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Cutting propagation of foliage crops using a foliar application of auxin

E.K. Blythe[a,*], J.L. Sibley[a], J.M. Ruter[b], K.M. Tilt[a]

[a] *Department of Horticulture, College of Agriculture, Auburn University, 101 Funchess Hall, Auburn, AL 36849, USA*

[b] *Coastal Plain Experiment Station, Department of Horticulture, University of Georgia, Tifton, GA 31793, USA*

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Abstract

Rooting and initial shoot growth was evaluated on stem cuttings of four tropical ornamentals receiving no auxin treatment, a basal quick-dip in auxin (4920 μM IBA + 2685 μM NAA) prior to insertion into the rooting substrate, or a spray-to-drip foliar application of auxin (ranging from 4.9 μM IBA + 2.7 μM NAA to 492 μM IBA + 269 μM NAA) after insertion into the rooting substrate. Terminal cuttings of *Aglaonema modestum* Schott ex Engler treated with the basal quick-dip produced 9.5 roots per cutting and total root length of 386 mm, while untreated cuttings produced 6.1 roots per cutting and total root length of 270 mm; auxin spray treatments gave intermediate results. Two-node cuttings of *Gardenia augusta* (L.) Merrill 'Radicans' (*Gardenia jasminoides* Ellis 'Radicans') treated with the basal quick-dip produced 9.1 roots per cutting and total root length of 311 mm, untreated and sprayed cuttings produced similar or lesser results (as low as 5.2 roots per cutting and total root length of 66 mm for untreated cuttings). Total root length on terminal cuttings of *Ficus benjamina* L. was 332 mm when untreated, 400 mm when treated with a basal quick-dip, and 280–355 mm when sprayed with auxin at rates of 49.2 μM IBA + 26.9 μM NAA or higher; auxin sprays at lower rates produced lesser total root length (189–218 mm) than the basal quick-dip. Medial cuttings of *Hedera helix* L. 'Ivalace' treated with the basal quick-dip produced 8.3 roots per cutting and total root length of 257 mm; untreated cuttings and sprayed cuttings produced similar results. Subsequent shoot or foliage development on cuttings of all species receiving the spray treatments was similar in most cases to cuttings receiving no auxin treatment or a basal quick-dip treatment.

Keywords: Plant growth regulators; Root-promoting chemicals; Spray application; Vegetative propagation; *Aglaonema modestum*; *Ficus benjamina*; *Gardenia augusta* 'Radicans'; *Hedera helix* 'Ivalace'

* Corresponding author. Tel.: +1-334-844-3018; fax: +1-334-844-3131.
E-mail address: blythek@auburn.edu (E.K. Blythe).

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1. Introduction

Cutting propagation is commonly used in the commercial production of ornamental foliage crops. Cuttings of some species root readily without an auxin treatment, while cuttings of other species benefit from auxin treatment through enhanced promotion of rooting; benefits may be dependent upon the species and cultivar, condition of the cutting wood, time of year, and other factors (Griffith, 1998; Hartmann et al., 2002).

Root-promoting chemicals for cutting propagation commonly contain indole-3-butyric acid (IBA), 1-naphthaleneacetic acid (NAA), or a combination of the two, and are available in liquid, talc, tablet, and gel formulations. Liquid formulations are generally sold as solvent-based concentrates that may be diluted to the desired concentration for treating cuttings of specific crops.

As with other agricultural chemicals, governmental regulations generally mandate employee safety training prior to the use of root-promoting chemicals and use of personal protective equipment (chemical-resistant gloves, eye protection, appropriate clothing) during the preparation and use of these chemicals. Process modifications that permit a reduction in the time required to apply the root-promoting chemicals may result not only in cost savings, but also an increase in employees' sense of safety, comfort, and health.

Commercial root-promoting chemicals are normally applied to the basal portion of cuttings using a liquid or talc formulation of auxin. The quick-dip method is often preferred by commercial propagators for application of liquid auxin formulations for reasons of economy, speed, ease, and uniformity of application and results. An extended basal soak may be utilized for some difficult-to-root species (Hartmann et al., 2002). Some unusual methods of auxin application that have been studied, but have not found commercial application, include insertion of auxin-impregnated toothpicks into the base of the cutting, forced entry of auxins into cuttings using a vacuum, and total immersion of cuttings in an auxin solution for varying lengths of time (Blazich, 1988).

A foliar spray application of auxin to cuttings of selected crops is a technique known via anecdotal reports from commercial propagators. The technique has been noted in literature, but detailed research findings have not been presented (Chadwick and Kiplinger, 1938; Hartmann et al., 2002; Kroin, 1992). With application made after cuttings have been inserted into the rooting substrate, the technique has potential for reducing the number of employees who deal with the chemicals in the cutting propagation process.

