Antitranspirant Treatments of Stock Plants do not alter Growth and Adventitious Rooting of Shoots of ‘Montaigne’ Lilac and White Fringetree[1]

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Abstract

Antitranspirants were evaluated for their effectiveness as a stock plant treatment to improve adventitious rooting of softwood cuttings of *Syringa vulgaris* L. ‘Montaigne’ (Montaigne lilac) and *Chionanthus virginicus* L. (white fringe tree). New shoots of *S. vulgaris* ‘Montaigne’ and *C. virginicus* were sprayed with one of two film-forming antitranspirants including Clear Spray® (aqueous acrylic emulsion) and sodium silicate; or Atrazine®, a herbicide that acts as a stomate-regulating antitranspirant. Shoot caliper of antitranspirant-treated lilacs increased more slowly than controls. Thirty days after treatment cuttings were taken from both taxa. All treatments resulted in 80 to 85% rooting of cuttings in lilac after 6 weeks, but cuttings from Clear Spray®-treated plants rooted more quickly. *Chionanthus virginicus* cuttings treated with Clear Spray® had significantly lower rooting (16%) than cuttings taken from Atrazine® treated plants (50%). In a subsequent experiment, antitranspirant treatment had no significant effect on shoot length or caliper of ‘Montaigne’ lilac. Photosynthetic rate, transpiration rate, and location of cutting on the stock plant were all positively correlated with shoot length, shoot caliper, and cutting diameter. Shoot length and caliper and cutting diameter, however, were all negatively correlated with root number and root length. There were no significant treatment effects on rooting percentage, root number or root length.

Index words: *Syringa vulgaris* L. ‘Montaigne’, *Chionanthus virginicus* L., asexual propagation, softwood cuttings, adventitious rooting, photosynthesis, transpiration.

Chemicals used in this study: Atrazine®, (1-chloro-3-ethylamino-5-isopropylamino-2,4,6-triazine); sodium silicate, (Na_2SiO_4); Clear Spray®, (aqueous acrylic emulsion); Leaf Shield™, (paraffin wax emulsion).

Significance to the Nursery Industry

Costly and time-consuming techniques such as tissue and embryo culture have been used to propagate *Syringa vulgaris* and *Chionanthus virginicus.* Vegetative stem cuttings have generally resulted in inconsistent rooting. Improved techniques that would make vegetative stem cuttings a more reliable propagation technique for these species would save growers money by reducing time under mist and producing salable plants faster and in higher numbers. In this study antitranspirants are evaluated as a potential foliar treatment to improve adventitious rooting. This study also identifies shoot characteristics that are correlated with increased rooting percentages.

Introduction

Propagation of plants by vegetative cuttings is desirable for clones due to the high cost of alternative methods (6), unfortunately cuttings often do not root with acceptable consistency. Rooting ability varies among species, and among cultivars within species, as in *Syringa vulgaris* L. (2, 12, 15). Successful rooting of one *Chionanthus* species, *C. retusus* Lindl. & Paxt. has been achieved by some growers, but rooting tests with *C. virginicus* L. have been much less successful (5, 6). Various types of stock plant treatments applied prior to taking stem cuttings have improved rooting success of particular species. Stock plant treatments may include practices such as severe pruning in apple (*Malus* spp.), *Pinus radiata* D. Don, and *Eucalyptus* spp. L’Herit. (9) or light exclusion at budbreak, also known as etiolation, which is beneficial for a number of species (14).

Inhibition of photosynthesis is one of the primary effects of light exclusion. Inhibition of photosynthesis may also be realized by defoliation. In *S. vulgaris* ‘Madame Lemoine’ defoliation of new shoots during the first 2 weeks of growth resulted in thinner shoots as well as increased rooting compared to nondefoliated control shoots (12). Logistic regression models, in turn, showed stem diameter to be an accurate predictor of rooting percentage, root number and root length.

