Rooting Cuttings in Cupric Hydroxide-treated Pots Affects Root Length and Number of Flowers after Transplanting

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Abstract. Stem tip cuttings of *Evolvulus glomeratus* Nees & Mart., *E. tenuis* Nees & Mart., *Lantana camara* L. 'Dallas Red,' and *L. montevidensis* Briq. 'Alba' were rooted for 6 weeks in 57-mm-diameter (150 ml) square pots. Before rooting, interior surfaces of half of the pots were treated with 100 g Cu(OH)₂/liter, while remaining pots were left untreated. Elongation of adventitious roots stopped when root tips came in contact with a Cu(OH)₂-treated surface. Cupric hydroxide treatment reduced total root length and the length of the longest root for all four species, but did not influence root, shoot, or total plant weight. One month after transplanting to 150-mm-diameter (1.2 liter) hanging baskets, plants moved from Cu(OH)₂-treated pots had more flowers than those transplanted from nontreated pots. Applying Cu(OH)₂ to interior surfaces of pots used for propagation prevented root deformation, reduced root length, and increased flowering following transplanting.

Container-induced root deformation can adversely affect the growth of bedding plants (Arnold et al., 1993; Latimer, 1991) and woody species (Nichols and Alm, 1983; Preisig et al., 1979) following transplanting. Cuttings of perennials rooted in small pots are subject to the same root deformation. Treating interior container surfaces with Cu(OH)₂ eliminated or reduced root deformation in *Coreopsis lanceolata* L. and *Chrysanthemum × superbum* Bergmans ex J. Ingram (Arnold et al., 1993). In this study, we evaluated the effect of Cu(OH)₂-treated containers on shoot and root growth of four perennial species during cutting propagation and on growth and flowering following transplanting to hanging baskets.

Materials and Methods

On 9 May 1992, 140-mm-long, stem-tip cuttings were removed from stock plants of *Evolvulus glomeratus* and *E. tenuis*. Leaves were removed from the basal 45 mm of the stem before inserting the basal ends of the cuttings into ProMix BX media (Premier Brands, Stamford, Conn.) in 57-mm-top-diameter (150 ml) square pots. No rooting

compounds were used. Before being filled with medium, interior surfaces of half the pots were sprayed with a liquid latex-Cu(OH)₂ compound [100 g Cu(OH)₂/liter; ≈4.6% metallic Cu equivalent], formulated as Spin Out (Griffin Corp., Valdosta, Ga.), while the other half was left untreated. Cuttings were rooted under intermittent mist (5 sec every 10 min) in a fiberglass greenhouse providing 420 μmol·m⁻²·s⁻¹ maximum photosynthetic photon flux (PPF), 85% relative humidity, 31/26C (max/min), and natural daylengths (lat. 26.1°N, long. 80.2°W; Fort Lauderdale, Fla.).

On 22 June 1992, seven pots from each species × Cu(OH)₂ treatment combination were harvested to determine stem length and shoot (stems and leaves) and root dry weights (3 days at 70°C). Roots were washed free of medium, and total root length was estimated using a line-intersect method (Tennant, 1975) before roots were dried.

Nonharvested rooted cuttings were transplanted two per pot into ProMix BX medium in 150-mm-top-diameter (1.2 liter) hanging baskets (Lerio Corp., Kissimmee, Fla.), providing seven pots for each species × Cu(OH)₂ treatment combination. Pots were top-dressed with 13 g of Osmocote 13N-5.2P-10K (Grace-Sierra, Milpitas, Calif.). Plants were grown in a screenhouse covered with black saran-type shade cloth providing 780 μmol·m⁻²·s⁻¹ maximum PPF, average air means of 35/27C (max/min), and daily overhead irrigation supplemented with natural rainfall. On 22 July 1992, postpropagation growth was evaluated using stem length, number of branches per stem, shoot width index [(narrowest + widest plant width perpendicular to its vertical axis)/2], shoot size index [(stem length + shoot width index)/2], and number of nonsenescent flowers.

Experimental procedure and evaluation used for *Lantana camara* 'Dallas Red' and *L.*

montevidensis 'Alba' were similar to *Evolvulus* except that cuttings were stuck on 8 May 1992, and pots from each species × Cu(OH)₂ treatment combination were harvested (n = 7) or transplanted into hanging baskets on 22 June 1992.

All data were tested using analysis of variance (SAS Inst., 1989) in a two species × two Cu(OH)₂ factorial treatment arrangement in a completely randomized design (n = 7). Genera were analyzed as separate experiments.

