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Understanding The Differences Between Photoperiodic And Supplemental Lighting

Let's clear the confusion over different types of greenhouse lighting.

AS I talk to growers around the country, I often find that there is confusion between (1) photoperiodic lighting used to create a long day for flower induction of long-day plants and (2) supplemental lighting used to increase the total quantity of photosynthetic light received over the course of the day, which is referred to as daily light integral (DLI) in the greenhouse.

For more information on DLI, please visit http://bit.ly/11x79eK

To add to the confusion, supplemental lighting is sometimes referred to as photosynthetic or assimilation lighting. In this article, I will attempt to clarify the differences to assist you in selecting the appropriate lighting strategy for your greenhouse crops.

Figure 1. Greenhouse photoperiodic lighting using both incandescent and compact fluorescent lamps.

Understanding Photoperiodic Lighting

The number of hours of light in a 24-hour period (photoperiod) controls flowering of both short-day and long-day crops. It is actually the uninterrupted period of darkness that controls flowering responses. Long-day plants are those that only flower (obligate), or flower more rapidly (facultative), when the photoperiod is longer than a critical duration. Unlike supplemental lighting, photoperiodic lighting requires only low-intensity light (typically 10 footcandles or 2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$). Long-days can be achieved by using day-extension or night-interruption lighting (NI; Figure 1).

Day extension lighting consists of turning on a light source such as high-pressure sodium (HPS) or incandescent lamps before the sun sets and keeping the lamps on until the desired day length is achieved. NI consists of using some type of light to "interrupt" the dark period in the middle of the night. Traditionally, NI lighting is provided from 10 p.m.

Table 1. Cumulative amount of supplemental light (DLI; $mol \cdot m^{-2} \cdot d^{-1}$) provided by high-pressure sodium lamps achieved by varying light intensities and durations (hours).

Duration of light operation (hours)	Daily Light Integral				
	Supplemental light intensity (Footcandles/$\mu mol \cdot m^{-2} \cdot s^{-1}$)				
	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

Figure 2. Greenhouse supplemental lighting of potted flowering orchids (photo courtesy of P.L. Lighting).

Reduce Crop Time With DLI

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 4a and b). Purdue University 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 and 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 percent.

to 2 a.m. By interrupting the dark period, plants will perceive a short night length and, therefore, a long day photoperiod.

Cyclic or intermittent photoperiodic lighting is an alternative long day lighting strategy that can reduce energy costs. It is the use of periodic lighting in the middle of the night, where lights are on for 10 minutes and off for 20 minutes during a four-hour period. This can be achieved with timers that turn lamps on and off (this technique is not recommended for high-intensity discharge (HID) as they have a relatively long igniting period, and bulb life is reduced with on/off cycles), using HPS lamps with rotating reflectors (such as Beamflickers), or with HID lamps mounted on booms that move back and forth over crops. Remember that cyclic lighting using HID lamps can be useful to manipulate the photoperiod, but it provides a very negligible amount of photosynthetic light and increase in DLI.

For more information about photoperiodic lighting, visit bit.ly/19kKzaG.

Understanding Supplemental Lighting

During the winter months (especially in northern latitudes) or overcast days, the amount of solar radiation reaching greenhouse crops is insufficient to maintain adequate growth rates to produce uniform, consistent and high-quality crops. Therefore, growers can use supplemental light to increase the DLI in their greenhouses (Figure 2).

In order to appreciably increase DLI, a high intensity of light (typically 400 to 600 footcandles or 50 to 75 µmol·m^{-2}·s^{-1}) from HID lamps such as high-pressure sodium (HPS) and metal halide 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.

Due to greenhouse glazing, superstructure, shade cloth, hanging baskets, etc., DLIs above 30 mol·m^{-2}·d^{-1} are seldom achieved in greenhouses (Figure 3). The green squares in Figure 2 represent the DLI in the Purdue University double-poly greenhouse without shade over the course of 3½ years. From April to September, 50 percent shade is used to modulate the temperatures (red triangles), which can reduce lights below the target of 10 to 12 mol·m^{-2}·d^{-1}. From November to February, the DLI is below the target range and supplemental lighting is needed. Therefore, we used HPS lamps for 16 hours to increase the DLI by 4 mol·m^{-2}·d^{-1} (orange circle).

