Managing Light During Propagation

Michigan State University research examines how environmental factors — especially light — influence the rooting and growth of vegetative annual cuttings.

By Roberto Lopez and Erik Runkle

Michigan State University propagation house. Using woven shade curtains, four different light levels were created to determine the effects of light quantity on rooting of petunia and New Guinea impatiens cultivars. (Photos courtesy of Erik Runkle)

Over the past nine years we have seen a 300-percent increase in the number of cuttings imported into the United States. In 2003, greenhouse growers in the United States imported more than 724 million unrooted cuttings (URCs) of annuals and perennials with a reported wholesale value of $53 million. Growers have little influence on the stock plant management techniques and the methods employed to harvest, store and ship these cuttings, but they can improve how they propagate URCs to reduce rooting time and consequently increase profitability. In this article, we discuss how environmental factors can be adjusted to create a successful propagation environment for vegetative annual cuttings, with a focus on light intensity and daily light integral (DLI) during propagation.

Ideal Propagation Environment

An ideal rooting environment for vegetative propagation is one that maintains hydrated cuttings, minimizes stress, prevents disease and promotes rapid root formation to support a growing and transpiring cutting. Most vegetative annual URCs can be fully rooted within 2-3 weeks if proper environmental conditions are maintained. The critical environmental factors to manage during rooting are:

- Controlling light intensity.
- Providing adequate mist.
- Maintaining high relative humidity.

Figure 1. Maximum and average light intensities (umol·m-2·s-1) during 16 days of propagation for one replication of the petunia rooting experiment in August 2004.

DLI (mol·m^{-2}·d^{-1})	Maximum light intensity umol·m^{-2}·s^{-1} (foot-candles)	Average light intensity umol·m^{-2}·s^{-1} (foot-candles)
1.6	74 (370)	37 (185)
2.8	173 (865)	63 (315)
5.4	411 (2,055)	122 (610)
8.4	749 (3,745)	190 (950)

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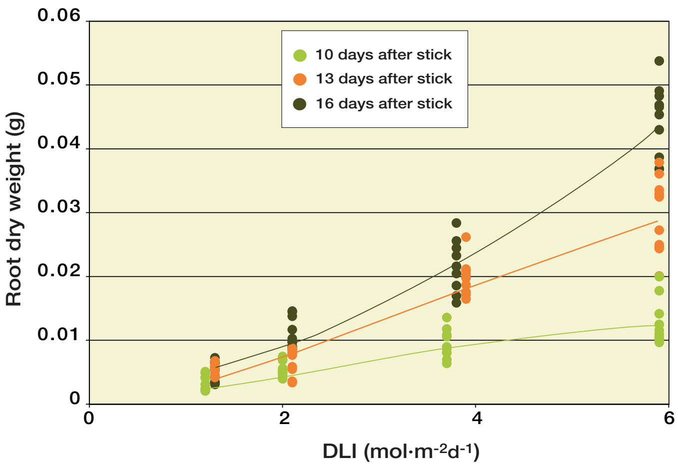
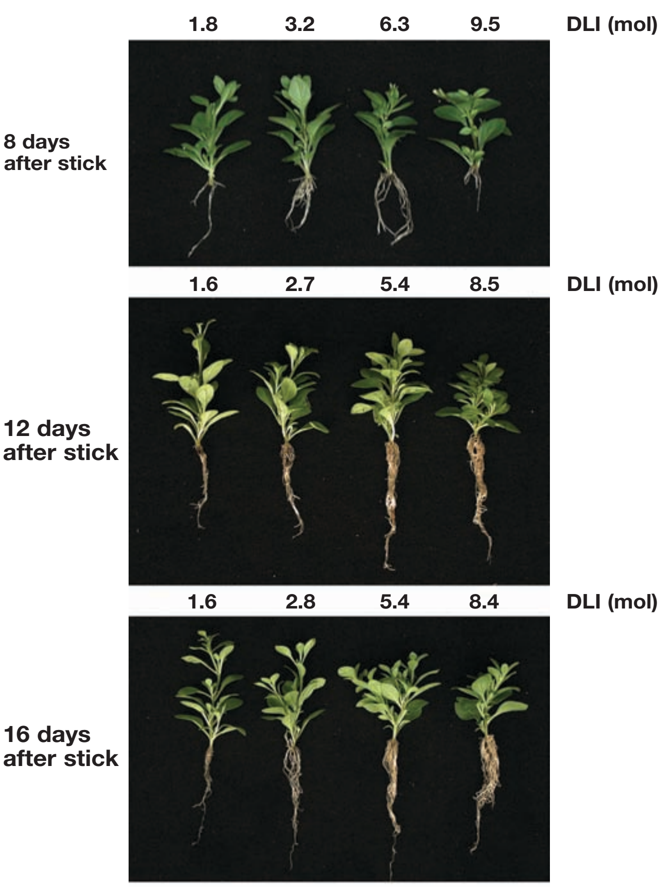
Figure 2. Root dry weight of New Guinea impatiens 'Harmony White' cuttings increased as the daily light integral (DLI) during rooting increased. Dots represent individual plants, and the solid lines represent the average increase in root growth under each DLI.