Results and Discussion

Elongation of adventitious roots stopped when root tips came in contact with the Cu(OH)₂-treated container sidewall or bottom surface, preventing the development of a deformed root system. Root tips in contact with the Cu(OH)₂-treated surface were blackened and swollen, with lateral root branching at least 15 mm behind the inhibited root tip. Foliar symptoms of Cu toxicity were absent. These observations are consistent with previous reports of mild Cu toxicity being localized to the area around the root tips of plants grown in Cu-treated containers (Arnold and Struve, 1989; Flanagan and Witte, 1991). Roots growing within nontreated pots continued to grow along the pot-medium interface, forming a mat of roots conforming to the shape of the pot. Roots elongating along the pot-medium interface were susceptible to damage during transplanting.

After a 6-week rooting period, roots of *E. glomeratus* weighed 23% more than those of *E. tenuis* ($P > 0.05$), and roots of *Lantana* species had similar weights (mean of 42.8 mg dry weight per plant). Cupric hydroxide treatment did not influence root, shoot, or total plant weights of *Evolvulus* or *Lantana* species (data not shown). Reported dry weight responses to Cu(OH)₂ treatment have varied among species (Arnold et al., 1993; Beeson and Newton, 1992; Krieg and Witte, 1993).

Although root dry weight differed between species of *Evolvulus*, Cu(OH)₂ treatment did not affect root dry weight of rooted cuttings. However, Cu(OH)₂ treatment did reduce total root length and the length of the longest root for all four species (Table 1). When rooted in nontreated pots, the longest root of *E. tenuis* was longer than that of *E. glomeratus*, but when rooted in Cu(OH)₂-treated pots, *E. tenuis* had shorter roots than *E. glomeratus* (significant interaction for length of longest root). Similar results were found between *L. camara* and *L. montevidensis*, but differences were nonsignificant.

After 1 month, stem length, number of lateral branches per stem, shoot width index, and shoot size index were similar for species within genera or between plants transplanted from Cu(OH)₂-treated pots compared to plants transplanted from nontreated pots (data not shown). However, transplanting from Cu(OH)₂-treated pots increased the number of flowers for all species in this study (Table 1). For example, *E. glomeratus* and *L. montevidensis* had 98% and 160% more flowers, respectively, when transplanted from

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Table 1. Influence of Cu(OH)₂-treated pots used during propagation on root length of *Evolvulus* and *Lantana*, and on the number of flowers 1 month after transplanting from propagation pots into hanging baskets.

Species	Cu(OH) ₂ treatment during propagation	Total root length (m)	Length of longest root (mm)	No. flowers ^z
<i>E. glomeratus</i>	+	0.46	61	26.3
	—	0.55	102	13.3
<i>E. tenuis</i>	+	0.31	54	13.0
	—	0.33	121	8.4
Significance ($P > F$)				
Species		**	*	**
Cu(OH) ₂		*	**	**
Interaction		NS	*	*
<i>L. camara</i>	+	0.31	55	19.7
	—	0.33	119	12.6
<i>L. montevidensis</i>	+	0.51	66	23.7
	—	0.60	109	9.1
Significance ($P > F$)				
Species		**	NS	NS
Cu(OH) ₂		*	**	**
Interaction		NS	NS	**

^zNumber of flowers per pot 1 month after transplanting.NS, *, **Nonsignificant at $P > 0.05$ or significant at $P \leq 0.05$ or 0.01, respectively.

Cu(OH)₂ pots than from nontreated pots. Improved flowering after transplanting from Cu(OH)₂-treated pots was also reported for *Impatiens wallerana* Hook f., but not for *C. ×superbum*, *Pelargonium ×domesticum* L., or *Tagetes patula* L. (Arnold et al., 1993). By increasing the number of flowers on shoots of similar size, transplanting from Cu(OH)₂-treated pots improved the overall appearance of all four species in hanging baskets. *Evolvulus glomeratus* had more flowers than *E. tenuis*, but the two *Lantana* species had a similar number of flowers.

Roots of rooted cuttings elongating along the pot–medium interface in nontreated pots were susceptible to damage during transplanting. While increased potential for injury did not influence vegetative growth after transplanting, plants from nontreated pots had fewer

flowers 1 month after transplanting compared to plants transplanted from Cu(OH)₂-treated pots.

Root length was a sensitive indicator of root growth regulation by Cu(OH)₂ during propagation. While root weight is more easily determined, it is generally accepted that root absorption of water and minerals is more directly related to root length than to root weight. For example, when irrigation was withheld after cuttings had rooted in pots, *E. tenuis* and *L. camara* plants wilted at dawn 1 day sooner than *E. glomeratus* and *L. montevidensis*, respectively. *Evolvulus glomeratus* and *L. montevidensis* had 59% and 77% more total root length compared to *E. tenuis* and *L. camara*, respectively.

Applying Cu(OH)₂ to pots used during propagation prevented root deformation, re-

duced root length, and enhanced flowering following transplanting. The potential of Cu(OH)₂ treatment to increase the number of flowers should be investigated on a wider range of species.

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