Influence of Light and Heated Medium on Rooting and Shoot Growth of Two Foliage Plant Species

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Abstract. ***Ficus benjamina* and *Codiaeum variegatum* 'Gold Dust' stem tip cuttings were rooted in a mist bed at 290 or 90 µmol·s⁻¹·m⁻² Photosynthetic photon flux (PPF) with or without 28° ± 1°C medium heating and then potted. Number of roots in *C. variegatum* was unaffected by either PPF or medium heating; however, both factors enhanced root elongation. Forty days after potting, cuttings rooted under 290 µmol·s⁻¹·m⁻² had more lateral shoots than those rooted under 90 µmol·s⁻¹·m⁻² PPF. Although cuttings rooted in heated medium under the lower PPF had roots more than twice as long as those on cuttings rooted in unheated medium under the high PPF, it had little effect on subsequent shoot growth. *F. benjamina* rooting was improved in heated medium and was not affected by PPF. Unheated cuttings rooted better under high than low PPF. Shoot growth 10 weeks after transplanting was unaffected by the initial differences in root grade.**

Rate of root formation on cuttings is directly affected by medium temperature, with raised temperatures accelerating root initiation and development (4, 5, 9). Increasing carbohydrate supply by increasing light intensity or leaf retention improves rooting (2, 8, 10). Most research on rooting has concentrated on environmental effects on root grade, whereas very little attention has been given to correlate the degree of root growth with subsequent shoot growth. Root growth of *Aphelandra squarrosa* was improved by the addition of dolomite to rooting media, but subsequent plant growth after transplanting into pots was unaffected (1). Supplementary lighting during rooting increased root grade and subsequent growth of chrysanthemum cuttings (6). The cost of heating, however, may not be justified if subsequent plant growth does not increase sufficiently from the enhanced root growth.

This experiment was conducted to determine the effect of medium temperature and light intensity on root formation and its relationship with subsequent shoot growth of two foliage plant species.

Stem tip cuttings of *Ficus benjamina* and *Codiaeum variegatum* 'Gold Dust', 20 and 10 cm in length, respectively, were taken from stock plants grown in pots under 370 µmol·s⁻¹·m⁻² maximum PPF. Cuttings were placed in a mist propagation bed containing a rooting mixture of 1 peatmoss: 1 perlite (v/v) without other amendments. The mist interval was 6 sec every 6 min from 0700 to 1900 HR.

The experimental design was a 2 × 2 factorial arrangement in a randomized complete block design with two light levels and heated and unheated rooting medium. The greenhouse was covered with one layer each of 6-mil polyethylene and 73% polyproplene shade fabric that provided 290 µmol·s⁻¹·m⁻² maximum PPF (high light). An extra layer of 73% shade fabric was placed over sections of the mist bed to supply a maximum PPF of 90 µmol·s⁻¹·m⁻² (low light).

Heating was provided by placing electrical heating pads (Agritape, Ken-Bar, Reeding, Mass.) under the rooting medium. The medium temperature was maintained at 28° ± 1°C by a thermostat. Temperatures in the unheated medium were between 10° and 16°, depending upon the prevailing air and water temperatures. Greenhouse air temperatures during the rooting period were 17° to 28°.

Root grade was evaluated 3 weeks after initiation of treatments. Number of roots and length of longest root on *C. variegatum* were recorded. Root system on *F. benjamina* was very delicate and had numerous secondary roots and extensive root hair. Separating the medium from the root system would break the roots from the stem base. Hence, *F. benjamina* was measured for root ball diameter, which was the average of two measurements made at perpendicular angles, and length of longest root.

Cuttings were planted in 15-cm pots with Sunshine Mix No. 1 (Fisons Western Corporation, Vancouver, B.C., Canada) and grown under 540 µmol·s⁻¹·m⁻² maximum PPF. Plants were watered as needed, and 200 ppm N from a 20N–8.6P–18.6K fertilizer was added with irrigation water once a week. Air temperatures during the growth phase were 17° to 35°C. Due to the different growth patterns of the two species, data taken from *C. variegatum* were initial and final shoot lengths, number of new leaves longer than 2 cm, length of the longest leaf, number of actively growing lateral shoots, and root dry weight at 40 days after transplanting. Width and height were measured on *F. benjamina* after 10 weeks. There were two replicates per treatment with 10 cuttings representing an experimental unit. Analysis of variance was performed on data and LSDs are presented for mean comparisons.

