Production and Rooting of Shoots Generated from Dormant Stem Sections of Maple Species

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Additional index words. *Acer palmatum*, *Acer rubrum*, *Acer saccharum*, Japanese maple, red maple, sugar maple, vegetative propagation

Abstract. Vegetative shoots were forced in the greenhouse from excised stem (branch) sections of dormant Japanese maple (*Acer palmatum* Thunb.), red maple (*Acer rubrum* L.), and sugar maple (*Acer saccharum* Marsh.). Softwood shoots generated in this way were used as stem cuttings in a subsequent adventitious rooting study. Data indicate that maple shoots can be forced using this technique, but that both the percentage of stem sections forming shoots and the number of shoots produced are highly variable among both species and clones. Whereas Japanese and red maple formed shoots on >50% of stem sections, shoots were generated on only 20% of sugar maple stem sections. Significant variability was also observed in rooting response, with red maple shoots rooting at much higher percentages (60%) than either Japanese maple (26%) or sugar maple (15%).

A number of important ornamental tree species can be propagated vegetatively by stem cuttings. Vegetative propagation allows cloning of superior individuals and makes it possible for nurseries to supply both landscapers and homeowners with uniform planting stock. Certain tree species, including those within the genus *Acer*, may only be rooted in commercially acceptable percentages if cuttings are collected while they are in a softwood or actively growing condition (Dirr and Heuser, 1987). This limits propagation of these species to the relatively short period of the year (spring and early summer) after newly generated shoots have developed sufficient size and before they have ceased active growth.

The ability to generate softwood shoots at additional times of the year would make the scheduling of propagation tasks more flexible, and several methods have been developed to force softwood shoots from woody plant material. For example, Read and Yang (1991) used a forcing solution to stimulate tip growth from dormant woody stems, and subsequently used the shoots both for tissue culture and softwood cuttings.

Softwood shoots can also be forced from axillary buds that are suppressed under ordinary circumstances. These buds often break vigorously in response to heavy pruning and are generally considered undesirable on tree species. However, shoots formed from these buds are of interest to propagators because they may, if collected from the juvenile portion of a tree, have enhanced rooting potential (Hackett, 1985).

Received for publication 3 Feb. 1997. Accepted for publication 23 June 1997. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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It has been shown with several species that stem sections removed from mature trees can be forced to produce shoots and that these shoots can be rooted (Cameron and Sani, 1994; Harmer, 1988; Ikemori, 1987). Harmer (1988), working with dormant 35-year-old oaks (*Quercus* spp.), reported that shoots forced in this manner could be rooted but that the number of shoots generated and the rooting percentage (9% to 65%) were variable depending on clone. Cameron and Sani (1994) forced birch (*Betula* spp.) shoots and reported that rooting declined both with tree age and height from which branch sections were collected.

Development of this forcing technique into a commercially viable practice has received little attention. A number of ornamental tree species can only be rooted as softwood cuttings, and the ability to force and root shoots during the winter would prolong the availability of rooted cuttings and increase the flexibility associated with propagation tasks. Therefore, the objective of this study was to investigate if *Acer* species could be propagated using this method, and to quantify both species and clonal differences that might exist within the genus.

Materials and Methods

Shoot generation. Branches were collected from mature well-established seedlings of Japanese maple, red maple, and sugar maple growing on the campus of Southern Illinois Univ., Carbondale. Branches were collected from the lower crown of three different clones (trees) of each species growing in the same area and of similar height (12 to 15 m) and caliper (35 to 45 cm). Branches were collected on 1 Mar. 1996 before the trees had begun to leaf out. Following collection, branches were cut into sections 50 cm long and between 9.5 and 12.0 cm in average diameter.

Stem sections were stored in black plastic

bags at 4 °C for 4 d, then placed horizontally in black plastic flats filled with horticultural grade coarse perlite. Sections were pressed into the perlite so that about one-half of the diameter was covered, watered well, and placed on benches in a heated greenhouse (75 °C day/60 °C night) under sunlight and natural photoperiod. Flats were watered twice daily for the duration of the experiment.

The experimental design was a randomized complete block with 10 blocks and nine treatments (three clones per species). Each block contained three flats with an individual flat containing one stem section of each clone of each species; sections were blocked by diameter.

Data on number of shoots were subjected to analysis of variance (ANOVA) using the General Linear Model procedure (SAS Institute, Cary, N.C.). Sources of variation included block, species, and clone. Shoots were harvested 28 d after stem sections were placed in flats and every 6 d thereafter for 30 d. Only shoots ≥4 cm long were harvested at a particular collection date.

Rooting of shoots. All shoots generated were used as stem cuttings in the subsequent rooting study. Additional shoots were harvested from stem sections (of the same clones) that were not included within the initial experiment. The experimental design was completely randomized with nine treatments (three species, three clones per species). Species comparisons were based on unequal replication since the number of shoots and their rate of generation varied among species. Timing of harvest was identical to that in the first experiment. At each harvest, the proximal 2 cm of shoots was treated with 0.1% indole-3-butyric acid (IBA; talc formulation), stuck in flats containing a medium of 1 perlite : 1 vermiculite (v/v), and put in a greenhouse under intermittent mist (4 s every 6 min, daylight hours). Greenhouse conditions were similar to those described previously. For purposes of comparison, hardwood shoots (collected at the same time as initial stem sections and stored at 4 °C) were also stuck. Each set of shoots was kept in the rooting media for 40 d, and data were collected on rooting percentage and number of roots formed.