Foliar application of auxin by means of complete immersion of cuttings in an auxin solution has been reported as effective in comparison to a basal quick-dip treatment in an auxin powder (Van Bragt et al., 1976). Several crops have been rooted effectively when the foliage of the cuttings was dipped into an auxin-containing solution (Anuradha and Sreenivasan, 1993; McGuire, 1967; McGuire and Sorenson, 1966). However, both of these techniques involve application of auxin prior to sticking, and so require subsequent handling of the treated cuttings.

Spray applications of auxins have found wide application in agriculture, including their use as herbicides, as thinning agents on fruit trees, and as agents able to control regrowth of tree sprouts after pruning, induce flowering of bromeliads, and promote fruit set (Fletcher and Kirkwood, 1982). Auxin applied exogenously is known to be translocated basipetally in plant tissue (Skoog, 1938).

McGuire (1967) reported that auxin, when applied to the foliage and terminal buds of *Ilex crenata* 'Convexa' cuttings, was sufficiently absorbed to result in effective increases in rooting, with presence of terminal foliage required to maximize transport to the base of the cuttings. Sun and Bassuk (1993) reported that exogenous application of auxin to cuttings could inhibit budbreak on rose cuttings.

The objective of our trials was to examine the effectiveness of a foliar spray application of the auxins IBA and NAA (in combination) on the rooting and initial growth of cuttings of selected foliage crops.

2. Materials and methods

Cutting propagation material of *Aglaonema modestum* and *Ficus benjamina* was collected from greenhouse container-grown plants and *Gardenia augusta* 'Radicans' and *Hedera helix* 'Ivalace' from established landscape plants on the campus of Auburn University, AL (32°36′N, 85°29′W, USDA Hardiness Zone 8a). Fafard 3B mix (Conrad Fafard, Inc., Agawam, MA, USA), a blend of peat, perlite, vermiculite, and pine bark, was used as the rooting substrate for all cuttings.

Cuttings of *A. modestum* were stuck in T1801 polystyrene pots (364.2 cm^3 soil volume per pot), cuttings of *F. benjamina* were stuck in LE801 polystyrene single-cell packs (777.2 cm^3 soil volume per cell), and cuttings of *G. augusta* 'Radicans' and *H. helix* 'Ivalace' were stuck in LE1201 polystyrene single-cell packs (484.6 cm^3 soil volume per cell), with all packs placed into L1020NCR polystyrene trays (Landmark Plastics, Akron, OH).

Terminal softwood cuttings of *A. modestum* and terminal semi-hardwood cuttings of *F. benjamina* were prepared with three apical leaves and a leaf removed from the basal node. Subterminal semi-hardwood cuttings of *G. augusta* 'Radicans' and *H. helix* 'Ivalace' were prepared with two nodes and leaves removed from the basal node. Cuttings of *A. modestum* were inserted into the rooting substrate with 1 cutting per pot and 10 pots per treatment, while cuttings of the other 3 species were inserted with 8 cuttings per pack and 4 packs per treatment. All cuttings were prepared and stuck on 25 September 2002.

Cuttings in treatment 1 received no auxin treatment. Cuttings in treatment 2 received a basal quick-dip for 1 s in a solution of 4920 μM IBA + 2685 μM NAA (Dip ′N Grow® diluted with water; Dip ′N Grow, Inc., Clackamas, OR, USA) to a depth of 2 cm for *A. modestum* and 0.63 cm for the other three species prior to sticking. Cuttings in all other treatments were sprayed to the drip point using a plastic hand spray bottle with auxin concentrations ranging from 4.9 μM IBA + 2.7 μM NAA to 492.0 μM IBA + 268.5 μM NAA after sticking. Spray solutions also contained 1.0 ml l^{-1} Kinetic organosilicone surfactant (Helena Chemical Company, Memphis, TN). Cuttings were stuck and sprayed in the late afternoon and allowed to dry overnight. All cuttings were placed under a greenhouse mist system at the Paterson Greenhouse Complex at Auburn University, providing overhead mist for 6 s every 16 min during daylight hours for a rooting period of 28 days. Maximum photosynthetically active radiation in the greenhouse was 600 μmol/m^2/s and daily maximum/minimum temperature in the greenhouse was 27 ± 6 °C (80 ± 10F)/18 ± 3 °C (65 ± 5F). After evaluation of rooting, all cuttings were replanted in the same containers, placed back under intermittent mist (for irrigation), and allowed to grow for an additional 76 days

(*A. modestum*, *F. benjamina*, and *H. helix* 'Ivalace') or 153 days (*G. augusta* 'Radicans').