Effect of daily light integral (DLI) on rooting of petunia 'Tiny Tunia Violet Ice' cuttings.

- Maintaining desirable air and media temperatures.
- Limiting the air flow around leaves.

These five factors are all essential for rapid rooting and preventing cuttings from drying out. Efforts should be made to root cuttings with the least amount of mist possible to minimize disease, leaching of nutrients and water-logged media.

Growers often find that it is difficult to keep these conditions in balance because of external environmental factors. Consequently, on warm and sunny days growers may opt to heavily shade their propagation houses, increase misting frequency and duration, and vent more often, leading to a stressful environment for the URCs. Let's now discuss how to properly manage and keep environmental parameters in balance to ensure rapid and uniform rooting.

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 root initiation and development. Light intensities below this minimum result in little or no root development, leading to a delayed crop or rooting failure. Conversely, too much light can bleach leaves and reduce root formation due to excessive stress on the cuttings.

Photoperiod. Ideally, URCs are vegetative and lack flower buds. This can require photoperiodic management of stock plants or Florel (ethephon, Monterey Chemical) applications by the cutting producer. If cuttings are harvested from reproductive stock plants, flower development will occur during propagation, possibly delaying root formation. Also, premature flowering on cuttings will impact the timing and growth potential for those plants following transplant.

Photoperiod is often not controlled during the propagation of vegetative annual or perennial URCs. In certain annual plants, flowering is promoted by certain photoperiods (i.e., long days for petunia and argyranthemum) and should be managed to prevent premature flower induction during propagation or finishing. We recommend a photoperiod of 12-13 hours for the propagation of most annuals, especially for long-day plants such as petunia.

Light Intensity. Desirable levels of light vary, depending primarily on the stage of root development. The following is a guideline for managing light intensity for high-light crops.

Stage 1: Stick to callus formation. During the early stages of propagation maximum recommended light intensity is between 120 and 200 umol·m^{-2}·s^{-1} (600-1,000 foot-candles) to provide enough energy for callus formation and root initiation without causing desiccation. In addition, light transmission through the propagation house should be indirect or diffuse. White wash or exterior shade in combination with retractable shade curtains can provide a good system for light modulation, especially in the spring and summer. 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.

Stage 2: After root initiation. Once roots have initiated (generally 5-12 days after stick), maximum light intensity can be increased to 200-400 umol·m^{-2}·s^{-1} (1,000-2,000 foot-candles). Again, the light should be diffused.

Stage 3: After roots fill half the plug. Once roots fill about half of the plug cell (generally 10-16 days after stick), maximum light levels can be increased to 500-800 umol·m^{-2}·s^{-1} (2,500-4,000 foot-candles). This higher intensity helps acclimate plants to the post-propagation environment.

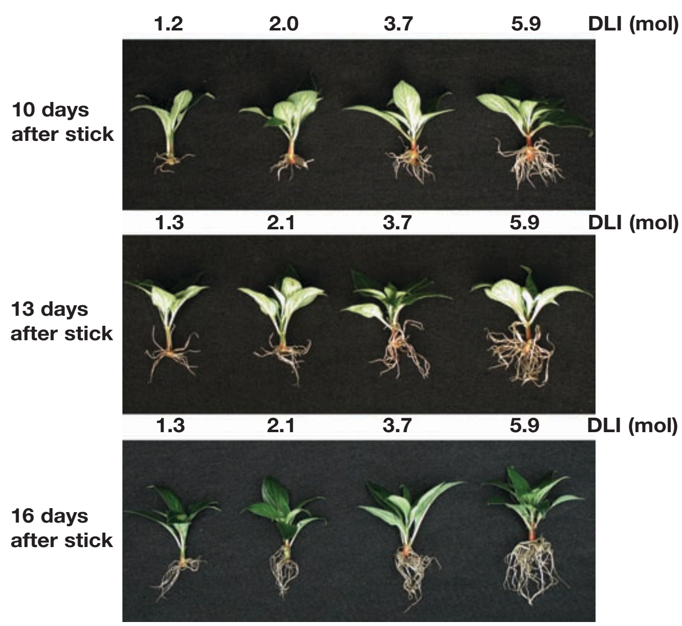
Daily light integral (DLI). DLI is defined as the quantity of light received each day as a function of light intensity (instantaneous light: umol·m^{-2}·s^{-1}) and duration (day). It is expressed as the amount of light per square meter in one day (mol·m^{-2}·d^{-1}). The amount of light that a cutting receives per day during propagation can have a profound impact on the quality of the rooted cutting in terms of root formation, stem elongation and shoot growth.

We quantified the effects of DLI on rooting and growth 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.

