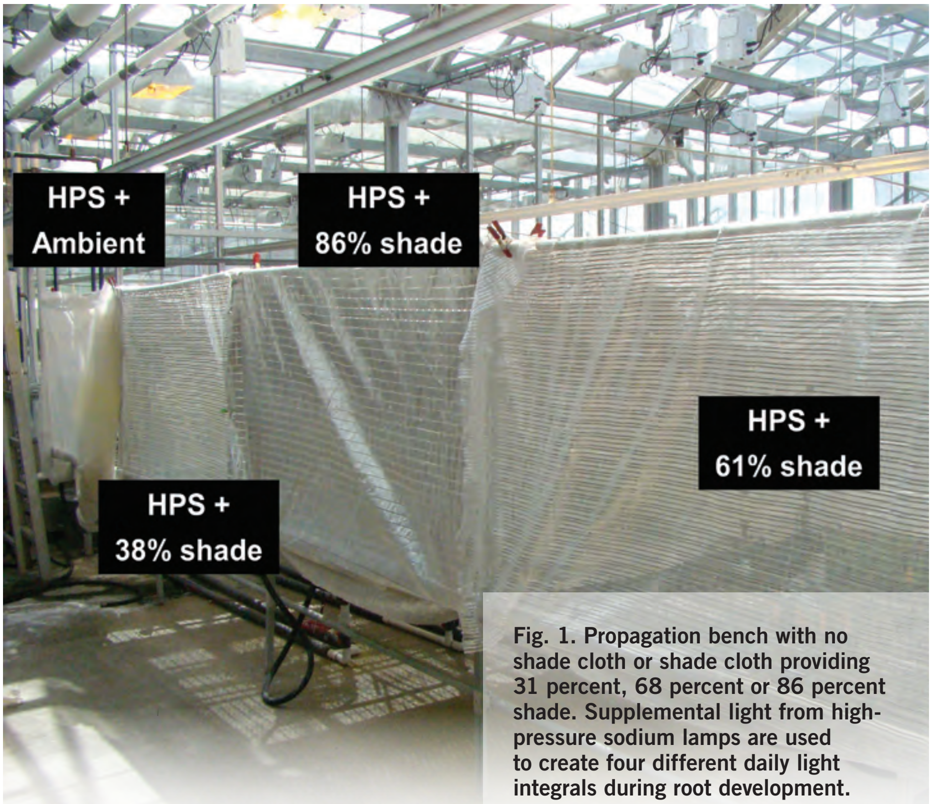

Fig. 1. Propagation bench with no shade cloth or shade cloth providing 31 percent, 68 percent or 86 percent shade. Supplemental light from high-pressure sodium lamps are used to create four different daily light integrals during root development.

Producing **High-Quality Rooted Cuttings**

Researchers study the impact of light during propagation on growth and quality of vegetatively propagated annual bedding plants.

by **CHRISTOPHER J. CURREY** and **ROBERTO G. LOPEZ**

WHETHER you are a propagation specialist or are rooting cuttings for your own in-house production, the goals of propagators are the same — to efficiently produce high-quality rooted cuttings. In order to meet the spring and early summer market dates for flowering bedding plants, cuttings are typically rooted in mid- to late-winter and early spring when the outdoor daily light integrals (DLIs) are at seasonally low levels. The DLI inside a greenhouse is often further reduced as a result of glazing material and interior structures, as well as hanging baskets suspended above benches to maximize