A completely randomized design was utilized in all trials, with cuttings of *F. benjamina*, *H. helix* 'Ivalace', and *G. augusta* 'Radicans' in each pack regarded as subsamples. All cuttings were evaluated for rooting percentage, root number, and total root length. Rooted, replanted cuttings of *A. modestum* were evaluated for number of new leaves produced at the end of their additional growth period. Rooted, replanted cuttings of *F. benjamina*, *H. helix* 'Ivalace', and *G. augusta* 'Radicans' were evaluated for percent of cuttings with shoot growth and total shoot length at the end of their additional growth period. Least squares means were calculated for root number, root length, and shoot length using rooted cuttings only. Regression analysis was used to look for trends in response to the spray treatments. Results were also evaluated with analysis of variance and Dunnett's test to compare spray treatments with the untreated and basal quick-dip treatments. Statistical analyses were performed using the SAS® System, Release 8.2 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. *A. modestum*

Cuttings in all treatments rooted at 100% and all cuttings produced new foliage subsequent to rooting. Cuttings receiving the basal quick-dip treatment produced a mean of 9.5 roots and total root length of 386 mm, untreated cuttings produced 6.1 roots per cutting and total root length of 270 mm, and cuttings receiving the foliar spray treatments produced intermediate results. Mean number of new leaves per cutting was 2.2 for cuttings the basal quick-dip treatment and 1.8 for untreated cuttings; cuttings treated with the foliar spray produced 1.3–1.8 new leaves per cutting. There was no trend in number of roots, root length, or number of new leaves with increasing auxin concentration using the spray treatments.

3.2. *F. benjamina*

Rooting percentage, number of roots, and total root length per rooted cutting for sprayed cuttings was similar to untreated cuttings and similar or less than for cuttings in the spray treatments (Table 1). Shoot development on sprayed cuttings was similar to untreated cuttings and basally dipped cuttings.

3.3. *G. augusta* 'Radicans'

Sprayed cuttings exhibited a generally increasing response in rooting percentage, number of roots per cutting, and total root length with increasing auxin concentration (Table 1). Rooting percentages produced by cuttings receiving the basal quick-dip treatment or sprayed with auxin concentrations of 24.6 μM IBA + 13.4 μM NAA and 123.0 μM IBA + 67.1 μM NAA or higher were greater than for untreated cuttings, while rooting percentages in all spray treatments were similar to the basal quick-dip treatment. Number of roots was greater with cuttings receiving the basal quick-dip treatment or the spray treatment with 492.0 μM

Table 1
Root and shoot development on cuttings of *F. benjamina*, *G. augusta* 'Radicans', and *H. helix* 'Ivalace' in response to no auxin treatment and auxins applied as a basal quick-dip and a foliar spray

Application method	IBA + NAA rate (μM)	Rooting (%)	Number of roots per cutting[a]	Total root length per cutting (mm)[a]	Cuttings with shoots (%)	Shoot length per cutting (mm)[a]
F. benjamina						
Untreated	0	90.6	6.3	332	90.2	61.8
Basal quick-dip	4920 + 2685	100.0	7.7	400	90.6	57.0
Foliar spray	4.9 + 2.7	93.8	5.3	218 b	96.9	67.6
	24.6 + 13.4	90.6	4.4 b[b]	189 b	96.4	48.6
	49.2 + 26.9	90.6	5.6	280	96.4	63.8
	123.0 + 67.1	81.3	6.0	330	100.0	71.9
	246.0 + 134.3	96.9	7.6	355	96.9	54.9
	492.0 + 268.5	93.8	4.8 b	296	96.9	79.5
	Significance[c]	NS	Q***	NS	NS	NS
G. augusta 'Radicans'						
Untreated	0	59.4	5.2	66	91.7	41.0
Basal quick-dip	4920 + 2685	93.8 a[d]	9.1 a	311 a	93.8	55.6
Foliar spray	4.9 + 2.7	71.9	5.7 b	104 b	100.0	55.5
	24.6 + 13.4	87.5 a	5.6 b	118 b	92.9	41.4
	49.2 + 26.9	71.9	5.3 b	115 b	96.4	62.5 a
	123.0 + 67.1	90.6 a	6.9	177 ab	100.0	46.3
	246.0 + 134.3	90.6 a	7.8	189 ab	100.0	36.6 b
	492.0 + 268.5	96.9 a	9.3 a	342 a	96.9	38.2 b
	Significance[c]	L**	L***	L***	NS	L**
H. helix 'Ivalace'						
Untreated	0	100.0	9.3	253	100.0	19.9
Basal quick-dip	4920 + 2685	96.9	8.3	257	100.0	16.0
Foliar spray	4.9 + 2.7	100.0	8.2	232	100.0	20.5 b
	24.6 + 13.4	96.9	7.7	223	100.0	15.6
	49.2 + 26.9	96.9	7.0	218	100.0	18.5
	123.0 + 67.1	100.0	7.9	254	100.0	15.7
	246.0 + 134.3	100.0	6.5 a	207	100.0	17.2
	492.0 + 268.5	100.0	8.0	297	100.0	12.7 a
	Significance[c]	NS	Q**	L*Q*	NS	L***

[a] Least squares means calculated using rooted cuttings only.

