# The rooting response of evergreen and deciduous cuttings to foliar applications of the rooting hormone indole-3-butyric acid©

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***Abstract***

**This study sought to answer the question of whether a foliar application of indole-3-butyric acid (Hortus IBA Water Soluble Salts) could replace a basal treatment of indole-3-butyric acid plus 1-naphthaleneacetic acid (Dip 'n Grow), in the production of evergreen and deciduous rooted cuttings, without a loss of plant quality or rooting percentage. The evergreen cuttings were given three treatments, including a basal quick dip of Dip 'N Grow (IBA/NAA) with concentrations ranging from 1000-7500 ppm, a foliar spray of Hortus IBA Water Soluble Salts (IBA) at half the concentration of the basal quick dip, and a second identical foliar spray one week later. The deciduous cuttings were also given three treatments, including a basal quick dip of Dip 'N Grow (IBA/NAA) with a concentration of 500 ppm, a foliar spray of Hortus IBA Water Soluble Salts (IBA) of 500 ppm, and a control with no hormone treatment. Evergreen rooted cuttings were evaluated half way through, and at the end of the production cycle, while the deciduous rooted cuttings were evaluated only at the end of the production cycle. Both groups of cuttings were evaluated using a quantative 0-5 scale, 0 being necrotic and 5 being fully rooted. Results were compared by using RStudio statistical program, including the one-way ANOVA test and the Tukey HSD test, both at the 0.05 level. Results showed that rooting scores of broad leaved evergreens with a foliar treatment were less than those of the basal quick dip treatment, rooting scores of needle leaved evergreens with a foliar treatment were not significantly different than those of the basal quick dip treatment, while rooting scores of scale leaved evergreens with a foliar treatment were greater than those of the basal quick dip treatment. Most deciduous taxa were not significantly different when comparing foliar and basal quick dip treatments. Both evergreen and deciduous taxa that were significantly improved, or not significantly different when comparing foliar and basal quick dip treatments could be produced by using a foliar treatment without loss of plant quality or rooting percentage.**

## INTRODUCTION

There are multiple methods for applying rooting hormone on cuttings in order to encourage root growth. One method is a basal quick dip, which involves dipping the stem of the cutting into concentrated hormone for a few seconds and then sticking into media. Another method is spraying rooting hormone onto the leaves of the cutting to the point of dripping after they are stuck into media and placed in a controlled environment (Kroin, 2011). The basal quick dip method is the standard practice at Spring Meadow Nursery, in Grand Haven, Michigan.

Spring Meadow Nursery recently purchased four ISO Group (www.isogroep machinebouw.nl) sticking machine robots (Figure 1). The basal quick dip method of hormone application was used before the cuttings were placed in the machine. This caused the cuttings to stick together and prevented the cameras from recognizing the cuttings, which resulted in decreased productivity. These issues led to trials of foliar applications of rooting hormone on evergreen and deciduous cuttings, after they were stuck in media and placed in the greenhouse. This study was designed to determine whether a foliar treatment

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of auxin can replace the standard basal quick dip treatment, without reducing the quality and percentage of rooted cuttings.

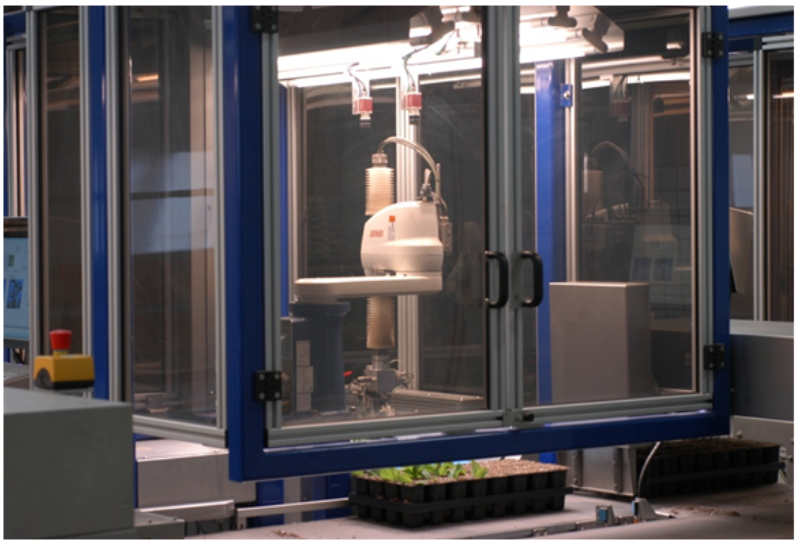

Figure 1. ISO Group sticking machine robot.

