Significance to the Nursery Industry

Nurserymen and scientists may now, by using the techniques and recommendations given in this paper, test large numbers of small woody plants for the ability to compartmentalize trunk wounds. These tests could be applied to large unselected populations of seedling origin or to smaller groups of plants that had already undergone some selection for other desirable landscape characteristics. At the present time, it would appear that the simplest and most accurate method of visualizing the compartmentalization response of very small plants would be by sawing off the tree stem through the wound. This procedure would indeed remove the top of the plant, but the genotype may still be preserved because of the natural tendency of most angiosperm genera to produce sprouts. For material larger than 2 in (5 cm) diameter, an increment borer might be used (3). Trees that show strong wound compartmentalization will be more likely to be landscape assets for longer periods of time and plants exhibiting this trait may be more amenable to propagation by budding and grafting (3).

Literature Cited

1. Garrett, P.W., W.K. Randall, A.L. Shigo, and W.C. Shortle, 1979. Inheritance of Compartmentalization of wounds in sweetgum (*Liquidambar styraciflua* L.) and eastern cottonwood (*Populus deltoides* Bartr.). USDA For. Serv. Res. Paper NE-443, 4 p.

2. Santamour, F.S., Jr. 1979. Inheritance of wound compartmentalization in soft maples. J. Arboriculture 5:220-225.

3. Santamour, F.S., Jr. 1984. Wound compartmentalization in cultivars of *Acer, Gleditsia,* and other genera. J. Environ. Hort. 2:123-125.

4. Santamour, F.S., Jr., P.W. Garrett, and D.B. Paterson. 1980. Oak provenance tests: The Michaux Quercetum after 25 years. J. Arboriculture 6:156-160.

5. Santamour, F.S., Jr., and P. Demuth. 1981. Variation in cambial peroxidase isozymes in *Quercus* species, provenances, and progenies. Northeastern Forest Tree Improv. Conf. Proc. 27:63-71 (1980).

6. Shigo, A.L. 1979. Tree decay—an expanded concept. USDA Forest Service, Agric. Inform. Bull. No. 419, 72 p.

7. Shigo, A.L., and H.G. Marx. 1977. Compartmentalization of decay in trees. USDA Forest Service, Agric. Inform. Bull. No. 405, 73 p.

8. Shigo, A.L., W.C. Shortle, and P.W. Garrett, 1977. Genetic control suggested in compartmentalization of discolored wood associated with tree wounds. Forest Sci. 23:179-182.

Growth Response of *Acer grandidentatum* Nutt. to Chilling Treatments[1]

E. Sorenson,[2] C.F. Williams,[3] R.H. Walser, T.D. Davis, and P. Barker[4]

Department of Agronomy and Horticulture
Brigham Young University
Provo, UT 84602

Abstract

The response of dormant canyon maple (*Acer grandidentatum* Nutt.) seedlings to chilling was investigated. The most rapid, uniform bud break occurred after the plants were chilled for 1,000 or 1,500 hours at 5 °C (41 °F). Plant height and caliper were also greater for chilled plants than unchilled controls. These results suggest that *A. grandidentatum* production can be accelerated by alternately growing the plants in a greenhouse until growth ceases and then chilling them for at least 1,000 hours to overcome rest.

Index words: Chilling requirement, bud break, rest, canyon maple, big tooth maple

Introduction

Acer grandidentatum Nutt. bigtooth or canyon maple, is a potentially useful native landscape plant in the Intermountain West (2, 3) and could be adapted to many areas of the United States. The tree is drought-tolerant, cold hardy, and has attractive fall foliage. Research on canyon maple, however, has been very limited. Canyon maple growth is slow, particularly during the first few growing seasons. Barker (3) observed seedling growth and found that an extensive root system was developed during the first growing season, but shoot growth was only about 5 cm (2 in). Hence, it would take several years to produce a saleable plant under normal growing conditions.

The present work was undertaken to determine if shoot growth of canyon maple could be accelerated using a combination of greenhouse production and induced chilling to promote growth flushes. The requirement of many woody plants to undergo chilling to break rest is well known (1, 4, 5, 6, 7), but the chilling requirement for canyon maple has not been determined.

Materials and Methods

The plants used in this study were grown from seed collected during December from canyon maple growing

[1]Received for publication February 13, 1984; in revised form July 2, 1984.

[2]Former Graduate Research Assistant. Current address: 955 Hulsey Court SE, Salem, OR 97302.

[3]To whom reprint requests should be addressed.