[b] Means for spray treatments followed by 'b' within a column and species are significantly different than the mean for the basal quick-dip treatment according to Dunnett's test; $P = 0.05$.

[c] Nonsignificant (NS), linear (L), or quadratic (Q) regression response at $P = 0.05$ (*), 0.01 (**), or 0.001 (***) for spray treatments only.

[d] Means followed by 'a' within a column and species are significantly different than the mean for untreated cuttings according to Dunnett's test; $P = 0.05$.

IBA + 268.5 μM NAA compared to the untreated cuttings. Number of roots on cuttings sprayed with auxin concentrations of 123.0 μM IBA + 67.1 μM NAA or higher was similar to the basal quick-dip treatment, while lower auxin concentrations in the spray treatments produced fewer roots than the basal quick-dip treatment. Total root length was greater with cuttings receiving the basal quick-dip treatment or the spray treatment with 123.0 μM IBA + 67.1 μM NAA or higher compared to the untreated cuttings. Total root length on cuttings sprayed with 492.0 μM IBA + 268.5 μM NAA was similar to cuttings receiving the basal quick-dip treatment, but less with lower auxin spray concentrations.

Sprayed cuttings showed no trend in percent of cuttings with shoots and a generally decreasing response in shoot length per cutting with increasing auxin concentration (Table 1). Shoot length on cuttings sprayed with the two highest concentrations of auxin was similar to untreated cuttings and less than cuttings treated with a basal quick-dip; however, after an additional month of growth, shoot development among these treatments was visually similar.

3.4. *H. helix* 'Ivalace'

Rooting percentages were similarly high among all treatments (Table 1). With one exception, number of roots in the spray treatments were similar to untreated cuttings and cuttings receiving a basal quick-dip. Total root length was similar in all treatments.

All rooted cuttings produced shoot growth. Sprayed cuttings exhibited a decreasing linear trend in shoot length with increasing auxin concentration. Shoot length on cuttings sprayed with the lowest concentration of auxin was higher than for cuttings receiving the basal quick-dip treatment, and similar for other spray treatments. Shoot length on cuttings sprayed with the highest concentration of auxin was less than for untreated cuttings, but similar for other spray treatments.

4. Discussion

Overall results with *A. modestum* suggest that the basal quick-dip is of benefit for rooting cuttings of this species, while the two spray treatments with the highest auxin concentration may improve rooting over untreated cuttings. However, a larger scale trial would be required to confirm this.

A basal quick-dip may provide some improvement in rooting of *F. benjamina* compared to untreated cuttings, but the improvement may be small. Spray applications of auxin do not appear to be of benefit for this species.

The best overall rooting on cuttings of *G. augusta* 'Radicans' was obtained using a foliar spray of 123.0 μM IBA + 67.1 μM NAA or greater or using a basal quick-dip in comparison to untreated cuttings. The positive rooting response of gardenia cuttings to a foliar application of auxin is consistent with the findings of Anuradha and Sreenivasan (1993) with cuttings of *Coffea arabica* L., another member of the Rubiaceae.

Results indicate that an auxin treatment may be unnecessary for *H. helix* 'Ivalace'. However, a similar trial (results not presented) using cuttings from the common landscape form of *H. helix* showed a foliar spray of auxin to improve rooting over untreated cuttings and cuttings treated with a basal quick-dip, suggesting that benefits from a spray treatment may vary by cultivar and by condition of the material used for propagation.

5. Conclusion

Results from this trial and similar trials with cuttings of landscape ornamentals indicates that some crops respond as well to a foliar application of auxin as to a basal quick-dip, while the standard basal quick-dip or no auxin treatment continue to be preferable with many other species. Blythe et al. (2003) reported that cuttings of *Chrysanthemum pacificum* Nakai sprayed with IBA + NAA or K-IBA alone showed generally similar root development measures compared to a basal quick-dip. Cuttings of *Forsythia* × *intermedia* Zab. '*Lynwood Gold*' typically did not differ in root development under the two application methods, but a basal quick-dip appeared to inhibit initial budbreak on the rooted cuttings. A basal quick-dip was generally preferable to a foliar spray for cuttings of *Abelia* × *grandiflora* (André) Rehd., *Hydrangea paniculata* Sieb., and *Lagerstroemia* (*indica* × *fauriei*) 'Natchez'.

Use of foliar applications of auxin has been recommended for selected crops such as chrysanthemum, begonia, *Dieffenbachia*, heath, and hibiscus (Kroin, 1992). However, applicability to a wide range of crops has yet to be established. Examination of the variability in absorption and translocation of foliar-applied auxin to the site of root initiation may merit further study.

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