## MATERIALS AND METHODS

### Experiment 1: rooting response of evergreen cuttings to foliar or basal applications of IBA

Evergreen cuttings were taken from field-grown stock plants at Spring Meadow Nursery, in Grand Haven, Michigan from mid-October through December of 2016. Seventeen taxa from eight genera were used in the study (Table 1), including *Buxus microphylla* var. *japonica* 'Winter Gem'; *Buxus* 'Green Velvet'; *Cephalotaxus harringtonia* 'Duke Gardens' and 'Fritz Huber'; *Chamaecyparis pisifera* 'Gold Mop' and 'Dow Whiting', Soft Serve® false cypress; *Ilex crenata* 'ANNYS1', Brass Buckle® Japanese holly and 'FarrowSK6', Patti O® Japanese holly; *Ilex glabra* 'Compacta'; *Ilex* × *meserveae* 'Hachfee', Castle Spire® blue holly; *Juniperus horizontalis* Good Vibrations® Gold; *J. squamata* 'Blue Star'; *Microbiota decussate*; *Taxus* × *media* 'Densiformis'; and *Thuja occidentalis* 'Congabe', Fire Chief™ arborvitae; *T. occidentalis* 'Nigra Dark Green' and 'SMTOYB', Polar Gold™ arborvitae. All cuttings measured between 2 and 3 in. and were handled in bundles of 25-50 cuttings, depending on the size of the cutting. Cuttings were stored in plastic containers overnight in a walk-in cooler set at 7.2°C (45°F). Per standard protocol, *Ilex* cuttings were treated with EthylBloc™ ethylene inhibitor in air-tight containers overnight and stuck the next day.

The experiment included three treatment groups: a basal quick dip, a foliar treatment applied once and a foliar treatment applied twice with treatments separated by one week. All foliar treatments were applied at 50% of the concentration of the standard treatment (Blythe et al., 2004). Each treatment group had two 72-cell trays (144 cuttings) per treatment, per evaluation round. Treatment groups were labeled and placed within the commercial production group.

The basal quick dip treatment varied from 1000 ppm to 7500 ppm Dip 'n Grow (indole-3-butyric acid plus 1-naphthaleneacetic acid), depending on taxon, and was based on standard production protocol (Table 1). Bundles were treated using the basal quick dip method (stems were dipped into the hormone for two seconds and directly stuck into the media). The cuttings were stuck into 72-cell trays containing soilless media (50% decomposed pine bark by volume, 50% perlite and 3.5 pounds per cubic yard limestone).

Table 1. List of evergreen taxa, hormone concentration of treatments, and timing of evaluations. The basal quick dip hormone concentration was based on standard protocol at Spring Meadow Nursery. The foliar hormone concentration was half the basal quick dip concentration. Round 1 rooting evaluations took place when the roots of the commercial production cuttings filled the cell half way. Round 2 rooting evaluations took place when the commercial production cuttings were rooted well enough to be transplanted to the finished size. The time was measured in weeks from sticking in order to normalize elapsed time, since the cuttings were stuck in different production weeks, depending on taxon.

| Plant | Hormone (ppm) | | Number of weeks from sticking | |
|---|---|---|---|---|
| | Basal quick dip | Foliar | Evaluation round 1 | Evaluation round 2 |
| *Buxus microphylla* var. *japonica* 'Winter Gem' | 1000 | 500 | 16 | 33 |
| *Buxus* 'Green Velvet' | 1500 | 750 | 16 | 28 |
| *Cephalotaxus harringtonia* 'Duke Gardens' | 5000 | 2500 | 20 | 26 |
| *C. harringtonia* 'Fritz Huber' | 7500 | 3750 | 22 | 27 |
| *Chamaecyparis pisifera* 'Gold Mop' | 3000 | 1500 | 24 | 31 |
| *C. pisifera* Soft Serve® false cypress | 3000 | 1500 | 16 | 22 |
| *Ilex crenata* 'ANNYS1', Brass Buckle® Japanese holly | 1000 | 500 | 11 | 33 |
| *I. crenata* 'FarrowSK6', Patti O® Japanese holly | 1000 | 500 | 14 | 24 |
| *I. glabra* 'Compacta' | 1500 | 750 | 12 | 32 |
| *I.* × *meserveae* 'Hachfee', Castle Spire® blue holly | 1000 | 500 | 8 | 25 |
| *Juniperus horizontalis* 'Hegedus', Good Vibrations® Gold | 3000 | 1500 | 18 | 22 |
| *J. squamata* 'Blue Star' | 5000 | 2500 | 19 | 27 |
| *Microbiota deussata* | 2000 | 1000 | 22 | 32 |
| *Taxus* × *media* 'Densiformis' | 3000 | 1500 | 15 | 28 |
| *Thuja occidentalis* 'Congabe', Fire Chief™ arborvitae | 2000 | 1000 | 11 | 29 |
| *T. occidentalis* 'Nigra Dark Green' | 3000 | 1500 | 22 | 31 |
| *T. occidentalis* 'SMTOYB', Polar Gold™ arborvitae | 3000 | 1500 | 12 | 28 |

