Rooting and Subsequent Overwinter Survival of Stem Cuttings of *Stewartia ovata*[1]

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Abstract

Three experiments were conducted using stem cuttings of *Stewartia ovata* (Cav.) Weatherby to evaluate: 1) effects of indolebutyric acid (IBA) concentration on percent rooting and rooting index (root system size), 2) influence of N rate and medium amendments (dolomitic lime and/or complete fertilizer) on budbreak prior to overwintering and survival and shoot growth of cuttings following overwintering, and 3) effects of chilling duration on overwinter survival and subsequent shoot growth. Softwood cuttings of *S. ovata* were taken on June 19 and July 23, 1992, and treated with 0, 1000, 2000, 4000, or 8000 ppm IBA in 50% isopropyl alcohol. Rooting percentages and rooting index were highest for cuttings taken in June and treated with 2000 or 4000 ppm IBA. In the second experiment, cuttings were rooted in pine bark containing three different amendment combinations, and fertilized weekly with either 0, 50, 100, or 200 ppm N following root initiation. Overwinter survival was higher for cuttings rooted in pine bark or pine bark amended with lime, but decreased for cuttings in pine bark amended with lime and a complete fertilizer. Increasing N fertilization up to 200 ppm weekly stimulated budbreak prior to overwintering, resulted in greater shoot growth following overwintering, but had no effect on overwintering survival. In the third experiment, rooted cuttings were subjected to 0, 2, 4, 6, 8, or 10 weeks chilling at 6C (43F). Cuttings chilled for 10 weeks had the highest percent budbreak (survival) and greater overall shoot growth over a 12 week forcing period.

Index words: vegetative propagation, native plants, auxin, indolebutyric acid, mountain camellia.

Significance to the Nursery Industry

Stewartia ovata is a rare tree native to the southeast United States. Although *S. ovata* can be propagated by stem cuttings (1, 4), rooted cuttings often fail to overwinter successfully (11). This research demonstrates that *Stewartia ovata* can be propagated by stem cuttings and successfully overwintered. Percent rooting of 95% and overwintering survival of 92% were achieved using the following methods. Terminal, softwood (mid June) stem cuttings were treated with 2000–4000 ppm IBA in 50% isopropyl alcohol. Cuttings were stuck in quart containers filled with Pine Bark (with or without dolomitic lime) and fertilized weekly with a complete fertilizer containing from 0–200 ppm N. Rooted cuttings were then overwintered in a cooler at 6C (43F) for at least 10 weeks to satisfy their chilling requirement.

Introduction

Stewartia ovata (Cav.) Weatherby (mountain camellia) is a rare, deciduous species indigenous to the mountains and piedmont of the southeastern United States (13). It is a highly prized landscape plant, blooming in mid to late June (USDA hardiness zone 6–7) with large creamy white flowers. The flowers are 6 to 8 cm (3 to 4 in) across with cupped petals similar to those of *Camellia japonica* L. (Japanese camellia); hence, the common name mountain camellia. *Stewartia ovata* commonly grows as a shrub or small tree reaching a height of 5 m (15 ft). The bark is typically gray-brown, slightly ridged, and non-showy.

Despite several outstanding landscape features, *S. ovata* is rarely found in the nursery trade due to propagation and cultural difficulties. Sexual (seed) propagation is slow and difficult because of complex dormancy controlling mechanisms. Asexual (vegetative) propagation by stem cuttings also presents problems because rooted cuttings often die during overwintering.

Low overwinter survival of rooted stem cuttings has been reported as a major limitation to propagating species of *Stewartia* and other woody genera such as *Acer* L. (maples), *Cornus* L. (dogwoods), *Hamamelis* L. (witch hazels), *and Viburnum* L. (viburnums) (6, 11, 12, 14). Stem cuttings of these species often root in high percentages and develop healthy root systems, yet fail to break bud the following spring after a period of winter dormancy. If budbreak does occur with a resumption of growth, the new growth often withers and the cuttings soon die.

Low carbohydrate levels of rooted cuttings is the most widely offered explanation regarding the inability to overwinter rooted stem cuttings of particular woody species (2, 7, 12, 17). It has been reported that survival of rooted cuttings can be increased if new growth is initiated following rooting (8, 9, 12, 17). Stimart and Goodman (14) suggested that increased survival is accomplished by replenishing carbohydrates that were either low in the cuttings at the time they were taken for rooting or were utilized during the rooting process. Research has demonstrated that carbohydrate reserves increase in rooted cuttings that resume growth following rooting and that carbohydrate levels in cuttings are important in overwinter survival (12).

