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Growth Evaluation of the Norway Maple (*Acer platanoides* L.) Under Different Natural Temperature Regimes[1]

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Abstract

Acer platanoides L. (Norway maple) was evaluated for hardiness and growth potential at eight sites in Quebec and one site in Northeastern Ontario over a period of 5 years. Results show that this maple had a low level of mortality at all sites despite very cold conditions and even grew well in Canadian Zones 4 and 5 (USDA Zone 3). However, trees were more severely damaged in Canadian Zone 2a (USDA Zone 2) and cultivation in this area should be avoided. In Canadian Zones 4 and 5, seedlings were only slightly damaged so production is recommended for these areas.

Index words: hardiness trials, growth.

Species used in this study: Norway maple (*Acer platanoides* L.).

Significance to the Nursery Industry

Previously, production of *Acer platanoides* was limited to USDA Zones 4b to 10a in the west and USDA Zones 4b to 7b in the Midwest and east. However, this study shows that the Norway maple's growth range can be extended to Canadian Zone 2b (USDA Zone 2) where the tree exhibits satisfactory growth and resists cold damage. Tree production in Canadian Zone 2a (USDA Zone 2) should be avoided because of substantial injury and very slow growth. Winter damage to seedlings was minimal in Canadian Zones 4 and 5 (USDA Zone 3) and can therefore be produced commercially in these areas. As a result of these findings, nurserymen will be able to identify new markets for the sale of the Norway maple provided the species characteristics are suited to the zonal weather or other growth conditions.

Introduction

Acer platanoides L. (Norway maple) is indigenous to most of Europe (central and northern Norway to northern Spain) extending into the Caucasus Mountains, Asia Minor and northern Iran (11). This maple was introduced to North America around 1756 and now grows extensively in the eastern and north-central United States as well as in southern Canada (6). This prized ornamental tree is very hardy and has an optimal growing range from USDA Zones 4b to 10a in the west and 4b to 7b in the east and midwest. It is used extensively for street plantings in cities, for shade and for the beauty of its autumn foliage.

Although this maple grows well in the mid-atlantic and new England states (6). These authors further indicated that the northern United States and Southern Canada were considered only marginal areas for growth of this tree because of minimum temperatures of –35°C to –37°C (–25°F to –35°F), although the Norway maple can withstand ice and snow damage better than other maples, Nowak and Rowntree (6) reported also that cold winter temperatures caused a high incidence of frost cracks and sun scald. They recommended that this maple not be grown in most of Canada and the northern plains states. Dumont (1) reported that the Norway also grew well in Montreal (Zone 5a) but that late spring or early autumn frosts could kill or damage these trees. Freezing injuries related to low temperatures appeared as bark splits on the south and south-west side of the trunk as described by Hepting (4).

Potential winter damage to the Norway maple described by Nowak and Rowntree (6) and Hepting (4) is of particular concern to northern growers, landscapers and retailers. Therefore, a testing network called Réseau d'Essais de Plantes Ligneuses Ornementales du Québec or REPLOQ was established in different temperature Zones in Quebec and northern Ontario to study the cold damage to this maple, determine its hardiness under moderate to extreme winter conditions and the effect of temperature on seedling growth. Although a number of other plant species were studied in the REPLOQ network, only the results for the Norway maple are reported here. Detailed information on the network is reported in a previous paper (8).

Materials and Methods

Seeds of Norway maple were harvested in October 1982 from vigorous 40-year-old trees growing on Montreal Botanical Garden collection (Canadian Zone 5a). The seeds were stratified for two weeks immediately after harvest and then sown in a mixture of peat-moss and perlite (1.5:1, by vol). Seedlings grown over a two-year period measured 25 cm (10 in) in height and 4 mm (0.16 in) in diameter. They were shipped to the nine evaluation sites (Table 1) and transplanted in a randomized block design with three replicates of seven plants per replicate. The transplants were spaced 50 cm (20 in) in the row and 2 m (6.5 ft) between the rows. Fertilizer was broadcast at the rate of 54 g (2 oz) of 34-0-0 (NPK) per replicate in the first year. In all subsequent years the plants, in a replicate, were fertilized with 36 g (1.3 oz) of 34-0-0 and 39 g (1.4 oz) of 0-15-30 in May, 36 g (1.3 oz) of 34-0-0 in June and 39 g (1.4 oz) of 0-15-30 in July. Trees were pruned as required after winter damage was recorded.

