Propagation of *Thuja* x 'Green Giant' by Stem Cuttings: Effects of Growth Stage, Type of Cutting, and IBA Treatment[1]

Jason J. Griffin, Frank A. Blazich, and Thomas G. Ranney[2]
Department of Horticultural Science
North Carolina State University
Raleigh, NC 27695-7609

Abstract

Stem cuttings of *Thuja* L. x 'Green Giant' ('Green Giant' arborvitae), consisting of 22 cm (8.6 in) terminals (tips of first-order laterals) or 20 cm (7.8 in) laterals (side shoots removed from those portions of terminal cuttings inserted into the rooting medium), were collected on three dates associated with specific stock plant growth stages (softwood, semi-hardwood, and hardwood) and treated with indolebutyric acid (IBA) in 50% isopropanol ranging from 0 to 9000 ppm (0.9%). Regardless of cutting type or auxin treatment, cuttings rooted in high percentages at each growth stage. Overall rooting for softwood, semi-hardwood, and hardwood, cuttings was 85%, 86%, and 96%, respectively. Semi-hardwood cuttings were the only cuttings in which percent rooting was affected by IBA treatment or cutting type, with lateral cuttings rooting in higher percentages than terminal cuttings (92% vs. 79%, respectively), while IBA concentrations of 3000 (0.3%) or 6000 ppm (0.6%) proved optimal for both cutting types. Mean root number and mean root length varied by growth stage, cutting type, and IBA concentration. In general, rooting percentages and root length were optimized at the hardwood stage with either cutting type treated with 3000, 6000 or 9000 ppm (0.3%, 0.6% or 0.9%) IBA, resulting in >10 roots per cutting.

Index words: adventitious rooting, arborvitae, auxin, indolebutyric acid, interspecific hybrid.

Significance to the Nursery Industry

'Green Giant' arborvitae is a narrow, upright, pyramidal evergreen tree with a rapid growth rate, and lustrous dark green foliage. Adaptability to a wide range of soil conditions, resistance to windthrow, absence of any significant pest problems, and no reports of damage by white tail deer (*Odocoileus virginianus* Zimm.) make 'Green Giant' arborvitae an ideal landscape plant. Results herein indicate that regardless of growth stage, stem cuttings of 'Green Giant' arborvitae can be rooted successfully throughout the year at percentages >85%. However, percent rooting and mean root length were maximized for hardwood cuttings treated with 3000, 6000 or 9000 ppm (0.3%, 0.6% or 0.9%) indolebutyric acid (IBA) in 50% isopropanol.

Introduction

Thuja L. x 'Green Giant' is a hybrid of *Thuja plicata* J. Donn ex D. Don (western red cedar) x *Thuja standishii* (Gord.) Carrière (Japanese arborvitae) (7). 'Green Giant' exhibits rapid height growth, which can reach 1 to 1.5 m (3 to 5 ft) per year, to a mature height of 18 m (60 ft), while maintaining a tightly pyramidal habit. Summer foliage is a lustrous dark green, turning a shade of bronze in winter. The cultivar is reported to be hardy to USDA Zone 5 and tolerant of a wide range of soils and climatic conditions (1, 2, 7, 9). Trees do not appear to be susceptible to windthrow and have few pest problems.

Due to several desirable landscape attributes, there is currently great interest in propagation and culture of 'Green Giant' arborvitae. Although other investigators (3, 4, 6, 8) have achieved rooting percentages of 50% to 90% using auxin concentrations of 0 to 10,000 ppm (1.0%) for various species of *Thuja*, little has been reported on propagation of 'Green Giant' (1, 2, 7, 9). Therefore, the objectives of this research were to study the influence of growth stage, type of cutting, and indolebutyric acid (IBA) treatment on propagation of 'Green Giant' arborvitae by stem cuttings.

Materials and Methods

Terminal cuttings (tips of first-order laterals), approximately 45 cm (18 in) in length, were collected from the lower 2 m (6.5 ft) of each of seven trees. Each tree, approximately 5.5 m (18 ft) in height, was growing under uniform fertility at Boonville, NC, when cuttings were collected on three dates associated with specific growth stages: August 29, 1997 (softwood), October 24, 1997 (semi-hardwood), and February 15, 1997 (hardwood). Thirty softwood, and 25 semi-hardwood and hardwood cuttings were taken per tree.