Softwood cuttings of *S. ovata* can be rooted in high percentages when treated with indolebutyric acid (IBA) at concentrations ranging from 5000 to 10,000 ppm (1). However, recent studies have reported that high concentrations of IBA may inhibit subsequent budbreak on stem cuttings of certain taxa (16) and are therefore undesirable.

Nitrogen fertilization of rooted cuttings has also been reported to be detrimental to overwinter survival (3, 11, 15). Overwinter survival of rooted stem cuttings of *Acer palmatum* Thunb. 'Bloodgood' (Japanese maple) and *Cornus florida*

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L. var. *rubra* (red bracted flowering dogwood) was greatest when N fertilization was excluded. Smalley and Dirr (11) suggested that fertilization of rooted cuttings should not be utilized to induce budbreak but to promote growth after budbreak has been initiated. Pellet and Carter (10), however, emphasized that mineral nutrient deficiencies can also compromise cold hardiness in plants.

Donnely and Yawney (2) studied the influences of various storage conditions on overwinter survival of rooted stem cuttings of *Acer saccharum* Marsh. (sugar maple). Overwinter survival was higher for rooted cuttings stored at 1C (34F) for 5 months in comparison to those planted directly outdoors into the nursery in the fall. Fordham (4) reported that rooted cuttings of *Stewartia* spp. will survive and grow following storage at 1C (34F) for 3 to 4 months.

To develop further information on stem cutting propagation and overwinter survival of rooted stem cuttings of *S. ovata,* the following research was conducted to 1) determine the influence of IBA treatment on rooting softwood cuttings, 2) evaluate the influence of medium amendments and N fertilization on subsequent growth and overwinter survival, and 3) study the influence of chilling duration following rooting on budbreak survival and subsequent shoot growth.

Materials and Methods

IBA treatment (Experiment 1). On June 19 and July 23, 1992, softwood cuttings were taken from a native stand of *S. ovata* growing in Swain County NC (lat. 36° N, long. 84° W) and from a single specimen growing at the Botanical Gardens at Asheville, Asheville, NC (lat. 35° N, long. 82° W), respectively. Cuttings were taken throughout the entire crown of each tree. Dates selected for obtaining cutting material coincided with the range of optimum dates reported from other work for the same species (1).

Cuttings were collected, placed in plastic bags in a cooler, and transported to the Mountain Horticultural Crops Research Station greenhouse at Fletcher, NC. Cuttings were prepared by making a fresh cut on the basal portion of each cutting and stripping the leaves from the lower portion of a cutting leaving one to two leaves. For each date, cuttings from both sources were pooled. Due to substantial variation in length of the current year's growth among trees, final cutting lengths ranged from 4 to 9 cm (1.5 to 3.5 in).

Following preparation, the basal 3 cm (1.2 in) of each cutting was treated with 0, 1000, 2000, 4000, or 8000 ppm IBA (reagent grade IBA in 50% isopropyl alcohol) for 5 sec and then allowed to air dry before insertion to an approximate depth of 3 cm (1.2 in) in 5 × 5 cm (1.96 × 1.96 in.) pots (one cuttings per pot) containing a medium of perlite:peat (3:1 by vol). Pots were placed on a raised greenhouse bench in a randomized complete block design with 5 cuttings per treatment and 14 replications. Cuttings were placed under intermittent mist regulated by a screen balance mist controller.

Cuttings were subjected to supplemental lighting (high pressure sodium bulb providing an irradiance of 50–60 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetically active radiation) at the end of each day for an additional 5 hr providing a 17-hr photoperiod. After 8 weeks, cuttings were evaluated for percent rooting and root index. Root index was calculated by multiplying the maximum width and depth of the root system. Standard analysis of variance procedures were used for data analysis.

