BY ROBERTO LOPEZ & CHRISTOPHER CURREY

Understanding Light

Part 1 of two articles discusses the differences between photoperiodic and supplemental lighting.

In commercial greenhouses, photoperiodic and supplemental lighting are two lighting strategies that can be used to help properly manage light levels throughout the day and seasonally. Some of the primary reasons why greenhouses manipulate light levels include temperature and irrigation management, to promote or inhibit flowering, and to optimize photosynthesis.

However, a recent survey found that 47% of greenhouse growers don't understand the difference between photoperiodic and supplemental lighting. To add to the confusion, the greenhouse industry uses a lot of jargon when referring to these two different lighting strategies. In this two-part series, we'll shed some light (pun intended) on the appropriate use of each lighting strategy. We'll begin by talking about supplemental lighting, which is sometimes referred to as "photosynthetic" or "assimilation" lighting. In next month's article, we'll discuss photoperiodic lighting.

Supplemental lighting

Supplemental lighting is used to increase the total quantity of photosynthetic light (or daily light integral; DLI) in a greenhouse by supplementing the natural sunlight received over the course of the day. In order to produce an *acceptable* quality floriculture crop, our general goal is to maintain a DLI of 10 to 12 mol m^{-2} d^{-1}. If you're marketing higher-quality floriculture crops or vegetables such as tomatoes, then your goal should be to maintain a higher DLI. Of course, this varies from species to species. For more information on DLI, please visit www.extension.purdue.edu/extmedia/HO/HO-238-W.pdf.

Due to greenhouse glazing, superstructure, shade cloth, hanging baskets, etc., DLIs above 30 mol m^{-2} d^{-1} are seldom achieved in commercial greenhouses from solar radiation (Figure 1). Over the past three and a half years, we've been recording the solar DLI in our unshaded double-poly greenhouse at Purdue University located in West Lafayette, Indiana. This DLI is represented by the green squares in Figure 1. From April to September, most growers use some sort of shading (in our greenhouses, we use automatic woven curtains that provide ≈50% shade) to modulate the temperature (red triangles), which can significantly reduce solar DLI below 10 to 12 mol m^{-2} d^{-1}.

Supplemental lighting is most often used during the winter months (especially in northern latitudes) or overcast days when the amount of solar radiation reaching the greenhouse is insufficient to achieve a DLI of 10 to 12 mol m^{-2} d^{-1}. High-value crops such as young plants (plugs and cutting liners), cut flowers, herbs and vegetables are most often placed under supplemental lighting (Figure 2) because increased growth and yield corresponds to greater revenue. Other benefits from increased DLI include more greenhouse turns for young plants due to shorter production times, plants that are compact, well-rooted and branched, and earlier flowering in the finished container. Growers that provide supplemental lighting to cut flowers, herbs and vegetables have increased yields and receive greater value per stem (cut flowers) due to increased stem length, flower size and larger fruits.

In order to appreciably increase the DLI, a supplemental light intensity (typically 400 to 600 foot-candles or 50 to 75 µmol m^{-2} s^{-1}) from high-intensity discharge (HID) lamps, such as high-pressure sodium (HPS), metal halide (MH) lamps or light-emitting diodes (LEDs) are used. Table 1 gives some examples of how *supplemental* DLIs ranging from 1.4 to 9 mol m^{-2} d^{-1} may be achieved by using HPS lamps providing different instantaneous light intensities (foot-candles or µmol m^{-2} s^{-1}) for different durations of operation time. In our scenario in Figure 1, from November to February, the DLI is below 10 to >>>

Figure 1. Daily light integral with or without shade and supplemental lighting in a greenhouse located in West Lafayette, Indiana.

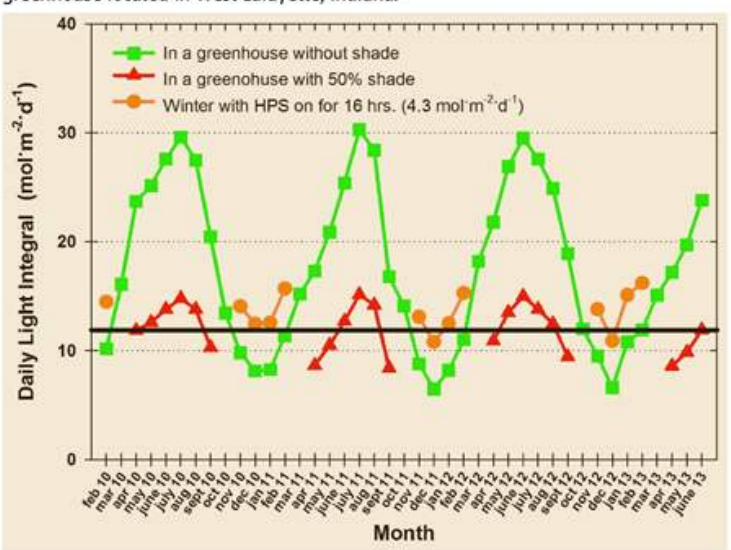
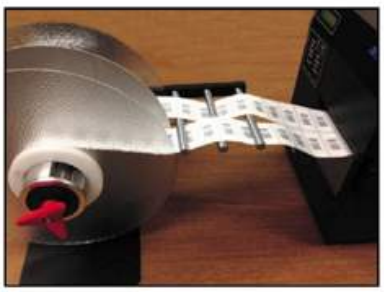


Table 1. Cumulative amount of supplemental light (DLI) provided by high-pressure sodium lamps achieved by varying light intensities and durations.