The foliar treatment applied once varied from 500-3750 ppm Hortus IBA Water Soluble Salts (20% indole-3-butyric acid) depending on taxon, and 700 ppm Kinetic (polyalkyleneoxide and modified polydimethylsiloxane) as a surfactant (Blythe et al., 2004). The foliar treatment concentration was 50% of the basal quick-dip treatment (Table 1) (Blythe et al., 2004). The cuttings were sprayed by hand, using a 750-mL spray bottle, immediately after being stuck in 72-cell trays and placed in the greenhouse. The media used was the same as the basal quick dip treatment. Each tray was sprayed with about 40 mL of solution in order to reach the point of dripping. This volume was based on the spray rate of 1 gal per 200 sq. ft (Drahn, 2007). The foliar treatment applied twice was the same treatment as described, applied to the same trays one week after sticking (Kroin, 2008).

The cuttings were rooted in a Westbrook greenhouse, with internal dimensions of 72 ft wide, 300 ft long and 14 ft tall. All growing conditions were maintained by Argus Titan version 8.2 systems control software. The air temperature was maintained between 4.4-10°C (40-50°F), while the floor heat was set at 21°C (70°F). Relative humidity levels were maintained between 60 and 100%, using an automated high-pressure fog system. Cuttings were misted periodically with automated travelling booms, set to run on vapor pressure deficit thresholds between 2.85 millibars and 9.5 millibars, depending on the rooting progress of the cuttings. Shade curtains were not used during the time of the study. Some taxa were rooted under supplemental lighting, including *C.* 'Duke Gardens' and 'Fritz Huber', *J. squamata* 'Blue Star', and *T. occidentalis* 'Nigra Dark Green' and 'SMTOYB', Polar Gold™ arborvitae. Supplemental lighting occurred for 12 h between 7:00 a.m. and 7:00 p.m. at 80 µmol $m^{-2}$ $s^{-1}$. All environmental conditions were based on standard production protocol at Spring Meadow Nursery.

Rooting progress of the experimental treatments was evaluated two times: first, when the roots of the commercial production group half-filled the cell and second, when the

commercial production group was rooted well enough to be transplanted into its finished size. The first evaluation took place between 8-24 weeks after sticking (15 Dec. 2016, through 16 May 2017), while the second evaluation took place between 22-33 weeks after sticking (13 April 2017, through 22 June 2017), depending on taxon (Table 1). Rooting progress was evaluated twice, in order to record any differences within a given treatment over time. Cuttings were carefully removed from the cell using a plastic fork, in order to avoid breaking the roots. They were rinsed with water to remove the media, so the quality of the roots could be determined.

Rooting quality was graded on a scale from 0-5, with these descriptions: 0-necrotic stem, 1-live cutting with no response, 2-swelling, breaking or root initials, 3-few small visible roots, 4-developed roots at the base of the stem and 5-developed roots along the length of the stem (Figure 2). This scale was modified from a similar scale by McGuire and Sorensen (1966). Rooting percentage was determined by considering a rooting score of 0-3 as unrooted, while a score of 4-5 as rooted. This delineation represented the quality of rooted cuttings that were potted to the finished size.


Figure 2. Rooting evaluation guideline for all taxa. Each cutting was assigned a rooting score based on the quality of rooting: 0-necrotic stem, 1-live cutting with no response, 2-swelling, breaking or root initials, 3-few small visible roots, 4-developed roots at the base of the stem, 5-developed roots along the length of the stem (*I.* × *meserveae* 'Hachfee', Castle Spire® blue holly basal quick dip, 8 weeks after sticking).

