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Working Harder and Making Less: The Curse of Chasing Gross Revenue

by Peter Konjoian

Several years ago I participated in an OFA outreach seminar titled "Partnering for Profitability." Along with several academic colleagues I traveled the country discussing OFA's hot-off-the-presses book titled *Tips on Operating a Profitable Greenhouse*. Lessons learned during the tour have broadened my understanding of both our industry as a whole and my business in particular.

One section of the program included an audience participation cost and profit analysis. At one stop on the tour the growers in attendance chose to analyze a crop of seed geraniums. We plugged in numbers for the cost of a 4.5-inch pot, growing medium, fertilizer, seedling, labor, overhead expenses, etc. Then we agreed on a wholesale selling price. Jim Faust from Clemson University had developed a spreadsheet that we used for the exercise. The spreadsheet automatically calculated crop profit after production costs and selling price were identified.

In our hypothetical seed geranium exercise, based on our costs and selling price, the crop lost money, registering a negative profit. What I heard next from one grower in the audience has haunted me every day since that seminar. From the back of the room on that fateful

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Cutting Production and Propagation: Is There Room for Improvement?

by Roberto Lopez, Erik Runkle, Jim Faust, and John Dole

Over the past 15 years, an increasing percentage of bedding plants and herbaceous perennials have been propagated by vegetative cuttings. For example, the wholesale value of non-rooted cuttings imported by U.S. greenhouse growers increased by 350 percent from 1994 to 2005. As demand for cuttings has increased, companies have opened production sites offshore, including Costa Rica, Guatemala, Mexico, Kenya, Israel, and China, to take advantage of high light, moderate temperatures, and abundant and inexpensive labor. Cuttings are harvested and then shipped to rooting stations or finished plant producers, including many growers in the United States. In 2005, U.S. greenhouse growers imported 868 million non-rooted cuttings of annuals and perennials with a reported wholesale value of $60 million. With this in mind, we asked the following question: Is there room for improvement in stock plant production and cutting propagation to reduce cutting losses and increase profits?

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serve my family, employees, customers, and business best? Truthfully, we all need to do some of both. I need to grow some seed geraniums to balance my specialty crops like mandevilla. But if I trust the law of supply and demand and cut seed geranium production to the point where my customers fight over them, the price will go up, they will be more profitable, and bench space will have opened up for more specialty crops. Improving profitability isn't always about building more greenhouses. It can be as much about working your existing production capacity more thoughtfully.

Overproduction or Undermarketing?

In conclusion, there are two sides to consider to our current dilemma of shrinking profit margins. I've discussed the overproduction side, others believe we are less guilty of overproducing and suffering much more from undermarketing.

Personally, I've heard the marketing argument for more than 30 years. We keep talking the talk about market potential and how much domestic consumption remains untapped. But whenever push comes to shove, every time we have the chance to walk the walk, we always choose to invest in production technology over marketing and promotion. We've learned how to grow plants much faster than we've learned how to sell them.

Call it overproduction, or call it undermarketing. At this point, it really doesn't matter. What should concern us is that an industry showing shrinking profit margins coupled with excess capacity is, by definition, living on the mature side of its life cycle curve. When an industry enters its mature stage, it can either re-invent itself to reset its cycle, or slowly fade away and lose relevance with its customers.

Peter Konjoian
Konjoian's Floriculture Education Services
48 Brundrett Ave
Andover, MA 01810
978-683-0692
peterkfes@aol.com

ofa Grower

Cutting Room Production and Propagation: Is There Room for Improvement?

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In 2004, researchers at Clemson, North Carolina State, and Michigan State joined forces to improve the performance of vegetatively-propagated plants. The research program is focused on improving cutting performance by increasing the understanding of stock plant production, the post-harvest physiology of non-rooted cuttings, packaging methods, and their subsequent effects on propagation, growth, and flowering.

During the past two years, the group has collectively provided cutting producers with research-based information that has begun to increase cutting yield and quality, and enhance post-harvest longevity. In this article, we focus on environmental and cultural information generated from our research program at Michigan State University, which can be used during propagation of non-rooted cuttings to reduce rooting time and finish time, and increase cutting quality and profits.

Propagation 101

Creating the ideal rooting environment for vegetative cutting propagation can be challenging and expensive, especially in northern regions of the United States and Canada. Most herbaceous annual and perennial propagation occurs from December to March when outdoor light levels and temperatures are low. With rising energy costs, growers are challenged with how to properly balance temperature and light during propagation. In this article, we address how these two environmental parameters influence cutting propagation during the three different rooting stages.