Duration of light operation (hours)	Daily light integral (DLI; mol·m^{-2}·d^{-1})				
	Supplemental light intensity (Foot-candles/µmol·m^{-2}·s^{-1})				
	250/33	400/52	500/65	600/78	800/104
12	1.4	2.3	2.8	3.4	4.5
15	1.8	2.8	3.5	4.2	5.6
18	2.1	3.4	4.2	5.1	6.7
21	2.5	3.9	4.9	5.9	7.9
24	2.8	4.5	5.6	6.7	9.0



The new GS-80 label applicator (left) and label slitter/rewinder (above) are custom-engineered for growers of potted plants.

The Challenge:

NEW!

Casertano's Greenhouse & Farm in Cheshire CT is an 85-year-old, family-owned business that grows millions of potted plants a year. The business needed a way to economically **automate application of labels on potted plants**, often in harsh outdoor environments, while allowing for quick changeover based on the type and size of plants.

The Solution:

John Casertano, General Manager, contacted Action Packaging Systems for help. We custom engineered the new **Gold Seal GS-80 label applicator** with label slitter/rewinder for their application and the horticultural industry.

The Results:

Casertano is delighted with their three new GS-80s. "*Action Packaging has been 100% committed to developing a labeling system that works,*" reports Casertano; "*They understand the need for consistency and reliability, and they were willing to evaluate and improve all of our processes related to label purchasing, printing and application. Thanks to Action Packaging, we are able to apply a variety of specific labels to all our product and improve our potting speed and efficiency.*"

On top of that, the GS-80 costs substantially less than anything else on the market, and is made in the USA. Talk about a win-win! Please contact us today to explore how we can help your productivity and profitability to bloom in 2014.

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Figure 2. Greenhouse supplemental lighting of herbs.

Table 2. Purpose, crops, responses and characteristics of photoperiodic and supplemental lighting strategies.

	Photoperiodic lighting	Supplemental lighting
Purpose	To create a long-day photoperiod	To increase the daily light integral (DLI) which increases photosynthesis (growth), quality and yield
Crops	Flowering crops influenced by day length	Young plants or crops requiring high light
Responses	Inhibit flowering in short-day plants or promote flowering in long-day plants	Increased flower number, branching, rooting and yield (i.e., cut flowers, herbs and vegetables), thicker stems and sometimes reduced time to flower
Lamp types (greenhouse use)	Incandescent, compact fluorescent, high-pressure sodium (HPS), metal halide (MH) or light-emitting diodes (LEDs)	High-intensity discharge (HID): HPS, MH or high intensity (LEDs)
Lighting strategies	Intermittent (cyclic), fixed HPS bulb with rotating reflector or on a moving boom	Stationary or fixed
Minimum intensity desired at plant height	10 foot-candles (2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$)	400 to 500 foot-candles (50 to 75 $\mu mol \cdot m^{-2} \cdot s^{-1}$)
Time of year typically used	August to April	October to March (North) November to February (South)
Time of day used	After sunset (day-extension), during the middle of the night (night interruption)	During the day when it's overcast and at night

Adapted from Runkle, 2009.

Figures 3a and 3b. Supplemental lighting of young plants [a] cuttings (liners) and [b] seedlings (plugs).

12 mol m^{-2} d^{-1} in our greenhouse in West Lafayette and supplemental lighting is needed just to produce an *acceptable* quality floriculture crop. Therefore, on very overcast days, we use supplemental lighting from HPS lamps for 16 hours to supplement the solar DLI by 4 mol m^{-2} d^{-1} (orange circles).

We're often asked by growers, "How many hours should my HPS lamps be on to increase my DLI?" The answer depends on many factors including: the amount of supplemental instantaneous light your lamps provide, the crops you're growing, the solar DLI reaching your crop, etc. In order to address some of these questions, we designed DLICALC (http://extension.unh.edu/Agric/AGGHFL/dlicalc/index.cfm). With DLICALC, growers can estimate the supplemental DLI from their supplemental light source and estimate the number of hours their lamps must be operated to achieve a target supplemental DLI.

Most growers perceive supplemental lighting as too expensive without careful analysis of all economic factors involved. Installing and operating supplemental lighting systems can be expensive. However, crop growth, quality and yield are considerably higher during periods of the year when prices are generally much higher. The successful use of a greenhouse supplemental lighting system requires: 1) careful design to ensure proper light intensity, distribution and uniformity; 2) monitoring light levels to ensure efficient use; and 3) proper equipment maintenance. **GT**

Young plants are often produced from December to March when the solar DLI in greenhouses can range from 1 to 12 mol m^{-2} d^{-1} in northern latitudes, thus requiring supplemental lighting (Figure 3a and b). Purdue and Michigan State University research recommends a target DLI of 10 to 12 mol m^{-2} d^{-1} for young plants. When the DLI is lower than this, uniformity, quality and timing can be negatively affected. For example, young plants may have delayed root and shoot growth, become elongated and weak. By providing a DLI of 10 to 12 mol m^{-2} d^{-1}, time to produce a marketable liner or plug tray can be reduced by 25% to 50% depending on the species.

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