**Experiment 2: rooting response of deciduous cuttings to foliar or basal applications of IBA**

Deciduous cuttings were taken from field-grown stock plants at Spring Meadow Nursery, in Grand Haven, Michigan, from June to August 2017. Four taxa were used in the study, including *Buddleia* 'Miss Molly', *Hydrangea paniculata* 'SMHPFL', Fire Light® panicle hydrangea, *Physocarpus opulifolius* 'SMPOTW', Tiny Wine® ninebark and *Weigela florida* 'Verweig 6', Sonic Bloom® Red weigela. The cuttings were either terminal or two-leaf, depending on taxon, condition of stock plants and standard production protocol. The storage environment was the same as for the evergreen cuttings described in the previous experiment.

This experiment included three treatment groups: a basal quick dip treatment, a foliar treatment applied once at 100% concentration of the standard treatment, and a control with no treatment. Each group had two 32-cell trays (64 cuttings) per treatment. Treatment groups were labeled and placed within the commercial production group.

The basal quick dip treatment hormone was 500 ppm Dip 'n Grow (indole-3-butyric acid plus 1-naphthaleneacetic acid). Bundles were treated using the basal quick dip method as described previously. The cuttings were stuck by hand into 32-cell trays containing

soilless media (30% decomposed pine bark by volume, 35% peat, 35% perlite, 3.5 pounds per cubic yard limestone and 6 pounds per cubic yard 15-9-12 slow release fertilizer).

The foliar treatment hormone was 500 ppm Hortus IBA Water Soluble Salts (20% indole-3-butyric acid) and 700 ppm kinetic (polyalkyleneoxide and modified polydimethylsiloxane) as a surfactant (Blythe et al., 2004). Since there was not a second foliar application in this experiment due to quick rooting times of softwood cuttings, the concentration for the foliar treatment was the same as the basal quick dip treatment (Kroin, 2011). This was applied to the commercial production group and the experimental group at the spray rate of 1 gal per 200 sq. ft (Drahn, 2007). It was applied using a 15 L (4 gal) back-pack sprayer, due to the increased volume needed to cover the large commercial production group. The cuttings were stuck using the ISO Cutting Planter 2500, in the same tray and media as described above. Timing of the application occurred in the morning following sticking, in order to avoid high misting rates from the automated booms in the afternoon (Kroin, 2011).

The control was directly stuck by hand into 32-cell trays and not treated with either a basal quick dip or a foliar application.

The cuttings were rooted in a Westbrook greenhouse as described in the previous experiment. The air temperature was maintained between 18.3-28.9°C (65-84°F), while the floor heat was set at 21°C (70°F). Relative humidity levels ranged between 30-100%, depending on the time of day. The cuttings were not grown in a high-pressure fog house as in the previous experiment, but were misted in the same manner.

Rooting scores were evaluated when the commercial production group was rooted well enough to move out to growing greenhouses. This took place between 3 and 5 weeks after sticking, depending on taxon. Rooting quality was graded in the same manner as described in the previous experiment.

Rooting scores for both experiments were evaluated using the statistical program RStudio, using one-way analysis of variance and Tukey's highly significant difference test, both at the 0.05 level. Variables compared included: taxon, weeks from sticking, treatment, hormone concentration, evaluation round, and leaf type.

## RESULTS

### Experiment 1: Rooting response of evergreen cuttings to foliar or basal applications of IBA

The rooting scores of each taxon were graphed as boxplots, using RStudio statistical software (Figure 3). Statistical differences were determined by using one-way analysis of variance and Tukey's highly significant difference test at the 0.05 level.

In order to simplify comparisons within each taxon, the mean rooting scores were found for each treatment and each evaluation round (basal quick dip Round 1, basal quick dip Round 2, foliar once Round 1, foliar once Round 2, foliar twice Round 1, and foliar twice Round 2). The foliar treatment with the highest mean was compared to the basal quick dip treatment with the highest mean. Based on these comparisons, the taxa were grouped into three categories:

1) The foliar treatment was significantly higher than the basal quick dip treatment.
2) The foliar treatment was not significantly different than the basal quick dip treatment.
3) The foliar treatment was significantly lower than the basal quick dip treatment.

The highest mean rooting scores of each treatment and evaluation round were compared in order to control for notable crop losses in the time between round 1 and round 2, including *J. horizontalis* 'Hegedus', Good Vibrations® Gold and *C. pisifera* 'Gold Mop'.

Three of the taxa, *B.* 'Green Velvet', *C. pisifera* 'Gold Mop' and *C. pisifera* 'Dow Whiting', Soft Serve® false cypress; and *I.* × *meserveae* 'Hachfee', Castle Spire® blue holly, showed that the foliar treatment with the highest mean was significantly lower than the basal quick dip treatment with the highest mean.

