Research Reports

Survival and Growth of *Stewartia pseudocamellia* Rooted Cuttings and Seedlings[1]

Daniel K. Struve and L. Mark Lagrimini[2]
Department of Horticulture and Crop Science
The Ohio State University, Columbus, OH 43210-1086

Abstract

Japanese Stewartia, *Stewartia pseudocamellia (*Maxim.*),* cuttings were rooted and seeds germinated to compare growth and survival of the two plant types. Softwood cuttings collected from 18-month-old, 1 to 1.3 m (3 to 4 ft) tall stock plants were rooted successfully (greater than 64%) at two propagation times by giving severed cuttings a basal quick dip in 0.1 M ascorbic or caffeic acid, before a basal quick dip in 100 ppm indolebutyric acid (IBA). Cuttings were overwintered in either a minimum heat (3C, 35F) polyhouse (89% survival), or in a 7C (45F) cooler (97% survival). There was no difference in height following overwintering, but by the end of the first growing season following propagation, seedlings were significantly taller than rooted cuttings, 84 vs 72 cm (33 vs 28 in), respectively. Although growth was vigorous, survival after upcanning was poor; rooted cutting survival was 17%, seedling survival was 48%. This study demonstrates that Japanese Stewartia can be propagated readily by softwood and semi-hardwood stem cuttings dipped in low IBA concentrations if cuttings are pre-treated with either ascorbic or caffeic acid. These cuttings can also be overwintered successfully.

Index words: Japanese Stewartia, sexual and asexual propagation, rooted cuttings, overwinter survival.

Growth regulator used in this study: indolebutyric acid (IBA).

Significance to the Nursery Industry

Japanese Stewartia is a valuable landscape species whose availability is limited by effective propagation techniques including a narrow propagation window for rooted cuttings. When vigorous-growing 18-month-old seedlings were used as stock plants, softwood stem cuttings (taken in early June) were rooted in high percentages (90%) with low auxin concentrations (100 ppm IBA). The propagation window can be extended into August if cuttings are first treated with a basal dip in 0.1 M ascorbic or caffeic acid before being given a basal quick dip in a 100 ppm IBA solution. Cuttings from both propagation times can be successfully overwintered. Growth of seedlings over an 18-month period was greater than that of rooted cuttings. Based on the results of this study, seedlings grew more vigorously than rooted cuttings. However, a final recommendation on whether seedlings are superior to rooted cuttings must wait until long-term performance results available.

Introduction

Japanese Stewartia is a desirable landscape species that possesses year-round ornamental interest (2, 3, 21). Its availability is limited by propagation protocols. Seeds are recalcitrant and desiccate rapidly (16) and require sequential warm-cold stratification periods to germinate (3, 4, 14, 16, 18, 21). Stewartia softwood and semi-hardwood stem cuttings are relatively easy-to-root, although high, 3,000 to 8,000

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[2]Associate Professors.

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ppm, auxin solutions are used (1, 4, 6, 7, 10, 11, 17, 21). However, the propagation window is narrow, only two to four weeks (4, 6, 7, 10, 11, 17, 18, 21).

Stewartia cuttings can be rooted successfully, but they are difficult to overwinter (4, 6, 10, 11, 17); although some researchers have reported success (1, 17). Symptoms of overwintering damage in difficult-to-overwinter species include stem splitting at the soil line and no or poor bud break in spring followed by collapse of the shoot system even when the root systems seem to be healthy (9, 19, 22). Overwintering losses of softwood cuttings have been attributed to carbohydrate depletion during rooting (19). Carbohydrate depletion can be overcome and overwintering success ensured by inducing bud break on rooted cuttings before the end of the growing season in which the cuttings were propagated (19). Various treatments have been tried to promote bud break after rooting including extended day length, chemical sprays and/or fertilizer applications (13, 19). Also, delaying transplanting until rooted cuttings have survived their first winter was recommended for Japanese Stewartia cuttings and cuttings of other hard-to-overwinter species (4, 6, 7, 10, 11, 17, 19, 20, 22).