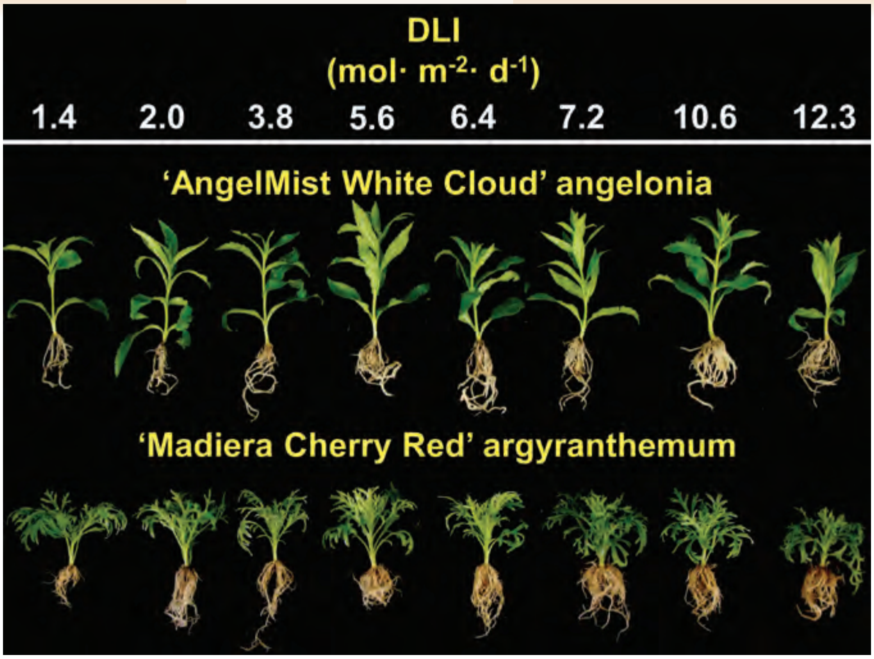

Fig. 2. ***Angelonia*** **'AngelFace White' and** ***Argyranthemum*** **'Madiera Cherry Red' cuttings are grown under a range of daily light integrals for two weeks in propagation after one week of callusing. The photo was taken three weeks after the beginning of propagation.**

production space.

Research has recently shed some light on the impact of light levels during propagation of New Guinea impatiens and petunias. However, the number of species and cultivars grown from cuttings is quite large and diverse. Therefore, we wanted to better understand the impact of DLI during propagation on growth and quality of several vegetatively propagated annual bedding plant species.

How the Study Was Conducted

Cuttings of *Angelonia* 'AngelFace White,' *Argyranthemum* 'Madeira Cherry Red,' *Sutera* 'Abunda Giant White (bacopa),' *Diascia* 'Wink Coral,' *Lantana* 'Lucky Gold,' *Nemesia* 'Aromatica Royal,' *Osteospermum* 'Voltage Yellow,' *Scaevola* 'Blue Print' and *Verbena* 'Aztec Violet' were stuck in 105-cell trays filled with a propagation substrate that was 50-percent soilless substrate and 50-percent coarse perlite. Cuttings were maintained in a propagation greenhouse with an air and substrate temperature set point of 73°F. During the first seven days of callusing, the average DLI was maintained at about 5 mol·m^{-2}·d^{-1}.

After seven days, cuttings were placed in a greenhouse with high-pressure sodium lamps operating for 16 hours per day with either no shade cloth or shade cloth providing 38 percent, 61 percent or 86 percent shade (Fig. 1). We repeated the experiment two additional times to achieve a span of DLIs representing a range of greenhouse DLIs, from 1.2 (very low) to 12.3 mol·m^{-2}·d^{-1} (moderately high). Two weeks after being placed under the shade/lighting treatments, rooted cuttings were harvested. We measured stem length and caliper and washed the substrate off the roots so we could separate roots and shoots to record dry weights.

Supplemental Lighting Increased Both Shoot And Root Growth

Shoot dry weight (a measure of plant size) increased for all species as DLI increased during propagation, though species also varied in the magnitude of their response (Figs. 2 and 3). As DLI increased from 1.2 to 12.3 mol·m^{-2}·d^{-1}, shoot dry weight of all species increased, from 50 percent (lantana) to 384 percent