Stage 1: Stick to Callus Formation

During the early stages of cutting propagation, maintaining air temperatures of 68 to 73°F (20 to 23°C) and media temperatures of 73 to 77°F (23 to 25°C) is important because callus formation is primarily driven by temperature, and to a lesser extent by light. For most crops, the maximum recommended light intensity is between 120 to 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (600 to 1,000 foot-candles) to provide enough photosynthetic energy for callus formation and root initiation without causing desiccation. Retractable shade curtains alone can be an effective way to modulate light transmission, as they can remain open on cloudy days or in the morning and late afternoon on sunny days. Curtains should be closed during the brightest hours of the day to prevent excessively high light levels. In addition, curtains can be closed from around sunset until sunrise to help prevent heat loss and to increase plant temperature.

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We recommend a photoperiod of 12 to 13 hours for the propagation of most annuals, especially for long-day plants such as petunia.

Stage 2: Root Initiation

Once roots have initiated (generally 5 to 10 days after stick, depending on the species), maximum light intensity can be increased to 200 to 400 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (1,000 to 2,000 footcandles) for most species. Again, the light should be diffuse. At this time, temperature can be slightly lowered: air temperatures of 66 to 70°F (19 to 21°C) and media temperatures of 72 to 75°F (22 to 24°C) are suggested.

Stage 3: Toning the Rooted Cutting

Once roots fill about half of the plug cell (generally 10 to 16 days after stick), the rooted liners should be moved from the mist area to an area with lower humidity and lower temperatures, and maximum light levels should be increased to 500 to 800 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (2,500 to 4,000 footcandles). These higher light intensities and lower temperatures help to acclimate plants to the post-propagation environment. With these three rooting stages in mind, let's discuss how to reduce rooting time and possibly influence time to flower by managing light levels during propagation.

Managing Light

Light is the driving energy source for photosynthesis and carbohydrate accumulation in plants. Vegetative cuttings require a minimum quantity of light to provide the energy for callus formation, root initiation, and development. Light intensities below this minimum result in little or no callus and root development, leading to a delayed crop or rooting failure. Conversely, too much light can reduce root formation due to excessive stress on the cuttings and lead to bleached leaves.

Daily Light Integral (DLI)

DLI is defined as the quantity of light received each day as a function of light intensity (instantaneous light: $\mu mol \cdot m^{-2} \cdot s^{-1}$) and duration (day). It is expressed as the amount of light per square meter in one day ($mol \cdot m^{-2} \cdot d^{-1}$). For more information on DLI please refer to the September 2003 *Greenhouse Grower* issue or Chapter One of *Lighting Up Profits*. The amount of light that a cutting receives per day during propagation can have a profound impact on the quality of the rooted cutting in terms of root formation, stem elongation, shoot growth, and subsequent flowering.

We have quantified the effects of DLI on rooting, growth, and subsequent flowering of petunia Supertunia 'Mini Purple', Tiny Tunia 'Violet Ice', and Double Wave 'Spreading Rose', and New Guinea impatiens 'Harmony White', 'Harmony Magenta', and 'Celebrette Red' cuttings during propagation. In our experiments, uniform cuttings were harvested from vegetative stockplants maintained at Michigan State University. Cuttings stuck in 72-cell liners were propagated throughout the year under four different

Table 1. Maximum light intensities $\mu mol \cdot m^{-2} \cdot s^{-1}$ (footcandles) and shade percentages used to create DLI environments (1.3 to 10.7 $mol \cdot m^{-2} \cdot d^{-1}$) during 16 days of propagation of petunia and New Guinea impatiens cuttings in 2004 and 2005.

DLI ($mol \cdot m^{-2} \cdot d^{-1}$)	Maximum light intensity $\mu mol \cdot m^{-2} \cdot s^{-1}$ (footcandles)	Shade	Month
1.3	60 (300)	75%	September
1.4	102 (510)	75%	February
1.6	110 (550)	75%	February
1.8	155 (775)	55%	February
2.2	167 (835)	55%	February
2.9	285 (1,425)	30%	February
3.6	338 (1,690)	none	February
4.2	379 (1,895)	30%	October
5.4	411 (2,055)	30%	August
6.1	494 (2,470)	30%	August
6.3	514 (2,570)	none	October
7.5	616 (3,080)	none	September
8.4	749 (3,745)	none	August
10.8	778 (3,890)	none	August

