

BULLETIN

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Managing Photosynthetic Light During Liner Production

By Roberto G. Lopez and Christopher J. Currey

During this time of year, ambient outdoor light levels are at seasonally low levels across the United States. Inside a greenhouse light may be further reduced by 40 percent to 70 percent due to the greenhouse structure, glazing material and age, energy curtains, overhead baskets, and a host of other factors. This may raise a few questions. How low is low with light? With a large volume of young plant production occurring during this time, what impact does light have on rooted cutting (liner) production timing and quality? Our objectives in this article are to review some concepts including the relationship between light measurements, photosynthesis, and plant growth; discuss the impact of daily light integral



(DLI) during the production of liners; and provide general guidelines and recommendations for increasing the DLI inside your propagation greenhouse.

Light

First, we need to focus on the light that plants utilize for photosynthesis, which influences growth and quality. Most growers use instantaneous foot-candle (f.c.) meters to measure light in the greenhouse. These “photometric” units are based on

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Containers for Four Seasons: A Step-by-Step Guide to Year-Round Container Gardening

By Rita Randolph

Editor's Note: Rita is the author of Taunton Press/Fine Gardening's CONTAINER GARDENING issue 2009. Portions of this article are reprinted with permission from that special issue.

Containers for Your Collection

There are all levels of gardeners – from the youngest child with novice dirty hands, to Master Gardeners, to professional growers and retailers. And then there are the true nerds, plant-

crazy collectors and hard-core horticulturists that want to add the new, most sought-after items to their collection. These perpetually plant-hungry people have the drive to collect plants, and when they find a cool new one, they may not want to put it in the ground. Containers are a perfect way to house your collection until it grows a little bit more or you eventually find the perfect place for it. Many plants and combinations in my “collection” have lived in containers for years, with only periodic repotting and changing of their

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the amount of visible light detected by the human eye (primarily green light). That means foot-candles are focused on people and not appropriate for indicating plant photosynthesis.

Most horticultural researchers measure instantaneous light in micromoles (μmol) per square meter (m^{-2}) per second (s^{-1}), or $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. This “quantum” unit quantifies the number of photons (individual particles of energy) used in photosynthesis that fall on a square meter (10.8 square feet) every second. However, like foot-candles this light measurement also is an instantaneous reading and instantaneous light levels can change dramatically throughout the course of a day.

Daily light integral (DLI) is the amount of photosynthetically active radiation (PAR) received each day as a function of light intensity (instantaneous light, or $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and duration (hours of light, or day length). It is expressed as moles of light (mol) per square meter (m^{-2}) per day (d^{-1}), or $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ (moles per square meter per day). One can compare the DLI concept to a rain gauge. Just as a rain gauge collects the total rain in a particular location over a period of time, DLI measures the total amount of PAR received in a day. Greenhouse growers can use light meters and data loggers to measure the number of light photons that accumulate in a square meter over a 24-hour period.

Photosynthesis & Growth

Plant growth can be thought of as a carbohydrate balance, similar to a bank account, and can be described using a simple formula: $\text{growth} = \text{photosynthesis} + \text{stored reserves} - \text{respiration}$. Photosynthesis is the process where plants absorb light and synthesize carbohydrates, or sugars. Respiration is the process of breaking down the carbohydrates for energy. Stored reserves are the excess carbohydrates from photosynthesis not consumed by respiration. Photosynthesis increases available carbohydrates and can be considered a “deposit” and stored reserves can be considered a “positive balance” resulting from previous deposits from photosynthesis. On the other hand, respiration can be considered a “withdrawal” which utilizes carbohydrates and reduces the overall balance. When the overall balance of the account is positive, or when photosynthesis and stored reserves are greater than respiration, growth occurs and cuttings root quickly. When respiration is equal to the sum of photosynthesis and stored reserves, no growth occurs and the plant enters a “maintenance” mode. If respiration has used up stored carbohydrate reserves and is occurring faster than photosynthesis, the carbohydrate balance is negative and rooting can be delayed and a decline in plant health can occur.

So how can we increase our carbohydrate balance? As previously mentioned, a majority of young plant production takes place throughout winter and spring when light levels are low. Many growers provide the proper air and substrate temperatures, mineral nutrients, and high-quality water during

propagation of young plants. However, we frequently observe and hear that little or no efforts are made to monitor or record light during propagation. Figure 1 shows the response of net photosynthesis (photosynthesis – respiration) of common annuals to light levels. There are several points on the figure that are important. The dark respiration rate (R_d) is the rate of respiration in darkness when available carbohydrates are used up. The point at which net photosynthesis is equal to zero is called the light compensation point (LCP), when respiration is equal to photosynthesis. Lastly, the point at which the increase in photosynthesis stops is the light saturation point (LSP), the point when photosynthesis is maximized.