As cuttings were collected, they were placed in polyethylene bags that were placed on ice and transported to the Horticultural Science Greenhouses, Raleigh, NC. From the initial cutting material, two types of cuttings were prepared: 22 cm (8.6 in) terminals and 20 cm (7.8 in) lateral cuttings. A lateral cutting consisted of a side shoot removed from that portion of a terminal cutting that was inserted into the rooting medium. Stem tissue at the proximal end of hardwood and semi-hardwood cuttings was highly lignified, dark brown in color, and resembled that of mature stem tissue. Tissue at the proximal end of softwood cuttings was less lignified, tan

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[2]Graduate Research Assistant, Professor, and Associate Professor, respectively.

in color, and phenotypically, resembled stem tissue of the more distal portion of the cutting.

Following preparation, the basal 1 cm (0.4 in) of all cuttings were treated for 1 sec with 0, 3000 (0.3%), 6000 (0.6%) or 9000 ppm (0.9%) reagent grade IBA in 50% isopropanol. Cuttings were air dried for 15 min before inserting the basal 4 cm (1.6 in) into a raised greenhouse bench containing a medium of perlite:peat (2:1 by vol) with bottom heat maintained at 24 ± 1C (75 ± 2F). Softwood cuttings received the same treatments with an additional treatment of 1500 ppm (0.15%) IBA. Bottom heat was not provided during rooting of softwood cuttings. For each growth stage the experimental design was a randomized complete block with a factorial arrangement of treatments (two types of cuttings × four or five IBA concentrations), six blocks, and six cuttings per treatment per block.

Cuttings were maintained under natural photoperiod and irradiance with day/nights of 24 ± 5C (75 ± 9F)/18 ± 5C (65 ± 9F). Intermittent mist operated daily 5 sec every 6 min from sunrise to sunset. Mist was applied by deflection type nozzles with a capacity of 32.2 liters (8.5 gal) per hour. As a preventative measure, Daconil (chlorothalonil), a broad spectrum fungicide, was applied weekly, as a spray application to runoff, at a concentration of 4 ml/liter (1.0 tbsp/gal).

At 6 weeks, cuttings were harvested and data recorded. Data included, percent rooting, number of primary roots ≥ 1 mm (0.04 in) in length, and individual root lengths. All data except rooting percentages were based on the actual number of cuttings that rooted (at least one primary root). Data were subjected to analysis of variance and regression analysis. Where appropriate, means were separated using least significant difference (LSD) procedures at $P = 0.05$.

Results and Discussion

Stem cuttings rooted in high percentages at all growth stages. Overall percent rooting was 85%, 86%, and 96% for softwood, semi-hardwood, and hardwood cuttings, respectively. Rooting occurred rapidly, with root emergence visible 3 to 4 weeks following treatment of cuttings and insertion into the rooting medium.

For the semi-hardwood growth stage, percent rooting varied with IBA treatment and cutting type (Tables 1 and 2). Percent rooting of softwood and hardwood cuttings was unaffected by cutting type or IBA treatment (data not presented). Although no interaction occurred at the semi-hardwood growth stage, both IBA and cutting type affected independently percent rooting. Semi-hardwood lateral cuttings rooted in higher percentages than terminal cuttings when averaged over all IBA treatments (92% vs. 79%). This is consistent with reports that lateral cuttings taken from more lignified tissue (semi-hardwood) tend to root better than terminal cuttings (5). Rooting response to IBA treatment was quadratic, with the greatest rooting (92%) occurring after treatment with 3000 (0.3%) or 6000 (0.6%) ppm IBA (Table 1).

During this study, semi-hardwood and hardwood cuttings were subjected to bottom heat although it does not appear necessary for successful rooting of 'Green Giant' arborvitae. For many propagators, bottom heat is a routine practice, particularly when rooting hardwood cuttings, and has been recommended when rooting species of *Thuja* (3, 8). In unrelated studies with 'Green Giant', the authors observed that rooting occurred more slowly without bottom heat although overall percent rooting remained high.

