

Getting The Most Out Of Light Measurements

Managing and manipulating greenhouse light levels puts your operation at an advantage. Let's get your operation started.

by **ARIANA P. TORRES, CHRISTOPHER J. CURREY** and **ROBERTO G. LOPEZ**

DOES the quality of your greenhouse-grown plants or number of cut flowers harvested decrease in the winter? Do your cuttings take longer to fully root during certain times of the year? Do you own HID lamps but don't know when you should use them? If your answer is yes to any of these questions, this article will shine some light on how to solve some of these production problems.

In commercial greenhouses, growers can implement several strategies to in-

crease quality and yield, decrease propagation or production time, and enhance root and shoot development of seedlings and cuttings. One fundamental way this can be achieved is by successfully managing and manipulating greenhouse light levels. However, before managing the light in your greenhouse, it is important to know what type of light you are measuring, how to measure it and how manipulating it will affect your crops.

Measuring Light 101

The footcandle and lux are the most common units used to measure instantaneous light in the United States and other



Figure 2. Light quantum sensors connected to a computer can measure and record instantaneous light levels throughout the day.

parts of the world, respectively. However, growers should understand the limitations of using these photometric units.

First, photometric units are instantaneous readings that do not accurately represent the amount of light a plant has received during a 24-hour period. Second, photometric units represent the amount of light perceived by the human eye (primarily green light, which is the type of light plants do not absorb and only reflect) and are not correlated to plant photosynthesis.

Another measure of light that is directly correlated to photosynthesis is quantum light. Quantum light, which is also an instantaneous measurement, is widely used by horticultural researchers and is expressed in $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. This type of light quantifies the number of photons that are used for photosynthesis falling in a square meter per second.

Daily Light Integral

Are you familiar with the term daily light integral or DLI? DLI is the amount of photosynthetically active radiation (PAR) between 400 and 700 nm (the wavelength of light that plants perceive for photosyn-

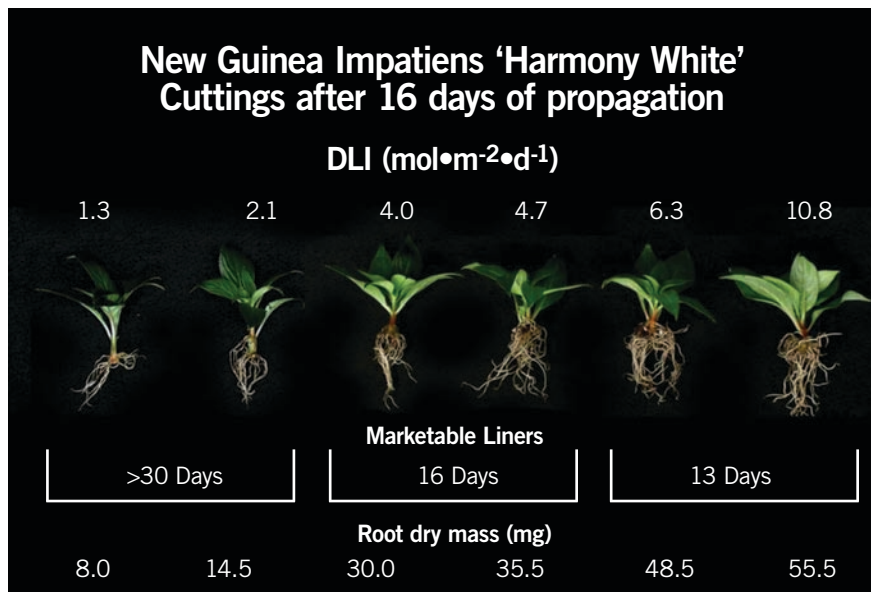


Figure 1. Influence of propagation daily light integral on root development and liner marketability in New Guinea impatiens. As DLI increased from 1 to 11 $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ time to produce a marketable liner decreased from 30-plus days to 13 days.

Production Lighting

thesis) received each day as a function of light intensity (instantaneous light) and duration (daylength or photoperiod). In other words, DLI is the cumulative amount of light received by your plants during a 24-hour period.

Conceptually, it is similar to how we measure rainfall. Light is "collected" cumulatively throughout the day, similar to

how rain is collected in a rain gauge during a storm. Because DLI is measured over the course of the day it is expressed as moles per square meter per day, or $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$.