The majority of the taxa did not show a statistical difference between the basal quick

dip treatment and the foliar treatment with the highest means, including: *B. microphylla* var. *japonica* 'Winter Gem'; *C. harringtonia* 'Duke Gardens'; *C. pisifera* 'Gold Mop'; *I. crenata* 'FarrowSK6', Patti O® Japanese holly; *I. glabra* 'Compacta'; *M. decussate; T.* × *media* 'Densiformis'; *T. occidentalis* 'Congabe', Fire Chief™ arborvitae; *T. occidentalis* 'Nigra Dark Green'; and *T. occidentalis* 'SMTOYB', Polar Gold™ arborvitae.

Five of the taxa showed that the foliar treatment with the highest mean was significantly higher than basal quick dip treatment with the highest mean, including *C. harringtonia* 'Fritz Huber'; *I. crenata* 'ANNYS1', Brass Buckle® Japanese holly; *J. horizontalis* 'Hegedus', Good Vibrations® Gold; and *J.* 'Blue Star'.

When comparing rooting scores of evaluation round one and round two within treatments, all of the taxa showed either a significant increase in rooting scores or no significant difference. The only taxa that showed a significant decrease were taxa that had notable crop losses during the experiment as mentioned previously.

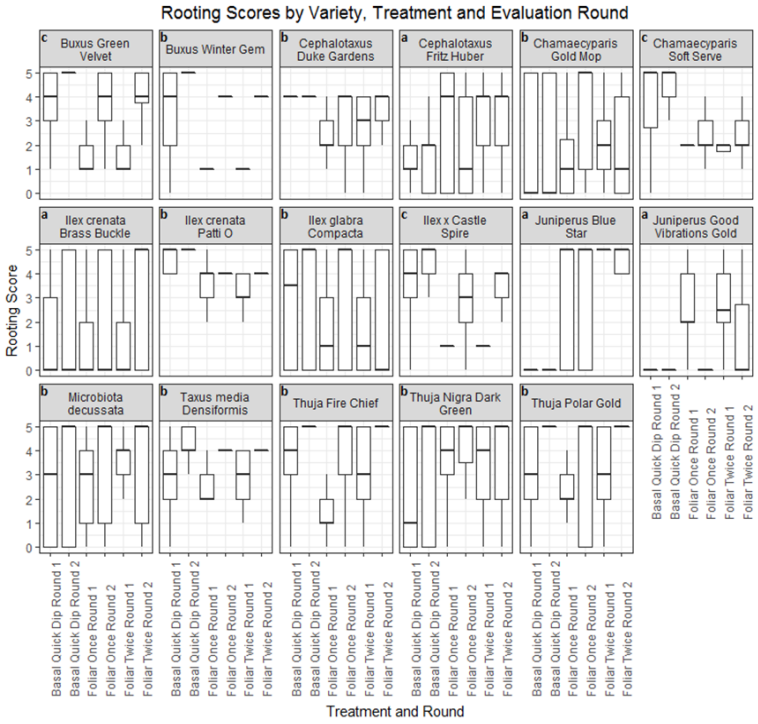


Figure 3. Comparison of rooting scores, treatments, evaluation rounds and hormone concentration for each taxon. Rooting quality was evaluated on a scale of 0-5: 0-necrotic stem, 1-live cutting with no response, 2-swelling, breaking or root initials, 3-few small visible roots, 4-developed roots at the base of the stem, 5-developed roots along the length of the stem. Rooting hormone treatments included: a basal quick dip (1000-7500 ppm IBA/NAA), a foliar application once at sticking, and a second foliar application one week after sticking (500-3750 ppm IBA). The first rooting evaluation took place when the roots of the commercial production cuttings half-filled the cell. The second evaluation took place when the commercial production cuttings were transplanted to their final size. All foliar treatments were half the concentration of the basal quick dip of the same taxon. Groups were evaluated using Tukey's HSD test at 0.05 significance level. Letters denote a significant difference: a- highest foliar treatment was significantly higher than the highest basal quick dip treatment, b- highest foliar treatment was not significantly different than the highest basal quick dip treatment, and c- highest foliar treatment was significantly lower than the highest basal quick dip treatment.