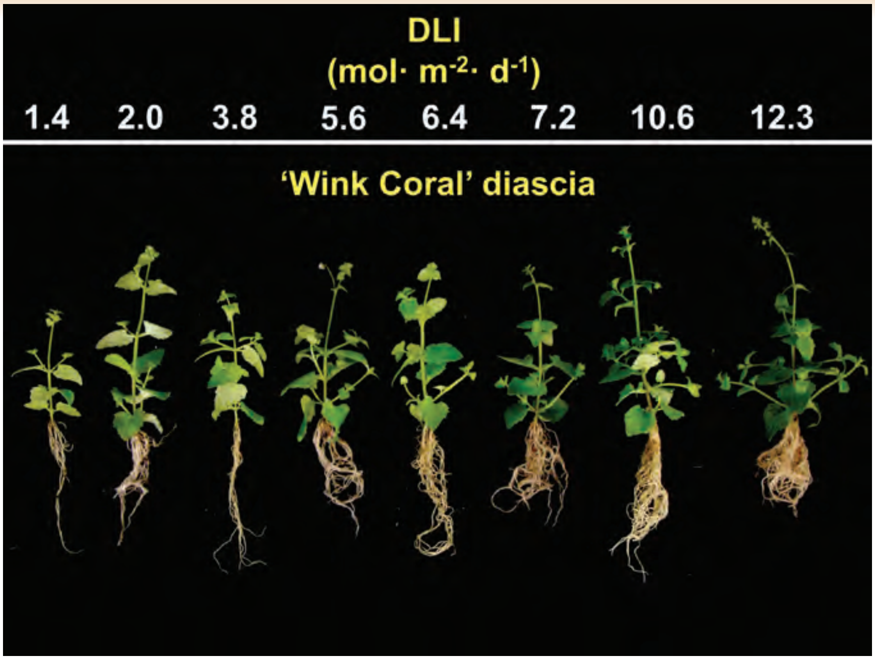

Fig. 3. ***Diascia*** **'Wink Coral' cuttings are grown under a range of daily light integrals for two weeks in propagation after one week of callusing. The photo was taken three weeks after the beginning of propagation.**

(diascia). More importantly for cutting propagators, increasing DLI increased the root dry weight for all nine species. For example, increasing the DLI by 11 $mol \bullet m^{-2} \bullet d^{-1}$ resulted in a 156 percent increase in root dry weight of verbena, while root dry weight of diascia increased by 1,137 percent. Additionally, the root:shoot dry weight ratio increased for all species as DLI during propagation increased. While the root:shoot ratio of verbena increased by 18 percent as DLI during propagation increased, the root:shoot ratio of osteospermum and scaevola increased by 329 percent and 419 percent, respectively. This means that although both shoot and root growth increased with DLI, cuttings allocated more growth into roots as opposed to shoots.

Increased DLI Has Variable Effect On Stem Length

While shoot and root growth increased with DLI for all species, there was no consistent trend in stem length in response to DLI during propagation. For example, as DLI during propagation increased from 1.2 to 12.3 $mol \cdot m^{-2} \cdot d^{-1}$, the stem length of lantana and nemesia both increased by 20 percent while stem length of diascia increased by 76 percent. Alternatively, stem length of argyranthemum, osteospermum and scaevola was unaffected by DLI during propagation. Similarly, stem caliper of bacopa, lantana and scaevola were unaffected by DLI, while stem caliper of angelonia, argyranthemum, diascia, nemesia, osteospermum and verbena increased with DLI during propagation by 11 percent (verbena) to 119 percent (diascia).

Measuring The Impact On Plant Quality

We often talk about plant quality, and several attributes contribute to our perception of this. It is generally desirable to have rooted cuttings and plugs with good root and shoot growth, a higher root:shoot ratio. They should be sturdy and not too leggy. Though we collected all of this data for cuttings, we wanted to integrate it to assess overall quality.

To do this, we used something we called the "quality index" (Fig. 4), a value derived from an equation combining the total mass, root:shoot ratio and the ratio of stem caliper to stem length. The quality index increased differently for all species as DLI during propagation increased from 1.2 to 12.3 mol·m^{-2}·d^{-1}, from 53 percent (lantana) to 960 percent (diascia).

Supplemental Lighting May Save Money

In addition to producing high-quality rooted cuttings, lighting during propagation may actually save you money by reducing overall production time for rooted cuttings. How can adding supplemental light reduce energy costs? Let's look at a few examples using

