Daily Light Integral Influences Rooting and Quality of Petunia Cuttings

Roberto G. Lopez and Erik S. Runkle
Department of Horticulture, Michigan State University
East Lansing, MI 48824
USA

Keywords: light quantity, plug, propagation

Abstract

Light intensity is often reduced during propagation of nonrooted herbaceous cuttings to minimize temperature and water stress, but the effects of light quantity on rooting and cutting growth have not been quantified for horticulturally important annuals that are vegetatively propagated. Petunia Tiny Tuna ‘Violet Ice’ (Petunia ×hybrida) cuttings were propagated under a daily light integral (DLI) of 1.2 to 3.9 mol·m⁻²·d⁻¹. DLI environments were created using no shade or 30, 55, and 70% woven shade cloth. All cuttings were rooted in a glasshouse with overhead mist, maintained at 25 ºC with a vapor pressure deficit of 0.3 kPa. A 12-h photoperiod was delivered using a 9-h natural day extended with light from soft-white fluorescent lamps. Rooting and growth evaluations of cuttings were made 8, 12 and 16 d after stick. Rooting and quality of cuttings increased when the DLI under which they were propagated increased. For example, after 16 d of propagation an increase in DLI from 1.2 to 3.9 mol·m⁻²·d⁻¹ decreased cutting shoot length from 6.3 to 4.1 cm, increased average root number from 17 to 36, and increased average length of the longest root from 9.4 to 12.9 cm. Root and shoot dry weight of cuttings harvested after 16 d of propagation increased by 452% and 47%, respectively, as the DLI increased. Therefore, the DLI during propagation should be properly managed to reduce rooting time and produce high quality rooted transplants.

INTRODUCTION

From 1994 to 2004, the wholesale value of nonrooted cuttings imported by U.S. greenhouse growers increased by 315% (USDA, 2005). In 2004, greenhouse growers in the U.S. imported over 766 million nonrooted cuttings of annuals and perennials with a reported wholesale value of US$55 million. Greenhouse growers have little influence on the stockplant management techniques and the methods employed to harvest, store, and ship these cuttings, but improvements can be made in how nonrooted cuttings are propagated to reduce rooting time, increase rooting quality, and consequently increase profitability. Clearly, to obtain high-quality rooted transplants in the shortest possible time, cuttings must root quickly, uniformly, and abundantly.

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 growth and development, leading to a delayed crop or rooting failure. Costa and Challa (2002) show that root growth is only affected by current photosynthesis and not by reserves formed previously in leaves. Conversely, too much light can inhibit root formation due to excessive water and temperature stress on the cuttings, and can bleach leaves (Lovell et al., 1972; Joeright et al., 2001; Enfield, 2002). The effects of daily light integral (DLI) or light intensity during propagation of cuttings on rooting percentage, root number and mass, stem elongation and mass, and shoot growth has been studied in several herbaceous and woody species, including Acer palmatum (Behrens, 1988), Gypsophila paniculata (Islam and Willumsen, 2001), Hibiscus sp. (Kachecheba, 1976), petunia cuttings (Cabaleiro and Economou, 1992), Phlox paniculata (Enfield, 2002), Quercus sp. (Zaczek et al., 1999) and Rhododendron (Davis and Potter, 1987). Our objectives were to quantify the effects of DLI on rooting and shoot growth of the popular petunia Tiny Tuna ‘Violet Ice’. Here, we present preliminary results after one replication.
MATERIALS AND METHODS