From 1985 to 1989, minimum and maximum temperatures from November to April were recorded at the nine sites.

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Table 1. Location and average temperatures of experimental sites.

Sites	Region[z]	Zone[y]	Meteorological conditions between November 1984 and April 1989								
			November			December			January		
			Temp. °C		Prec.	Temp. °C		Prec.	Temp. °C		Prec.
			Max.	Min.	Snow (cm)	Max.	Min.	Snow (cm)	Max.	Min.	Snow (cm)
L'Assomption (sandy soil) PQ											
L'Assomption (clay soil) PQ	1	5a	4.4	−3.2	21.3	−2.3	−11.5	42.1	−5.7	−16.6	35.2
Sainte-Clotilde, PQ	1	5a	5.4	−2.4	3.6	−0.7	−8.4	6.2	−4.0	−13.2	4.4
Sainte-Anne-de-Bellevue, PQ	1	5b	5.5	−1.8	34.6	1.1	−9.5	43.7	−4.6	−14.2	54.1
Sainte-Foy, PQ	2	4b	2.7	−4.5	42.3	−4.0	−12.7	52.3	−7.2	−17.1	79.2
Deschambault, PQ	2	4b	3.1	−3.7	22.5	−3.8	−11.8	32.8	−6.7	−17.2	58.9
La Pocatière, PQ	2	4a	3.1	−3.7	20.9	−3.8	−11.4	35.6	−6.7	−15.2	57.3
Normandin, PQ	3	2b	0.0	−8.1	31.6	−8.2	−19.3	42.9	−11.3	−23.0	44.0
Kapuskasing, ONT.	3	2a	−1.1	−8.3	3.5	−8.6	−18.5	53.1	−11.4	−23.4	44.1

Sites	Region[z]	Zone[y]	February			March			April		
			Temp. °C		Prec.	Temp. °C		Prec.	Temp. °C		Prec.
			Max.	Min.	Snow (cm)	Max.	Min.	Snow (cm)	Max.	Min.	Snow (cm)
L'Assomption (sandy soil) PQ											
L'Assomption (clay soil) PQ	1	5a	−4.9	−13.9	33.8	−1.6	−8.9	36.6	11.7	2.3	6.6
Sainte-Clotilde, PQ	1	5a	−3.9	−13.1	4.3	3.2	−6.7	7.0	12.1	1.8	0.2
Sainte-Anne-de-Bellevue, PQ	1	5b	−3.9	−13.9	33.9	3.1	−7.0	33.1	12.6	2.0	12.9
Sainte-Foy, PQ	2	4b	−5.8	−16.4	59.6	0.3	−10.1	34.7	8.8	−0.2	15.1
Deschambault, PQ	2	4b	−6.0	−16.3	44.9	−0.2	−10.2	29.1	8.3	0.7	4.0
La Pocatière, PQ	2	4a	−6.0	−14.8	48.4	−0.2	−9.1	37.4	8.3	−0.8	7.6
Normandin, PQ	3	2b	−10.0	−23.1	35.1	−2.3	−15.1	30.7	9.9	−5.2	22.4
Kapuskasing, ONT.	3	2a	−9.7	−24.2	36.1	−2.3	−16.0	39.7	7.8	−4.3	14.7

[z] 1 = Montréal-Outaouais; 2 = Eastern Township Québec, Beauce; 3 = Saguenay Lac St-Jean, Lower St-Lawrence, Abitibi-Témiscamingue, Gaspé.
[y] Canadian climatic Zones (Ouellet and Sherk, 1967).