Perkins and Bassuk (17) tested the hypothesis that overwintering survival of carbohydrate-depleted rooted cuttings is promoted by bud break following rooting. They found that Japanese Stewartia cuttings could be successfully overwintered (94% survival) without breaking bud if stored in a 3C (37F) cooler. In contrast, cuttings stored in a cold frame, whether they broke bud or not, could not be overwintered; they suffered 98% mortality. Further, there was no difference in root system carbohydrate content between rooted cuttings that broke bud and those that did not. Thus, they rejected the hypothesis.

In another study, Sun and Bassuk (23) further explored the relationship between auxin application, bud break and cutting survival. They showed that high auxin applications (> 600 ppm IBA) to rose softwood rose cuttings caused increased defoliation and ethelyene biosynthesis, and inhibited bud break after rooting. Silver thiosulfate applications reduced the negative effects of IBA stimulated etheylene biosynthesis, but it also decreased rooting.

A well-characterized plant response to wounding is the production of enzyme peroxidase at the cut site (5). Peroxidase is associated with suberization of the cut surface (15) and many plant peroxidases are effective at metabolizing indole-3-acetic acid (8). The manipulation of peroxidase activity in genetically-engineered plants has resulted in significant growth effects including adventitious root formation (12) as a result of altered steady-state endogenous auxin levels (Wang and Lagrimini, unpublished results). Japanese Stewartia is a member of the Theaceae, a family known to have high peroxidase activity. Therefore, exogenous applications of peroxidase inhibitors or competitors (ascorbic acid and caffeic acid, respectively) may increase rooting in Japanese Stewartia stem cuttings at lower auxin levels.

These experiments were conducted to determine: 1) if an antioxidant (ascorbic acid) or a peroxidase competitive inhibitor (caffeic acid) applied before treating cuttings with a low IBA concentration will promote rooting in Japanese Stewartia cuttings; 2) if these applications will extend the propagation window and increase overwintering success; and 3) if the post-propagation growth of rooted cuttings is similar to that of seedlings.

Materials and Methods

Seed-propagated stock plants were 18 months old and averaged 1 to 1.3 m (3 to 4 ft) in height when the first cuttings were collected. Stock plants were grown in #3 nursery containers (Nursery Supplies, Chambersburg, PA) in a 3:1 (by vol) pine bark:Comtil (composted municipal sewage sludge, Columbus, OH) medium during 1996. Plants were fertigated with 200 mg/liter N from 20N–8.8P–16.6K (Peters 20–20–20, O.M. Scotts, Marysville, OH) from June 1 to July 1 and then fertigated once per week until September 1 in 1996 and 1997. The stock plants were half-sibs; all the seeds were collected from one tree at Dawes Arboretum, Newark, OH, in fall 1994.

For the first propagation time, cuttings 10 cm (4 in) in length, were collected before 10:00 am on June 24, 1997, from upright or vigorous, horizontally growing lateral branches. As cuttings were collected, the basal ends were given a post-severance quick dip in 0.1 M ascorbic acid or caffeic acid solutions or water. After treatment, the cuttings were placed on a tray and kept shaded.

Before sticking, cuttings were given a five-second basal dip in 100 ppm IBA solution and placed in a peat moss:perlite (1:1 by vol) propagation medium. Cuttings were rooted under natural photoperiods under a computer-controlled intermittent mist (Phytotronics Misting Controller, Model 1626, St. Louis, MO) in a randomized complete block design with two 24-cutting replications per treatment.

The first set of cuttings was evaluated for rooting on July 28, 1997, and again on September 30, 1997. A cutting was classified as rooted if there were more than three roots greater than 3 cm (1.25 in) in length. Cuttings not rooted on July 28, 1997, were re-stuck and returned to the propagation house. Rooted cuttings were potted in quart nursery containers (250 XL Classic, Nursery Supplies, Chambersburg, PA) in Metro Mix 360 (O.M. Scotts, Marysville, OH) and placed under 70% shade in a greenhouse for one month to acclimate before being grown in full sun. Rooted cuttings were grown under natural photoperiods, and fertilized once per week with 100 mg/liter N from 20N–8.8P–16.6K.

A second propagation experiment was begun on August 18, 1997. Procedures were similar to the first experiment with two exceptions. Two additional treatments were added: 1) a control in which cuttings received no post-severance dip but a 100 ppm IBA quick dip, and 2) cuttings that received neither a post-severance dip nor a 100 ppm IBA dip. There were two 32-cutting replications per treatment. Cuttings were evaluated on October 15, 1997; rooted cuttings were potted and grown as described above.