woven shade curtains to obtain different DLI environments, ranging from 1.2 to 10.7 mol·m^{-2}·d^{-1} (Table 1). All cuttings were rooted in a glass greenhouse with overhead mist providing 50 ppm nitrogen, and steam or fog was injected as necessary to maintain a vapor pressure deficit of 0.3 kPa (89% relative humidity). Bottom heating was not available, so we maintained air temperatures between 75 to 77°F (24 to 25°C) and achieved media temperatures of 72 to 75°F (22 to 24°C). A 12-hour photoperiod was created using a nine-hour day (using black cloth) extended with light from soft-white fluorescent lamps. Petunia cuttings were evaluated from each DLI environment after 8, 12, or 16 days and New Guinea impatiens cuttings were evaluated 10, 13, or 16 days after stick (Figure 1).

Responses to DLI differed among petunia and New Guinea impatiens cultivars. However, in both species, rooting and quality of cuttings increased and time to flower decreased when the DLI under which they were propagated increased. For example, as the DLI during propagation increased from 1.2 to 7.5 mol·m^{-2}·d^{-1}, root number of petunia Tiny Tunia 'Violet Ice' increased from 17 to 40 and cutting shoot length decreased from 2.5 to 1.8 inches (6.3 to 4.5 cm) when measured 16 days after stick. In addition, cutting root and shoot dry weight of cuttings harvested after 16 days of propagation increased by 737 percent and 106 percent, respectively, as the DLI increased from 1.2 to 8.4 mol·m^{-2}·d^{-1}. Time to flower from stick decreased from 50 to 29 days as DLI during propagation increased from 1.4 to 10.7 mol·m^{-2}·d^{-1}.

In New Guinea impatiens 'Harmony White', root and shoot dry weight of cuttings increased by 1038 percent and 82 percent, respectively, and time to flower decreased from 85 to 70 days as the DLI during propagation increased from 1.2 to 10.7 mol·m^{-2}·d^{-1}.

With the above information, we were able to determine how long it would take to reach a certain root or shoot biomass and time to flower under a range of propagation DLIs (Tables 2 and 3, page 12) with air temperatures of 75 to 77°F (24 to 25°C). For petunia Tiny Tunia 'Violet Ice' cuttings, we determined that a fully rooted or "pullable" plug occurs when the cutting has >35 roots, and root and shoot dry mass is >10 mg and >65 mg, respectively. New Guinea impatiens 'Harmony White' are considered pullable plugs when they have a root and shoot dry mass >30 mg and >150 mg, respectively.

From Tables 2 and 3 we can then predict that petunia Tiny Tunia 'Violet Ice' cuttings propagated under a DLI of 6 to 8 mol·m^{-2}·d^{-1} will be fully rooted into the plug tray within 12 days (highlighted in green) compared to a cutting rooted under a DLI of 2 to 4 mol·m^{-2}·d^{-1}, which would take more than 16 days. We can also predict that those cuttings propagated under an average DLI ≥6 mol·m^{-2}·d^{-1} will flower 10 to 15 days earlier if forced at 68°F (20°C) than those propagated under very low light levels (Figure 2). It is important to note that we tested three cultivars each of petunia and New Guinea impatiens and other cultivars may respond differently to DLI. In addition, cuttings were not exposed to storage or shipping conditions and all other environmental parameters during propagation (temperature, misting, nutrition, and humidity) were controlled. During forcing, rooted transplants were not provided with growth regulators or pinching.

Too often, growers use excessive shading during propagation. These results show the value of controlling DLI during propagation to obtain rapid, uniform rooting and the production of high quality (compact) rooted transplants that flower earlier, especially when rooting cuttings during the darkest periods of the year. Table 1 provides an example of the maximum light intensities during our propagation experiment with shade percentage and the month during which the experiments were performed. Growers can now

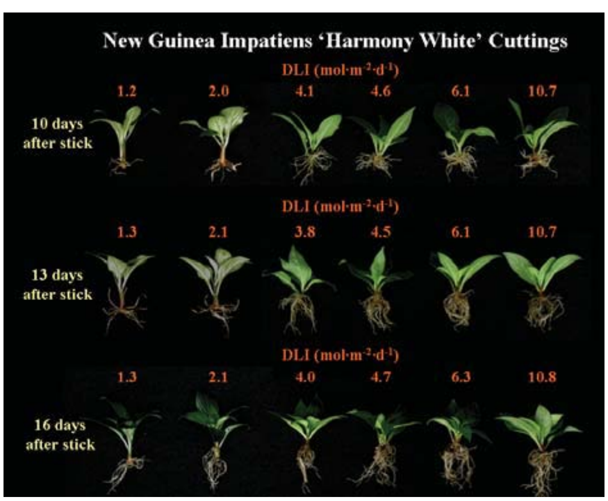

Figure 1. *Effect of propagation daily light integral (DLI) on rooting of New Guinea impatiens 'Harmony White' cuttings 10, 13, and 16 days after stick.*