It has been suggested that reduced shoot caliper may indicate reduced sclerification and hence improved rootability (12). Small shoot caliper has been identified as a marker for high rooting potential in both *S. vulgaris* and *Rubus idaeus* L. (11). Dry weights of etiolated shoots and defoliated shoots are lower than those of light-grown controls, which is likely due to decreased lignification as well as reduced carbohydrate content (12). Decreased sclerification has been correlated with improved rooting in *Malus* clones (7, 14) and *Carpinus betulus* ‘Fastigiata’ (13). Film-forming antitranspirants applied to leaf surfaces reduce photosynthesis (4) as well as transpiration, and so might result in improved rooting through a mechanism similar to defoliation and light exclusion. Antitranspirants, applied after cuttings were removed from stock plants, have been investigated as a substitute for automated mist systems (1, 10, 24). These studies showed little benefit in treating cuttings with antitranspirants. Wang et al. (22) applied an antitranspirant to *Epipremnum aureum* (Lind. & Andre) bunting prior to

[1]Received for publication June 26, 2002; in revised form September 20, 2002. Minnesota Agricultural Experiment Station, Journal Series Article 1210068. This research was supported in whole or in part by the Minnesota Agricultural Experiment Station. The authors wish to thank the Minnesota Nursery and Landscape Association for financial contributions, and Chad Giblin, Daniella Blini, Mykola Chornyy, and Carl Meyer for technical assistance.

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cutting excision, but cuttings were taken 24 hr after antitranspirant treatment, allowing little treatment effect on the physiology and anatomy of the cuttings. To our knowledge, the effects of antitranspirants on shoot growth for the purpose of producing cuttings that are more capable of producing adventitious roots has not been investigated.

The effects of antitranspirant treatment on shoot growth is unclear based on previous literature. Studies on woody perennials report either no effect on shoot length (21, 23) or a slight increase in length (3, 18). Increases in shoot length are dependent upon appropriate water status, reduced photosynthate supply, and the availability of stored carbohydrates (21).

The objective of these experiments was to evaluate the effect of antitranspirant treatments on growth and subsequent rooting ability of shoots from *C. virginicus* and *S. vulgaris* 'Montaigne' and to correlate shoot characteristics with rooting success.

Materials and Methods

Antitranspirant effects on ***C. virginicus*** *(Experiment 1).* Sixteen 46 cm (18 in), 1-year-old dormant multistem *C. virginicus* seedlings were potted in a sterile medium of composted softwood chips:sphagnum peat:horticultural perlite (4:2:1 by vol) in #2 nursery containers (6.3 liters) and placed in a 20C/18.3C (68F/65F) day/night greenhouse in St. Paul, MN, in April 1999. All plants were placed on the same bench and each was top-dressed at planting with 21 g (0.8 oz) 14N–6P–11.6K controlled release fertilizer (Nutricote 14–14–14; Chisso-Asahi Fertilizer Co. Ltd., Tokyo, Japan) upon planting. The plants were blocked randomly by location on the bench, with a total of four blocks. Each block contained four plants with each treatment applied to a single plant per block. After 2 weeks in the greenhouse, each plant had multiple shoots with each shoot having at least four fully expanded leaves. Treatments were applied using hand sprayers and included: 5.80×10^{-4} mol/liter (125 ppm) Atrazine® solution (Aldrich, Milwaukee, WI) (19), 2.3% (v/v) Clear Spray® (aqueous acrylic emulsion, recommended rate on label; W.A. Cleary Corp., Sommerset, NJ), 7.0 mol/liter (200 ppm) sodium silicate solution (Fisher Scientific, Fair Lawn, NJ), or deionized water as the control. Stock plants were moved to a separate bench during treatment to prevent drift. Both the upper and lower surfaces of the leaves were sprayed to runoff. Shoot length and caliper measurements at the shoot base from 5 shoots per plant were taken prior to treatment and 28 days after treatments were applied. Stem cuttings were taken after the final measurement on June 11, 1999. Cuttings were 8 cm (3.2 in) long and consisted of terminal cuttings with the basal 4 cm (1.6 in) stripped of leaves. The basal ends of cuttings were dipped into 16,000 ppm IBA in talc (Hormex 16 rooting powder; Brooker Chem., North Hollywood, CA) to a depth of 4 cm (1.6 in), inserted into 10 cm (4 in, 475ml) rooting cells containing horticultural perlite:sphagnum peat (3:1, by vol), and placed immediately onto a misting bench. Cuttings were randomized within treatment. The cuttings were divided into eight blocks by location on the mist bench with four cuttings per treatment placed randomly in each block. The misting bench was covered with 50% shade cloth. Mist was applied to cuttings for 6 sec every 8 min for 16 hr (05:00–23:00) daily. Rooting was evaluated for the first time 6 weeks after sticking and every 2 weeks after that until 12 weeks had elapsed after the cuttings were taken. Cuttings were recorded as having roots (roots ? 1mm), callus formation, or nothing. At the end of the experiment root number per cutting was recorded and the longest root per cutting measured.