To simplify comparisons, taxa were grouped by leaf type and rooting scores were compared (Figure 4). Broad leaved taxa included *Buxus* and *Ilex*, needle leaved taxa included *Cephalotaxus* and *Taxus*, while scale leaved taxa included *Chamaecyparis, Juniperus, Microbiota*, and *Thuja.*

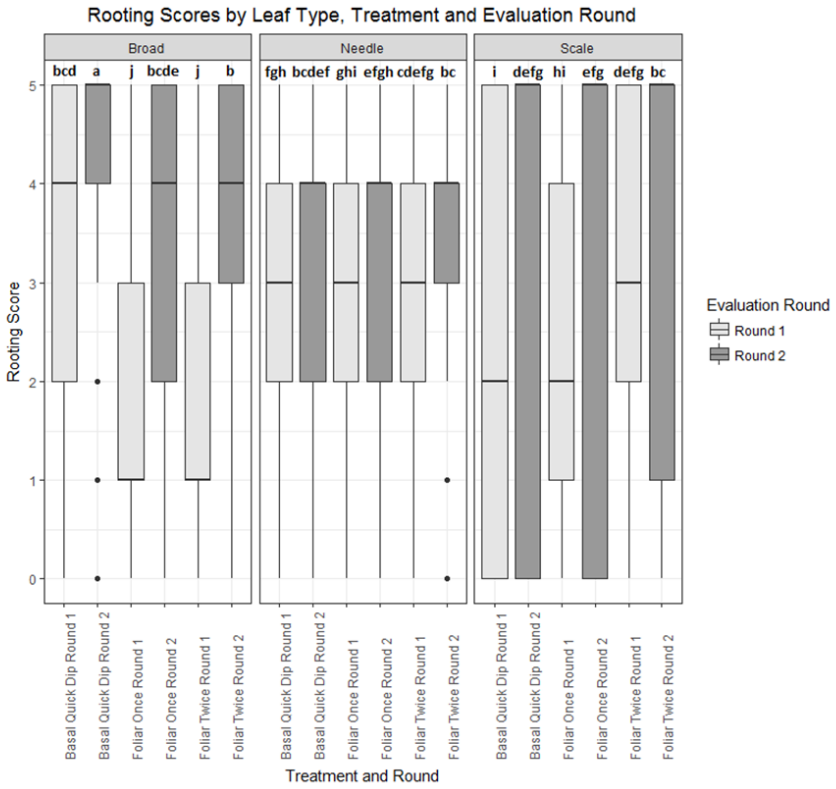


Figure 4. Comparison of rooting scores, treatments and evaluation rounds for each leaf type. Broad leaved taxa included Buxus and Ilex, needle leaved taxa included *Cephalotaxus* and *Taxus*, and scale leaved taxa included *Chamaecyparis, Juniperus, Microbiota* and *Thuja*. Rooting quality was evaluated on a scale of 0-5: 0-necrotic stem, 1-live cutting with no response, 2-swelling, breaking or root initials, 3-few small visible roots, 4-developed roots at the base of the stem, 5-developed roots along the length of the stem. Rooting hormone treatments included: a basal quick dip (1000-7500 ppm IBA/NAA), a foliar application once at sticking, and a second foliar application one week after sticking (500-3750 ppm IBA). The first rooting evaluation took place when the roots of the commercial production cuttings half-filled the cell. The second evaluation took place when the commercial production cuttings were transplanted to their final size. All foliar treatments were half the concentration of the basal quick dip of the same taxon. Groups were evaluated using Tukey's HSD test at 0.05 significance level. Letters of groups with significant differences are at the top of the boxplot. All median lines of round 2 for both needle and scale are at the top of the boxplot.

The mean rooting score for each treatment was compared within leaf types, and between evaluation rounds one and two. There was a significant decrease in the mean broad-leaved rooting score when the basal quick dip treatment was compared to either foliar treatment in round one and round two. There was no statistical difference in the mean needle-leaved rooting score when all treatments were compared in round one, but there was a significant increase when the foliar once treatment was compared to the foliar twice treatment in round two. There was a significant increase in the mean scale-leaved rooting

score when the basal quick dip treatment was compared to the foliar twice treatment in round one and round two.

Rooting scores by taxon were converted to rooting percentages by considering a rooting score of 0-3 as unrooted, while a score of 4-5 as rooted (Figure 2). This delineation represented the quality of rooted cuttings that were potted to the finished size. Rooting percentages of evaluation round 2 for both types of foliar treatments were compared to standard expected rooting percentages. These are based on historical rooting records while using the basal quick dip method at Spring Meadow Nursery.