Rooted cuttings from the first experiment were placed in a polyhouse on December 15, 1997, for overwintering. The polyhouse was heated to maintain a temperature no lower than 1C (33F). Rooted cuttings from the second experiment were placed in a walk-in cooler set at 7C (47F).

In another experiment, seedlings were germinated between April and June 1996 (16). These seeds were collected from the same mother tree at Dawes Arboretum as the seeds from which the stock plants were raised. The seedlings were grown under the same conditions as the rooted cuttings in 1997 and overwintered in the same minimum heat polyhouse as the rooted cuttings from the first experiment.

On Feburary 16, 1998, all the rooted cuttings and seedlings were returned to a heated greenhouse and grown under natural photoperiods. Plants were fertilized once per week

Table 1. Rooting of Japanese Stewartia stem cuttings from the first propagation time (June 24, 1997).

Post severance treatment[z]	Percent rooting July 28	Percent rooting September 30	Total rooting (%)[w]
Ascorbic acid	69ab[y]	21a	90a
Caffeic acid	81b	15a	96a
Water	63a	27a	90a

[z]Immediately after severing the cutting from the stock plant, cuttings were given a basal quick dip in either 0.1 M ascorbic or caffeic acids, or water. Before sticking, the cuttings were given a basal quick dip in 100 ppm indolebutyric acid (IBA).

[y]Each value is the mean of two, 24-cutting replications. Means within a column followed by different letters are significantly different from each other at the $\alpha = 0.05$ level using Duncan-Waller test.

[w]Total percent rooting was the sum of the rooting percentages on July 28 and September 30 evaluations for each treatment.

Table 2. Rooting of Japanese Stewartia stem cuttings from the second propagation time (August 19, 1997).

Treatment[z]	Rooting (%)
Control	38a[y]
Ascorbic acid + IBA	64b
Caffeic acid + IBA	67b
Water + IBA	28a
IBA	31a

[z]Immediately after severing the cutting from the stock plant, cuttings were given a basal quick dip in either 0.1 M ascorbic or caffeic acids, water or no post-severance treatment. Before sticking, all cuttings were given a basal quick dip in 100 ppm indolebutyric acid (IBA), except for the control cuttings which received neither a post severance basal dip nor an IBA application. Cuttings were evaluated on September 30, 1997.

[y]Means are the average of two 32-cutting replications per treatment. Means within a column followed by different letters are significantly different from each other at the $\alpha = 0.05$ level, using Duncan-Waller test.

with 200 mg/liter N from 20N–8.8P–16.6K. Heights of seedlings and rooted cuttings from the first experiment were measured monthly for three months beginning in February, 1998. Rooted cuttings from the second experiment were smaller than the seedlings, so they were excluded in the height comparison with the seedling-origin plants.

On May 15, 1998, all the plants were moved outdoors to 70% shade for one week. By June 1, all plants were repotted into #3 nursery containers and placed under conditions similar to those of the stock plants in 1997. End-of-season plant heights were measured on November 20, 1998. After each production stage (end of propagation, before overwintering, after overwintering, end of greenhouse phase and at end of season) live plants were counted and percent mortality calculated. Rooting percentages and plants heights were subject to analysis of variance using SPSS for the personal computer. Means were separated using the Duncan-Waller procedure with a significance level of 0.05.

Results and Discussion

At the first evaluation (July 18, 1997) of the first experiment, cuttings treated with caffeic acid and IBA had a significantly greater rooting percentage than cuttings treated with water and IBA (Table 1). There were no significant differences among the treatments at the second evaluation or in the final rooting percentage. Rooting success was greater than 90%, higher than that reported in other studies in which IBA concentrations more than 30 times greater were used (1, 4, 7, 11, 18, 21). Bud break following rooting was low (20%) and not related to treatment.