Antitranspirant effects on ***S. vulgaris 'Montaigne'*** *(Experiment 2).* Twenty 46 cm (18 in) tall, dormant, multistem 3-year-old 'Montaigne' lilacs were potted in a sterile medium of composted softwood chips:sphagnum peat:horticultural perlite (4:2:1 by vol) in #5 squat nursery containers (14.2 liter) and placed in a 20C/18.3C (68F/65F) day/night greenhouse in St. Paul, MN (March 19, 1999). Each container was top-dressed with 36 g (1.3 oz) 14N–6P–11.6K controlled release fertilizer. The plants were treated with Clear Spray®, Atrazine®, sodium silicate and deionized water as described in Expt. 1. Plants were blocked randomly by location on the bench, with a total of five blocks and four plants per block. Each treatment was applied to a single plant per block. The length of five shoots per stock plant and the caliper at the base of these shoots were measured before treatments were applied 30 days after the treatments were applied (May 7, 1999).

Cuttings were prepared as terminal cuttings 6 cm (2.4 in) long and leaves were removed from the basal 3 cm (1.2 in) of each cutting. Cuttings were re-randomized within treatment and were inserted into 10 cm (4 in, 475ml) square rooting cells containing sphagnum peat:horticultural perlite (1:3 by vol). Before being placed into the rooting cell, the base of each cutting was dipped to a depth of 3 cm (1.2 in) for 5 sec into 3,000 ppm IBA (Dip 'N Grow; Astoria-Pacific Inc., Clackamus, OR). Cuttings were blocked by location on a mist bench with 11 blocks and four cuttings of each treatment randomly placed in each block. The mist bench was covered with 50% shade cloth. Cuttings were misted following the same regime as in Expt 1. The same rooting criteria were used as described in Expt 1. Cuttings were first examined for roots 3 weeks after they were stuck, and weekly thereafter for 6 weeks.

Physiological characteristics related to rooting in ***S. vulgaris 'Montaigne'*** *(Experiment 3).* The twenty *S. vulgaris* 'Montaigne' lilacs that were used in Expt. 2 were rerandomized the following year to be used in a third experiment. Lilacs were placed in a 20C/18.3C (68F/65F) day/night greenhouse and top-dressed with 36 g per container of 13N–5.6P–10.8K (13N–13P–13K Nutricote controlled release fertilizer; Chisso-Asahi Fertilizer Co. Ltd., Tokyo, Japan) on March 31, 2000. Four different treatments were applied on April 16, 2000, using hand sprayers and included: a single application of 5.80×10^{-4} mol/liter (125 ppm) Atrazine® solution (Aldrich, Milwaukee, WI), a single application or weekly applications of 2.3% (v/v) paraffin wax emulsion (Leaf Shield®, Aquatrols, Cherry Hill, NJ), or deionized water as a control. Plants were blocked randomly by location on the bench, with a total of five blocks and four plants per block. Each treatment was applied to a single plant per block. Photosynthetic measurements were made using a CIRAS-1 Combined Infrared Gas Analysis System (PP Systems, Hitchin Herts, United Kingdom) prior to treatment and every 4 days thereafter. Measurements were made on the same five apical shoots per plant over the course of the experiment. Shoot length and caliper at the third or fourth internode were also measured prior to treatment and every 4 days during the treatment period. At the end of the treatment pe-

Table 1. Percent increase in shoot lengths and calipers {[(final size – initial size) / initial size] × 100} of *C. virginicus* (Expt. 1) and *S. vulgaris* 'Montaigne' lilacs (Expt. 2) 28 and 30 days after being treated with antitranspirants respectively.

