The Influence of DNA Herbicides and Glyphosate on Root and Shoot Hardiness During Nursery Field Overwintering

Principle investigators: Hannah Mathers and Luke Case

Significance to the industry. Herbicides are essential for good weed control in field nurseries. It is common practice for nursery growers to apply preemergence applications of herbicides to trees grown in the field. Typically, one application is done in the spring, and the other application is done in the fall, just prior to overwintering. Applications of glyphosate are supplemented throughout the growing season. Many of the preemergence herbicides used are from the dinitroaniline (DNA) herbicide family, which includes oryzalin, pendimethalin, prodiamine and trifluralin. Many seedlings are also shipped bareroot in the fall from the West coast and then placed into containers for further growth in Ohio. The objectives of this study were 1) to determine if the DNA herbicides and glyphosate can affect the cold hardiness of trees grown in the field, and 2) determine if bottom heat during overwintering has any effect on the cold hardiness in interaction with the herbicide application. While essential for weed control, it would be advantageous to the grower to know if these weed control practices need to be modified, and if bottom heat would be advantageous for root development.

Materials and methods. *Application of herbicide treatments in field*. Japanese tree lilac (*Syringa reticulata* 'Ivory silk'), red maple (*Acer rubrum*), and crabapple (*Malus domestica*) were planted into the field at the Waterman Farm of The Ohio State University on May 31, 2007 in a split plot design (main = treatment, subplot = species) with seven subsamples per species per treatment and five replications. Plants were all 1-year old liners spaced 1.5 feet apart, and were immediately watered after transplanting. Preemergence herbicide treatments were applied on June 27, 2007 and October 5, 2007. Treatments consisted of: trifluralin alone at 2 lb ai/ac, prodiamine alone at 2 lb ai/ac, oryzalin alone at 2 lb ai/ac, trifluralin with supplemental glyphosate (Kleenup Pro) at 3 oz/gallon solution, prodiamine with supplemental glyphosate at 3 oz/gallon solution, and clean cultivation. Glyphosate was applied on July 24, September 12, and October 1, 2007 to the supplemental glyphosate treatments. Clean cultivation was performed approximately every three weeks for the clean cultivation treatment.
Subjection to cold treatments. Five subsamples of each species per treatment were dug from the field on December 3, 2007. The plants were soaked overnight in water to loosen the dirt from the roots. After soaking, the roots were washed. After washing, the root volumes were determined by water displacement in volumetric flasks. The plants were then put into plastic bags with enough moistened mix (1:1 sand:perlite) to cover the roots, and the bags were sealed around the tree with wire-ties. The plants were then put into a walk-in cooler, where the trees were placed into wooden boxes with heat mats placed on the bottom set at 8-, 11-, 14-, and 17- °C, with the 5th subsample just setting in the cooler representing ambient temperature (≈ 5 °C). Starting February 25, 2008, plants were taken out of the cooler by temperature treatment and then subjected to freezing treatments. Before putting into freezing treatments, root volumes were again determined to find root growth and shigometer (Osmose, Buffalo, New York) readings were done on the shoots (≈ 1" above soil line) and roots (bottom most part of tap root or crown area) (2). Cold hardiness was assessed by cutting 1-3 mm segments of shoots (2007 growth – if possible)

and roots (roots nearest to tap root or crown) and putting 2-3 segments each into test tubes which were then put into an ultralow freezer. Temperatures for the cold treatments were: no freezing, -5, -10, -15, -20, and -25 °C. Immediately after segments were frozen to the predetermined level, 3 mL distilled water was added to each test tube, shaken overnight at 200 rpm and then an initial electrical conductivity (EC) was taken. After the initial EC was determined, tubes were autoclaved at 121 °C for 20 minutes and then shaken once again overnight at 200 rpm. A final Ec was then taken of each treatment and replicate. The initial EC was subtracted from the final Ec to find electrolyte leakage during freezing (2).

