OVERWINTER SURVIVAL OF NEWLY-PROPAGATED STEM CUTTINGS OF CERTAIN DECIDUOUS WOODY PLANTS

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INTRODUCTION

Stem cuttings of deciduous woody plants such as *Acer*, *Cornus*, *Hamamelis*, *Magnolia*, *Prunus*, *Rhododendron*, and *Viburnum* root satisfactorily but either do not survive the first winter or die after spring bud break (1,2,3,4,8,11,14). Inadequate carbohydrate levels to sustain plants during the winter or to support bud break in the spring have been postulated for the overwintering problem (1,11). Shoot growth following rooting improved survival of some species (1,3,4,8), supposedly by carbohydrate replenishment (1,11), but in other studies it had no effect (3,11,19).

Studies have been inconclusive as to the effect of fertilizer applications on cold acclimation. Fuchigami and Weiser (5) reported that plant health and carbohydrates may not be as important for development of vegetative maturity and cold acclimation as plant nutrition and cessation of growth. *Salix purpurea* grown without nitrogen, phosphorus, or sulfur resulted in early growth cessation and early onset of vegetative maturity. Vegetative maturity occurs just prior to the increase in plant cold hardiness (15). Cold acclimation begins at the time of growth cessation (6,20).

The objective of this study was to investigate the effects of cutting time, nitrogen, photoperiod, and shoot growth on survival of newly propagated terminal stem cuttings of *A. palmatum* 'Bloodgood' and *Cornus florida* 'Rubra'.

MATERIALS AND METHODS

Terminal stem cuttings of *A. palmatum* 'Bloodgood' and *C. florida* 'Rubra' were taken at Angelica Nurseries Inc., Chesterville, Maryland. Cuttings momentarily were submerged in water, wrapped in moist burlap and plastic, and placed in flats in the shade. At the University of Maryland, College Park, Maryland they were submerged (a few seconds) in water, rewrapped in burlap, and stored overnight at 4°C.

Cuttings were cut to lengths of 20 cm for *A. palmatum* and 15 cm for *C. florida*. Basal leaves on the cuttings of both species were removed so 4 fully expanded leaves remained. Surface area of *C. florida* leaves was reduced by one third. Four 2.5 cm long vertical basal wounds through the cambium

were made with a razor blade on both species. The bases (2.5 cm) of the cuttings were dipped in water and then a talc powder preparation of 1 H-indole-3-butanoic acid at 20,000 ppm (Hormo-Root 2; Hortus Products Co.) or 4,000 ppm plus Thiram at 15% active ingredient (Hormo-Root B; Hortus Products Co., for *A. palmatum* and *C. florida*, respectively. Cuttings were placed in wooden flats containing moistened medium of equal parts coarse grade perlite and sphagnum peat (v/v) and rooted under intermittent mist.

Rooted cuttings (roots ca 2.5 cm) were transplanted into 10.2 cm square pots (0.5 liter) in a medium of 3 parts sphagnum peat and 2 parts coarse perlite (v/v) amended with 7.5 g fritted trace elements #503 (Peters Fertilizer Products, W.R. Grace & Co., Fogelsville, Pennsylvania), 300 g dolomitic limestone, 80.9 g of ON-19.2P-OK, and 71.2 g of ON-OP-41.5K per 50 liters of medium. Potted plants were returned to the propagation house and misted twice daily for 1 week, then grown in the greenhouse under polypropylene shade fabric (33% light reduction) until 21 September. The greenhouse remained open and unheated until plants were moved outdoors into an open coldframe on 24 November.

Experiment I. The purpose of this experiment was to determine if nitrogen, photoperiod, shoot growth, and type of storage affected overwintering. In 1981, *A. palmatum* and *C. florida* cuttings were taken on 18 June and rooted. At transplanting, half of the rooted *A. palmatum* cuttings had a terminal leaf and petiole detached to expose the subtending bud and promote apical growth (21). Following acclimation, *A. palmatum* from each treatment and *C. florida* were divided between natural day (ND) and long day (LD) (18 hr day continuation from 100 W incandescent bulbs placed 2 m apart and 1.1 m above plants, 9 μmols s^{-1} m^{-2}) photoperiods. Plants were given a constant feed of either 0 or 200 ppm of NH_4NO_3 (N). The ND and LD treatments were continued through 30 October. A completely random design was used within photoperiods. Plants were moved outdoors on 16 November to receive freezing temperatures.