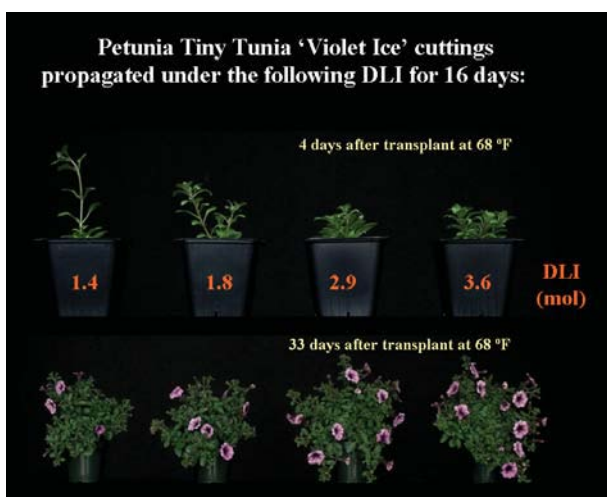

Figure 2. *Effect of propagation daily light integral (DLI) on subsequent flowering of petunia Tiny Tunia 'Violet Ice" cuttings.*

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Table 2. Predicted root and shoot dry mass and time to flower for petunia Tiny Tunia 'Violet Ice' cuttings propagated for 8, 12, or 16 days under daily light integrals (DLI) of 2 to 8 $mol \cdot m^{-2} \cdot d^{-1}$. These predictions are based on propagation air temperatures of 75 to 77°F (24 to 25°C) and forcing temperatures of 68°F (20°C). Highlighted cells represent a fully rooted cutting.

	Dry root mass (mg)			Dry shoot mass (mg)			
DLI ($mol \cdot m^{-2} \cdot d^{-1}$)	8 days	12 days	16 days	8 days	12 days	16 days	Days to flower from stick
2	1.7	2.4	4.2	37	43	53	47
4	4.2	6.7	9.7	44	56	70	41
6	6.1	10.4	14.0	50	65	81	36
8	7.4	13.7	16.9	54	72	86	32

Table 3. Predicted root and shoot dry mass and time to flower for New Guinea impatiens 'Harmony White' cuttings propagated for 10, 13, or 16 days under daily light integrals (DLI) of 2 to 8 $mol \cdot m^{-2} \cdot d^{-1}$. These predictions are based on propagation air temperatures of 75 to 77°F (24 to 25°C) and forcing temperatures of 68°F (20°C). Highlighted cells represent a fully rooted cutting.

	Dry root mass (mg)			Dry shoot mass (mg)			
DLI ($mol \cdot m^{-2} \cdot d^{-1}$)	10 days	13 days	16 days	10 days	13 days	16 days	Days to flower from stick
2	6.5	10.1	13.7	116	116	124	83
3	9.7	16.8	21.8	122	130	142	79
4	12.1	22.8	29.9	129	141	157	76
5	13.9	27.9	38.0	137	151	171	71
6	15.1	32.2	46.1	145	157	181	69

easily measure DLI in their greenhouses without converting between units with a data recording meter such as the one sold by Spectrum Technologies.

Summary

Propagation requires the proper balance between light (DLI), air and medium temperature, misting, humidity, and air circulation. Insects, pathogens, and nutrition should also be managed for rapid rooting. The propagation environment at Michigan State University as described above has been highly successful for the propagation of annuals, perennials, and tropicals, with high and rapid rooting percentages.

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Roberto Lopez
Michigan State University
A288 Plant and Soil Science Building
East Lansing, MI 48824
517-355-5191
Fax: 517-353-0890
lopezro4@msu.edu

Erik Runkle
Michigan State University
A288 Plant and Soil Science Building
East Lansing, MI 48824
517 355-5191
Fax: 517-353-0890
runkleer@msu.edu

Jim Faust
Clemson University
E-143 P&A Bldg
Clemson, SC 29634
864 656-4966
Fax: 864-656-4960
jfaust@clemson.edu

John Dole
North Carolina State University
Campus Box 7609
Raleigh, NC 27695
919 515-3537
Fax: 919-515-7747
john_dole@ncsu.edu