Evaluation of an Alternative Method of Rooting Hormone Application in Cutting Propagation[1]©

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Trials were conducted to determine whether a foliar spray application of the auxins indole-3-butyric acid (IBA) and 1-naphthaleneacetic acid (NAA) as a dilution of Dip 'N Grow® rooting hormone would be as effective as a basal quick-dip application, which is the standard industry practice for rooting cuttings. Terminal cuttings of *Ajania pacifica* (syn. *Chrysanthemum pacificum* and *Dendranthema pacificum*), two-node cuttings of *Forsythia* ×*intermedia* 'Lynwood', and single-node cuttings of *Rosa* 'Red Cascade' were dipped for 1 sec in a solution of 1000 ppm IBA + 500 ppm NAA or sprayed to the drip point with IBA + NAA concentrations of 0 + 0, 0.5 + 0.25, 1.0 + 0.5, 2.5 + 1.25, 5.0 + 2.5, 10.0 + 5.0, or 50.0 + 25.0 ppm, respectively. A foliar spray application of 50 ppm IBA + 25 ppm NAA after sticking was as effective as the basal quick-dip for cuttings of *A. pacifica*, while other spray treatments were less effective. Cuttings of *Forsythia* rooted well using a basal quick-dip, however subsequent shoot development from the rooted cuttings was generally better with foliar spray treatments. A basal quick-dip was more effective than a foliar spray for rooting cuttings of *Rosa* 'Red Cascade'.

INTRODUCTION

For many years, the use of auxins as rooting hormones in cutting propagation has focused on their application to stem cuttings as a basal quick-dip (using liquid or powder formulations) or an extended basal soak (using liquid formulations). Current worker protection standards require that each employee involved in the use of such chemicals receive specific safety training and wear required safety equipment. In the case of rooting hormones this includes protective gloves, eyewear, and appropriate clothing. Employees often note that the equipment is uncomfortable, and may also be concerned about their exposure to the chemicals. If an alternative means of auxin application were available that could reduce the number of nursery employees who must handle the chemicals or reduce the amount of time that each employee must work with the chemicals, nursery safety could be enhanced. Foliar spray applications of auxins for rooting stem cuttings may be one alternative.

Scientific literature contains limited mention of spray applications of auxin for rooting stem cuttings. Kroin (1992) reported that certain cuttings could be rooted using foliar spray treatment with auxin, but provided no data from research studies. Chadwick and Kiplinger (1938) noted that *Chrysanthemum* cuttings rooted better with a 24-h basal dip than with a foliar spray using low concentrations of auxin. Cuttings of several woody species with terminal bud and foliage dipped

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into an auxin solution rooted as well as cuttings receiving a basal dip (McGuire and Sorensen, 1966). Anuradha and Sreenivasan (1993) reported that cuttings of coffee plants rooted better using an auxin foliar dip compared to a basal dip. Van Bragt et al. (1976) determined that cuttings of various woody species rooted better when immersed in a solution of auxin for 2 min compared to a basal dip in an auxin powder. McGuire (1967) found that sufficient auxin applied through a terminal dip entered the foliage and terminal bud of *Ilex crenata* 'Convexa' cuttings, resulting in increased rooting.

The objective of this research was to determine whether a foliar spray application of the auxins indole-3-butyric acid (IBA) and 1-naphthaleneacetic acid (NAA) supplied as dilutions of Dip 'N Grow® rooting hormone (Dip 'N Grow, Inc., Clackamas, Oregon) would be as effective as a basal quick-dip (standard industry application practice) for rooting stem cuttings of *Ajania pacifica* (syn. *Chrysanthemum pacificum*), *Forsythia ×intermedia* 'Lynwood', and *Rosa* 'Red Cascade'.

