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Evaluation of Surfactants for Use in One-Time Foliar Auxin Applications in the Propagation of Woody Ornamentals

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Summary

Use of foliar applications are increasing in the nursery and greenhouse industries. However, previous research has shown that insufficient auxin is being absorbed or translocated to the site of action. Addition of surfactants to foliar applications of auxin may help with the absorption and translocation of auxin to the site of action. Research was conducted to determine whether addition of surfactants to one-time foliar applications of indole-3-butyric acid (IBA) would be as effective as the current industry standard, the basal quick dip. Terminal cuttings of common camellia (*Camellia japonica*) and Teddy Bear® magnolia (*Magnolia grandiflora* 'Southern Charm') were sprayed to the drip point using Hortus IBA Water Soluble Salts™ at concentrations of 0, 500, 1,000, or 1,500 ppm or dipped for 1-sec in a solution of either 4,000 or 2,500 ppm for camellia or magnolia, respectively. A foliar application of 1,500 ppm after sticking was as effective as the basal quick-dip for cuttings of Teddy Bear®, while other spray treatments were less effective. A basal quick-dip was more effective than a foliar spray for rooting cuttings of camellia.

INTRODUCTION

Research into foliar applications methods over the past decade indicated that one-time applications are the industry standard (Blythe et al., 2007; Kroin, 2014). When applied post-sticking, much lower concentrations (50 to 100 ppm) of rooting hormones are required compared to other conventional application methods (Dole and Gibson, 2006). Overhead applications of water soluble IBA are increasing in the nursery industry. Bailey Nurseries Inc. in Minnesota and Oregon has been conducting repetitive on-farm trialing for the last decade. Their results indicated that many of the taxa commonly propagated respond similarly to foliar-applied auxin compared to a traditional basal quick-dip. At Bailey Nurseries, propagation trays and beds are treated with a single application of water-soluble IBA ranging from 250 to 2,000 ppm (Drahn, 2007). Decker's Nursery in Ohio uses a battery-powered backpack sprayer to treat their cuttings since it atomized the auxin similarly to the mist from the mist system and applied a very small droplet with excellent coverage over both the top and bottom of the cutting (Decker, 2016). Since propagation areas vary in size, overhead applications are applied via a backpack sprayer for small houses and reel-and-hose sprayers for larger production areas.

When being applied overhead, Kroin (2014) of Hortus USA recommends to "spray the solution evenly over the cuttings until drops fall onto the media". To do this, Bailey Nurseries aims to deliver 1 L per 60 ft^2 (roughly 25-30 gal. per 6,000 ft^2). Currently, both Decker's Nursery and Bailey Nurseries generally treat their cuttings within 24-h of being stuck, either at the end of each day or the following morning, but application occurring during the day in conjunction with frequent mist intervals has not reduced efficacy (Drahn, 2007; Decker, 2016). Cuttings are treated in the early morning or late afternoon due to both lower light levels and reduced misting requirements. For both nurseries, the switch to overhead application led to a decrease in handling and the time cuttings spend in cold storage and the preparation room, where problems associated with lengthened exposure to low temperatures, high humidity, and/or handling can occur (Drahn, 2007). In 2003, 99.6% of cuttings at Bailey Nurseries were quick dipped and 0.4% were treated with foliar applications. By 2007, the percentages had reversed, with 95% of all propagated material being treated with overhead applications and 5.2% of material being quick-dipped (Drahn, 2007). Currently, overhead applications of water-soluble IBA are used to treat the following genera at Bailey Nurseries Minnesota operation: *Acer, Berberis, Cornus, Diervilla, Euonymus, Forsythia, Hydrangea, Juniperus, Lonicera, Philadelphus, Physocarpus, Rhus, Rosa, Spiraea, Symphoricarpos, Syringa, Thuja, Viburnum,* and *Weigela*. (Drahn, 2007).