Stock Plant Management
Petunia Tiny Tuna ‘Violet Ice’ stock plants were maintained in the Plant Science Research Glasshouses at Michigan State University, East Lansing, Mich. (42 °N lat.) at 20 ± 2 °C under a 12-h photoperiod and an average DLI of 11.3 mol·m⁻²·d⁻¹. The photoperiod consisted of a 9-h day completed by day-extension lighting (≈2 µmol·m⁻²·s⁻¹ at canopy level) from incandescent lamps. Opaque black cloth was pulled at 1700 HR and opened at 0800 HR everyday. From 0800 to 1700 HR, high-pressure sodium lamps provided a supplemental photosynthetic photon flux (PPF) of ≈150 µmol·m⁻²·s⁻¹ at plant height [as measured with a light quantum sensor (Apogee Instruments, Inc., Logan, Utah)] when the outdoor PPF was <140 µmol·m⁻²·s⁻¹. Temperature on each bench was measured by a thermocouple in an aspirated chamber every 10 s, and hourly averages were recorded by a CR-10 datalogger (Campbell Scientific, Logan, Utah). Ethephon (Florel®; Rhône-Poulenc Ag Company) was applied at a rate of 150 mg·L⁻¹ every four weeks to maintain vegetative growth. Stock plants were grown in 15-cm (1.3-L) round containers (Dillen Products, Middlefield, Ohio) filled with a mix containing 70% peat moss, 21% perlite, and 9% vermiculite (Sure-Mix, Michigan Grower Products, Galesburg, Mich.). Plants were irrigated as necessary with reverse osmosis water supplemented with water-soluble fertilizer to provide the following (mg·L⁻¹): 125 N, 12 P, 100 K, 65 Ca, 1.0 Fe and Cu, 0.5 Mn and Zn, 0.3 B, and 0.1 Mo (MSU Special, Greencare Fertilizers, Chicago, Ill.).

Propagation Environment
Uniform 3-cm vegetative petunia cuttings (≈150 cuttings) were harvested from stock on 25 Oct. 2004 at 1000 HR. Cuttings were propagated in 72-cell (30-mL) plug trays (Landmark Plastic Corporation, Akron, Ohio) in a 50% commercial peat (Sure-Mix; Michigan Grower Products, Galesburg, Mich.) and 50% screened coarse perlite (Therm-O-Rock, East, Inc., New Eagle, Pa.) mix.

Cuttings were rooted in a glasshouse with medium and air temperatures of 25 ± 2 °C under a 12-h photoperiod. The 12-h photoperiod consisted of a 9-h natural day extended with light from soft-white fluorescent lamps (≈3 µmol·m⁻²·s⁻¹ at canopy level) as described above. Medium temperature was measured using 40-gauge type E thermocouples (TT-E-40; Omega Engineering Inc., Stamford, Conn.). Overhead misting was controlled by an environmental computer as a function of time and accumulated PPF. The overhead mist contained reverse osmosis water and water-soluble fertilizer to provide the following (mg·L⁻¹): 50 N, 8 P, 42 K, 22 Ca, 1.0 Fe and Cu, 0.5 Mn and Zn, 0.3 B, and 0.1 Mo (MSU Special). DLI environments were created using no shade or permanent woven shade cloth that reduced light by ~30, 55, and 70% (OLS 30, 50 and 70; Ludvig Svensson, Charlotte, N.C.) over individual propagation compartments. Line quantum sensors containing 10 photodiodes (Apogee Instruments) were placed directly above the cuttings under each of the four lighting compartments to measure the PPF. Thermocouples and line sensors were connected to a CR10 data logger (Campbell Scientific, Logan, Utah), and data were recorded every 10 s. The average DLI under each environment after 8, 12 and 16 d of propagation was 1.2, 1.9, 3.4 and 3.9 mol·m⁻²·d⁻¹, respectively.

Data Collection and Analysis
Ten cuttings per DLI treatment were harvested 8, 12, or 16 d after the start of propagation. The number of roots, length of the longest root, shoot length (from the media level to the shoot apex), total root and shoot dry mass were recorded at harvest. Linear regression analysis on treatment means was performed using PROC REG procedures in SAS version 8.0 (SAS Institute, Cary, N.C.). The average DLI from the beginning of propagation to data collection on day 8, 12 and 16 were used in regression analysis. Regression analysis was performed using all observations, not treatment means.
RESULTS

The number of roots that developed, the length of the longest root, and root and shoot dry mass accumulation increased linearly with DLI after 8, 12, and 16 d of propagation (Fig. 1 A-C and E). The numbers of roots formed after 8 and 16 d of propagation increased from 12 to 34 and 17 to 36 as average DLI increased from 1.2 to 4.3 and 1.2 to 3.9 mol·m^{-2}·d^{-1}, respectively. The average length of the longest root increased from 9.4 to 12.9 cm as DLI increased during the 16 d of propagation. The height of cuttings was significantly greater when propagated under an average DLI of 1.2 mol·m^{-2}·d^{-1} compared to a higher DLI (Fig 1D). For example, after 16 d of propagation, average cutting shoot height increased from 4.1 to 6.3 cm as DLI decreased from 3.9 to 1.2 mol·m^{-2}·d^{-1}. Root and shoot dry weight of cuttings harvested after 16 d of propagation increased by 452% and 47%, respectively, with increasing DLI. Following 16 d of propagation, root and shoot dry mass increased by 3.3 and 6.0 mg per cutting for every one mol·m^{-2}·d^{-1} increase in DLI (from 1 to 4 mol·m^{-2}·d^{-1}).