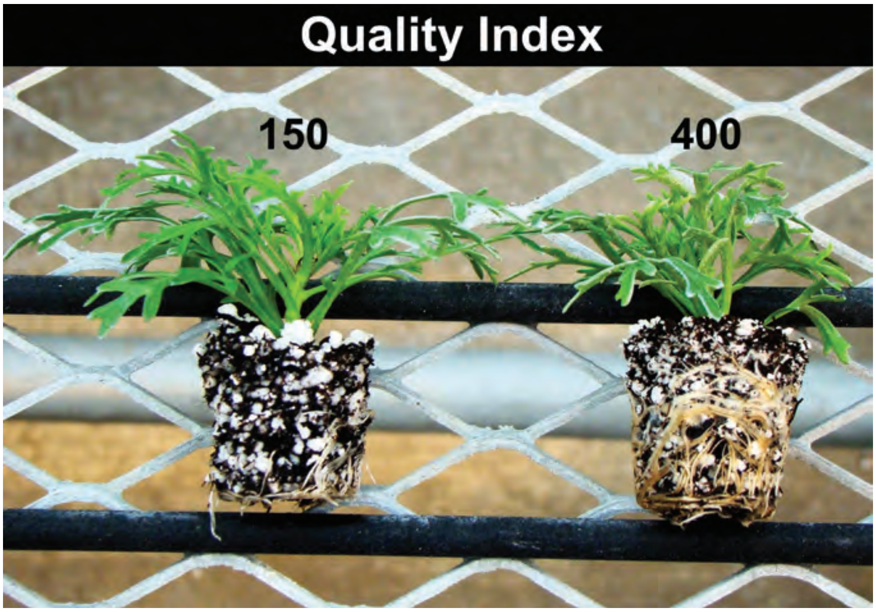

Fig. 4. Two rooted cuttings of *Argyranthemum* 'Madeira Cherry Red' are grown under different daily light integrals during root development, demonstrating the difference in quality as measured by the quality index. The photo was taken three weeks after the beginning of propagation.

For more information on measuring and monitoring light, see "The Basics of Monitoring: Greenhouse Environment" from the July 2011 issue of Greenhouse Grower or "Measuring Daily Light Integral in a Greenhouse" available in English and Spanish at **GreenhouseGrower.com/September 2012.**

Virtual Grower, a tool developed by the USDA-ARS to estimate energy consumption during greenhouse production. We will start by simulating propagation of angelonia in a 1-acre glass-glazed greenhouse in Indianapolis, Ind., in March. Assuming an average greenhouse DLI of ~5 $mol \cdot m^{-2} \cdot d^{-1}$, production will take about five weeks. Our day and night temperature set points will be 73°F and 70°F, respectively, for the first four weeks (callusing and rooting), followed by one week of 73°F days and 65°F nights (toning). It would cost approximately \$1.02/ft^2 for the five-week period to finish angelonia cuttings if you are heating with propane. Now, if we provide 75 $\mu mol \cdot m^{-2} \cdot d^{-1}$ (577 foot-candles) for 18 hours using 400-W HPS lamps this will provide ~$mol \cdot m^{-2} \cdot d^{-1}$, bringing our total DLI up to approximately 10 $mol \cdot m^{-2} \cdot d^{-1}$ during root development and toning. The energy costs for operating the HPS lamps would be \$0.03/ft^2 for the three-week lighting period. However, our heating costs are reduced, because under the higher DLI the cuttings finish one week earlier. Therefore, when the total energy cost for producing rooted angelonia cuttings with supplemental light (\$0.86/ft^2) is compared to no supplemental light (\$1.02/ft^2), we can realize a 15 percent savings.

Let's look at another example using a species that has a stronger response to DLI during propagation — argyranthemum. Using the same production facility and temperatures already described, we would have the same energy cost for heating during the five weeks of production — \$1.02/ft^2. When we add the same supplemental light after a week of callusing, our cuttings would be finished in a total of three weeks. Our total energy costs for two weeks of supplemental lighting and three weeks of heating would be \$0.77/ft^2, resulting in a 25 percent reduction in energy costs compared to argyranthemum cuttings rooted without supplemental light. When interpreting these costs, it is important to know that energy costs will vary with greenhouse structures and glazing material, location and time of year. However, we think these examples are useful in seeing how lighting during propagation may affect your production costs.

Consider Whether Supplemental Lighting Will Work For You

If you are currently rooting cuttings and looking for ways to improve both the quality of your liners and your efficiency in production, we encourage you to evaluate using supplemental light during propagation. A good starting point would be to begin monitoring the DLI in your propagation area to see how much light you are receiving during propagation. **GG**

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