Surfactants are common in agricultural production as penetration of the leaf cuticle is required for efficacy of foliar-applied compounds (Robertson and Kirkwood, 1969). Effectiveness of foliar-applied compounds depends on its ability to penetrate through the cuticle and translocate to the site of action (White et al., 2002). Surfactants enhance penetration of these chemicals by increasing the wetting capacity up to the critical micelle concentration (CMC), defined as the concentration above which any added surfactant molecules appear with high probability as micellar aggregates (Ruckenstein and Nagarajan, 1975; Lownds et al., 1987). Research was conducted by Lownds et al. (1987) to determine the effects surfactants would have on foliar penetration of NAA and NAA-induced ethylene production by cowpea [*Vigna unguiculata (*L.) Walp. subsp. *unguiculata* cv. Dixielee]. This research indicated that foliar penetration of NAA was increased when co-applied with a surfactant (Pace, Regulaid, or Tween 20) and all three induced similar qualitative changes in surface tension, contact angle, and droplet: leaf interaction. All three surfactants increased the droplet: leaf ratio. However, Regulaid was the only surfactant tested that showed a correlation between NAA penetration and interface area (Lownds et al., 1987). The objective of this research was to evaluate whether addition of surfactants to foliar auxin solutions increased root growth and uniformity compared to the industry-standard basal quick dip for common camellia (*Camellia japonica*) and Teddy Bear® magnolia (*Magnolia grandiflora* 'Southern Charm').

MATERIALS AND METHODS

Camellia

An experiment was performed to evaluate the effect of four foliar auxin concentrations [0, 500, 1,000, and 1,500 ppm IBA indole-3-butyric acid (IBA) (Hortus IBA Water Soluble Salts™; Phytotronics Inc., Earth City, MO)] each at two concentrations (0 and 0.85 ppm Regulaid®) on rooting of common camellia. Additionally, a basal quick-dip of 4,000 ppm IBA was used as an industry control. The experiment was a completely randomized design, consisting of an augmented factorial (4 auxin rates × 2 surfactant concentrations, plus the industry quick-dip control of 4000 ppm IBA). There were 15 cuttings per treatment, n=15.

Five-inch (12.7-cm), five-node terminal cuttings of *Camellia japonica* were harvested from established landscape plants and stuck to a depth of 0.5 inch (1.3 cm) on 18 August 2020. During cutting preparation, a one-inch (2.54 cm) wound was applied to one side of the basal end of cutting. The propagation medium was 100% pine bark placed into 3.5 inch (8.3 cm) square production pots (T.O. Plastics, Inc., Clearwater, MN). Cuttings receiving foliar applications of auxin were sprayed once to runoff with a 1-gal battery operated sprayer (One World Technologies, Inc., Anderson, SC). The pine bark propagation media was sourced from Eakes' Nursery Supply (Seminary, MS) and delivered as a mix of 50% aged and 50% fresh bark passed through a 3/8-inch (0.95 cm) screen. After treatment, cuttings were placed under intermittent mist applied for 6 sec/10 min during daylight hours and adjusted as needed for the studies duration.

The data was collected after 80 days included rooting percentage, shoot height, total root number, average root length (three longest roots), and root quality (1-5, with 1=no roots and 5= ≥ 10 roots). Additionally, net photosynthetic rate (A) and stomatal conductance (gs_w) values were sampled from five cuttings per treatment, for a total of 45 cuttings, between the hours of 7:30 A.M. and 11:30 A.M. using a LiCOR 6800 Portable Photosynthesis System (LI-COR Biosciences; Lincoln, NE). Data were analysed using linear mixed models and generalized linear mixed models with the GLIMMIX procedure of SAS (ver. 9.4; SAS Institute Inc., Cary, N.C.).

Teddy Bear® Magnolia

A similar experiment was done with Teddy Bear® magnolia which included four foliar auxin concentrations [0, 500, 1,000, and 1,500 ppm IBA indole-3-butyric acid (IBA) treated with two concentrations (0 or 0.85 ppm Regulaid®)]. However, the industry standard control was a quick-dip of 2500 ppm IBA. The experiment was also a completely randomized design, consisting of an augmented factorial (4 auxin rates × 2 surfactant concentrations, plus the industry quick-dip control of 2500 ppm IBA). There were 15 cuttings per treatment, n=15

Five-inch (12.7-cm), five-node terminal cuttings of *Magnolia grandiflora* 'Southern Charm' were harvested from established landscape plants and stuck to a depth of 0.5 inch (1.3 cm) on 14 April 2021. During cutting preparation, one-inch (2.54 cm.) wounds were applied to opposite sides of the basal end of the cutting. The propagation medium was 100% pine bark placed into 4.5 inch (12 cm) square production pots (T.O. Plastics, Inc., Clearwater, MN). Data collected after 125 days included rooting percentage, shoot height, total root number, average root length (three longest roots), and root quality (1-5, with 1=no roots and 5= ≥ 10 roots).