DLI's Importance

DLI is a very important measurement for greenhouse growers because it influences plant growth, development, yield and



Figure 3. The Light Scout is a small, mobile sensor without data logging capabilities.

quality. For example, DLI affects rooting and aboveground growth of seedlings and cuttings, time to flower, and finish plant quality, including branching, compactness, stem caliper, flower number and size.

So how can you use DLI in your greenhouse? First, familiarize yourself with crop-specific DLI recommendations, which are available in English and Spanish at <http://www.extension.purdue.edu/extmedia/HO/HO-238-W.pdf>. Or, download a pamphlet for greenhouse use at the same website. Next, begin monitoring and recording the DLI inside your greenhouse. Knowing the DLI inside your greenhouse and crop DLI requirements will allow you to determine when supplemental lighting, white wash or retractable shade curtains are needed to produce a premium product.

DLI During Propagation

The vast majority of cutting and seed propagation takes place from December to March when outdoor DLI levels are between 5 and 30 $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ across the U.S. However, when we take into account the shading from greenhouse structures, glazing materials, thermal curtains and hanging baskets, DLI values are often reduced by 40 to 70 percent.

Consequently, if you are propagating greenhouse crops under light-limiting conditions (low DLI), you can expect delayed rooting, growth and development. How do you know your crops are growing under limited DLI values? During propagation of most herbaceous crops, researchers at Michigan State and Purdue Universities have found that providing between 4 and 5 $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ from sowing/

It All Starts Here

Build your perennial programs on our starters

- New varieties from leading breeders
- Spec production = year-round inventory & short lead time
- Custom growing syncs with your production timetable
- Generations of growing experience

For perennial quality and variety, call us today!

EMERALD COAST GROWERS

Toll Free: 1.877.804.7277 www.ECGrowers.com sales@ecgrowers.com

sticking until rooting initiation/callusing – then increasing DLI between 6 to 8 mol.m⁻².d⁻¹ – will promote rooting and enhance shoot and root biomass accumulation (Figure 1). Providing an optimum DLI during propagation can decrease propagation time, enhance rooting and compactness to facilitate shipping and transplant, and reduce subsequent time to flower.



Figure 4. WatchDog weather stations contain a light sensor and automatically calculate DLI.

NEXUS... THE NATURAL CHOICE FOR NATURAL VENTILATION.



Nexus Zephyr™ & Zail™

Naturally ventilated greenhouses help optimize growing conditions by giving growers a superior, affordable cooling solution. Whether it is new construction or a retrofit, Nexus delivers greenhouse solutions that save you time and money.

Visit our website at nexuscorp.com to get additional information on this and other naturally ventilated models. Browse through the project galleries and see pictures of existing projects and other available products.



800.228.9639 • WWW.NEXUSCORP.COM • ANSWERS@NEXUSCORP.COM

DLI During Finishing

The DLI during finishing is very important for producing high-quality crops. Generally, increasing the DLI during finishing can produce more compact plants, while increasing the number of branches, flowers and overall plant mass. Additionally, increasing the DLI can also reduce the time to flower by reducing the number of leaves unfolded before the first flower or inflorescence (facultative irradiance response) or by increasing the rate of plant development through the radiant heat generated from increased irradiance.

However, all crops do not have the same DLI requirements. Jim Faust from Clemson University categorized crops based on DLI requirements of 5 to 10, 10 to 20, 20 to 30 and greater than 30 mol.m⁻².d⁻¹ as low, medium, high and very high-light crops, respectively. Identifying the optimal DLI for the crops you are producing is a great step to take toward producing a high-quality finished plant.

How Do We Measure DLI?

There are several ways to quantify the DLI in your greenhouse, including estimating, calculating and measuring. These options range in accuracy and cost from low to high and as cost or accuracy increases, generally the other will as well – and vice versa.

Greenhouse growers can estimate outdoor DLI levels by locating their facilities on DLI maps developed by Jim Faust and colleagues. These maps illustrate monthly outdoor DLI throughout the U.S. But again, these values should be reduced by 40 to 70 percent to give you very rough estimates of the DLI values your greenhouse-grown crops are receiving each month.