Ten taxa had at least one foliar treatment that had a rooting percentage within 5% or higher of the expected rooting percentage, including: *B.* 'Winter Gem', *C. harringtonia* 'Duke Gardens', *I. crenata* 'ANNYS1', Brass Buckle® Japanese holly and *I. crenata* 'FarrowSK6', Patti O® Japanese holly, *J.* 'Blue Star', *M. deussata, T.* 'Densiformis' and *T. occidentalis* 'Congabe', Fire Chief™ arborvitae, 'Nigra Dark Green', and 'SMTOYB', Polar Gold™ arborvitae.

All remaining taxa had foliar rooting percentages that were lower than 5% of the expected rooting percentage, although *C. harringtonia* 'Fritz Huber'; *C. pisifera* 'Gold Mop'; and *J. horizontalis* Good Vibrations® Gold all had foliar treatment rooting percentages that were higher than the basal quick dip treatment. *Buxus* 'Green Velvet', *C. pisifera* 'Dow Whiting', Soft Serve® false cypress, *I. glabra* 'Compacta' and *I.* × *meserveae* 'Hachfee', Castle Spire® blue holly had foliar rooting percentages that were lower than both the expected rooting percentage and the rooting percentage of the basal quick dip treatment.

**Experiment 2: rooting response of deciduous cuttings to foliar or basal applications of IBA**

The rooting scores of each taxon were graphed as boxplots, using RStudio statistical software (Figure 5). Statistical differences were determined by using one-way analysis of variance and Tukey's highly significant difference test at the 0.05 level. All taxa were evaluated at 3 weeks after sticking, except *W. florida* 'Verweig 6', Sonic Bloom® Red weigela, which was evaluated at 5 weeks after sticking due to a longer rooting time.

There was no significant difference in rooting scores between all treatments of *B.* 'Miss Molly' and *H. paniculata* 'SMHPFL', Fire Light® panicle hydrangea, with means between 4.7 and 5. There was a significant decrease in rooting scores of *P. opulifolius* 'SMPOTW', Tiny Wine® ninebark, when comparing basal quick dip treatment to either the foliar treatment or the control group (which were not significantly different from each other). There was no significant difference in rooting scores between the basal quick dip treatment and the foliar treatment of *W. florida* 'Verweig 6', Sonic Bloom® Red, but the control group had significantly lower rooting scores.

**DISCUSSION**

Results from both the evergreen and the deciduous foliar treatments of IBA showed that there are certain taxa that respond as well as a basal quick dip, but the rooting response was highly variable. At this time, foliar treatments will not completely replace basal quick dip treatments as standard practice at Spring Meadow Nursery, but certain taxa will continue to be studied. Protocol for certain scale leaved evergreen cuttings is likely to change to a foliar treatment for the 2018 evergreen production season. Protocol for certain deciduous cuttings has already changed from a basal quick dip to a foliar treatment.

The evergreen study showed that foliar treatments of some broad leaved evergreens do not respond as well as a basal quick dip treatment. This outcome could be because the concentration for the foliar treatment was half that of the basal quick dip treatment, although there was no significant difference in rooting scores of broad and needle leaved evergreens when the foliar once and foliar twice treatments were compared. Another possibility for lower rooting scores is that the application temperature of 4.4-10°C (40-50°F) was not warm enough for the evergreen stomata to be open (Kroin, 2011). The majority of the rooting scores of broad leaved evergreens with a foliar treatment improved during the time between the first and second round of evaluation. For some broad leaved taxa, this improvement over time was enough to be comparable to the basal quick dip treatment.

Some rooting scores of needle and scale leaved evergreens were comparable to a basal quick dip treatment. In some cases, the foliar treatment had better rooting scores than the basal quick dip treatment. One possibility for this positive response is the larger total surface area of scale leaved cuttings, compared to the smaller surface area of broad leaved cuttings (White, 1983). Another possibility is that broad leaved evergreens have less stomata per surface area, whereas scale leaved evergreen cuttings have a higher concentration of stomata available to take up the rooting hormone (Woodward and Kelly, 1995), which is the entry point into the leaf tissue (Kroin, 2011). Future studies could include evergreen control groups with no hormone treatment and a foliar spray at the same concentration as the basal quick dip treatment. More evergreen taxa would also be studied. Because of the comparable results of the study, certain varieties within the genera *Buxus, Cephalotaxus, Ilex, Juniperus, Microbiota,* and *Thuja* could now be treated with a foliar spray as standard production protocol.