Codiaeum variegatum. Neither PPF nor medium temperature affected number of roots initiated (Table 1). However, PPF and medium heating interacted to affect root elongation. Roots that developed on cuttings in warm medium under high light were six-fold longer than those on cuttings in unheated medium under low light. The former also had much more advanced shoot growth than the latter after 40 days (Table 1). Within each PPF, increased root growth on cuttings improved shoot growth. Heated medium during rooting under either PPF increased number of new leaves, with greater effect under the high PPF (Table 1). Roots on cuttings from the low PPF and warm medium were more than twice the length of roots on cuttings from the high PPF and unheated medium; however, there was no difference in leaf length and stem growth between the two treatments at the time of final evaluation. This lack of difference suggests that shoot growth may not directly relate to improved root growth at transplanting and can be affected by other environmental factors under which cuttings are rooted. Leaves on cuttings rooted under 90 µmol·s⁻¹·m⁻² could have been acclimatized to this low PPF and hence had lower net carbon exchange rates at the high PPF (540 µmol·s⁻¹·m⁻²) (3, 7) during the 40-day period, giving less-than-expected shoot growth. Therefore, one should select carefully a proper light level at which cuttings are to be rooted. Final root dry weight averaged 0.9 g (data not shown) and was unaffected by treatments.

Ficus benjamina. Root ball diameter on cuttings in the heated medium was not affected by PPF and was larger when compared with that in unheated medium (Table 2). However, unheated cuttings under high PPF had larger root systems than those under low PPF. Regardless of the difference in root development at the time of transplanting, plant width and height were similar after 10 weeks of growth (Table 2).

High temperatures associated with increasing sunny days after cuttings were transplanted into pots made the greenhouse environment more favorable for plant growth. Infrequent watering at that time of year caused soil temperature in pots to be higher than that in the unheated propagation bed. *F. benjamina* might have been very responsive to this raised soil temperature so that root growth on unheated cuttings soon equaled that of plants from heated rooting medium, giving full support to shoot growth.

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Table 1. The influence of light intensity (PPF) and medium temperature on root formation and subsequent growth of *Codiaeum variegatum* 'Gold Dust' cuttings.

				40 days after transplanting			
PPF ($\mu mol \cdot s^{-1} \cdot m^{-2}$)	Medium temp (°C)	No. roots	Root length (cm)	No. new leaves[z]	Leaf length[y] (cm)	No. lateral shoots	Stem growth (cm)
290	28	17.0	6.5	6.1	16.0	8.0	6.2
	10–16	17.6	2.0	4.4	12.4	7.8	3.7
90	28	15.8	4.4	5.0	13.0	6.2	4.0
	10–16	16.8	0.9	4.0	10.4	4.9	2.5
LSD (0.05)		NS	0.5	0.5	1.5	1.2	0.9

[z]Longer than 2 cm.
[y]The longest new leaf.
[NS]Not significant.

Table 2. The influence of light intensity (PPF) and medium temperature on root formation and subsequent shoot growth of *Ficus benjamina* cuttings.

				70 days after transplanting	
PPF ($\mu mol \cdot s^{-1} \cdot m^{-2}$)	Medium temp (°C)	Root ball diam (cm)	Root length (cm)	Width[z] (cm)	Height (cm)
290	28	7.4	7.9	60.9	61.9
	10–16	3.4	4.8	59.0	57.9
90	28	7.4	7.4	57.5	57.8
	10–16	1.9	2.9	58.0	62.3
LSD (0.05)		1.1	1.3	NS	NS

[z]The average of two measurements made at perpendicular angles.

Although the thermostat controlling the forced-air heaters was located at bench level, temperature of unheated rooting medium was always <16°C, due to the discharge of cold water from the misting system. Root initiation and subsequent elongation were both restricted at lower temperatures. In addition to promoting root growth, heated medium also promotes the use of photosynthates from the foliage and the production of dry matter (11).

Whether improved root growth on cuttings increases shoot growth is dependent on plant species, as well as on the environmental factors under which cuttings were rooted. Researchers studying factors affecting rooting need to direct their attention to subsequent shoot growth after transplanting of rooted cuttings.

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Effect of Nodal Position, Cutting Length, and Root Retention on the Propagation of Golden Pothos

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Abstract. **Growth was reduced from leaf-bud golden pothos [*Epipremnum aureum* (Linden & Audre) Bunt.] cuttings taken from an apical node with the most recent, fully expanded leaf. Days to first leaf unfolding increased as cuttings were taken more basipetally from the second apical node to node 14. Accelerated growth of the axillary shoot and increases in leaf number, stems length, leaf area, and shoot fresh weight were associated with cuttings from the apical nodes. Shoot growth was accelerated when cuttings had a 3-cm or longer internode below the nodes. Retaining a 6 to 8-mm section of the old aerial root on cuttings promoted axillary shoot growth.**

Golden pothos is among the most important foliage plants produced commercially. Growers cut the long vines into single node, leaf-bud cuttings for propagation. Nonuniform growth of axillary shoots has been observed among cuttings of golden pothos. Basal cuttings in *Schefflera arboricola* and *Hedera helix* develop longer shoots and more roots than apical cuttings (3, 5). Nodal position also may affect shoot growth after rooting in golden pothos.

The length of the internode below the node in golden pothos varies from one cutting to another, depending on the propagator. As

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