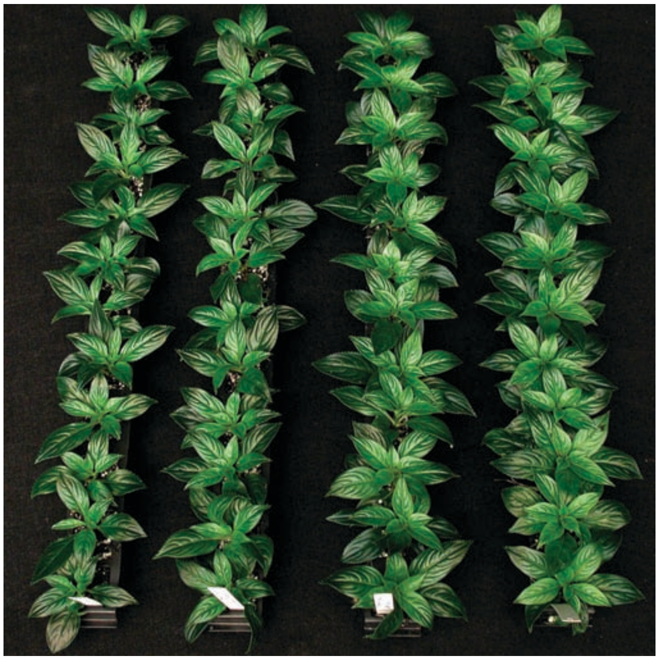
In our experiments, uniform cuttings were harvested from vegetative stock plants grown at Michigan State University. URCs stuck in 72-cell liners were propagated under four different woven shade curtains to obtain four different DLI environments, ranging from 1.2 to 8.4 mol·m^{-2}·d^{-1}. All cuttings were rooted in a glass greenhouse with overhead mist, and steam or fog was injected as necessary to maintain a vapor pressure deficit of 0.3 kPa (89 percent relative humidity). Air temperature was maintained at 79º F and media temperature was maintained at 75º F. A 12-hour photoperiod was created using a 9-hour day (using black cloth) extended with light from soft-white fluorescent lamps. Petunia cuttings were evaluated from each DLI environment after eight, 12 or 16 days and New Guinea impatiens cuttings were evaluated 10, 13 or 16 days after stick.

Responses to DLI differed among petunia and New Guinea impatiens cultivars. However, in both species, rooting and quality of cuttings increased when the DLI under which they were propagated increased. For example, as the DLI during propagation increased from

Effect of daily light integral (DLI) on shoot development of petunia 'Tiny Tunia Violet Ice' 16 days after stick. The average DLI during rooting (from top to bottom) was 1.2, 1.9, 3.4 and 3.9 mol·m^{-2}·d^{-1}.



Effect of daily light integral (DLI) on rooting of New Guinea impatiens 'Harmony White' cuttings.



Effect of daily light integral (DLI) on shoot development of New Guinea impatiens 'Harmony White' 16 days after stick. The average DLI during rooting (from left to right) was 1.3, 2.1, 3.7 and 5.7 mol·m^{-2}·d^{-1}.

1.2 to 3.9 mol·m^{-2}·d^{-1} root number of petunia 'Tiny Tunia Violet Ice' increased from 17 to 36 when measured 16 days after stick. Root and shoot mass of cuttings harvested after 16 days of propagation increased by 467 and 67 percent, respectively, as the DLI increased from 1.6 to 8.4 mol·m^{-2}·d^{-1}. In addition, cutting shoot length decreased from 2.5 to 1.6 inches, as the average DLI increased from 1.2 to 3.9 mol·m^{-2}·d^{-1}.

In New Guinea impatiens 'Harmony White' root and shoot growth of cuttings increased by 760 and 84 percent, respectively, as the DLI increased from 1.3 to 5.9 mol·m^{-2}·d^{-1}.

Too often, we see 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 rooted transplants. Figure 1 provides an example of the average and maximum light intensities during our propagation experiment with petunia.

Temperature and Humidity

As we have seen, light intensity plays an important role in rooting and growth of cuttings. Air temperature and especially medium temperature are also important because temperature controls the rate of callus and root development. A desirable medium temperature for many species is 73-77º F, which usually requires bench heating. Air temperature should be maintained between 68 and 73º F when bottom heat is utilized. However, if bottom heat is not available, air temperature should be increased to 77-80º F so that medium temperature is adequately high. Maintaining air temperature lower than medium temperature retards shoot growth and promotes root development.

We recommend maintaining the relative humidity in a propagation house at a minimum of 85 percent. This can be done with steam or fog delivered by either high pressure or a fan-driven water atomizer. If environmental conditions are ideal (i.e., warm medium temperature, humid still air and adequate DLI) requirements for misting should be minimal and frequency can be low. The following is a good rule of thumb to follow: Mist should be applied often enough to prevent URCs from wilting and long enough so water evenly coats the leaf surface but does not drip off.

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 and few plant losses. GPN

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