

Examining the Seed Yield and Germination Potential of *Acer platanoides* Cultivars[®]

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INTRODUCTION

Invasive plant species are considered threats to the biodiversity of natural areas and some estimates suggest that they make up 8% to 47% of the plants in each state. Invasive plants can displace natives and reduce biodiversity of nonmanaged or low-managed landscapes by escaping cultivation through the production of large quantities of highly viable seed capable of germination and remaining viable in the seed bank for years. Trees present a greater challenge in that their mature size provides a greater dispersal pattern and the larger the tree the higher the seed yield (Dieringer, 1991; Ollerton and Lack, 1998).

Norway maple (*Acer platanoides*) is a horticulturally well developed shade tree species with numerous cultivars and hybrids selected for leaf color and character, tree form, and size that has been identified as potentially invasive. Based on observations, Norway maple produces high quantities of seed, shade-tolerant seedlings, and dense canopies which further reduce light and moisture reaching the understory (Gresham, 2000; Randall, 1996). At the Drew University Forest Preserve, Webb et al. (2001) reported that Norway maple seed banks consisting of both long-lived and short-lived seeds were capable of establishing in the forest (Webb and Kaunzinger, 1993).

Estimating seed yield, finding similar age replicate samples, mature plants, and complete collections in close proximity makes evaluating shade tree invasive potential much more difficult than previously reported evaluations of shrubs and perennial ornamental grasses. This research represents the first attempt at examining the invasive potential of Norway maple by estimating seed yield, germination, and viability (Conklin and Sellmer, 2009a and 2009b) (Table 1).

Tree sites used in the study included: The Holden Arboretum (Kirtland, Ohio; lat. 41°36'N, long. 81°18'W; USDA Hardiness Zone 5), Dawes Arboretum (Newark, Ohio; lat. 39°58'N, long. 82°24'W; USDA Hardiness Zone 6), and the Pennsylvania State University (University Park, Pennsylvania; lat. 40°48'N, long. 77°51'W; USDA Hardiness Zone 6).

METHODS

Seed Production Estimates. Four lateral branches off of the main stem of each cultivar were randomly selected and marked at various heights of the canopy and from each cardinal direction to obtain a consistent sampling estimate of seed production throughout the tree. Annual seed production estimates were calculated for each branch (total samara clusters × average number of samaras/cluster). This was accomplished by randomly selecting 10 samara clusters/branch, counting the number of samaras/cluster, and then calculating the average number of samaras/cluster. Finally total samara clusters were counted for each marked branch.

Table 1. Norway maple cultivars examined for seed yield, germination, and viability.

Plant	Taxa	Seed yield	Germination	Viability
<i>Acer platanoides</i>	species	X	X	X
	'Columnare'	X	X	X
	'Crimson King'	X	X	X
	'Emerald Queen'	X	X	X
	'Erectum'		X	X
	'Faassen's Black'	X	X	X
	'Fairview'		X	X
	'Globosum'	X	X	X
	'Green Lace'		X	X
	'Reitenbachii'		X	X
	'Royal Red'		X	X
	'Rubrum'	X	X	X
	'Schwedleri'		X	X
	Summershade™ PP1748		X	X
	'Superform'		X	X
'Undulatum'		X	X	
<i>Acer truncatum</i> × <i>A. platanoides</i>	Keithsform, Norwegian		X	X
	Sunset™ Norway maple PP7529			
	'Warrenred', Pacific Sunset™ maple PP7433		X	X

To estimate seed yield, the diameters of each marked branch and all primary branches were recorded and used to calculate the cross-sectional area of each branch [$A = (\pi \div 4) \times d^2$, where A = cross-sectional area, $\pi = 3.14$, and d = branch diameter]. Percent canopy area covered by each marked branch was then calculated (marked branch cross-sectional area \div sum of all primary branch cross-sectional areas).