Table 1. Effect of IBA concentration on percent rooting and mean root number of semi-hardwood cuttings of 'Green Giant' arborvitae.

IBA concn. (ppm)	Rooting (%)	Mean root no.
0	73.6	6.0
3000	91.7	13.8
6000	91.7	17.4
9000	86.1	18.0
Linear	NS	**
Quadratic	*	*

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

Table 2. Effect of cutting type on percent rooting and mean root number of semi-hardwood cuttings of 'Green Giant' arborvitae.

Cutting type	Rooting (%)	Mean root no.
Terminal	79a[z]	12a[y]
Lateral	92b	16b

[z]Mean separation within column by $LSD_{0.05} = 9$, n = 24.
[y]Mean separation within column by $LSD_{0.05} = 2.5$, n = 24.

Table 3. Effect of IBA concentration by cutting type on mean root number of softwood cuttings of 'Green Giant' arborvitae.

	Cutting type	
IBA concn. (ppm)	Terminal	Lateral
0	6.9a[z]	8.7a
1500	11.3a	12.4a
3000	14.8a	18.5a
6000	13.2a	27.4b
9000	24.0a	27.3a
Linear	**	**
Quadratic	NS	NS

[z]Mean separation within rows by $LSD_{0.05} = 6.21$, n = 5.
NS, ** Nonsignificant or significant at $P \leq 0.01$, respectively.

Table 4. Effect of IBA concentration by cutting type on mean root length (mm) of hardwood cuttings of 'Green Giant' arborvitae.

	Cutting type	
IBA concn. (ppm)	Terminal	Lateral
0	17.9a[z]	31.2b
3000	32.7a	32.0a
6000	33.6a	28.8a
9000	29.8a	27.3a
Linear	*	NS
Quadratic	**	NS

[z]Mean separation within rows by $LSD_{0.05} = 7.6$, n = 6.
NS, *, ** Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

At the different growth stages, root number varied as a function of cutting type and IBA treatment. At the softwood growth stage an interaction occurred between IBA treatment and cutting type for root number (Table 3). Increasing IBA concentration increased the number of roots per rooted softwood cutting with lateral cuttings treated with 6000 ppm (0.6%) having a greater response than terminal cuttings. When in the semi-hardwood growth stage, both IBA treatment and cutting type affected root number with no interaction (Tables 1 and 2). The main effect of IBA treatment was quadratic with a maximum number of roots (18 roots per rooted cutting) occurring following treatment with 9000 ppm (0.9%) IBA. Lateral cuttings at the semi-hardwood growth stage produced more roots than terminal cuttings (16 vs. 12, respectively). Root number of hardwood cuttings responded only to IBA treatment. Response to increasing IBA concentration was quadratic with 0, 3000, 6000, or 9000 ppm (0%, 0.3%, 0.6%, or 0.9%) resulting in 7, 10, 14, or 14 roots per rooted cutting, respectively. Developing roots at all growth stages had radial symmetry around the cutting base which may explain why trees are reportedly not subject to windthrow.

Mean root length of softwood cuttings was unaffected by either IBA concentration or cutting type and averaged 18 mm (0.7 in) per root. A quadratic response to IBA was observed for mean root length of semi-hardwood cuttings with the optimum concentration of 6000 ppm (0.6%) producing roots > 25 mm (1.0 in) in length. For hardwood cuttings, mean root length of lateral cuttings was unaffected by IBA concentration, whereas root lengths of terminal cuttings exhibited a quadratic response with an optimal IBA concentration of 6000 ppm (Table 4).

Results herein demonstrate that asexual propagation of *Thuja* x 'Green Giant' by stem cuttings is rapid and efficient. Moreover, cuttings root in high percentages throughout the year, reducing the importance of growth stage as a factor in successful rooting. In addition, hardwood cuttings, which are less perishable and inexpensive to handle (5), consistently rooted > 95% regardless of cutting type or auxin concentration.

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