[4]Plant Physiologist, U.S.D.A. Forest Services, Berkeley, CA 94701.

in Logan Canyon, Utah (elevation 1,900 meters [6,500 ft]). The seeds were placed in a peat-perlite mix (1:1 by vol) and stored at 1 °C (34 °F) until the following April at which time they were planted in 10 cm (4 in) pots containing a peat-perlite-soil medium (1:1:1 by vol) and placed in a greenhouse under a natural photoperiod. Greenhouse temperatures were 24-29 °C (75-85 °F) during the day and 18-21 °C (65-70 °F) during the nights. Plants were fertilized bi-weekly with a complete N-P-K liquid fertilizer (20-20-20). The plants remained in the greenhouse until shoot elongation ceased which required a period of about 100 days (mid-August). After this period of growth, plants of uniform size were selected and stored in a walk-in cooler at a temperature of 5 °C (41 °F) for 0, 500, 1000, or 1500 hours (25 plants per treatment). For the 0 hr chilling treatment, plants were defoliated by hand and were left in the greenhouse.

After the chilling treatments, any leaves remaining on the plants were removed and the plants were returned to the greenhouse. Bud break was then monitored daily for the next 56 days. Buds were considered broken when green tips began to show. Lateral as well as terminal bud break was monitored and it was observed that either all buds on a given plant broke or there was no bud break at all. Caliper (10 mm [0.4 in] above soil level) and the increase in plant height were measured after growth ceased which occurred by about 100 days after removal from the chilling treatments. Caliper and average increase in height were calculated considering only plants that exhibited bud break.

Results and Discussion

Unchilled plants had only 56% bud break after 45 days compared to chilled treatments which had 100% bud break (Table 1). Unchilled plants that failed to show bud break did not survive. Bud break was evident in all treatments by the 16th day after chilling. Plants that received either 1,000 or 1,500 hours of chilling, however, reached 100% bud break at 30 days after chilling while plants receiving 500 hours of chilling did not reach 100% bud break until after 45 days. Hence, chilling not only improved total bud break but also increased the rate of bud break. The relatively long period needed to achieve 100% bud break indicates that 1,500 hrs of chilling at 5 °C (41 °F) probably was not adequate to completely overcome rest. Apparently the chilling requirement for canyon maple is similar to that of sugar maple *(A. saccharum)* which requires about 2,000 hours at 5 °C (41 °F) to break rest (9). It does appear, however, that 1,000 hours of chilling is sufficient to induce fairly rapid bud break after plants are transferred to a warm environment.

Chilling did not affect the number of days required to observe the first bud break. In both chilled and unchilled treatments no bud break was observed on the 15th day after chilling but by the 16th day bud break began to be evident in all treatments (Table 1). This suggests that some seedlings require little or no chilling while others require considerable chilling before bud break can occur. Similar variability in chilling requirement has been observed in *Pyrus* seeds collected from the same location (10). These data also illustrate the need for canyon maple to undergo a certain number of days at warm temperatures after chilling before bud break can occur. A similar phenomenon has been observed with other woody species (4, 6, 7, 8). Richardson et al. (7) evaluated the heat requirement for peach tree bud break using a growing degree hour (GDH) model and found that the GDH requirement for 'Redhaven' and 'Elberta' peaches was about 5,000 °C (8,900 °F). Using this model, the GDH requirement for bud break in canyon maple can be approximated using our data. Assuming an approximate daily average greenhouse temperature of 21 °C (70 °F) and a base temperature of 4.4 °C (40 °F) (7), about 400 °C (720 °F) GDH would accumulate every 24 hrs. Because it required 15 days for bud break to occur, the GDH required for canyon maple bud break was approximately 6,000 °C (10,800 °F).

Table 1. Percentage of canyon maple plants that exhibited bud break after the different chilling treatments.

Duration of Chilling Treatment (hrs)	Days After Chilling 15	16	20	25	30	35	40	45	56
0	0[z]	4	4	4	24	40	44	56	56
500	0	4	20	36	80	88	96	100	100
1000	0	4	48	96	100	100	100	100	100
1500	0	4	56	96	100	100	100	100	100

[z]All figures represent 25 plants per treatment.

Chilling had a significant effect on caliper and increase in height (Table 2). Chilling increased caliper by 18-24% compared to controls and there were no significant differences in caliper between the 500, 1,000 and 1,500 hr chilling treatments. Increase in plant height was 48-74% greater in the chilling treatments compared to controls and the length of the chilling period above 500 hours did not influence plant height. These data suggest that the production of canyon maple can be accelerated by artificially chilling the plants for at least 1,000 hours and then forcing growth flushes in the greenhouse.

Significance to the Nursery Industry

This research demonstrates that relatively rapid bud break in canyon maple will occur after 1,000 hours of chilling at 5 °C (41 °F). Hence production can be accelerated by alternately placing the plants in a greenhouse until growth ceases and then chilling them for at least 1,000 hours. Compared to field production, such a production scheme should significantly decrease the time to produce canyon maple plants for landscape use.

Table 2. Effect of different chilling period lengths on canyon maple caliper and increase in height.

Duration of Chilling Treatment (hrs)	Growth[z] Caliper (mm)	Increase in Height (cm)
0	3.4 a[y]	6.5 a
500	4.0 b	10.0 b
1000	4.2 b	11.3 b
1500	4.0 b	9.6 b

[z]Means were calculated considering only plants that exhibited bud break.