Medium amendments and N fertilization (Experiment 2). Softwood cuttings of *S. ovata* were rooted in the following media: B1 (pine bark no amendments), B2 (pine bark plus 2.96 kg/m^3 (5 lbs/yd^3) dolomitic lime), and B3 (pine bark plus 2.96 kg/m^3 (5 lbs/yd^3) dolomitic lime, 3.56 kg/m^3 (6 lbs/yd^3) Esmigran (Scott Company, Marysville, OH), 0.89 kg/m^3 (1.5 lbs/yd^3) KNO_3, and 3.2 kg/m^3 (5.4 lbs/yd^3) 0–17–0). The pH of medium B1, B2, and B3, following preparation, was 4.4, 6.0, and 5.6, respectively. Three weeks after sticking, the cuttings received 0, 50, 100, or 200 ppm N (from KNO_3) applied weekly to container flow through. Cuttings also received weekly liquid applications of the following mineral nutrients: 31 ppm phosphorous, 39 ppm potassium, 50 ppm magnesium, 5 ppm iron, and 200 ppm calcium , plus trace elements provided with 67 ppm STEM (Soluble Trace Element Mix, Scott Company). The experimental design was a randomized complete block design with a factorial arrangement of treatments (3 medium amendments by 4 N rates) and 30 single plant replications per treatments.

Softwood cuttings from trees in Swain County and the Botanical Gardens at Asheville were taken on June 10, 1993. Cuttings were prepared as described previously except that all cuttings were treated with 3000 ppm IBA. Cuttings were inserted directly into 0.95 liter (1 qt) plastic pots containing one of the three pine bark media as described previously. The pots were placed under intermittent mist. Cuttings were subjected to long days by providing a 4-hr night interruption from 10:00 pm to 2:00 am daily. On September 3, 1993, rooted cuttings were placed in a greenhouse under natural photoperiod without fertilization for acclimation prior to overwintering. Cuttings were evaluated for post-propagation budbreak on October 12, 1993. On November 3, 1993, the rooted cuttings were placed in a cooler at 6C (43F) for 10 weeks to simulate a natural overwintering period. The pots were placed on shelves and covered with polyethylene sheeting to prevent desiccation. After 10 weeks the cuttings were moved to a heated greenhouse at approximately 21C (70F) with a 4-hr night interruption daily from (10:00 pm to 2:00 am) and evaluated for survival based on the initiation of shoot growth (budbreak). Standard analysis of variance procedures were used for data analysis.

Chilling duration (Experiment 3). Rooted cuttings growing in medium B3 and having received no additional fertilizer were transferred to a cooler at 6C (43F) on November 3, 1993, to simulate overwintering conditions. Pre-chilling and chilling environments were similar to those described for experiment 2. At 0, 2, 4, 6, 8, and 10 weeks, 18 pots were selected at random, removed from the cooler, and set in a greenhouse at 21C (70F) with a 4-hr daily night interruption (10:00 pm to 2:00 am). Plants moved to the greenhouse received weekly applications of a water soluble fertilizer containing 100 ppm N and other nutrients as described previously for experiment 2. Cuttings were evaluated for budbreak, shoot growth, and survival.

Results and Discussion

IBA treatment (Experiment 1). Rooting percentages were highest for cuttings taken on June 19, 1992 (Table 1). Rooting percentages showed a quadratic response to increasing rate of IBA with a maximum of 95% at 2000 and 4000 ppm IBA. The second group of cuttings taken on July 23, showed

Table 1. **Effects of IBA treatments on the rooting response of softwood cuttings of *Stewartia ovata* taken on two dates.**

	June 19, 1992		July 23, 1992	
IBA concn. (ppm)	Rooting (%)	Root index (cm^2)	Rooting (%)	Root index (cm^2)
0	50	4.3	47	6.8
1000	91	11.5	48	9.3
2000	95	18.4	65	12.8
4000	95	18.2	79	21.3
8000	90	12.7	66	18.8
Linear	**	**	**	**
Quadratic	**	**	**	*

*, ** Significant at $P \leq 0.05$ or ≤ 0.01, respectively.

a similar quadratic response to increasing rate of IBA with a maximum of 79% at 4000 ppm IBA. In subsequent work (experiments 2 and 3) it was observed that cuttings taken on June 10, 1993 and treated with 3000 ppm IBA rooted at 92%.

Root index responded quadratically to increasing rates of IBA regardless of cutting date (Table 1). Optimum rates of IBA for maximizing root index ranged from 2000 to 4000 ppm and 4000 ppm for cuttings taken in June or July, respectively.