During the winter and early spring, when DLIs are low, instantaneous light levels are often low. Therefore, many of our bedding plants are being grown under light levels that are below the LSP and even the LCP in some instances. As a result, the production of carbohydrates and growth of plants is not maximized. By managing light during cutting propagation, you will be able to maximize growth and minimize production time.

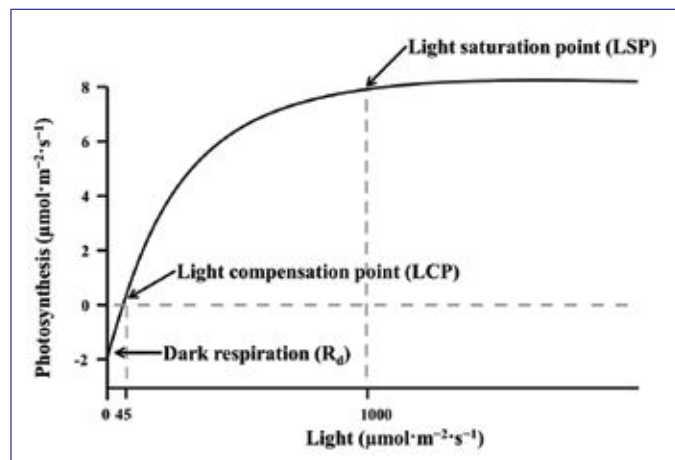


Figure 1. Photosynthetic light response curve of a typical bedding plant with the dark respiration (R_d), light compensation (LCP), and light saturation (LSP) points.

DLI during Cutting Propagation

Similar to plug production, there are four different stages of cutting propagation: Stage 1 = Harvesting, shipping, and sticking; Stage 2 = Callusing; Stage 3 = Root development; and Stage 4 = Toning. These stages not only differ in cultural requirements but light requirements as well. In Stage 1 (harvesting), the goal is to minimize stress for cuttings that have been recently harvested, shipped, and stuck. Once cuttings are packaged and shipped, they are exposed to dark conditions until exposed to light during sticking. Before sticking, keep cuttings out of direct sunlight to avoid increasing plant temperature, which increases respiration. Once cuttings have been stuck and are placed in the

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greenhouse for callusing (Stage 2), our research indicates a DLI of approximately $\approx 5 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ is desirable to minimize stress from high light. During callusing, cuttings are not photosynthesizing very much so increasing light will not benefit growth.

It is time to increase your greenhouse light levels once roots have initiated and they have entered Stage 3 (root development). The presence of roots allows cuttings to take up more water and maintain turgor. This means the guard cells surrounding stomata can open, allowing for increased gas exchange and, therefore, photosynthesis. What DLI should you try to achieve during root development? The response of different species to DLI during root development is variable. However, our research has led us to conclude that a general recommendation for DLI during root development is around 8 to $10 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$. Increasing the DLI during root development has been shown to increase root and shoot growth, stem caliper, and overall liner quality. During toning (Stage 4), the DLI can be further increased to levels recommended for finishing, from 10 to $12 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$.

By increasing the DLI during root development and toning, you can reduce the time until a liner is finished or “pullable,” while increasing the quality of the finished product (Figure 2). Furthermore, cuttings propagated under higher DLIs have been shown to flower earlier than cuttings propagated under lower DLIs, reducing production time for a finished, flowering crop (Figure 3).

Increasing Your DLI (Greenhouse Glazing, Cleanliness, Supplemental Light)

From our discussion, it is apparent that ambient DLI is low across most of the United States during young plant production. What can growers do to increase DLI within their facilities? One easy way to increase the amount of free PAR light from the sun within the greenhouse is to remove whitewash, dust, and algae from your glazing material. Greenhouse glazing alone can reduce light transmission by up to 25 percent depending on the material (glass, plastic,

polycarbonate, acrylic, etc.) and age. The greenhouse frame and sash can further reduce light transmission by 10 percent to 12 percent and 5 percent to 7 percent, respectively.