[y]Data within a column followed by the same letter are not significantly different at the 5% level according to the Neuman-Keul Multiple Test.

Literature Cited

1. Bachelard, E.P. and F. Wightman. 1973. Biochemical and physiological studies on dormancy release in tree buds. I. Changes in degree of dormancy, respiratory capacity, and major cell constituents in overwintering vegetative buds of *Populus balsamifera*. Can. J. Bot. 51:2315-2326.

2. Barker, P.A. 1974. The spectacular canyon maple. Utah Sci. 35(1):7-10.

3. Barker, P.A. 1975. *Acer grandidentatum* and its propagation. Proc. Intern. Plant Prop. Soc. 25:33-38.

4. Couvillon, G.A. and C.H. Hendershott. 1969. A characterization of the "after rest" period of flower buds of two peach cultivars of different chilling requirements. J. Amer. Soc. Hort. Sci. 95:431-434.

5. Dumbroff, E.B. and D.C.W. Brown. 1976. Cytokinins and inhibitors activity in roots and stems of sugar maple seedlings through the dormant season. Can. J. Bot. 54:191-197.

6. Overcash, J.P. 1963. Heat and chilling requirement for plum blossoming in Mississippi. Fruit Var. Digest. 17:33-35.

7. Richardson, E.A., S.D. Seeley, and D.R. Walker. 1974. A model for estimating the completion of rest for 'Redhaven' and 'Elberta' peach trees. HortScience 9:331-332.

8. Rom, R. and E.H. Arrington. 1966. The effect of varying temperature regimes on degree days to bloom in Elberta peach. Proc. Amer. Soc. Hort. Sci. 88:239-244.

9. Taylor, J.S. and E.B. Dumbroff. 1975. Bud, root, and growth-regulator activity in *Acer saccharum* during the dormant season. Can. J. Bot. 53:321-331.

10. Westwood, M.N. and H.O. Bjornstad. 1968. Chilling requirements of dormant seeds of fourteen pear species as related to their climatic adaptation. Proc. Amer. Soc. Hort. Sci. 92:141-149.

Modeling Transpiration from Selected Urban Shade Tree Species[1]

A.J. Vrecenak and L.P. Herrington[2]
School of Forestry
SUNY-CESF
Syracuse, NY 13210

Abstract

A computer model of transpiration from individual tree crowns was modified, tested and verified using container-grown Norway maple (*Acer platanoides*) and sugar maple *(Acer saccharum),* two widely planted street trees in the Northeastern United States. Within each species, three soil moisture regimes were established to simulate non-drought stressed, moderately drought stressed and severely drought stressed conditions. Model estimates of transpiration were compared to lysimetric determinations as a verification of the model's ability to simulate the transpirational process. Model estimates of average hourly transpiration rates ranged from 6.8 to 55.5 g/m^2/hr (0.24 to 2.00 oz/yd^2 of leaf surface/hr) while lysimetric determinations ranged from 10.4 to 63.4 g/m^2/hr (0.37 to 2.28 oz/yd^2 of leaf surface per hour). The success of the model as a mechanistic simulation of transpiration, its areas of weakness and the need for further research to strengthen the model are discussed.

Index words: computer modeling, transpiration, *Acer saccharum,* sugar maple, *Acer platanoides,* Norway maple

Introduction

The benefits of trees and other vegetation in urban and suburban areas has long been intuitively accepted (14), but the empirical data to either verify or refute intuition have been lacking. If trees are indeed "nature's air conditioners," how much benefit can be expected to be derived from their presence in the landscape? We need to know the role vegetation plays in the overall urban and suburban energy budget to assess its amenity value in those settings.

The characteristic of the "urban forest," as it is called, is the lack of surface homogeneity of its vegetative cover. Due to this inhomogeneity, any study of the vegetative modification of the urban physical environment must consider the system at the level of the individual elements (7). Mechanistic modeling of the transpirational process of individual trees, however, allows for analysis of system function while arriving at estimates of transpirational water use and plant energy exchange.

Of more direct practical application for the nursery industry is the model's use as a predictor of the transpirational water use of individual trees. Any species/cultivar or size of tree under any set of environmental conditions can be simulated by the model, assuming some basic information is available for the plant. The model's output would be very useful in irrigation planning, both in the landscape and in production.

Past efforts in the modeling of transpiration have been directed primarily toward the development of canopy models (3, 5, 16, 17). There has not been a comparable effort in the development of models for trans-

[1]Received for publication March 13, 1984; in revised form July 13, 1984. This research was supported by funds provided by the Northeast Forest Experiment Station of the United States Department of Agriculture Forest Service, through the Northeast Consortium of Environmental Forestry, grant number 23-161.

[2]Address of Senior Author: Assistant Professor of Horticulture, Department of Horticulture and Forestry, Cook College—Rutgers University, New Brunswick, NJ 08903.