Medium amendments and N fertilization (Experiment 2). A significant interaction existed between medium amendments and N rate for budbreak prior to overwintering (Table 2). Increasing N rate up to 200 ppm weekly, stimulated budbreak, especially for cuttings in the B1 bark mix. Stimulating a second flush of growth has been associated with increased overwinter survival in a number of taxa including species of *Acer, Cornus, Quercus* L. (oaks), and *Viburnum* (3, 11, 12, 14). Nitrogen fertilization prior to overwintering in cuttings that have not broken bud has been reported to be detrimental to survival of cuttings of some species (3, 5, 15).

There was no interaction between medium amendments and N rate on survival. However, rooted cuttings grown in media B1 (pine bark, no amendments) and B2 (pine bark with dolomitic lime) had greater overwinter survival with main effect means of 82% and 83%, respectively, while the cuttings in medium B3 (pine bark with dolomitic lime and nutrient amendments) had lower overwinter survival of 61%. Rate of N had no significant effect on overwinter survival. However, increased N rates prior to overwintering increased shoot growth the following growing season, particularly for plants growing in unamended pine bark (Table 2).

Table 2. **Effects of nitrogen rate and medium fertilization on budbreak prior to overwintering, and survival and shoot growth following overwintering of rooted stem cuttings of *Stewartia ovata*.**

Medium[z]	N rate (ppm)	Budbreak (%)	Survival (%)	Shoot growth (cm)
B1	0	0	84	1.6
	50	0	79	3.1
	100	0	81	4.7
	200	37	81	11.6
B2	0	0	92	1.6
	50	4	86	1.7
	100	0	89	2.9
	200	8	63	8.7
B3	0	0	63	1.0
	50	0	58	1.4
	100	0	60	3.0
	200	4	64	5.4
	Medium (M)	**	**	**
	N rate (N)	**	NS	**
	M × N	**	NS	*

[z]B1 = pine bark, no additives; B2 = pine bark plus dolomitic lime [2.96 kg/m^3 (5 lbs/yd^3)]; B3 = pine bark plus dolomitic lime [2.96 kg/m^3 (5 lbs/yd^3)], Esmigran [3.56 kg/m^3 (6 lbs/yd^3)], KNO3 [0.89 kg/m^3 (1.5 lbs/yd^3)], and 0-17-0 [3.2 kg/m^3 (5.4 lbs/yd^3)].

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

Chilling duration (Experiment 3). A significant chilling duration by forcing period interaction was noted for both budbreak and shoot length. Increasing chilling from 0 to 10 weeks stimulated both budbreak (Fig. 1A) and shoot growth (Fig. 1B) as weeks of forcing increased. Following 12 weeks

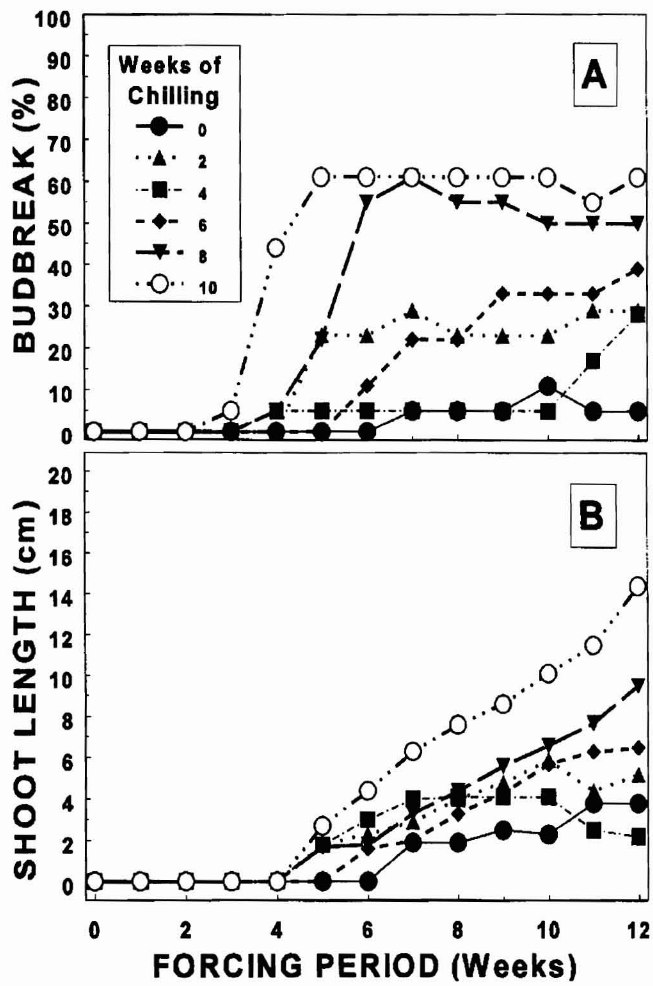

Fig. 1. **Budbreak (A) and shoot growth (B) response of rooted stem cuttings of *Stewartia ovata* following 0 to 10 weeks of chilling. Legend in (A) applies to both figures.**

of forcing, both budbreak and shoot growth were positively correlated with weeks of chilling ($r = 0.97$ and 0.85, respectively).