MATERIALS AND METHODS

Ajania pacifica material was collected from landscape stock plants and prepared as 2.5 cm (1 inch) terminal cuttings. *Forsythia* material was collected from landscape plants and prepared with two nodes, a 5-cm (2-inch) stem, entire leaves on the upper node, and leaves removed from the lower node. Rose material was collected from greenhouse-grown stock plants and prepared as 2 cm (0.75 in) single-node cuttings. All cuttings were stuck into Fafard 3B mix (Conrad Fafard, Inc., Agawam, MA), a blend of peat, perlite, vermiculite, and pine bark, in T1204 polystyrene four-cell packs placed in L1020NCR polystyrene trays (Landmark Plastics, Akron, Ohio) with two or three cuttings per cell. All trials were initiated in June 2001.

Cuttings in the control treatment were basally quick-dipped for 1-sec in a solution of 1000 ppm IBA + 500 ppm NAA. Cuttings in all other treatments were sprayed to the drip point using a plastic hand spray bottle with IBA + NAA concentrations of 0 + 0, 0.5 + 0.25, 1.0 + 0.5, 2.5 + 1.25, 5.0 + 2.5, 10.0 + 5.0, or 50.0 + 25.0 ppm, respectively. Cuttings were stuck and sprayed in the late afternoon and allowed to dry overnight. *Ajania pacifica* and *Forsythia* cuttings were placed under a greenhouse mist system providing overhead mist for 6 sec every 16 min during daylight hours for a rooting period of 18 and 26 days, respectively. *Rosa* cuttings were placed inside a high-humidity enclosure within a greenhouse with overhead mist provided for 10 sec once per day for a rooting period of 23 days. Rooted *Forsythia* cuttings were replanted into Fafard 3B mix in L1020NCR polystyrene trays with one row of plants per treatment and one set of replicates per tray, placed back under intermittent mist, and allowed to grow for an additional 80 days.

A completely randomized design was utilized with four replicates (packs) per treatment and eight cuttings of *Ajania* and *Forsythia* and ten cuttings of *Rosa* per replicate. All cuttings were evaluated for rooting percentage, number of roots, and total root length. *Rosa* and *Forsythia* cuttings were evaluated for percent of cuttings with shoot growth and shoot length at the end of the rooting period. *Forsythia* cuttings received a second evaluation for percent of cuttings with shoot growth and shoot length after the additional 80-day period. Regression analysis was used to examine relationships between auxin concentration in the spray treatments and the development of roots and shoots. Dunnett's Test (one-tailed) was used to compare spray treatments with the basal quick-dip treatment.

RESULTS

Rooting percentage in response to a foliar application of auxin on the *Ajania* cuttings did not vary by auxin concentration, while the number of roots and the total root length per rooted cutting showed an increasing trend with increasing auxin concentration (Table 1). Rooting percentages for cuttings sprayed with auxins at all concentrations greater than 0 were similar to cuttings receiving a basal quick-dip. The number of roots per rooted cutting was the same for cuttings sprayed with 50 ppm IBA + 25 ppm NAA as for cuttings treated with the basal quick-dip, but was lower for all other spray treatments. Total root length per rooted cutting was similar to the basal quick-dip for spray treatments of 2.5 ppm IBA + 1.25 ppm NAA and above.

Rooting percentage did not vary by auxin concentration in response to a foliar application of auxin on the *Forsythia* cuttings, while the number of roots and the total root length per rooted cutting exhibited an increasing trend with increasing auxin concentration (Table 2). Rooting percentages with the spray treatments were similar to the basal quick-dip. Number of roots per rooted cutting for spray applications of auxin at 0 + 0 and 5.0 + 2.5 ppm IBA + NAA was lower than for cuttings receiving a basal quick-dip, but were similar for all other spray treatments. Total root length per rooted cutting for spray applications of auxin at 0 + 0, 1.0 + 0.5, 2.5 + 1.25, and 5.0 + 2.5 ppm IBA + NAA was lower than for cuttings receiving a basal quick-dip, but was similar for all other spray treatments.