Data on root number were subjected to ANOVA using the General Linear Model procedure. Sources of variation included species and clone within species.

Results

The percentage of stem sections forming shoots was similar for Japanese and red maple (53% to 60%). Only 20% of sugar maple stem sections formed shoots. The percentage of sections forming shoots was highly variable for clones of both Japanese (20% to 80%) and sugar maple (0% to 40%), but less so for red maple (50% to 70%). When the data set included all stem sections, red maple generated twice as many shoots as Japanese maple (Table 1). Clonal shoot production ranged from 1.0 to 6.9 for red maple and 0.4 to 2.9 for Japanese maple (Table 1). Sugar maple averaged ≤0.5 shoots per section.

Table 1. Shoot production from excised stem sections of dormant Japanese, red, and sugar maple (10 per clone) and subsequent rooting of shoots.

Maple species	Clone	N	Mean no. shoots			Mean no. roots			Shoots forming roots
			All stem sections	N	Stem sections forming shoots	N	All shoots	N	
Japanese	All	30	1.9	16	3.6	103	0.8	27	3.2
Red	All	30	4.0	18	6.5	212	3.4	125	5.7
Sugar	All	30	0.2	6	1.2	13	0.4	2	2.5
		Significance	**		**		**		**
		t test 5%	1.4		2.2		0.8		1.1
		t test 1%	1.9		3.1		1.1		2.4
Japanese	1	10	2.9	8	3.6	47	0.5	9	2.4
	2	10	0.4	2	2.0	13	0.5	3	2.0
	3	10	2.5	6	4.2	43	1.4	15	3.9
		Significance	**		NS		*		*
		t test 5%	1.7				0.7		1.4
		t test 1%	2.4						
Red	1	10	1.0	5	2.0	15	2.0	8	3.8
	2	10	6.9	7	9.9	139	3.2	82	5.5
	3	10	3.8	6	6.3	58	4.1	35	6.8
		Significance	**		*		**		**
		t test 5%	3.6		3.0		1.2		1.5
		t test 1%	5.0		4.3		1.6		2.0
Sugar	1	10	0	0	0	0	0	0	0
	2	10	0.5	4	1.3	8	0	0	0
	3	10	0.2	2	1.0	5	1.0	2	2.5
		Significance	*		NS		NS		NS
		t test 5%	0.4						

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

When the data set was confined to stem sections that formed shoots, average shoot number ranged from 1.2 for sugar maple to 6.5 for red maple. Red maple clones differed significantly ($P \leq 0.05$) in number of shoots produced, but clones of Japanese maple and sugar maple did not (Table 1).

Red maple shoots rooted at higher percentages (59%) than either Japanese (26%) or sugar maple (15%). Clonal variation in rooting response was generally less than that observed for shoot generation. Hardwood cuttings failed to form a single root regardless of clone.

When the data set included all shoots, red maple cuttings produced four times as many roots per shoot than either Japanese or sugar maple (Table 1). Significant ($P \leq 0.05$) clonal differences were evident in both Japanese and red maple. When the data set was confined to

shoots that formed roots, root number varied significantly ($P \leq 0.01$) among species (Table 1). Clonal effects were significant for both Japanese and red maple.

Discussion

Our results indicate that softwood shoots of maple species can be forced from dormant stem sections and that these shoots may be rooted. As reported for oak (Harmer, 1988), the percentage of stem sections forming shoots varies between both species and clones. Therefore, nurseries should screen various clones before using this technique. Higher auxin levels should be evaluated as they may increase uniformity of the rooting response.

This method would increase the length of a crop's first growing season since propagation need not be delayed until completion of nor-

mal shoot development. This would be useful on species, such as Japanese maple, which must produce a postpropagation growth flush to overwinter successfully and break bud vigorously the following spring (Dirr and Heuser, 1987).

An additional benefit of this method is that it may be accomplished under controlled conditions (greenhouse), permitting optimization of cultural conditions and easy monitoring of shoot development (Harmer, 1988). Whereas forcing of shoot tips requires the use of specific solutions (Read and Yang, 1991), this technique requires only materials commonly on site in any propagation operation. Also, because some tree species have large numbers of suppressed buds (Kramer and Kozlowski, 1979), the quantity of shoots that may be generated for use in cutting propagation is potentially much greater than that which can be generated through shoot tip forcing. With further refinement, this technique has potential to increase the efficiency of propagators in the nursery industry. Additional studies are under way to identify species/clones that have an enhanced ability to form shoots, and to improve methodology so that both the percentage of stem sections forming roots and the number of softwood shoots produced per stem section can be increased.

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