Propagation of Selected Clones of Eastern Redbud (*Cercis canadensis*) by Stem Cuttings[1]©

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Two experiments, one utilizing softwood cuttings and the other semi-hardwood cuttings, were conducted to investigate the influence of growth stage and auxin treatment on rooting four related clones of eastern redbud (*Cercis canadensis* L.). The clones were *C. canadensis* 'Flame', dwarf white, and two selections (99-6-1 and 99-6-2) of an F_1 generation of a cross of 'Flame' and dwarf white. At each growth stage, rooting responses of the clones varied and were influenced greatly by auxin treatment demonstrating the variable rooting potential of the genotypes. In both studies, *C. canadensis* 'Flame' performed well (63% rooting when treated with 5000 ppm K-IBA in the softwood study, 83% rooting when treated with 10,000 ppm K-IBA in the semi-hardwood study), indicating stem cuttings may be a commercially feasible means of propagation for 'Flame'. For the softwood cutting study, cuttings of Dwarf white (46%) and 99-6-2 (75%) rooted best when treated with 15,000 ppm K-IBA. Softwood cuttings of 99-6-1 rooted most successfully (46%) when treated with 10,000 ppm K-IBA. Dwarf white and the F_1s rooted poorly in the semi-hardwood study.

INTRODUCTION

Landscapers covet small flowering trees such as eastern redbud, and several selections are available, each bringing interest to the garden (Raulston, 1990). Stem cuttings of redbuds are reportedly difficult to root (Dirr and Heuser, 1987; Raulston, 1990), and nurserymen commonly use chip-budding, T-budding, or tissue culture to propagate desirable clones. These techniques require significant skill and time and are a limitation to wider utilization of redbuds in the landscape. Additionally, trees propagated by budding may be prone to disease and can develop problems at the bud union (Dennis J. Werner, North Carolina State University, personal communication). Many species propagated via tissue culture tend to lack vigor, and there are anecdotal reports of this occurring in redbuds. Thus, developing protocols for rooting stem cuttings of redbud would offer a simpler means of propagation and may yield more vigorous, problem-free plants.

Previous research on propagating eastern redbud by stem cuttings has yielded mixed results. Tipton (1990) working with *C. canadensis* var. *mexicana* (Rose) M. Hopkins (Mexican redbud) reported predicted maximum rooting response was 88% for cuttings taken 4 weeks after budbreak and treated with 21,000 ppm K-IBA [potassium salt (K-salt) of indolebutyric acid (IBA)]. Similarly, Dillion and Klingaman (1992) found high rooting (94%) of cuttings of a clone of *C. canadensis* taken 3 weeks after growth began and treated with 20,000 ppm IBA. In addition, Pooler and Dix (2001) reported 56% rooting of semi-hardwood cuttings of eastern

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redbud taken from plants in the juvenile growth phase. In contrast, Murphy (2005) attempted to propagate 'Forest Pansy' eastern redbud by hardwood cuttings and was unable to root a single cutting. Other anecdotal reports of attemPts to root softwood and semi-hardwood cuttings of 'Forest Pansy' support findings of Murphy (2005) and others (Dennis Werner, North Carolina State University, personal communication; Wooldridge et al., unpublished data). The aforementioned studies suggest genotype plays a large role in the rootability of *C. canadensis*. Therefore, two studies were conducted to investigate the effect of auxin treatment and growth stage on rooting stem cuttings of four related clones of *C. canadensis*.

MATERIALS AND METHODS

The experiments were both 4 × 4 factorials in a randomized complete block design with four replications and six cuttings per replication. The main factors were four clones: 'Flame', dwarf white (an unreleased selection of the J.C. Raulston Arboretum), and two selections (99-6-1 and 99-6-2) of an F_1 generation of a cross of 'Flame' and dwarf white; and four rates of K-IBA (0, 5000, 10,000, or 15,000 ppm). For each clone, cuttings were taken from a single tree in the adult growth phase. Trees of 'Flame' and dwarf white were located at the J.C. Raulston Arboretum, Raleigh, NC, while trees of the F_1 selections were located at the Sandhills Research Station, Jackson Springs, N.C. In the first study, softwood cuttings were taken approximately 6 weeks after budbreak on 10 May. For all four clones, the leaves of the softwood cuttings were not fully expanded and the stems were green. When the softwood cuttings were flexed, the stem broke without a snapping sound and remained attached. In the semi-hardwood study, cuttings of dwarf white, 99-6-1, and 99-6-2 were taken 7 July. At that time, the 'Flame' tree was judged to be in an earlier growth stage than the other trees, and cuttings were not taken until 2 weeks later on 24 July. For all the semi-hardwood cuttings, the leaves were fully expanded and stems were a medium brown color. When pressure was applied, the stem broke with a snapping sound, but did not separate.