	C. virginicus		*S. vulgaris*	
Treatment	**Shoot length**	**Caliper**	**Shoot length**	**Caliper**
Control	11.3a[z]	18.9a	10.2a	43.9a
Atrazine	10.9a	17.3a	12.1a	28.9b
Clear Spray	5.9b	19.3a	10.4a	28.9b
Silicon	9.7a	13.8a	12.2a	16.1c

[z]Significant differences within columns calculated using Duncan's multiple range test (P ? 0.05; n = 80 for *C. virginicus*, n = 100 for *S. vulgaris* 'Montaigne').

Table 2. Percent of *C. virginicus* cuttings that rooted and root number and length of rooted cutting 6 weeks after cuttings from treated plants were placed into rooting cells.

Treatment	% Rooted	Root number	Root length
Control	40.6ab[z]	7.8a	103.2a
Atrazine	50.0a	7.1a	75.0a
Clear Spray	15.6b	10.0a	95.2a
Silicon	34.3ab	7.8a	74.7a

[z]Significant differences within columns calculated using Duncan's multiple range test (P ? 0.05; n = 8 for % rooting, n = 45 for root number and root length).

riod, final plant height was recorded. The relative location of each measured shoot in each plant's canopy was established by dividing the distance of each of these shoots from the base of the plant by the total height of the plant.

Terminal cuttings were taken from five shoots per stock plant, on which the previous measurements were made, on May 9, 2000 (21 days after initial treatments were applied). Stem cuttings were taken beneath the second node from the shoot apex unless the top internode was shorter than 5.5 cm (2.2 in). In this case, cuts were made below the third node from the top. The length of each cutting and the diameter at the base were measured. Cuttings were blocked by location on the mist bench into five blocks with four cuttings from each treatment placed randomly in each block. Mist was applied as in Expt. 1. Fifty percent shade cloth was hung over the bench for the entire rooting period. Root evaluations, including root number and length of longest root, were performed 3 weeks after stem cuttings were placed into mist, and every subsequent week until 12 weeks after the cuttings were taken.

Statistical analysis. Significant differences between treatment means were determined using Duncan's multiple range test. Significant differences between percentages were calculated after transforming percentages using 2 × sqrt[arcsin(% / 100)] (19). Significant bivariate correlations were determined using the Pearson correlation coefficient (r) for normal data. All statistics were calculated using SPSS for Windows, version 8.0.0 (20).

Results and Discussion

Experiment 1. Percentage increase in shoot length {[(final shoot length – initial shoot length) / initial shoot length] × 100} in *C. virginicus* stock plants treated with Clear Spray® was significantly lower than in the other three treatments (Table 1). None of the other treatments showed any significant reduction in length increase. Antitranspirant treatments were applied after most shoot elongation was complete, explaining, in part, the lack of significant increase in shoot length that was observed in the other treatments. Shoot length

Table 3. Percent of *S. vulgaris* 'Montaigne' cuttings that rooted 3, 4, 5 and 6 weeks after cuttings from treated plants were placed into rooting cells, and root number and root length of cuttings that rooted 6 weeks after cuttings were placed into rooting cells.

	Week 3	Week 4	Week 5	Week 6	Week 6	Week 6
Treatment	**% Rooted**				**Root number**	**Root length**
Control	4.5b[z]	47.7ab	70.5a	84.1a	10.7a	43.6a
Atrazine	6.8b	43.2b	72.7a	81.8a	12.8ab	45.6a
Clear Spray	29.5a	72.7a	81.8a	79.5a	16.2b	56.2b
Silicon	11.4b	40.9b	84.1a	81.8a	14.1ab	51.4ab

[z]Significant differences within a column calculated using Duncan's multiple range test (P ? 0.05; n = 11 for % rooting, n = 148 for root number and root length).

Table 4. Average shoot length and diameter of antitranspirant treated lilacs (*Syringa vulgaris* 'Montaigne') over time.