Another method to calculate DLI is placing a quantum sensor near your crop (Figure 2). The sensor can be connected to a data logger, or environmental computer that records instantaneous light intensity (commonly footcandles, or μmol.m⁻².s⁻¹) over defined intervals (once every 10 to 60 seconds). Using the calculations in Table 1 in a spreadsheet, the 24-hour DLI can be calculated based on average hourly readings in either footcandles or μmol.m⁻².s⁻¹.

Finally, as greenhouse growers, you can

Jiffy® CarbonLite

Growblock®

Speedypot®

Preforma®

Jiffy-7®

Jiffy Coir Disc

Jiffy® Plug

Carefree®

Jiffy-pot®

Jiffy-7 Coir®

Jiffy®

it's all about the roots

Jiffy Products of America Inc.
1-800-323-1047
email: prosales@jiffygroup.com
www.jiffygroup.com

Production Lighting

Table 1. How to calculate from footcandles to PAR ($\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and from PAR to daily light integral (DLI ($\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$)) for sunlight and high-pressure sodium lamps (HPS). Note the conversion factor from footcandles to PAR depends on the light source.

Step 1	Determine the average number of footcandles per hour. Take the hourly footcandle averages for the day, add them, and then divide this sum by 24.	For example, you have 24 hourly footcandle (f.c.) readings: $0 + 0 + 0 + 0 + 0 + 5 + 12 + 21 + 40 + 43 + 159 + 399 + 302 + 461 + 610 + 819 + 567 + 434 + 327 + 264 + 126 + 15 + 4 + 0 = 4,408 \text{ f.c.}$ $4,408 \text{ footcandles} \div 24 \text{ hours} = 184 \text{ f.c. per hour}$
Step 2	Convert footcandles per hour to PAR ($\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) based on light source. Do this by multiplying f.c. per hour by a factor for the light source. Sunlight has 0.20 f.c. per $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. HPS lamps have 0.13 foot-candles per $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$.	Using the same example as above, the PAR for crops receiving natural sunlight would be calculated like this: $184 \text{ foot-candles per hour} \times 0.20 \text{ f.c. per } \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} = 36.8 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ For HPS lamps, the PAR would be: $184 \text{ foot-candles per hour} \times 0.13 \text{ f.c. per } \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} = 23.9 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
Step 3	Convert PAR to DLI. Do this by using the following equation: $\text{PAR } (\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}) \times 0.0864$ The 0.0864 factor is the total number of seconds in a day divided by 1,000,000	For crops receiving natural sunlight: $36.8 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} \times 0.0864 = 3.2 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ For crops receiving HPS lighting: $23.9 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} \times 0.0864 = 2.1 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$

now purchase devices that automatically measure the DLI your crops are receiving. This can be done with either mobile or self-contained units. The LightScout DLI 100 meter (Figure 3) and the WatchDog Weather Station (Figure 4) are two mobile, self-contained devices manufactured by Spectrum Technologies that are portable tools for measuring DLI.

While DLIs are not logged and stored in the LightScout, the WatchDog has a built-in data logger that records daily values and can be connected to a computer to export data. It is important to remember that all light sensors should be placed next to your crop and be kept at canopy height to accurately measure DLI.

What's next?

Once you know the DLI requirement for your crops and you have estimated the monthly DLI levels in your greenhouse, it is time to make light management decisions. You can decide if supplemental

lighting or shade curtains are profitable investments for your facility. Under cloudy days and extended overcast periods (winter and early spring), the use of HID lamps to supplement sunlight allows growers to increase plant quality and productivity. HID lamps, such as high-pressure sodium lamps, are a good way to maximize effectiveness of supplemental light because these types of lamps are efficient in converting energy into photosynthetic light. Most greenhouse crops benefit from supplemental lighting, but this technology is only worthwhile when increased crop quality or reduced production time leads to increased revenue and, ultimately, profitability. **GG**

About the authors: Ariana P. Torres (torres2@purdue.edu) is an M.S. candidate in horticulture; Christopher J. Currey (ccurrey@purdue.edu) is a Ph.D. candidate in horticulture; and Roberto G. Lopez (rglopez@purdue.edu) is an assistant professor and floriculture Extension specialist. All three conduct their research at Purdue University.