RESULTS

Camellia

Rooting percentage of camellia ranged from 23% to 50%, but surfactant nor auxin rate impacted rooting percentage (Table 1). Additionally, use of surfactant nor auxin rate had no effect on shoot height, or stomatal conductance (Table 1).

Table 1: Influence of surfactant and auxin rate on roots and shoots of a common camellia (*Camellia japonica*).

	Rooting (%)	Roots (no.)	Avg. length of three longest roots (cm)	Shoot height (cm)	Root quality rating[z]	Net photosynthesis ($\mu mol \cdot m^{-2} \cdot s^{-1}$)	Stomatal conductance ($mol \cdot m^{-2} \cdot s^{-1}$)
Surfactant:							
No surfactant	33	0.4b[y]	0.6b	0.3a	1.6b	2.3a	0.02a
Regulaid	50	1.4a	2.6a	0.2a	2.2a	1.4b	0.02a
Auxin Rate:							
0 ppm IBA	33	0.7bc	1.1a	0.3a	1.9a	2.0a	0.02a
500 ppm IBA	26	0.8b	0.4a	0.4a	2.0a	1.7a	0.02a
1,000 ppm IBA	23	0.5c	2.2a	0.2a	1.6a	1.7a	0.03a
1,500 ppm IBA	23	0.8bc	1.9a	0.4a	1.8a	1.9a	0.02a
4,000 ppm IBA	40	1.6a	2.5a	-	2.4a	1.8a	0.01a
Significance:							
Surfactant (S)	NS[x]	**	**	NS	**	**	NS
Auxin rate (A)	NS	**	NS	NS	NS	NS	NS
S × A	NS	NS	NS	NS	NS	NS	NS

[z]Root Quality (1-5, with 1 = no roots and 5 = ≥ 10 roots)
[y]Means within a column followed by the same letter were not different at α = 0.10 or 0.05.
[x] Significant at the $P \leq 0.10$ (*) or 0.05 (**) level according to the Holm's Simulated Method.
NS= Not significant

Both surfactant and auxin had an effect on root number. Cuttings that were treated with 0.85 ppm Regulaid® had more roots compared to cuttings that received no surfactant (Table 1). Cuttings that were treated with 4,000 pm IBA as a quick-dip had more roots compared to cuttings that were treated with foliar applications of 0, 500, 1,000, or 1,5000 ppm IBA. The use of 0.85 ppm Regulaid® resulted in greater root lengths, greater root quality values, and lower net photosynthesis compared to cuttings not treated with surfactant at treatment initiation (Table 1).

Teddy Bear® Magnolia

Rooting percentage of Teddy Bear® magnolia ranged from 33% to 73% but neither surfactant nor auxin rate impacted rooting percentage (Table 2). Neither use of surfactant nor auxin rate had no effect on the average length of the three longest roots, net photosynthesis, or stomatal conductance values (Table 2). Treating cuttings with a foliar application of 1,500 ppm IBA or a 2,500 ppm IBA quick-dip - had more roots compared to cuttings that received a foliar auxin application of 0, 500, or 1,000 ppm IBA (Table 2).

Table 2: Influence of surfactant and auxin rate on roots and shoots of Teddy Bear® Southern magnolia (*Magnolia grandiflora* 'Southern Charm').