Overwintering storage treatments were begun on 18 December and included microfoam (0.6 cm thickness; Dupont Company, Wilmington, Delaware) covered plants in a cold frame covered with a sash. Plants under microfoam were watered and tipped on their sides before covering. Air temperature changes under the microfoam were recorded every 5 days using a maximum-minimum thermometer until plants were uncovered, set upright, and watered in the spring (10 March 1982). On 10 May data were collected on the number of plants surviving (one active shoot).

Experiment II. The purpose of this study was to determine if combinations of ammonium (NH_4) and nitrate (NO_3) nitrogen equaling 200 ppm nitrogen influenced overwintering. Propagation of terminal stem cuttings from current season's growth of *A. palmatum* 'Bloodgood' and *C. florida* 'Rubra' in 1983 was carried out as described in Experiment I according to the schedule in Table 1. Early season cuttings of *A. palmatum* taken in May and of *C. florida* taken in June consisted of expanding shoots. Late season cuttings of *A. palmatum* taken in June and of *C. florida* taken in July consisted of fully expanded shoots. A shoot was considered expanding if the terminal shoot tip had unfolding leaves, and expanded if leaf unfolding ceased and terminal and lateral buds were set.

Table 1. Dates of cutting harvest, transplanting, and fertilizer application.

Plant	Group	Cutting harvest	Transplanting	Start of fertilization
Acer palmatum 'Bloodgood'	1	May 19	June 29	July 14
	2	June 16	July 18	July 28
Cornus florida 'Rubra'	1	June 16	July 18	July 28
	2	July 11	August 18	August 25

Combinations of NH_4 and NO_3 (Table 2) were applied to each plant (ca 100 ml of solution) once a week at 200 ppm according to the schedule of Table 1 through 27 October 1983. Water was provided until run-off as needed between N treatments.

Overwinter storage in the cold frame was started on 20 December 1983. Plants were overwintered under microfoam as described in Experiment I. Air temperatures were recorded under the microfoam every 5 days until uncovering on 7 March 1984. Media pH were measured on 20 December 1983 of all treatments.

Data were collected on the number of living plants after winter storage (16 May 1984). Plants were rated as dead if external and internal root and stem necrosis was observed.

Table 2. Ammonium and nitrate sources used to equal 200 mg/l of nitrogen.

Treatment (milligrams/liter)		Nitrogen source (grams/liter)			
NH_4^+	NO_3^-	$Ca(NO_3)_2 \cdot H_2O$	NH_4NO_3	$(NH_4)_2SO_4$	NH_4Cl
0	0	0	0	0	0
50	150	0.84	0.29	0	0
100	100	0	0.57	0	0
150	50	0	0.29	0.24	0.19
200	0	0	0	0.47	0.38
0	200	1.68	0	0	0

RESULTS

Experiment I. Overwinter survival was optimum for rooted cuttings of *A. palmatum* and *C. florida* which did not receive N and grew the previous season (Table 3). Those without N and without previous season shoot growth had high survival, but less than plants with shoot growth and not given N. Poorest overwintering occurred on both species which were given N and failed to grow prior to winter storage. Plant dieback following bud break in the spring occurred on both species, but in no detectable pattern (data not presented). No detectable patterns of overwinter survival were related to previous season photoperiod treatments.

Table 3. Percentage of *Acer palmatum* 'Bloodgood' and *Cornus florida* 'Rubra' cuttings surviving overwinter.

			Nitrogen (ppm)			
			0		200	
			Photoperiod[z]			
Plant	Propagation time (Month)	Shoot[y] growth	LD	ND	LD	ND
Acer	June	with	100[x]	100	92	86
		without	88	80	8	13
Cornus	June	with	98	—	66	—
		without	93	88	9	17

[z] ND-natural day length; LD-18 h of light as a day continuation.
[y] After transplanting.
[x] Data collected on May 10, 1982. Values based on 20 to 105 plants.

Experiment II. Survival after overwintering of *A. palmatum* and *C. florida* was maximum when there was no N application the previous season (Table 4). Losses increased on plants receiving N applications as the amount of NH_4 increased compared to NO_3. A higher percentage of plants with shoot growth survived compared to those without. Plants from the later cutting dates had the lowest survival rate.