During preparation of the cuttings at both stages of growth, terminal succulent growth was removed to the first or second distal node. The cuttings were trimmed at the base, resulting in a final length of 15 cm (6 in.), and leaves were removed from the basal 5 cm (2 in.). Leaves larger than 10 cm (4 in.) in width were cut in half perpendicular to the midrib and the basal 2 cm (0.8 inches) of each cutting was dipped for 2 sec in a solution of K-IBA at 0, 5000, 10,000, or 15,000 ppm. After 15 min of air-drying of the IBA solutions, each cutting was set in a plastic Anderson Deep Tree Band (Anderson Tool and Die, Portland, Oregon) [6 × 6 × 12 cm (2.4 × 2.4 × 5 in.)] containing peat and perlite (1 : 1, v/v) and placed under intermittent mist in a greenhouse. The mist operated from 7 AM to 7 PM for 4 sec every 10 min in the softwood study and 4 sec every 8 min in the semi-hardwood study. The greenhouse was maintained at days/nights of 21/16 °C (70/60 °F). Cuttings were left in the mist for 8 weeks. The softwood study was terminated 5 July. Semi-hardwood cuttings of dwarf white, 99-6-1, and 99-6-2 were removed and evaluated 18 Sept. Semi-hardwood cuttings of 'Flame' were removed and evaluated 2 Oct. A cutting having one primary root ≥ 1 mm (0.04 in.) in length was classified as rooted. After recording the number of primary roots, the length of each root was measured for the softwood study. In the semi-hardwood study, the number of roots was recorded and root length and root area were obtained using a Monochrome Agvision System 286

Image Analyzer (Decagon Devices, Inc., Pullman, Washington). For both studies, the roots were dried at 65 °C for at least 48 h and then weighed. Rooting percentages were calculated and all data were subjected to analysis of variance (ANOVA) and regression analysis, where appropriate. When regression analysis was significant, simple linear and polynomial curves were fitted to data. The maximum of the polynomial curve was calculated as a first order derivative of the independent variable where the dependent variable equaled zero.

RESULTS

Rooting percentage, root number, root length, and root dry weight in the softwood study were significantly affected by clone and K-IBA treatment, whereas the clone by K-IBA rate interaction was not significant (Table 1). The response ranged from 0% rooting for nontreated stem cuttings of 99-6-1 to 75% for cuttings of 99-6-2 treated with K-IBA at 15,000 ppm (Table 2). For this treatment, cuttings of 99-6-2 that rooted had a mean of 6.1 primary roots, a mean total primary root length of 30.6 cm (12.0 in.), and a mean root dry weight of 25 mg (0.0009 oz). While 99-6-2 had the highest rooting percentage, cuttings of 'Flame' also rooted in moderate percentages (63% for cuttings treated with 5000 ppm K-IBA). Cuttings of 'Flame' treated with 10,000 ppm K-IBA produced larger root systems than any other treatment-clone combination (Table 2). These rooted cuttings had a mean of 13.0 roots, a mean total root length of 57.3 cm (22.6 in.), and a mean root dry weight of 45.6 mg (0.0016 oz).

For semi-hardwood cuttings taken in July, rooting percentage was again affected by clone and K-IBA treatment. In addition, there was a significant clone by K-IBA rate interaction (Table 3). Dwarf white did not root regardless of IBA treatment (data not presented), whereas 83% rooting was noted for stem cuttings of 'Flame' treated with 10,000 ppm (Table 4). Rooted cuttings of 'Flame' treated with K-IBA at 10,000 ppm had a mean of 15.3 primary roots, a mean total root length of 80.9 cm (31.9 inches), and a root dry weight of 77 mg (0.0027 oz) (Table 4). The rooting response of semi-hardwood cuttings of 'Flame' to K-IBA treatment was quadratic (R^2 = 0.74) with maximum rooting percentage predicted at 10,250 ppm. In contrast to 'Flame', all measured variables of 99-6-1 and 99-6-2 were unaffected by rate of K-IBA (Table 4).

DISCUSSION

At both stages of growth, clones of *C. canadensis* responded differently. In the softwood cutting study, 'Flame' outperformed dwarf white for each response measured. The F_1s generally performed at a level intermediate to 'Flame' and dwarf white (Table 2).

Although these studies were not designed to test the influence of growth stage on rooting, dwarf white, 99-6-1, and 99-6-2 rooted in higher percentages in the softwood study, while 'Flame' had a higher rooting percentage in the semi-hardwood stage. This was surprising as Tipton (1990) as well as Dillion and Klingamen (1992) achieved better results by taking stem cuttings of eastern redbud soon after budbreak.