DISCUSSION

As propagation DLI increased from 1.2 to 3.9 mol·m^{-2}·d^{-1}, root number and length, and root and shoot dry mass increased, while shoot length decreased in petunia Tiny Tuna ‘Violet Ice’. Cabaliero and Economou (1992) found very similar results when petunia cuttings were grown in vitro under a DLI of 1 to 3 mol·m^{-2}·d^{-1}. Rooting increased linearly, and the number of roots, the length, the fresh weight, and the branching of the roots also increased with increasing DLI. In Phlox paniculata as DLI increased from 1.6 to 8.6 mol·m^{-2}·d^{-1}, rooting percentage, root number, and root fresh mass increased (Enfield, 2002). Rooting in Phlox was inhibited under a DLI ≤1.2 mol·m^{-2}·d^{-1} and decreased when DLI was >8.6 mol·m^{-2}·d^{-1}.

Collectively, these studies indicate that maintaining light quantity above a minimum (~2 mol·m^{-2}·d^{-1}) during propagation is critical for rapid and prolific rooting of herbaceous cuttings such as petunia and Phlox. Light is the driving energy source for photosynthesis (assimilates) and carbohydrate accumulation needed for root initiation and development. A maximum light intensity and DLI threshold also exist, where root initiation and development can be inhibited when light is excessive, as reported in Phlox. Similarly, when microcuttings of Rhododendron sp. were grown in vitro under a DLI of 0.6, 1.7 or 4.3 mol·m^{-2}·d^{-1}, shoot and root length and quality ratings were reduced at the highest DLI (Economou and Read, 1986). In this study, we did not provide a DLI that inhibited root initiation.

Rooting time can be significantly reduced if DLI is properly managed during the three critical stages of rooting: callus formation, root initiation, and root development into the medium. For example, cuttings took 12 d to form 23 roots under a DLI of 1.7 mol·m^{-2}·d^{-1}, but only took 8 d to reach that number under a DLI of 3.4 mol·m^{-2}·d^{-1}. Shoot biomass is equally as important, since plant size or biomass can affect the propagation timing and subsequent performance of the rooted transplant. For example, cuttings accumulated ~50 mg in 16 d under a DLI of 1.2 mol·m^{-2}·d^{-1}, but reached that mass in only 12 d under a DLI of 3.6 mol·m^{-2}·d^{-1}. In addition, maintaining an average DLI above 2 mol·m^{-2}·d^{-1} inhibited elongation of the developing shoot. Therefore, growers that provide excessive shading and thus a low DLI (<3 mol·m^{-2}·d^{-1}) during propagation can experience long propagation times and produce rooted cuttings that are of inferior quality compared to plants grown under higher light levels.

CONCLUSIONS

Some greenhouse growers use excessive shading during propagation in an effort to keep their cuttings hydrated, and minimize stress and desiccation. Petunia cuttings propagated under a DLI of <3 mol·m^{-2}·d^{-1} were elongated and generally of poor quality compared to those grown under a higher average DLI. These results show the value of controlling DLI during propagation especially in winter months to obtain rapid, uniform rooting and the production of high quality, compact rooted transplants.
ACKNOWLEDGMENTS

We gratefully acknowledge Jill Card, Mike Olrich, and Laura Shaver for greenhouse assistance, the support of the Floriculture Industry Research and Scholarship Trust (FIRST), growers providing support for Michigan State University floriculture research, and support from the Michigan Agricultural Experiment Station.

Literature Cited


Fig. 1. Number of roots formed, length of the longest root, root dry mass accumulation, shoot height, and shoot dry mass accumulation measured after 8 d (black circles), 12 d (gray triangles) and 16 d of propagation (open squares) for petunia Tiny Tunia ‘Violet Ice’ cuttings as a function of daily light integral. Error bars represent standard errors of the mean. *, **, ***Significant at $P \leq 0.05$, 0.01 or 0.001, respectively.