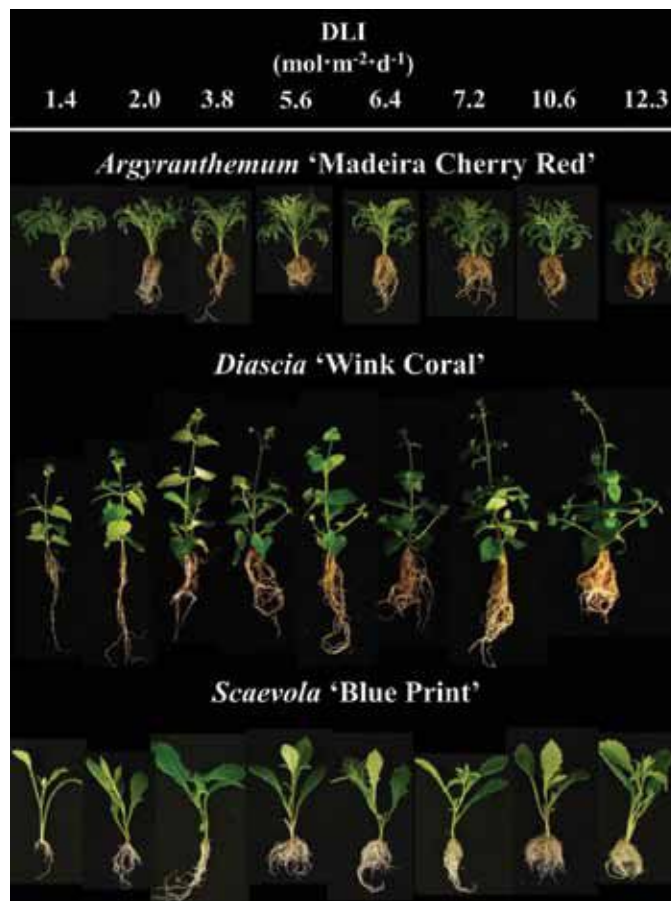


Figure 2. Cuttings of *Argyranthemum*, *Diascia*, and *Scaevola* grown under daily light integrals in propagation ranging from 1.4 to $12.3 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ during root development.



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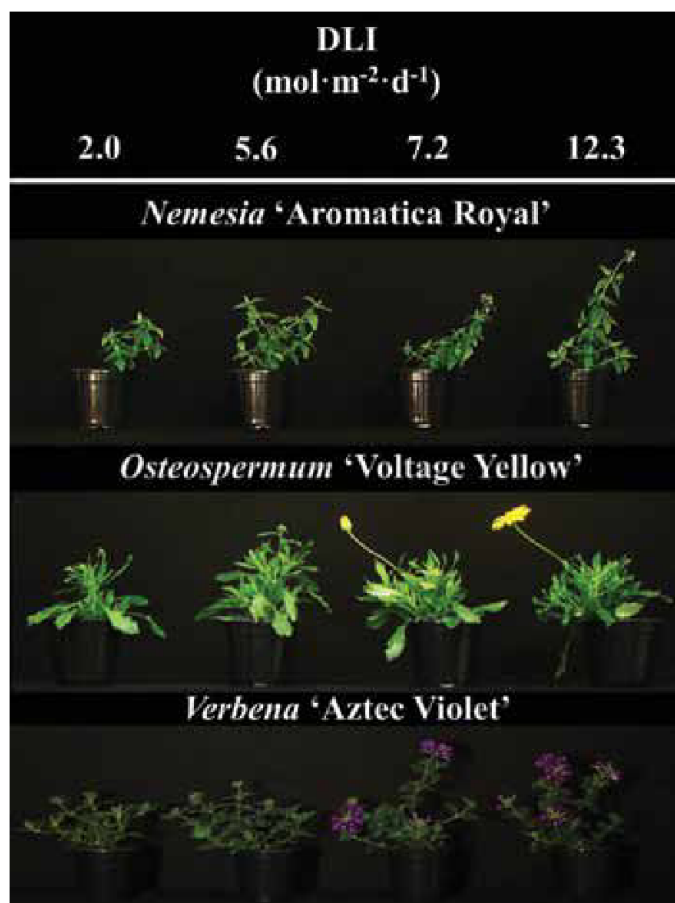


Figure 3. Plants of *Diascia*, *Osteospermum*, and *Verbena* grown under daily light integrals in propagation ranging from 2.0 to 12.3 mol·m⁻²·d⁻¹ during root development.

Another way to increase the DLI in your facility is to use supplemental lighting such as high-pressure sodium (HPS) lamps. How many hours should a HPS lamp be on? The amount of time the lamps are on is as important as the amount of supplemental instantaneous light they provide. Table 1 gives some examples of how DLIs ranging from 1.4 to 9 mol·m⁻²·d⁻¹ may be achieved.

Duration (hours)	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

Table 1. Cumulative amount of supplemental light (DLI; mol·m⁻²·d⁻¹) provided by high pressure sodium lamps achieved by varying light intensities and durations (hours).

The Take-Home Message

Propagation of cuttings for bedding plant production takes place when ambient and outdoor greenhouse DLIs are low. With a little knowledge of how to quantify light, how plants respond to light, and how to manage light in your greenhouse you can increase the efficiency and quality in cutting propagation while reducing propagation time and increasing profitability.

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