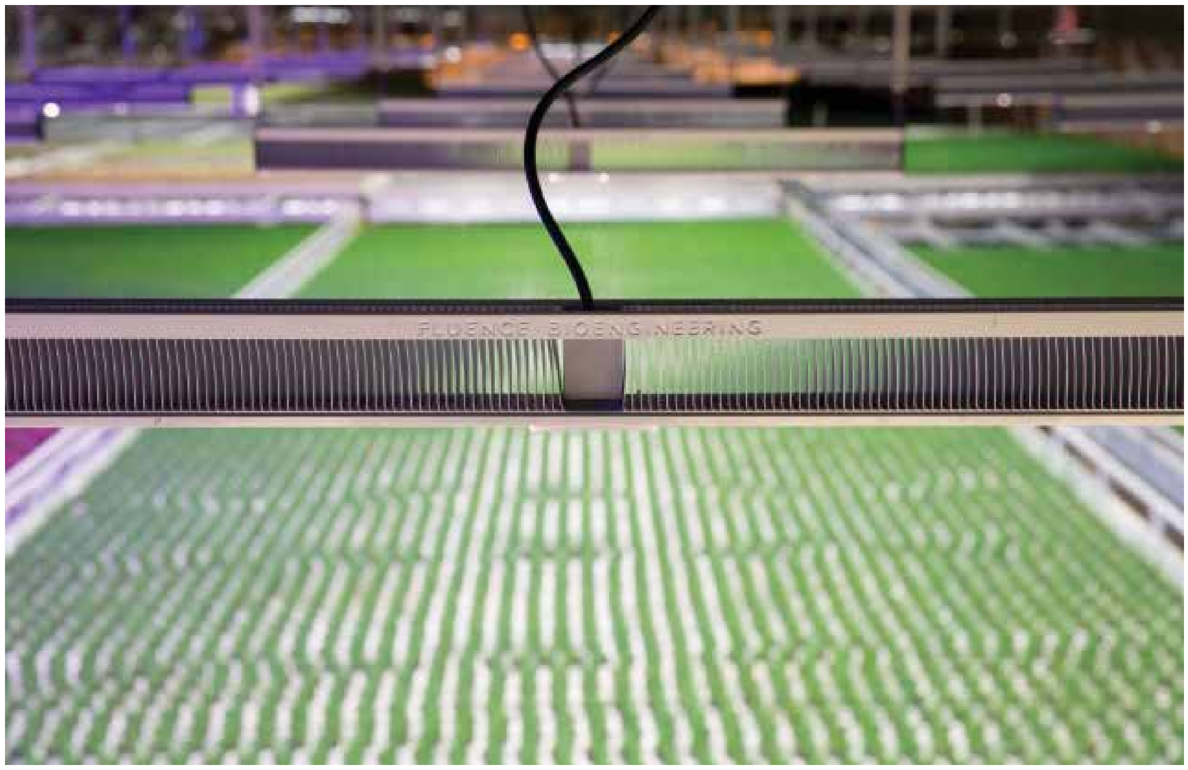

Figure 3. The form factor of a horticulture lighting solution is critical to avoid blocking ambient light from your crops.

LED BENEFITS

One major benefit of LED technology is the ability for manufacturers to custom tune the spectra of light to provide to your crop. The first versions of LED-based horticulture lighting systems mainly consisted of red (660 nm) and blue (450 nm) diodes to achieve the highest photon efficacy possible. While red LEDs have the highest photon efficacy, plants did not evolve in nature under narrow band wavelengths, so they are not always the most efficient spectra with regards to optimizing plant growth and development. This is especially true in situations where lighting systems are used for sole-source lighting, as compared to supplemental greenhouse lighting.

One problem that growers complained about with early red/blue LED fixtures was the inability to diagnose pests and diseases due to the purple hue cast upon plants (Figure 2). Another issue was inconsistent plant morphology during different growing seasons due to varying percentages of total red/blue light provided when the amount of ambient sunlight changes. On cloudy days plants receive a much higher percentage of light from a supplemental light source, and narrow band wavelengths can cause plants to have varying morphological responses during production, as you are significantly changing the spectra of light from day to day.

Both issues prompted a few horticulture lighting companies to implement white LEDs (which are blue LEDs with a yellow phosphor coating) to create a more broad-spectrum. White LEDs are now getting close to the energy efficacy of red and blue diodes which is allowing some manufacturers producing broad-spectrum fixtures to greatly surpassed that of HPS technology, and provide efficiencies greater than most red/blue fixtures available on the market.

COOLING IS CRITICAL

Not all LED lighting systems (or HPS for that matter) are created equally. Spectrum alone is not what causes a fixture to be more energy efficient. Heat sink design, the number of diodes on a circuit board and the input wattage that diodes are driven are important aspects that go into engineering energy-efficient LED fixtures. Removing heat from the back side of a diode is critical when designing LED luminaires.

There are two ways to cool lighting systems in commercial horticulture environments that will impact the efficiency of a fixture. Passively cooled fixtures use heat sinks to dissipate heat from the circuit board, while actively cooled fixtures rely on fans or water to dissipate heat. Fans used to cool fixtures consume energy and will decrease the overall photon efficacy of a fixture.

Additionally, if a fan fails during the operation of the fixture, the LEDs on the circuit board can overheat and burn out, and if they don't burn out, it will dramatically reduce the usable life of the LED fixture. This is a very important feature that growers need to consider when comparing horticulture lighting systems. It is also important to check with horticulture lighting companies to ensure they are using reputable diode manufacturers (e.g., Osram, Samsung and LG) in their fixtures. Many fixtures on the market utilize less expensive components that could reduce the reliability of a fixture (always inquire about a manufacturer's warranty as well).

LIGHTING DESIGN

If you want to make accurate comparisons between lighting technologies, it is important for growers to get lighting designs that show average PPFD at defined mounting heights and the light distribution pattern for their plant growth facility. The form factor and light distribution of a horticulture lighting system will influence the number of fixtures needed in a facility which is another factor that will impact the overall energy efficiency of a plant growth facility.

If a grower needs to install double the number of fixtures to achieve the same light intensity as an HPS lamp, then they are likely to incur more costs while achieving the same energy efficiency. Form factor is also important with regards to shading created by box style fixtures which reduce ambient light intensities (Figure 3). After all, the purpose of supplemental lighting is to increase the overall light intensity reaching your crop, if you are shading your crop with a fixture, then you are back at square one.

Other factors to consider when evaluating horticulture lighting include checking to see if your utility company offers rebates for switching to energy efficient supplemental lighting options (some companies will even file rebates for you before fixtures are shipped).

Another major benefit of LED technology that is overlooked is the ability to dim the fixtures to provide optimal light intensities during various times of the day or growing season. Several environmental control companies are adding the capability to automatically dim your fixtures based on the amount of ambient light during the day to maintain uniform light intensities throughout the day.

At the end of the day your choice of lighting technology is driven by a financial analysis to determine value to your business based on increasing revenue while reducing operating costs. Depending on the cost of electricity, hours of running supplemental lighting per year, and cost to purchase and maintain fixtures, different technologies may make more sense than others for your operation.

No matter which technology you choose, supplemental lighting can be extremely beneficial to many greenhouse facilities. If you would like to learn more about comparing horticulture lighting technologies please visit www.fluence.science/science/how-to-compare-grow-lights. gpn

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