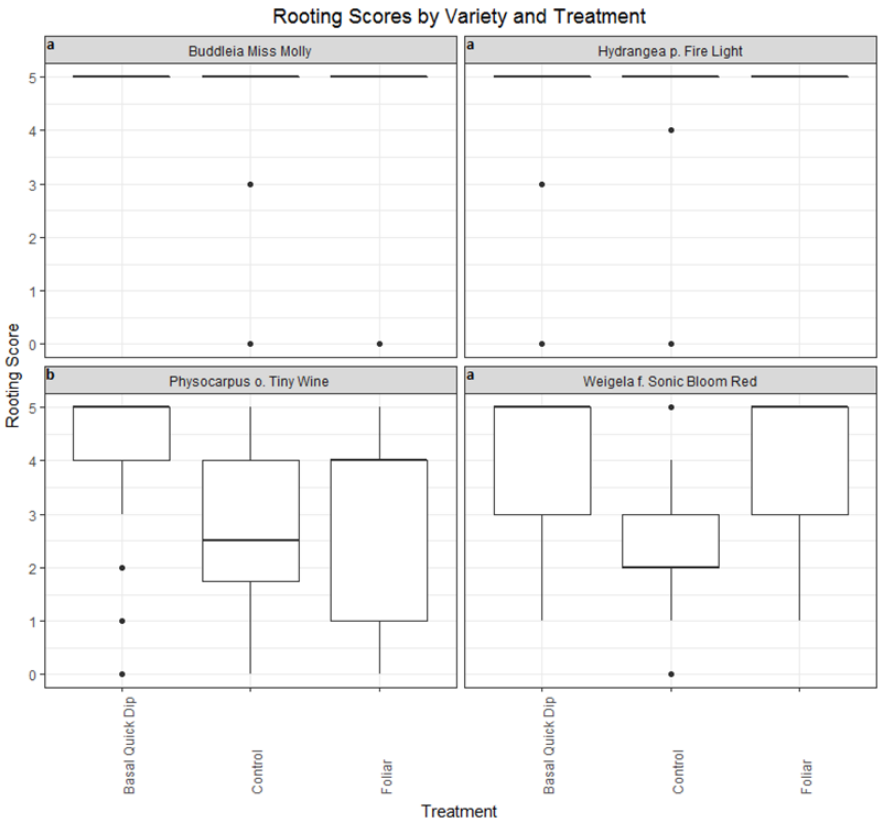


Figure 5. Rooting scores by taxon and treatment. Rooting quality was evaluated on a scale of 0-5: 0-necrotic stem, 1-live cutting with no response, 2-swelling, breaking or root initials, 3-few small visible roots, 4-developed roots at the base of the stem, 5-developed roots along the length of the stem. Rooting hormone treatments included: a basal quick dip treatment (500 ppm IBA/NAA), a foliar treatment (500 ppm IBA), and a control. Rooting was evaluated when the commercial production group was rooted enough to move out to growing greenhouses. Groups were evaluated using Tukey's HSD test at 0.05 significance level. Letters denote a significant difference: a- mean rooting score of the foliar treatment was not significantly different than the mean rooting score of the basal quick dip treatment, and b- mean rooting score of the foliar treatment was significantly lower than the mean rooting score of the basal quick dip treatment. There were no taxa that had a mean rooting score of the foliar treatment that was significantly higher than the mean rooting score of the basal quick dip treatment.

The deciduous study showed that for most taxa there was no significant difference when the basal quick dip and the foliar treatment were compared. This outcome has changed the standard production protocol from a basal quick dip treatment to a foliar treatment for the genera *Buddleia, H. paniculata*, and *Weigela*. In a large scale follow-up experiment, commercial production groups of *Buddleia* and *H. paniculata* taxa that were stuck using the ISO production line were treated with a foliar spray of 500 ppm IBA in the same manner as the experiment, but the application was done using a high pressure sprayer, due to the increased volume to cover the large production groups. Rooting percentages of these groups were compared to expected rooting percentages, and were all within an accepted 5% range. Long-term effects on growth and morphology could be monitored as foliar treated groups reach their ready date (Drahn, 2007). For two of the four taxa, *B.* 'Miss Molly' and *H. paniculata* 'SMHPFL', Fire Light® panicle hydrangea, there was no significant difference when all three treatments were compared, including the control group. The comparable response of the control group to the basal quick dip treatment could possibly lead to the discontinuation of hormone application, or a reduction in concentration for similar taxa. The same study could be repeated in the spring and in the fall to determine if there is a change in rooting response. Other cultivars within the genera that were included in the study (*Buddleia, H. paniculata* and *Weigela)* are currently being evaluated. Other genera that are stuck using the ISO production line that could be tested in the future are *Callicarpa, Cornus, Deutzia, Diervilla, Hibiscus, Loropetalum, Spiraea*, and *Syringa.*

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