From these calculations, annual total samara production was estimated for each cultivar (annual samara production estimates \div percent canopy area covered) with the assumption that samara production was proportional to branch cross-sectional area. Plant height, lowest branch height above ground, and canopy dimensions were also recorded for each cultivar. This data was used to calculate the surface area of each cultivar with the formula for one-half an ellipsoid:

$$SA = 0.5 \times \int_0^{2\pi} \int_0^{\pi} \sin t \sqrt{b^2 \times c^2 \times \sin^2 t \times \cos^2 p + a^2 \times c^2 \times \sin^2 t \times \sin^2 p + a^2 \times b^2 \times \cos^2 t} dt dp$$

where SA = face area; $\pi = 3.14$; t = theta and p = phi were angles of integration; and a , b , and c were canopy height (plant height – lowest branch height), $0.5 \times$ canopy length, and $0.5 \times$ canopy width such that $a \geq b \geq c$ (Wolfram, 1996). This formula was chosen because it best represents the canopy shape of each Norway maple cultivar. Surface areas were numerically calculated using Mathematica (version 4.1; Wolfram Research Inc., Champaign, Illinois). Samara densities standardized per

unit area were then estimated for each cultivar (annual total samara production estimates \div surface area) (Conklin and Sellmer, 2009a).

Germination and Viability Testing. About 1000 samaras of every cultivar (one to three plants/cultivar) were harvested by hand and bulked in bags to provide uniform seed lots each year (2004, 2005, and 2006). Fully expanded samaras were then used in germination and viability experiments. "Deformed samaras," defined as samaras which appeared to contain no seed, or whose seed appeared not fully expanded, were not used in this study. Five replicates of eight seeds/replication for each test plant were randomly chosen and soaked in tap water overnight at room temperature. Seeds were then cold stratified at 5 °C for 90 days, hand sown to a depth of 1 to 3 cm in a soilless media, and placed in growth chambers maintained at 5 °C. After 84 days, germination rates were recorded (Conklin and Sellmer, 2009b).

Statistical Analysis. Annual samara densities were subjected to one-way ANOVA using SAS's (SAS Institute Inc., Cary, North Carolina) MIXED procedure to determine if cultivars influenced these variables. Fisher's least significant difference was used to make pair-wise comparisons of the least squares means (lsmeans), if cultivars were significant ($P < 0.05$). One-way ANOVA, Duncan's multiple range, means, and standard errors were calculated for germination and viability. Statistics were performed using SAS (version 9.1) and graphs were generated with SigmaPlot (version 9.0; Systat Software Inc., San Jose, California).

RESULTS AND CONCLUSIONS

- Select cultivars demonstrated wide variation in seed yield between test years (Fig. 1).
- 'Crimson King', 'Faassen's Black', 'Globosum', and 'Rubrum' produced the fewest seeds during the study.
- Germination rates as a whole were low for all cultivars (Fig. 2).
- 'Keithsform' was consistently high in germination over 2-seed years and many were consistently low in germination.
- Seed viability varied from year to year among the cultivars tested (Fig. 3).
- Overall, seed viability was higher among the cultivars when compared to germination rates.
- 'Columnare', 'Crimson King', and 'Superform' showed low germination and viability among the cultivars tested.
- Based on this preliminary research there appears to be cause to consider reintroduction of older cultivars which are less available in the trade, but show consistently lower seed density, germination, and viability for use near sensitive low-maintenance landscapes.
- Long-term germination potential and seed viability for seed years was not addressed in this study and remains to be defined.

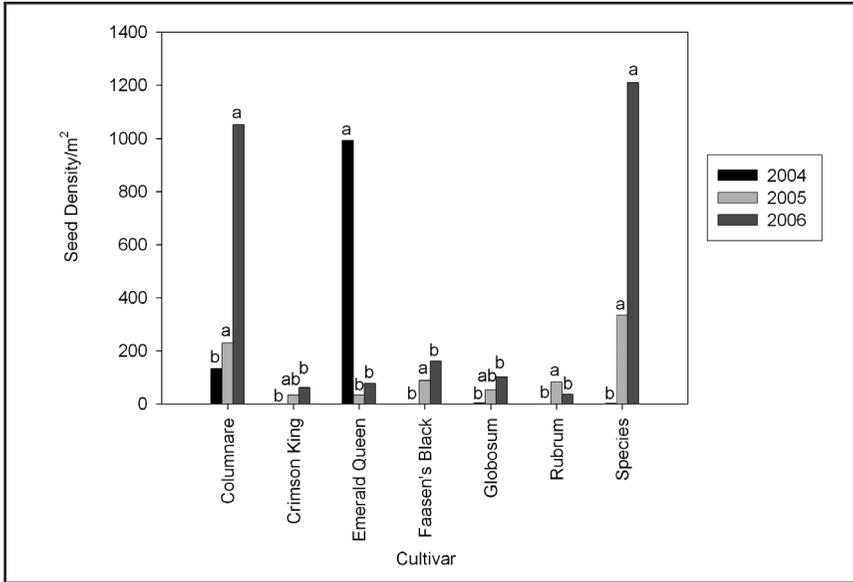


Figure 1. Seed densities standardized per unit area for Norway maple cultivars during the study period 2004–2006. All values are least squares means. Mean separation of cultivars within the same year (lower case letters) by Fisher’s least significant difference test at $P \leq 0.05$. $1\text{m}^2 = 10/7639\text{ft}^2$.