The average daily minimum and maximum temperatures during winter storage were 0.4° and 19.5°C, respectively. The highest recorded temperature was 30°C while the lowest was −11°C. The pH of the growing medium ranged from 6.3 to 5.7 with no clear trend relating to N treatment.

DISCUSSION

Similar patterns of overwinter survival were observed for *A. palmatum* and *C. florida*. Plants not given N had greatest survival, those with shoot growth receiving N slightly less, and plants without shoot growth plus N had poorest survival. This influence of N resembles cold acclimation responses reported previously for *Viburnum plicatum* f. *tomentosum*, *Cotoneaster*

divaricatus, and *Forsythia* × *intermedia* (10,16). Growth cessation must occur for cold acclimation to begin (6,20). Application of N during the growing season induces late season shoot growth and delays onset of vegetative maturity (5). This may be due to the promotional role of N in protein synthesis (5). Since cold hardiness increases following vegetative maturity (15), plants with delayed vegetative maturity would remain susceptible to cold injury. Nitrogen in our experiments likely delayed vegetative maturity and cold acclimation which resulted in reduced winter survival.

Table 4. Percentage of plants surviving overwinter in response to previous season nitrogen, propagation date, and shoot growth.

			N-form	ppm N					
Plant	Propagation month	Shoot growth	NH_4 NO_3	0 0	50 150	100 100	150 50	200 0	0 200
Acer palmatum 'Bloodgood'	May	with		100[z]	97	100	77	46	97
		without		100	55	88	20	0	44
	June	with		100	100	100	90	100	92
		without		86	41	36	18	0	24
Cornus florida 'Rubra'	June	with		100	67	85	74	29	74
		without		100	0	0	0	0	—
	July	with		100	45	65	0	0	30
		without		91	0	0	0	—	0

[z] Mean of 30 plants.

The prolonged application of NH_4 as a N source for higher plants may disrupt various aspects of metabolism leading to physiological and morphological disorders and death (7,9,12,13). However, some plants grow better with NH_4 than NO_3 as the sole N source (17,18). The data from the present study illustrate similar patterns of plant survival between *A. palmatum* and *C. florida* after overwintering in response to propagation date, shoot growth, and N form. Substantially more plants survived increased levels of NH_4 if plants were propagated early season and shoots grew after rooting. This suggests that NH_4 sensitivity exists in these plants but that seasonal climatic conditions such as temperature or light or the physiological state of the plant, depending on propagation date, may be interacting to create this sensitivity.

The results of the present study clearly suggest that newly rooted plants of *A. palmatum* and *C. florida* are sensitive to NH_4 and NO_3 nitrogen. However, this sensitivity varies throughout the season of propagation in response to the physiological state of the plant and/or climatic conditions. Future studies should investigate the role of temperature and light duration and intensity on their interactions with plant metabolism leading to physiological and morphological disorders. Also, the time of application and the concentration of N being

applied in relation to propagation date should be investigated. Nitrogen fertilization of newly rooted cuttings of *A. palmatum* and *C. florida* should be avoided in the year of propagation until its role is better understood.

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DICK WOLFF: Just a comment on Dr. Stimart's paper. We have found that nitrogen applied late in the season is a killer with *Acer palmatum*. We store our rooted cuttings over winter at about 35°F for two winters because of some stem splitting we have encountered.

MIKE DIRR: Another comment on Dr. Stimart's paper. I have a student who is just finishing research and looking at many of the same things you are. We find that those plants that do break bud have significantly greater quantities of carbohydrate and also overwinter in greater proportion than those that do not.

DENNIS STIMART: I might also add that if you can give short days, you can override the stage 1 cold acclimation with a late season application of ammonium nitrate. How that relates to carbohydrate balance in the plant I do not know.

PRE-SEASON PROPAGATION

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At Decker Nursery we have added a new propagation season to our schedule. This is a spring propagation of softwood or semi-softwood cuttings prior to our usual June, July, or August propagation. Our goal is to produce cuttings of high demand species, rooted directly in cell pacs, ready for container production within 4 to 8 weeks after propagation.

Our method of preseason propagation begins with the propagation medium. This mix is two parts pine bark, two parts styrofoam or its equivalent, and one part sand. Good drainage is the most important factor in this mix; however, it must also serve as a growing mix that will hold together as a root and soil plug.

The propagation containers are sheets of 72 count cell pacs held in a plastic tray. This size cell pac seems to work best for two reasons. First, the cost averages out to less than 0.5 cents