In the second experiment, cuttings pre-treated with ascorbic acid and caffeic acid rooted with greater success than cuttings pre-treated with water and then IBA, or those given no pre-treatment, and either treated with or without IBA (Table 2). In contrast, pre-treatment with ascorbic or caffeic acids in the first study did not increase total rooting percentage. Overall rooting was better in the first experiment than in the second. The first experiment used softwood cutting; the second experiment used semi-hardwood cuttings. In general, softwood cuttings are more easily rooted than semi-hardwood or hardwood cuttings. The high rooting success achieved in this study is partially attributed to the juvenile stock plants. Although the stock plants were three to four feet tall, they were less than 18 months old. Unfortunately, stock plant age was not given in other studies (1, 4, 7, 11, 18, 21) so comparisons with these studies can not be made.

Overwintering survival was high (Table 3). Of the 131 cuttings rooted in the first experiment, 129 survived through the greenhouse phase. Of the 146 cuttings rooted in the second experiment, 130 (89%) survived. All seedlings survived overwintering.

After overwintering, all plants broke bud. Rooted cuttings from the first experiment averaged 12 cm (4.6 in) of new growth during the greenhouse production phase; seedling heights averaged 13 cm (5.2 in).

Of the 262 rooted cuttings moved outdoors, 186 were repotted to larger containers, with 71% acceptability. Those discarded were judged as either too small or to have suffered too severe leaf scorch during the acclimation phase. All but two of the seedlings were repotted to larger containers, with

Table 3. Survival of Japanese Stewartia rooted cuttings and seedlings at various production stages.

Production stage	Assessment date	Survival (%)	Plant type
Overwintering (December 1997–February 1998)	May 15, 1998	100	Rooted cuttings from first propagation time
		89	Rooted cuttings from second propagation time
		100	Seedlings
Acclimation (May 15–June 1)	June 1, 1998	71	Rooted cuttings
		97	Seedlings
First growing season (June 1–November 20)	November 20, 1998	17	Rooted cuttings
		48	Seedlings
Overall (June 1997–November 20, 1998)		12	Rooted cuttings
		47	Seedlings

Table 4. Height of Japanese Stewartia plants grown from rooted cuttings and seeds at various times.

Plant type	Height (cm) February 16	March 16	April 16	November 20
Rooted cutting[z]	12a[y] (129)[x]	17a	33a	72a (42)
Seedling	21b (64)	24b	35a	84b (32)

[z]Plants were placed in a heated greenhouse under natural photoperiods on February 16, 1998, after overwintering in a minimum heat polyhouse. On May 15, 1998, all plants were transferred outdoors. After June 1, 1998, all plants were grown in #3 nursery containers outdoors.

[y]Means within a column followed by different letters are significantly different from each other at the $\alpha = 0.05$ level, using Duncan-Waller test.

[x]Number of individuals plants within each plant type during the greenhouse and outdoor production phases are given in parenthesis. Rooted cutting plant heights are for plants from the first propagation time, June 24, 1997, and are averaged over the three propagation treatments applied on that date.

97% acceptability. After a two to three week adjustment period to outdoor conditions, growth resumed. Surviving plants more than doubled their April height; however, seedlings were significantly taller than rooted cuttings by November (Table 4). Despite the rapid growth, survival was low. Only 32 of 186 (17%) rooted cuttings survived and 31 of 64 (48%) seedlings survived (Table 4). The cause for low survival is unknown, but it may be attributed to the high fertility program initiated in June; plants were fertilized daily with 200 mg/liter N for one month. Survival for the 18-month study period was 12% for rooted cuttings and 47% for seedlings, but unlike observations in other studies, high mortality did not occur over winter (4, 6, 10, 11, 17, 21). Low overwinter mortality could be attributed to the low IBA concentrations used to root the cuttings. Further, cuttings were successfully overwintered without exposure to artificial long day light treatments applied during or after rooting. This study confirmed the findings of Perkins and Bassuk (17) that Japanese Stewartia cuttings could be overwintered successfully whether or not they broke bud following rooting.

In summary, we found that Japanese Stewartia softwood cuttings can be rooted successfully with 100 ppm IBA. The propagation window can be widened if semi-hardwood cuttings receive a pre-IBA treatment with 0.1 M ascorbic or caffeic acid. Rooted cuttings can be overwintered successfully. Seedling growth was more vigorous than rooted cutting growth during the first growing season after propagation but, long-term results are needed to determine if seedlings are superior to rooted cuttings.

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