Each spring and fall during the five year test period, tree damage due to weather conditions and animals were assessed on a percentage basis, the stem diameter (30 cm (1 ft) from the ground) and tree height were also recorded. Data were analyzed with the SAS statistical package (12).

Results and Discussion

This study confirms that temperature and tree damage are closely related in the Norway maple. Maximum and minimum temperatures from November to April for the sites in region 1 vary from a high of 12.6°C (55°F) to a low of −16.6°C (2°F) (Table 1). This region has the mildest climate and trees at the L'Assomption and Sainte-Clotilde sites had the least cumulative damage—7 to 28 percent (Table 2). The trees in Sainte-Anne-de-Bellevue suffered the greatest injury (81 percent) which was mostly due to extremity of twigs. Research on the different types of damage in relation to meteorological conditions (9) showed that tip kill was related to differences between minimum and maximum daily temperatures in January. Although not evident from Table 1, these winter conditions are typical for Sainte-Anne-de-Bellevue (10) and would in part explain the damage that occurred.

Temperature for the same months in region 2 was slightly colder and varied from a maximum of 8.8°C (48°F) to a minimum of −17.2°C (1°F) (Table 1). In this region cumulative winter injury varied from 11% to 56% which was due to tip kill and twig death (Table 2). The greatest damage occurred to the current year's growth (43%) occured at La Pocatière. Richer *et al.* (9) showed that a high correlation existed between this type of injury and the absence of snow cover at the beginning of each winter, combined with temperatures of more than 0°C (32°F) in the month of April.

Region 3 had the coldest overall temperatures which ranged from a high of 9.9°C (50°F) to a low of −24.2°C (−12°F). As much as 69% of the injury at Normandin occurred as tip kill which did not affect tree growth. At Kapuskasing, there was a combination of 10% tip kill and 27% twig damage to the current year's growth. Even with adequate snow cover to protect the plants. 27% twig damage occurred in the first 3 years. In the last 2 years of the experiment no injury was observed which may be explained in part by change in cold hardiness with plantage (2, 3). Although the climate in this region is severe, little plant mortality was observed and the early autumn snows may have protected the young trees, particularly in the first year after transplant.

Tables 4 and 5 give a resume of % tree growth as a % of trees with gives by height and diameter ranges for each site. In only 4 years of culture, 60–75% of the trees respectively

Table 2. Percentage winter damage to *Acer platanoides* L. from 1984 to 1989.

Sites	Climatic zone	No damage	Type of winter damage[z] 1	2	3	4 and 5	6	7	Accumulated winter damage
Region 1									
L'Assomption, Sandy soil	5a	93	3				1	3	7
L'Assomption, Clay soil	5a	89			11				11
Sainte-Clotilde	5a	72	5		10	13			28
Sainte-Anne-de-Bellevue	5b	19	81						81
Region 2									
Deschambault	4b	89	11						11
Sainte-Foy	4b	65	35						35
La Pocatière	4a	44	13	43					56
Region 3									
Normandin	2b	29	69	1				1	71
Kapuskasing	2a	63	10	27					37

[z]1 = damage to extremity of twigs; 2 = damage to current year's twigs; 3 = dead; 4 = damage to old branches; 5= grazing on trunk; 6 = mechanical damage (snow, wind); 7 = rodent damage.

Table 3. Height (cm) and Stem Caliper (mm) of *Acer platanoides* L. seedlings after 5 years evaluation.