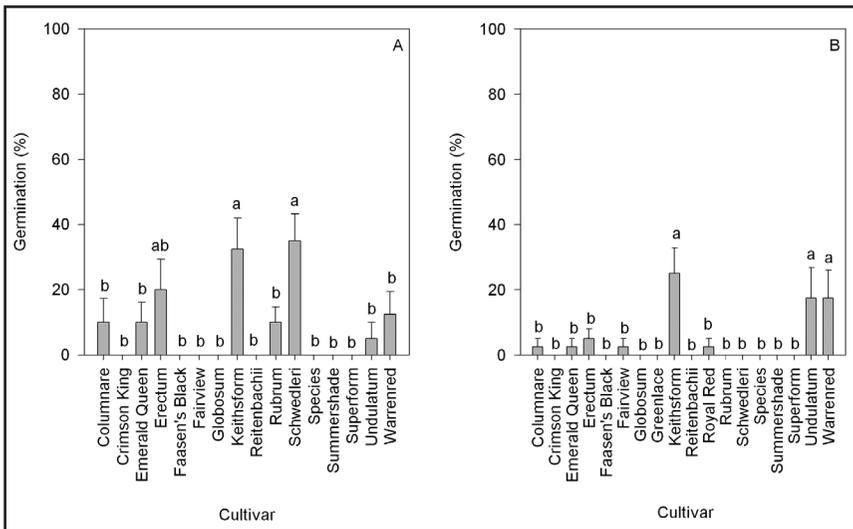


Figure 2. Germination of Norway maple cultivars, hybrids, and species from (A) 2004 and (B) 2005 seed lots. All values are means \pm SE. Mean separation of cultivars (lower case letters) by Duncan’s multiple range test at $P \leq 0.05$.

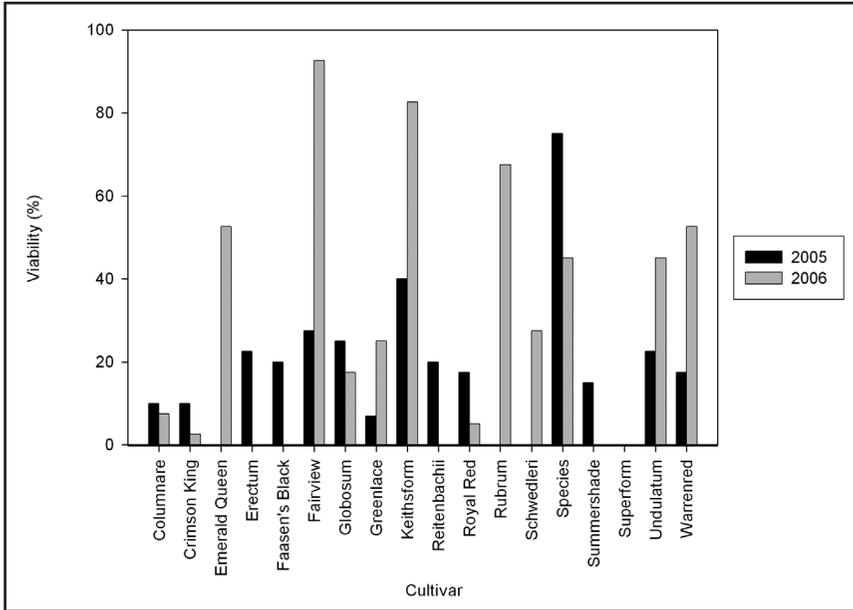


Figure 3. Viability results for seed crop years 2005 and 2006 using Grabe's 2,3,5-triphenyltetrazolium chloride (TTC) procedure. All values are means. Standard errors were not calculated due to small sample sizes.

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