	Rooting (%)	Roots (no.)	Avg. length of three longest roots (cm)	Shoot height (cm)	Root quality rating[z]	Net photosynthesis ($\mu mol \cdot m^{-2} \cdot s^{-1}$)	Stomatal conductance ($mol \cdot m^{-2} \cdot s^{-1}$)
Surfactant:							
No surfactant	33	0.9a[y]	7.9a	0.6b	2.2b	6.3a	0.1a
Regulaid	73	1.2a	7.2a	1.3a	2.5a	6.3a	0.1a
Auxin Rate:							
0 ppm IBA	33	0.6b	6.4a	0.3b	1.8b	5.0a	0.1a
500 ppm IBA	33	0.3b	7.8a	0.5b	1.7b	5.9a	0.1a
1,000 ppm IBA	60	0.9b	9.1a	0.5b	2.1b	5.9a	0.1a
1,500 ppm IBA	53	1.6a	8.4a	1.2ab	2.8a	7.1a	0.1a
4,000 ppm IBA	60	1.8a	5.9a	2.4a	3.3a	7.5a	0.1a
Significance:							
Surfactant (S)	NS[x]	NS	NS	**	*	NS	NS
Auxin rate (A)	NS	**	NS	**	**	NS	NS
S × A	NS	NS	NS	NS	NS	NS	NS

[z]Root Quality (1-5, with 1 = no roots and 5 = ≥ 10 roots)
[y]Means within a column followed by the same letter were not different at $\alpha = 0.10$ or 0.05.
[x]Significant at the $P \leq 0.1$ (*) or 0.05 (**) level according to the Holm's Simulated Method.
NS= Not significant

Use of surfactant and auxin rate were found to be significant for shoot height and root quality (Table 2). Use of 0.85 ppm Regulaid® resulted in greater shoot heights and root quality ratings than cuttings not receiving surfactant at treatment initiation. For shoot height, cuttings treated with a 2,500 ppm basal quick-dip resulted in a greater shoot length than cuttings treated with 0, 500 ppm, or 1,000 ppm IBA. Root quality rating for cuttings receiving foliar applications of 1,500 ppm or 2,500 pm IBA basal quick-dip were greater than cuttings treated with 0, 500 ppm, or 1,000 ppm IBA (Table 2).

DISCUSSION

Our results with *Camellia japonica* suggest that basal quick-dip is the preferred method for rooting cuttings of this species since other measured parameters were similar regardless of auxin treatment. However, if foliar applications of auxin are used, Regulaid™ improved most results. Therefore, regardless of the use of surfactant, one-time foliar applications are not sufficient to improve rooting responses compared to the commercial standard basal quick-dip. Our results are similar to the propagation parameters for camellia (Dirr and Heuser, 2006; Dirr, 2009). Previous research into the propagation of camellia that auxin rates between 3,000 and 5,000 ppm stimulate adventitious rooting of camellia (Dirr and Heuser, 2006; Dirr, 2009).

The best rooting parameters for *M. grandiflora* 'Southern Charm' were obtained using a foliar spray of 1,500 ppm IBA or using a 2,500 ppm basal quick-dip compared to foliar applications of lower concentrations or untreated controls. One-time foliar applications of auxin appear to be of benefit for this species.

Our results from this trial and similar trials into foliar applications of auxin suggest that benefits of foliar applications are species dependent (Blythe et al., 2004). Our results suggest that sufficient auxin was absorbed from foliar applications and translocated to the site of root initiation so that root response is comparable to a basal quick-dip for Teddy Bear® magnolia but not for common camellia. By using a foliar application of 1,500 ppm IBA on a crop of Teddy Bear® magnolia, growers can eliminate the use of a basal quick-dip for propagation of this plant but using a foliar application of auxin on common camellias could result in up to 17% fewer rooted cuttings. With current methods, including quick-dips, propagators handle cuttings multiple times before flats enter the propagation house – resulting in higher labor costs for the producer. For crops where foliar auxin applications yield equal or better results compared to traditional quick-dips, propagators only need to handle the cutting once while a licensed applicator can treat cuttings using a backpack sprayer. In this manner, growers can increase profits by reducing labor costs. One grower reported a savings of \$0.038/ft^2 (Drahn, 2007). In an industry where every penny affects the year-end profit, switching to foliar applications for 'Southern Charm' magnolia could potentially reduce labor costs and increase profits.

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