Evaluation sites	Climatic zones[z]	Height: Final (cm)	Height: Annual[y] growth (cm)	Stem caliper: Final (mm)	Stem caliper: Annual growth (mm)
L'Assomption (sandy soil)	5a	359.3ab[x]	63.5	43.8cdef	7.1
L'Assomption (clay soil)	5a	249.3c	47.4	37.8cdef	6.1
Sainte-Clotilde	5a	443.5a	99.4	63.0ab	10.3
Sainte-Anne-de-Bellevue	5b	420.4ab	92.8	58.8abc	10.5
Deschambault	4b	359.7ab	81.3	48.3bcde	8.7
Sainte-Foy	4b	351.0b	81.3	35.5def	5.8
La Pocatière	4a	342.6b	85.6	35.3def	6.3
Normandin	2b	217.1c	62.3	26.3ef	3.2
Kapuskasing	2a	215.8c	73.8	31.8ef	4.8
Mean separation 0.05		(56.2)	(49.7)	(7.1)	(3.5)

[z]Canadian Climatic Zones (Ouellet and Sherk, 1967).

[y]Mean annual growth comes from growth between the final measurement in October and the initial measurement in April. Means are based on 5 years evaluation.

[x]Mean separation within columns by Duncan's Multiple Range test. Means followed by the same letter are not significantly different (P = 0.05).

at Sainte-Clotilde and Sainte-Anne-de-Bellevue grew 46 to 70 mm (1.8 to 2.8 in) in diameter (Table 4) and about 60% of the trees reached a height of 350 cm (11.5 ft) (Table 5). Tree growth was much slower at both sites in L'Assomption which may be attributable to cooler temperatures (Table 1), soil types and later spring conditions (1). An additional year's growth was required before 75% and 17% of the trees respectively reached a comparable diameter at Deschambault and Sainte-Foy. None of the trees reached this diameter at La Pocatière. After 5 years, 55% or more of the trees grew to 350 cm (11.5 ft) or more in height at each of these sites while at Normandin and Kapuskasing, none of the trees grew to the 46 to 70 cm (1.8 to 2.8 in) diameter nor did any reach 351 cm (11.5 ft) or more in height. An examination of tree growth for the five-year test period showed that, on average, trees in Regions 2 and 3 have 20 and 44% less diameter growth and 6 and 39% less height growth compared with trees in Region 1.

Several factors seem to be involved in the development of trunk diameter and tree height. For example, this species has the peculiarity of producing its first growth at leaf-out and a second flush of growth under warm conditions (14). The second flush developed more slowly in Regions 2 and 3 compared with Region 1 because of the colder temperatures and partly explained the smaller tree diameter in the colder regions. The slower growth of axillary branches in Regions 2 and 3 further decreased stem diameter. Tree height is similarly affected.

The damage to the Norway maple described by Dumont (1), Hepting (4) and Nowak and Rowntree (6) generally occurs with low winter temperatures of –35°C to –37°C (–25°F to –35°F). However, comparable injuries were not observed during the whole trial period at any of the sites in Quebec or Ontario with comparable or colder temperatures (9). Since considerable variability exists among various cultivars of this maple (6) the trees in the reported studies may have come from tender stock while the mother trees (over 40 years old in Climatic Zone 5a) from which the seeds for this experiment were gathered showed no signs of winter damage and may have been superior winter-hardy trees. This hardi-

Table 4. Percentage of trees of Acer platanoides L. by category of mean stem diameter for the experimental period.