I'm 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 are growing, the solar DLI reaching your crop, etc.

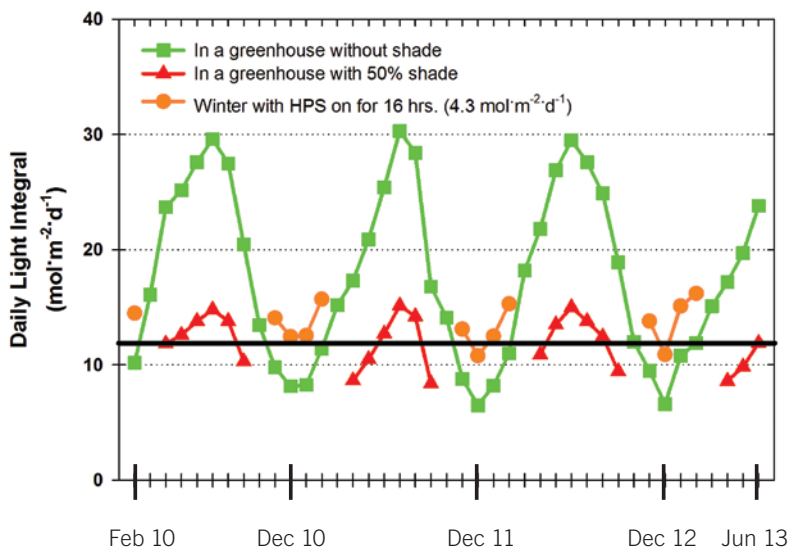

Figure 3. Daily light integral with or without shade and supplemental lighting in a greenhouse located in West Lafayette, Ind.

To address some of these questions, we designed DLICALC, an online DLI calculator (http://bit.ly/GJEf2d). With DLICALC, growers can estimate the supplemental DLI from their supplemental light source and the number of hours their lamps must be operated to achieve a target supplemental DLI.

Bringing It All Together

So where can the confusion come in? In certain instances, growers will use supplemental lighting from HID lamps to increase the DLI in their greenhouses, create a long-day photoperiod or both. For example, a grower can provide 16 hours of light from HPS lamps to their plugs. This will increase the DLI, as the lights are primarily used to increase the total light (supplemental). However, this simultaneously creates a long-day photoperiod, as well, so the lights also have some photoperiodic effects.

Alternatively, when incandescent lamps are turned on for four hours in the middle of the night to provide 10 footcandles (2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$), the light is interrupting the dark period. Therefore, it is considered photoperiodic lighting. Note that the total amount of photosynthetic light for NI lighting provided in this example would be quite minimal, so it should not be considered supplemental lighting.

Table 2 describes the characteristics of both photoperiodic and supplemental lighting strategies. **GG**

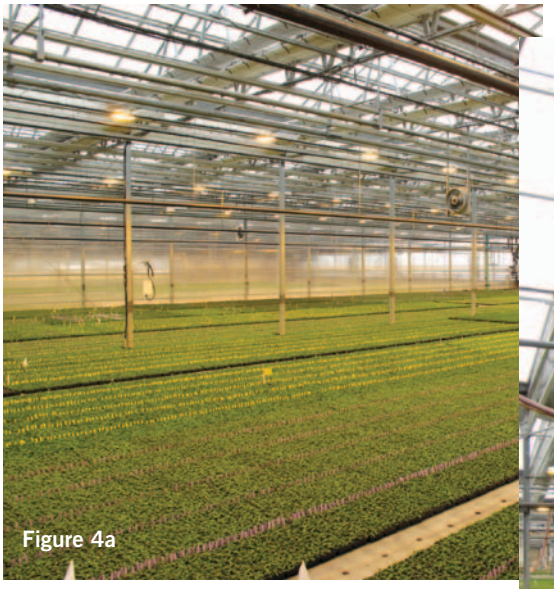

Figure 4a and b.
Supplemental lighting of young plants (A) cuttings (liners) and (B) seedlings (plugs).

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 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 footcandles (2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$)	400 to 500 footcandles (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 is overcast and at night

Adapted from "Strategies For Supplemental Lighting," Erik Runkle, 2009.

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