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Guidelines for High-Pressure Sodium (HPS) Lamp Use

This e-GRO Alert includes information on the benefits of supplemental lighting from HPS lamps and guidelines to help you determine when supplemental lighting is necessary. You will also learn how to properly clean certain HPS reflectors.

In order to produce uniform, consistent, and high-quality crops, reduce the production time of plugs, liners and potted plants and increase the yield of cut flowers and vegetables, greenhouse growers can use supplemental (photosynthetic or assimilation) lighting. High-pressure sodium (HPS) lamps are primarily used in production greenhouses because they are 25 to 30% efficient at converting electrical energy into photosynthetically active radiation (PAR) which influences plant growth (Figure 1). Until recently, traditional HPS fixtures had electromagnetic ballasts and lamps were single-ended (lamp attach to a single socket). Today, HPS fixtures with electronic ballasts are widely available on the market. These fixtures are

Figure 1. Midwest greenhouse using supplemental lighting from high-pressure sodiums lamps to provide 70 μmol·m^{-2}·s^{-1} to their young plants.

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typically smaller, cooler, quieter, lighter, and best of all they are 10 to 15% more energy-efficient then magnetic ballasts. Additionally, the light emitted from the bulbs degrades at a slower rate than with magnetic ballasts. Most recently, double-ended (attached to the socket at both ends) HPS lamps were introduced into the market by Philips and fixtures are now available from some manufacturers for greenhouse use. Data from Utah State University suggests that HPS fixtures with both electronic ballasts and double-ended lamps are now >46% more efficient than traditional HPS fixtures (Table 1).

When Should You Use HPS lamps?

Installing, maintaining, and operating HPS lamps are major investments and fixed costs for greenhouse operations. However, most of the costs can be calculated and weighed against the potential benefits (ex. yield gains for vegetables and cut flowers or shorter crop turns for young plants). Even though you have made a large capital investment in these lamps, there is a six month period (April to September) when the benefit of supplemental lighting is minimal and they should be turned off (this is a great time for mainte-

Table 1. Photon efficiency (micromoles per watt) of various high-pressure sodium (HPS), metal halide and light-emitting diode (LEDs) used for supplemental lighting.

Lamp type	PPF efficiency (µmol/W)
HPS, magnetic, 400 W	0.94
HPS, magnetic, 1000 W	1.16
HPS, electronic, 1000 W	1.30
HPS, electronic, 1000 W, double ended	1.70
Ceramic metal halide, 315 W	1.38 to 1.46
Red + Blue LED fixtures	0.90 to 1.70
Red + White LED fixtures	0.89 to 1.66

Source: Nelson J.A. and B. Bugbee. 2014. Economic analysis of greenhouse lighting: Light emitting diodes vs. high intensity discharge fixtures. PLoS ONE 9(6):e99010.

nance). From October until March the total quantity of light received per day, the daily light integral (DLI), can be a limiting factor in the production of greenhouse crops in northern latitudes. Therefore, the greatest benefit from supplemental lighting occurs at night or during cloudy days from October to March in the north and November to February in the south. Supplemental lighting requires much higher light intensities than photoperiodic lighting which requires 2 to 4 µmol·m^{-2}·s^{-1}. (10 to 20 foot-candles) and is usually delivered as a night break of four hours from 10 p.m. to 2 a.m. For example, most young plant growers provide supplemental light intensities of 50 to 80 µmol·m^{-2}·s^{-1} (400 to 600 foot-candles) at plant height. Much higher intensities of 120 to 180 µmol·m^{-2}·s^{-1} (900 to 1,400 foot-candles) are recommended for vegetables.

It is important to understand how light intensity influences plant photosynthesis in order to maximize the benefits of supplemental lighting. By using a light response curve for New Guinea impatiens, we can see how photosynthesis (sugar gain) increases with increasing light intensity (Figure 2). Those sugars can be used for growth,

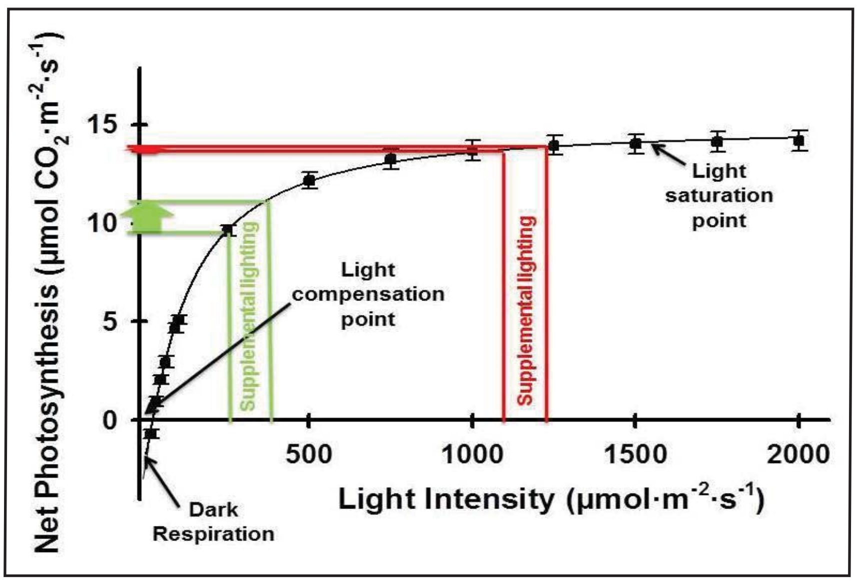

Figure 2. Photosynthetic light response curve of New Guinea impatiens with dark respiration, light compensation, and light saturation points.

respiration ("burning" of sugars), and storage.