Stem diameter (mm)	Region 1																			
	L'Assomption (sandy soil)					L'Assomption (clay soil)					Sainte-Clotilde					Sainte-Anne-de-Bellevue				
	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988
0–30	100	100	92	25	8	100	95	83	50	42	100	100	33	0	0	100	100	0	0	0
31–35	0	0	8	41	0	0	5	0	17	8	0	0	33	10	0	0	0	58	0	0
36–40	0	0	0	17	25	0	0	8	17	0	0	0	22	30	0	0	0	42	17	0
41–45	0	0	0	17	17	0	0	9	0	17	0	0	12	0	23	0	0	0	8	0
46–50	0	0	0	0	33	0	0	0	0	17	0	0	0	0	11	0	0	0	42	0
51–60	0	0	0	0	17	0	0	0	16	0	0	0	0	50	11	0	0	0	33	50
61–70	—	—	—	—	—	0	0	0	0	16	0	0	0	10	22	0	0	0	0	50
71–80	—	—	—	—	—	—	—	—	—	—	—	0	0	0	0	33	—	—	—	—
81–90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Stem diameter (mm)	Region 2															Region 3									
	Sainte-Foy					Deschambault					La Pocatière					Normandin					Kapuskasing				
	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988
0–30	100	100	100	83	8	100	100	75	8	0	100	100	100	100	9	100	100	100	100	100	100	100	100	100	25
31–35	0	0	0	17	50	0	0	17	25	0	0	0	0	0	27	—	—	—	—	—	0	0	0	0	67
36–40	0	0	0	0	25	0	0	8	33	25	0	0	0	0	64	—	—	—	—	—	0	0	0	0	8
41–45	0	0	0	0	17	0	0	0	25	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46–50	—	—	—	—	—	0	0	0	9	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
51–60	—	—	—	—	—	0	0	0	0	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
61–70	—	—	—	—	—	0	0	0	0	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 5. Percentage of trees of *Acer platanoides* L. seedlings by category of mean tree height for the experimental period

Height (cm)	Region 1																			
	L'Assomption (sandy soil)					L'Assomption (clay soil)					Sainte-Clotilde					Sainte-Anne-de-Bellevue				
	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988
0–200	100	90	67	0	0	100	90	67	42	33	100	38	22	20	0	100	62	0	0	0
201–250	0	10	25	8	10	0	10	8	17	8	0	38	0	0	11	0	38	17	0	0
251–300	0	0	8	42	0	0	0	25	17	25	0	24	22	0	0	0	0	67	9	0
301–350	0	0	0	42	33	0	0	0	17	17	0	0	33	10	0	0	0	16	33	0
351 and more	0	0	0	8	67	0	0	0	7	17	0	0	23	70	89	0	0	0	58	100

Height (cm)	Region 2															Region 3									
	Sainte-Foy					Deschambault					La Pocatière					Normandin					Kapuskasing				
	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988
0–200	100	100	17	0	0	100	100	67	0	0	100	90	25	33	9	100	90	50	17	42	100	100	100	92	42
201–250	0	0	25	0	0	0	0	25	0	0	0	10	58	25	0	0	10	42	42	8	0	0	0	8	50
251–300	0	0	58	17	0	0	0	8	33	25	0	0	17	33	0	0	0	8	33	33	0	0	0	0	8
301–350	0	0	0	75	42	0	0	0	33	17	0	0	0	9	36	0	0	0	0	17	—	—	—	—	—
351 and more	0	0	0	8	58	0	0	0	34	58	0	0	0	0	55	0	0	0	8	0	—	—	—	—	—

ness may have been inherited by the seedlings used in this experiment and could account for the difference between the reported and observed winter damage and growth. However, further experiments would be required to verify this hypothesis. Increase in cold hardiness could most likely be obtained by introductions of Norway maple from the central USSR where average annual absolute minimum temperature is below –40°C (–40°F) (5).

In summary, this study clearly shows that the Norway maple can make satisfactory growth in Canadian Zone 2b (USDA Zone 2) without bark damage from cold winter conditions and that the growth range can now be extended to this Zone. For adapted strains of this species, however, it is not recommended for planting in Canadian Zone 2a (USDA Zone 2) because of injury and poor growth. Although the percent damage was less in Zone 2a it was more severe than in Zone 2b and growth was more affected. Further, seedlings of this maple make rapid growth in Canadian Zones 4 and 5 (USDA Zone 3) without winter damage and can therefore be produced commercially in these Zones. Because this species of maple grows over such a wide temperature range it is important to use seed of appropriate selections of this species for the zonal range in which it is to be grown and to select desired progeny from open pollinated trees which show the desired characteristics such as winter-hardiness.

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