In addition, the percent of rooted cuttings showing new shoot development in response to a foliar spray of auxin on the *Forsythia* cuttings did not tend to vary with auxin concentration when evaluated 26 days after sticking (DAS), but showed a decreasing trend with increasing auxin concentration when evaluated 106 DAS (Table 2). Shoot length per rooted cutting did not exhibit a trend with increasing auxin concentration at either evaluation date. The percent of cuttings with new shoot development was greater for cuttings sprayed with 5.0 + 2.5 and 10 + 5 ppm IBA + NAA in comparison to the basal quick-dip when evaluated 26 DAS, and was greater for all spray treatments except 50 ppm IBA + 25 ppm NAA when evaluated 106 DAS. Shoot length for cuttings sprayed with all concentrations of auxin was similar to those receiving a basal quick-dip when evaluated 26 DAS, but was greater for cuttings sprayed with 0.5 + 0.25 and 1.0 + 0.5 ppm IBA + NAA when evaluated 106 DAS.

Response to a foliar application of auxin on the rose cuttings showed a decreasing trend in rooting percentage with increasing auxin concentration, no trend in the number of roots and the total root length per rooted cutting with increasing auxin concentration, and a decreasing trend in percent of cuttings with shoots and shoot length per rooted cutting with increasing auxin concentration (Table 3). Rooting percentages for rose cuttings sprayed with 50 ppm IBA + 25 ppm NAA were lower than for cuttings receiving a basal quick-dip, but was similar for other concentrations. Number of roots and shoot length per rooted cutting was lower for cuttings in all treatments compared with the basal quick-dip. Percent of cuttings with shoots and shoot length were lower for cuttings sprayed with 50 ppm IBA + 25 ppm NAA than for cuttings treated with the basal quick-dip, but were similar for other concentrations.

Table 1. Root development with cuttings of *Ajania pacifica* in response to IBA + NAA (Dip 'N Grow®) applied as a foliar spray and a basal quick-dip.

Auxin treatment (ppm)	Rooting (%)	Roots[x] (no.)	Total root length[x] (mm)
0 IBA + 0 NAA spray	78.1 * [y]	12.7 *	730 *
0.5 IBA + 0.25 NAA spray	93.8	14.8 *	788 *
1.0 IBA + 0.5 NAA spray	96.9	13.5 *	755 *
2.5 IBA + 1.25 NAA spray	90.6	15.6 *	814
5.0 IBA + 2.5 NAA spray	93.8	15.1 *	819
10.0 IBA + 5.0 NAA spray	93.8	15.6 *	845
50.0 IBA + 25.0 NAA spray	90.7	21.7	1054
1000 IBA + 500 NAA basal basal quick-dip	100.0	23.3	1060
Trend of foliar spray response[z]	None	Increasing	Increasing

[z]Trend in response of cuttings to increasing concentration of auxin applied as a foliar spray as indicated by linear regression analysis; $\alpha = 0.05$).
[y]Means followed by * within a column are significantly less than the mean for the basal dip treatment according to Dunnett's Test (lower-tailed test), $\alpha = 0.05$).
[x]Least squares means calculated using rooted cuttings only.

Table 2. Root and shoot development with cuttings of *Forsythia ×intermedia* 'Lynwood' in response to IBA + NAA (Dip 'N Grow®) applied as a foliar spray and a basal quick-dip.

Auxin treatment (ppm)	Rooting (%)	Roots [y] (no.)	Total root length (mm)[y]	Cuttings with shoots (%) 26 DAS[w]	Shoot length (mm) 26 DAS[y]	Cuttings with shoots (%) 106 DAS	Shoot length (mm) 106 DAS[y]
0 IBA + 0 NAA spray	100.0	15.6 * [x]	595 *	12.5	19.2	75.0 ξξ	127
0.5 IBA + 0.25 NAA spray	100.0	19.2	820	9.4	10.0	59.4 ξξ	155 ξ
1.0 IBA + 0.5 NAA spray	96.9	16.3	615 *	6.3	10.0	71.9 ξξ	152 ξ
2.5 IBA + 1.25 NAA spray	100.0	17.9	768 *	12.5	16.7	53.1 ξξ	135
5.0 IBA + 2.5 NAA spray	100.0	15.9 *	748 *	18.8 ξ [v]	20.0	71.9 ξξ	126
10.0 IBA + 5.0 NAA spray	100.0	17.0	805	18.8 ξ	30.8	56.3 ξξ	135
50.0 IBA + 25.0 NAA spray	100.0	20.3	1037	3.1	10.0	28.1	135
1000 IBA + 500 NAA basal quick-dip	100.0	21.1	1065	0	0	9.4	88
Trend of foliar spray response[z]	none	increasing	increasing	none	none	decreasing	none