Based on our results, it appears propagation protocols for clones of eastern redbud should be considered on a case-by-case basis. The clones tested did not respond alike, and 'Flame' did not respond as expected. It is unlikely a single protocol for

Table 1. ANOVAs for rooting percentage, root number, root length, and root dry weight of softwood cuttings of *C. canadensis* as influenced by clone, K-IBA rate, and clone by K-IBA rate interaction.

Treatment	Rooting (%)	Root (no.)	Root length	Root dry wt.
Clone	0.0101	< 0.0001	0.0001	< 0.0001
K-IBA rate	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Clone × K-IBA rate	0.3629	0.2235	0.2393	0.1200

Table 2. Response of softwood cuttings of four clones of eastern redbud to auxin treatment.

Clone	K-IBA (ppm)	Rooting (%)	Root (no.)[z]	Root length (cm)[z]	Root dry wt. (mg)[z]
dwarf white	0	8.3	1.5	2.8	3
	5,000	20.8	3.0	19.5	16
	10,000	37.5	2.1	16.3	22
	15,000	45.8	3.6	17.1	15
Linear		*	NS	NS	NS
Quadratic		NS	NS	NS	*
99-6-1	0	0.0	–	–	–
	5,000	37.5	2.3	9.2	7
	10,000	45.8	6.9	29.1	17
	15,000	41.7	3.8	16.8	14
Linear		**	NS	NS	NS
Quadratic		**	*	*	NS
99-6-2	0	4.2	1.0	1.0	4
	5,000	45.8	4.9	32.2	35
	10,000	41.7	5.2	29.2	24
	15,000	75.0	6.1	30.6	25
Linear		***	NS	NS	NS
Quadratic		NS	NS	NS	NS
'Flame'	0	29.2	3.6	9.3	11
	5,000	62.5	6.4	20.2	19
	10,000	50.0	13.1	57.3	46
	15,000	58.3	10.8	35.6	25
Linear		NS	*	NS	NS
Quadratic		NS	NS	NS	NS

[z]Data are means based on the number of cuttings which rooted.

[NS, *, **, ***]Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.

Table 3. ANOVAs for rooting percentage, root number, root length, and root dry weight of semi-hardwood cuttings of *C. canadensis* as influenced by clone, K-IBA rate, and clone by K-IBA rate interaction.

Treatment	Rooting (%)	Root (no.)	Root length	Root area	Root dry wt.
Clone	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
K-IBA rate	< 0.0001	< 0.0001	0.0002	0.0001	0.0003
Clone x K-IBA rate	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Table 4. Response of semi-hardwood cuttings of three clones of eastern redbud to auxin treatment.

Clone	K-IBA (ppm)	Rooting (%)	Root (no.)[z]	Root length[z] (cm)	Root area[z] (cm^2)	Root dry wt.[z] (mg)
99-6-1	0	0.0	–	–	–	–
	5,000	16.7	1.0	20.4	2.2	5
	10,000	20.8	1.7	29.5	3.0	9
	15,000	12.5	1.5	56.8	5.5	11
Linear		NS	NS	NS	NS	NS
Quadratic		NS	NS	NS	NS	NS
99-6-2	0	4.2	1.0	5.8	0.8	3
	5,000	0.0	–	–	–	–
	10,000	8.3	2.5	12.2	1.1	3
	15,000	20.8	2.1	27.4	2.9	7
Linear		NS	NS	NS	NS	NS
Quadratic		NS	NS	NS	NS	NS
'Flame'	0	12.5	5.8	23.9	3.0	28
	5,000	75.0	11.6	63.1	8.0	61
	10,000	83.3	15.3	80.9	10.4	77
	15,000	75.0	11.6	55.5	8.1	58
Linear		**	NS	NS	NS	NS
Quadratic		**	*	***	**	*

[z]Data are means based on the number of cuttings which rooted.

[NS, *, **, ***]Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.

propagation by stem cuttings would yield satisfactory results for all selections of eastern redbud.

We conclude propagation by stem cuttings may be commercially feasible for particular genotypes of eastern redbud as evidenced by the strong rooting response of 'Flame'. In the softwood study, 'Flame' rooted at 63% with well-developed root systems. In the semi-hardwood study 'Flame' rooted higher at 83% and had even larger root systems. It seems likely 'Flame' can be rooted in good percentages with cuttings taken in May through July. Our research indicates treating cuttings of 'Flame' taken during this period with 10,000 ppm K-IBA will yield the best results.

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