During the night and during very cloudy days (low light intensities), respiration continues and can result in negative net photosynthesis which is referred to as dark respiration. At some species-specific light intensity known as the light compensation point, the energy used for respiration is equal to the amount of energy generated from photosynthesis and therefore there is no net assimilation of carbon dioxide (CO_2) by the plant for growth. As light intensity increases, we see that net photosynthesis increases but at a decreasing rate. For example, the increase in net photosynthesis with an increase in light intensity (green line) with supplemental lighting from 260 to 380 $\mu mol \cdot m^{-2} \cdot s^{-1}$ is greater than the increase in light intensity from 1100 to 1220 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (red line). As light intensity increases, there is a point at which photosynthesis becomes saturated with light and this is referred to as the light saturation point. By providing supplemental lighting during the night or during cloudy days, we are providing enough photosynthetic light so that we are above the light compensation point to achieve plant growth.

Benefits of Supplemental Lighting

During peak young plant production (January and February), DLIs can range from 2 to 8 $mol \cdot m^{-2} \cdot d^{-1}$ in the north and 6 to 14 $mol \cdot m^{-2} \cdot d^{-1}$ in the south. Research at Michigan State and Purdue Universities indicate that not only do you produce high-quality young plant with supplemental lighting; more importantly crop time can be reduced by up to 50% depending on the species when the DLI is maintained between 10 to 12 $mol \cdot m^{-2} \cdot d^{-1}$. How many hours should an HPS lamp be on in order to achieve the target DLI of 10 to 12 $mol \cdot m^{-2} \cdot d^{-1}$? The amount of time the lamps are on is as important and the amount of supplemental instantaneous light they provide. Table 2 gives some examples of how supplemental DLIs ranging from 1.4 to 9 $mol \cdot m^{-2} \cdot d^{-1}$ may be achieved.

HPS Reflector Cleaning

In order to get the highest output form your HPS fixtures and lamps, routine maintenance is essential. In my recent visit to greenhouses in New York, I was pleasantly surprised to see an operation that was cleaning all of their HPS reflectors and lamps (Figure 3). I often see reflectors that

Table 2. Supplemental daily light integral (DLI; $mol \cdot m^{-2} \cdot d^{-1}$) achieved by high-pressure sodium lamps with varying PAR intensities and durations (hours).

Duration (hours)	HPS intensity in $\mu mol \cdot m^{-2} \cdot s^{-1}$ or (Footcandles)				
	33 (250)	52 (400)	65 (500)	78 (600)	104 (800)
	HPS Supplemental DLI ($mol \cdot m^{-2} \cdot d^{-1}$)				
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

are dusty, have water spots (Figure 4) or bulbs that are not working properly (Figure 6). It is estimated that light output can be reduced by 8 to 15% due to dirty reflectors. Therefore, I asked several HPS manufactures for their recommendations on cleaning reflectors. P.L. Light Systems says that if the installation is in a clean environment or if the reflectors are 1 to 3 years of age it is possible to clean them with a solution of vinegar and water at 1:100. They also advise cleaning your bulbs and reflectors annually for best performance.

PLEASE NOTE THAT NOT ALL MANUFACTURES RECOMMEND CLEANING REFLECTORS. PLEASE CONTACT YOUR SPECIFIC HPS MANUFACTURE FOR THEIR RECOMMENDATIONS.

P.L Light System Reflector Cleaning Instructions

1. Carefully remove the reflector. Flush the reflector with water inside and out to remove environmental contamination.
2. Fill a basin with water and cleaning agent at ratios provided above (Figure 5). Submerge reflector and clean with a very soft brush. Do not submerge bulbs.
3. Rinse reflector in a second basin of clear water to remove remaining cleaning solution.
4. Rinse reflector in third basin of distilled water to remove hard water residue. Otherwise hard water spots may remain. If residue is still present repeat steps 1 to 4.

For your safety, when cleaning reflectors always maintain the correct ratio and never add other chemicals to

Figure 3 (left). High-pressure sodium lamp reflector has been removed from the fixture and is ready to be cleaned. Note how dirty the cloth is after cleaning just a few reflectors.

Figure 4 (right). Reflector and lamps with dust and water spots.

Figure 5 (left). Elevated work station with materials needed for cleaning HPS reflectors.

solution. Wearing hand and eye protection is advised.

Figure 6. Dim HPS lamps that should be replaced.

For more information on Correcting Problems with HPS Lamps, visit: http://www.flor.hrt.msu.edu/assets/Uploads/CorrectingHPSproblems.pdf