[z]Trend in response of cuttings to increasing concentration of auxin applied as a foliar spray as indicated by linear regression analysis; $\alpha = 0.05$).

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

[x]Means followed by * within a column are significantly less than the mean for the basal dip treatment according to Dunnett's Test (lower-tailed test); $\alpha = 0.05$.

[w]DAS: days after sticking.

[v]Means followed by ξξ and ξ within a column are significantly greater than the mean for the basal dip treatment according to Dunnett's Test (upper-tailed test); $\alpha = 0.05$ and 0.10, respectively.

Table 3. Root and shoot development with cuttings of *Rosa* 'Red Cascade' in response to IBA + NAA (Dip 'N Grow®) applied as a foliar spray and a basal quick-dip.

Auxin treatment (ppm)	Rooting (%)	Roots[x] (no.)	Total root length (mm)[x]	Cuttings with shoots (%)	Shoot length (mm)[x]
0 IBA + 0 NAA spray	95.0	4.1 *	116 *	95.0	15.6
0.5 IBA + 0.25 NAA spray	100.0	4.1 *	139 *	92.5	23.2
1.0 IBA + 0.5 NAA spray	97.5	4.1 *	132 *	92.5	21.9
2.5 IBA + 1.25 NAA spray	100.0	4.3 *	139 *	100.0	18.5
5.0 IBA + 2.5 NAA spray	100.0	4.0 *	143 *	97.5	22.7
10.0 IBA + 5.0 NAA spray	92.5	4.2 *	141 *	85.0	17.0
50.0 IBA + 25.0 NAA spray	62.5 * [y]	4.5 *	139 *	17.0 *	3.0 *
1000 IBA + 500 NAA basal basal quick-dip	100.0	5.6	238	95.0	23.7
Trend of foliar spray response [z]	decreasing	none	none	decreasing	decreasing

[z]Trend in response of cuttings to increasing concentration of auxin applied as a foliar spray as indicated by linear regression analysis; $\alpha = 0.05$).

[y]Means followed by * within a column are significantly less than the mean for the basal dip treatment according to Dunnett's Test (lower-tailed test), $\alpha = 0.05$).

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

DISCUSSION

Results indicate that a single spray application of 50 ppm IBA + 25 ppm NAA after sticking was as effective as a basal quick-dip in 1000 ppm IBA + 500 ppm NAA prior to sticking for rooting terminal cuttings of *C. pacificum*. Cuttings of *F. ×intermedia* 'Lynwood' tended to root as well using a quick basal dip in comparison to a foliar spray of auxin. However, the basal quick-dip treatment tended to inhibit subsequent shoot development from the rooted cuttings. Basally applied auxin can be more inhibitory to axillary bud growth on cuttings than auxin applied to the shoot apex (Le Fanu, 1936) A basal quick-dip was more effective than a foliar spray for rooting cuttings of *Rosa* 'Red Cascade'.

Some crops, such as *C. pacificum*, may respond well to a foliar spray application at a specific concentration of auxin. Other crops, such as *F. ×intermedia* 'Lynwood', can benefit from the use of a foliar auxin spray through improved shoot development after rooting in comparison to the inhibitory effect of a basal quick-dip. However, *Rosa* 'Red Cascade' and many other cutting crops (unpublished data) respond better to the standard basal dip treatment.

Propagation employees' exposure to chemicals could be reduced if an alternate and economical method of applying auxin to cuttings can be developed that provides results equivalent to the standard basal quick-dip. This study helps to provide a starting point for investigation of methods other than the standard basal dip for applying auxin in cutting propagation.

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