	Atrazine		Single leaf shield application		Multiple leaf shield applications		Control	
Day[z]	**Length (mm)**	**Diameter (mm)**	**Length (mm)**	**Diameter (mm)**	**Length (mm)**	**Diameter (mm)**	**Length (mm)**	**Diameter (mm)**
0	19.8[y] ± 1.1	2.9 ± 0.3	19.3 ± 1.7	2.9 ± 0.4	20.4 ± 1.7	3.1 ± 0.2	20.6 ± 2.7	3.0 ± 0.7
3	24.5 ± 1.7	3.1 ± 0.3	23.2 ± 2.3	3.1 ± 0.4	25.4 ± 1.5	3.4 ± 0.2	25.5 ± 4.0	3.2 ± 0.7
7	29.1 ± 3.8	3.3 ± 0.3	28.1 ± 3.9	3.2 ± 0.4	32.7 ± 2.9	3.5 ± 0.2	30.5 ± 6.7	3.4 ± 0.7
10	29.9 ± 4.5	3.4 ± 0.3	29.4 ± 4.2	3.4 ± 0.4	34.1 ± 3.2	3.6 ± 0.3	31.3 ± 7.8	3.5 ± 0.7
14	30.4 ± 4.6	3.6 ± 0.3	30.2 ± 4.6	3.5 ± 0.4	35.8 ± 3.7	3.9 ± 0.2	32.2 ± 8.7	3.7 ± 0.7
18	29.6[x] ± 2.9	3.7 ± 0.4	30.8 ± 4.5	3.6 ± 0.3	36.0 ± 3.7	4.0 ± 0.2	32.3 ± 8.8	3.8 ± 0.8
21	30.7 ± 4.5	3.8 ± 0.3	30.9 ± 4.5	3.7 ± 0.4	36.1 ± 3.7	4.1 ± 0.2	32.4 ± 8.9	3.8 ± 0.8

[z]Days after treatment.

[y]Numbers are means of five replicates ± standard deviation.

[x]Average of 4 shoots.

Table 5. Correlations between shoot, cutting, and root characteristics of antitranspirant treated lilacs (*S. vulgaris* 'Montaigne') over time.

	Final shoot length (cm)	Final shoot diameter (mm)	Average photosynthetic rate[x] (mmoles/m2/s)	Average transpiration rate[x] (mmoles/m2/s)	Shoot position on stock plant[z]	Cutting diameter (mm)	Cutting length (cm)	Root number	Root length (mm)
Final shoot length	1.000	0.971[y]**	0.336**	0.370**	0.284**	0.729**	0.123NS	–0.505**	–0.552**
Final shoot diameter		1.000	0.376**	0.404**	0.396**	0.739**	0.163NS	–0.434**	–0.492**
Average photosynthetic rate			1.000	0.510**	0.164NS	0.31**	–0.600NS	–0.170NS	–0.222*
Average transpiration rate				1.000	0.165NS	0.255*	0.132NS	–0.059NS	–0.115NS
Shoot position on stock plant					1.000	0.455**	0.054NS	–0.165NS	–0.204*
Cutting diameter						1.000	0.239*	–0.305**	–0.358**
Cutting length							1.000	0.349**	0.335**
Root number								1.000	0.933**
Root length									1.000

[z]Calculated as (height of fourth leaf pair of shoot on stock plant/total stock plant height). All heights are measured from the base of the plant.

[y]Pearson correlation coefficient r.

[x]Average photosynthetic and transpiration rate of stock plants over the course of the experiment until cuttings were removed.

NS,**,*Nonsignificant or significant at $P < 0.01$ or 0.05, respectively.

increased between 0.8 and 1.3 cm (0.3–0.5 in) for all treatments. There were no significant differences in percentage shoot caliper increase {[(final caliper – initial caliper) / initial caliper] × 100} among treatments (Table 1).

The only significant difference in rooting that was found among treatments was that cuttings from Clear Spray®-treated plants rooted at a significantly lower rate than cuttings from Atrazine®-treated plants on the final evaluation date (Table 2). There were no significant differences among treatments in either the average number of roots per cutting or the average longest roots.

Experiment 2. There was no significant difference in percentage increase in shoot length among any of the treatments (Table 1). This observation agrees with a study by Weller and Ferree (23) and Steinberg et al. (21), demonstrating that antitranspirants do not increase shoot length. Total shoot elongation was only ? 1 cm (0.4 in) across all treatments. As in Expt. 1, the antitranspirants were applied after most stem elongation was complete.

Percentage increase in the shoot caliper of the control was significantly greater than all antitranspirant-treated stock plants (Table 1). We are unaware of any previous work measuring the caliper of succulent woody shoot growth after antitranspirant treatment.