These data indicate that overwinter survival of rooted stem cuttings of *S. ovata* is influenced by the duration of chilling during the overwintering period. This might explain why some growers (Per. Comm.) in warmer regions experience difficulty in overwintering rooted cuttings of *S. ovata*. Cuttings that are overwintered in a typical structure covered with white polyethylene are exposed to fluctuating temperatures that might not satisfy the chilling requirements to insure budbreak and survival the following spring.

Literature Cited

1. Dirr, M.A. and C.W. Heuser. 1987. The Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture. Varsity Press, Athens, GA.

2. Donnely, J.R. and H.W. Yawney. 1972. Some factors associated with vegetatively propagating sugar maple by stem cuttings. Proc. Intern. Plant Prop. Soc. 22:413–430.

3. Drew, J.J., M.A. Dirr, and A.M. Armitage. 1993. Effects of fertilizer and night interruption on overwinter survival of rooted cuttings of *Quercus* L. J. Environ. Hort. 11:97–101.

4. Fordham, A.J. 1982. *Stewartia*—propagational data for ten taxa. Proc. Intern. Plant Prop. Soc. 32:476–481.

5. Goodman, M.A. and D.P. Stimart. 1987. Factors regulating overwinter survival of newly propagated stem tip cuttings of *Acer palmatum* Thunb. 'Bloodgood' and *Cornus florida* L. var. *rubra*. HortScience 22:1296–1298.

6. Lamb, J.G.D. 1976. The propagation of understocks for *Hamamelis*. Proc. Intern. Plant Prop. Soc. 26:127–130.

7. Loach, K. and D.N. Whalley. 1975. Use of light, carbon dioxide enrichment and growth regulators in the overwintering of hardy ornamental nursery stock cuttings. Acta Hort. 54:105–116.

8. McConnell, J.F. and D.E. Herman. 1980. The effect of gibberellic acid and benzyladenine in inducing budbreak and overwintering of rooted softwood cuttings. Proc. Intern. Plant Prop. Soc. 30:398–404.

9. Nienhuy, H.C. 1980. Propagation of deciduous azaleas. Proc. Intern. Plant Prop. Soc. 30:457–459.

10. Pellet, H.M. and J.V. Carter. 1981. Effect of nutritional factors on cold hardiness of plants. Hort. Reviews 144–171.

11. Smalley, T.J. and M.A. Dirr. 1986. The overwinter survival problems of rooted cuttings. The Plant Propagator 32(3):10–14.

12. Smalley, T.J., M.A. Dirr, and G.G. Dull. 1987. Effect of extended photoperiod on budbreak, overwinter survival, and carbohydrate levels of *Acer rubrum* 'October Glory' rooted cuttings. J. Amer. Soc. Hort. Sci. 112:459–463.

13. Spongberg, S.A. 1974. A review of the deciduous-leaved species of *Stewartia* (Theaceae). J. Arnold Arboretum 55:182–214.

14. Stimart, D.P. and M.A. Goodman. 1985. Overwinter survival of newly-propagated stem cuttings of certain deciduous woody plants. Proc. Intern. Plant Prop. Soc. 35:526–532.

15. Stimart, D.P., M.A. Goodman, and E.N. Ashworth. 1985. The relationship of shoot growth and nitrogen fertilization to cold hardiness of newly rooted *Acer palmatum* Thunb. 'Bloodgood' stem cuttings. Scientia Hortic. 27:341–347.

16. Sun, W.Q. and N.L. Bassuk. 1991. Effects of banding and IBA on rooting and budbreak in cuttings of apple rootstock 'MM 106' and *Franklinia*. J. Environ. Hort. 9:40–43.

17. Waxman S. 1965. Photoperiodic treatment and its influence on rooting and survival of cuttings "lighting under mist". Proc. Intern. Plant Prop. Soc. 15:94–97.