Results and Discussion. *EC – Roots*. Freezing temperature was significant for the three species tested, bottom heat temperature was significant for maple, and there was a two-way interaction of bottom heat × freezing temperature for maple at the $\alpha = 0.05$ level (Table 1). Lilac had a p-value of 0.06 for the interaction of bottom heat × freezing temperature. EC of crabapple roots became significantly different at -15 °C, and for maple and lilac, the EC became significantly different at -10 °C from the no freezing treatment (Table 2).
EC – Shoots. Freezing temperature and bottom heat temperature were significant for maple and lilac for shoots, and there was a two-way interaction of bottom heat × freezing temperature for maple at the $\alpha = 0.05$ level (Table 3). There were no significant differences in EC values for crabapple across any of the factors. Both maple and lilac shoots became significantly different at -15 °C from the no freezing treatment (Table 4).
Shigometer readings. There were no differences between treatments for any of the parameters tested for shoots and roots (data not shown).
Root volumes. There were no differences in root volumes for maple; however, crabapple and lilac showed root growth differences across the bottom heat treatments (Table 5). Both crabapple and lilac showed the best root growth with a bottom heat of 14 °C. Crabapple also showed some root growth at 11- and 17- °C, but the lilac showed no root growth at the other temperatures.
It is well known that roots are less hardy than shoots, which this trial confirms. There were no effects of herbicide treatments, either as a main effect or as an interaction in this study, which leads to a conclusion of that there is no effect of the tested herbicides on the cold hardiness of crabapple, lilac, or maple. It has been found that at least some species do add root growth during overwintering (1, 2). However, very cold spells are common in the Northern U.S., and seeing how cold-air temperatures with bottom heat would interact would be beneficial for growers, especially in case of power outages. However, there was only one interaction, bottom heat × cold hardiness for the maple for both roots and shoots (Table 1). In terms of root hardiness, maple roots grown in a bottom heat set at 11 °C were less hardy than the roots grown at the other temperatures (data not shown). In terms of shoot hardiness, the maples grown without bottom heat (≈5 °C) and those with bottom heat at 17 °C were more cold hardy than those grown in the other temperatures, especially those that had bottom heat of 11 °C (data not shown). Finding optimal bottom heat temperatures for tree species may help to increase growth during the growing season, and should be further studied.

Literature cited.

Crider, F.J. 1928. Winter root growth of plants. Science. 68:403-404.
Okie, W.R. and A.P. Nyczepir. 2004. Effect of winter root-zone temperature on root regeneration of peach rootstocks. HortScience. 39:1607-1610.

Table 1. P-values of main effects and 2 way interactions on shoot cold hardiness of (*Syringa reticulata* 'Ivory silk'), red maple (*Acer rubrum*), and crabapple (*Malus domestica*).

Source	Crabapple	Maple	Lilac
Herbicide treatment	0.1899	0.1117	0.1883
Bottom Temp	0.4922	0.0018	0.1117
Herbicide * Bottom	0.3269	0.5971	0.0134
Freezing Temp	0.0001	0.0001	0.0001
Herbicide * Freezing	0.1172	0.897	0.4641
Bottom * Freezing	0.1472	0.0100	0.0615

Table 2. Electrical conductivity values of Japanese tree lilac (*Syringa reticulata* 'Ivory silk'), red maple (*Acer rubrum*), and crabapple (*Malus domestica*) roots after six different cold treatments.

Freezing temperature	Crabapple		Red Maple		JapaneLilac	
none	0.23[zy]	a	0.17	a	0.23	a
-5 °C	0.2	a	0.17	a	0.23	a
-10 °C	0.19	a	0.15	b	0.13	b
-15 °C	0.09	b	0.09	c	0.12	b
-20 °C	0.08	b	0.07	d	0.1	c
-25 C°	0.07	b	0.06	d	0.09	c

z = Electrical conductivities are expressed as millisiemens/cm

y = Values in the same column followed by the same letter are not significantly different based on lsmeans ($\alpha = 0.05$)

Table 3. P-values of main effects and 2 way interactions on root cold hardiness of three tree species.

Source	Crabapple	Maple	Lilac
Herbicide treatment	0.3909	0.5072	0.3325
Bottom Temp	0.1564	0.0018	0.0106
Herbicide * Bottom	0.5495	0.8514	0.2577
Freezing Temp	0.9003	0.0001	0.0001
Herbicide * Freezing	0.4414	0.7139	0.2007
Bottom * Freezing	0.3613	0.0100	0.8009

Table 4. Electrical conductivity values of Japanese tree lilac (*Syringa reticulata* 'Ivory silk'), red maple (*Acer rubrum*), and crabapple (*Malus domestica*) shoots after six different cold treatments.

Freezing temperature	Crabapple		Maple		Lilac	
none	0.13[zy]	a	0.108	a	0.162	a
-5 °C	0.13	a	0.103	a	0.155	a
-10 °C	0.1	a	0.103	a	0.151	a
-15 °C	0.15	a	0.095	b	0.122	b
-20 °C	0.08	a	0.08	c	0.11	c
-25 C°	0.18	a	0.074	d	0.101	c

z = Electrical conductivities are expressed as millisiemens/cm

y = Values in the same column followed by the same letter are not significantly different based on lsmeans (α = 0.05)

Table 5. Root growth of Japanese tree lilac (*Syringa reticulata* 'Ivory silk') and crabapple (*Malus domestica*) when grown at different bottom heat temperatures

Temperature	Crabapple		Lilac	
5 °C	0.43[zy]	ab	-4.36	a
8 °C	-0.52	a	-2.62	a
11 °C	1.61	ab	-0.8	ab
14 °C	5.54	c	3.65	b
17 °C	2.6	b	-4.54	a

z = Root growth expressed in differences in volume (mL) by volume displacement in water

y = Values in the same column followed by the same letter are not significantly different based on lsmeans (α = 0.05)