By the end of the root evaluation period, the cuttings from all treatments rooted between 80% and 85% (Table 3). Cuttings from Clear Spray®-treated plants rooted more quickly than all other treatments. It is possible that the thinner shoots of the anti-transpirant treated stems resulted from decreased lignification thereby producing cuttings that rooted more quickly (12).

Root length and number of roots per cutting were heavily dependent on time to rooting. Average number of roots per cutting among those cuttings that rooted in the Clear Spray®-treated plants was significantly higher than the control plants (Table 3). The average length of the longest root of cuttings from the Clear Spray®-treated plants was significantly longer than cuttings from both the control and the Atrazine-treated plants (Table 3). The longer roots of Clear Spray®-treated cuttings are likely explained by earlier rooting resulting in a longer period of root growth. The slight reduction in percent rooting from week 5 to week 6 in the Clear Spray® and silicon treatments is likely due to the repeated removal of cuttings during the experiment.

Experiment 3. Antitranspirant treatments showed no significant effect on shoot growth or actual shoot size (Table 4). Shoot lengths and calipers (Table 4) of antitranspirant-treated shoots were not significantly different from the control or from each other. No consistent treatment differences were seen over time in photosynthetic and transpiration rates (data not presented). Antitranspirant concentrations may not have been high enough for films to remain intact on vigorously growing leaves (3, 21). Davies and Kozlowski (4) reported decreased transpiration and photosynthesis for up to 30 days after treatment with a wax emulsion antitranspirant, but the concentration used was double what was used in this study.

At the conclusion of this experiment the control cuttings, single Leaf Shield™ application, multiple Leaf Shield™ applications, and Atrazine® treated cuttings rooted at 36%, 44%, 16%, and 20% respectively. There were no significant differences among these percentages unlike Expt. 2, in which single applications of a film-forming antitranspirant resulted in earlier rooting. This lack of difference was most likely due to large variations in rooting percentages among blocks within treatments. No treatment effect was seen on average root number per cutting or length of longest root per cutting.

When data from stockplants and cuttings were analyzed, shoot growth was correlated most strongly with average rates of photosynthesis, transpiration, and position on the stock plant (shoot height/total plant height). As the average rate of photosynthesis increased, so did final shoot length. Rate of photosynthesis was also positively correlated with shoot caliper and, subsequently, cutting diameter (Table 5). Correlations were also found between transpiration and shoot length, and between transpiration rate and shoot diameter (Table 5). Transpiration rate and cutting diameter showed a positive correlation (Table 5).

A significant positive correlation was noted between the diameter of the cutting base and the position of the shoot on the stock plant from which the cutting was taken (Table 5). The closer to the top of the plant the cutting was taken, the greater the shoot length and diameter as well as cutting diameter (Table 5). Larger growth in the top of the canopy where shoots are not subject to shading has also been reported in persimmon (*Diospyros khaki* L.) (8).

Both root number and length were negatively correlated to shoot length, shoot diameter and cutting diameter (Table 5). These data agree with a previous study correlating the caliper of the cutting base to rooting success in 'Madame Lemoine' lilacs (12). Cutting length was significantly correlated with both root number per cutting and longest root. So while higher rates of photosynthesis correlated with longer and thicker stems, these larger shoots were correlated with a lower number of roots per cutting and shorter root length. Root length was negatively correlated with rate of photosynthesis (Table 5). For certain species, including lilacs, a dark pre-treatment, and hence reduced photosynthesis, given to the stock plant prior to cutting collection increases rooting (15), while increased irradiance decreases rooting (16).

Antitranspirant treatments do not appear to reliably improve rooting in *S. vulgaris* 'Montaigne' or in *C. virginicus*. Decreased photosynthesis and transpiration, reduced shoot length, and small shoot and cutting diameter were correlated with improved rooting success in 'Montaigne' lilac. Based on these results, lilac cuttings taken from slimmer, shorter shoots will be more successful cutting material than that from thicker, longer shoots. However, methods to manipulate shoot growth other than antitranspirant application should be investigated and refined. For example, shading stock plants may improve rootability, as shading positively affects the processes which are implicated in this study as being beneficial to rooting (14). Further examination of these factors on rooting in different species is warranted.

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