Effect of Postemergent Herbicide on Sucker Removal/Injury of Field Tree Liners

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Significance to Industry: Many species of trees are susceptible to producing suckers (or waterspouts). Suckers are not appealing to the consumer, so they must be removed. Past practices of sucker removal included mechanically removing, then applying glyphosate to prevent the development of new suckers. When Roundup lost its' patent in 2000, many new formulations flooded the market. The concurrent trend for glyphosate-containing products includes the increased technologies of surfactants.

Glyphosate is a very hydrophyllic chemical. For the chemical to pass through the plasma membrane of the cell walls into the phloem, a surfactant must be mixed with the glyphosate. With new formulations' increased penetrant factor, more of the active ingredient is going into the phloem. Companies that produce glyphosate containing products utilize different surfactant packages, thus the need for research to determine the product with least phytotoxicity and most efficacy on weeds.

Glyphosate affects the EPSP-synthate (5-Enolpyruvylshikimate 3-phosphate synthase) pathway. This pathway is vital for production of the precursors to phenolic compounds (Weaver and Herrmann, 1997). Previous research has shown that these phenolic compounds, or secondary metabolites, provide defenses for the plant, such as environmental, insects and/or disease, and antioxidants (Rivero et. al., 2001) (Close and Mcarthur, 2002). The objectives of this study include: 1) To determine if various forms of glyphosate-containing products increase incidences of bark cracking. 2) To evaluate cold hardiness of trees subjected to various glyphosate-containing products.

Materials and Methods: At The Ohio State University (OSU) Waterman Farm, Columbus, OH, four species of tree liners were planted in the field on October 5, 2003. The species are: *Acer* x *freemanii* 'Jeffersred' (Autumn Blaze™ red maple), *Malus* 'Prairifire' (Prairifire crabapple), *Cercis canadensis* (Eastern redbud) and *Quercus rubra* (red oak). The treatments that the trees were subjected to are: Roundup Original, Roundup Pro, Kleen-up Pro, Scythe, mechanical, and a control. The experimental design was a randomized complete block by species with six replications.

Trees had suckers removed mechanically, in June 2007 and 2008 via hand pruners for corresponding treatments. Trees that lack suckers had an incision made 2.5 cm wide x 5 cm in length. Suckers removed and incisions made were, one each, on the north and the south sides. After injury was made, plots had corresponding herbicide treatments applied.

Spad 502 chlorophyll meter (Konica Minolta, Tokyo, Japan) readings were obtained in the summer and fall to obtain differences in transmitted light through the leaf. Shigometer (Osmos, Buffalo, NY) readings were taken in January 2008 to assess trunk cambial resistance (Okie and Nyczepir, 2004). Cuttings were taken from terminal ends of shoots in January of 2008 to assess cold hardiness. Cuttings were placed in a cooler overnight at 5^0 C for acclimation. The plants were then frozen at nine temperatures (-6 ºC, -9 ºC, -12 ºC, -15 ºC, -18 ºC, -21 ºC, -24 ºC, -27 ºC, and -30 ºC) in an ultra low chest freezer (Forma Scientific, Inc., Marietta, OH). The ultra low chest freezer was programmed to so that the temperature will be lowered at a rate of 3 ºC per hour. Cuttings were then removed from the freezer after the temperature reached the desired level and then kept again in the cooler overnight at 5 ºC for acclimation. Two evaluation methods, visual (amount of live tissue) and regrowth methods (Stergios and Howell, 1973) were used to evaluate amount of live tissue after being subjected to cold treatments. For the regrowth, the cuttings were placed in a 50-50 sand/perlite mixture in a mist propagation bench in a heated greenhouse for 40 days (Stergios and Howell, 1973). For the tissue browning, the trees were placed in an incubator with 100 percent humidity for 7 days. The cuttings were then evaluated utilizing a 4x microscope (Fisher Scientific, Hampton, NH). Visual observations were conducted on a scale of one to five (one being no damage, intact, green cambium layer; five being dead, brown, non-intact cambium layer). Regrowth was collected based on callus formation, root formation, bud break, green tissue, and/or dead cuttings. Visual observations, regrowth, and shigometer data were subjected to ANOVA using the GLM procedure within SAS® (SAS Institute, Inc., Cary, NC, 2000). Fisher's least significance difference test was used to compare means with $\alpha \leq 0.05$ was used (SAS© Institute Inc.). The Type II Sum of Squares analyses was performed.

Results and Discussion: Maple showed the greatest number of cracks over all treatments (Table 1). This correlates with what is being observed within the industry. Roundup Original and Roundup Pro exhibited the greatest number of cracks between all Genus of trees, while the Kleenup Pro and Scythe exhibited less cracks (Table 2). This could be attributed to the increased surfactant contained within the Roundup products. The browning data indicated that control and mechanical treatments were significantly more cold tolerant than Roundup Original and Roundup Pro (Table 3). This is most likely due to the disruption of the shikimate pathway (Duke and Powles, 2008), decreasing phenolics; so therefore decreasing cold tolerance (Rivero et. al., 2001). All trees showed a decline in hardiness across all treatments as temperature decreased with the browning observations (data not shown). This study confirms Kuhns' (1992) study that glyphosate injury produces cracking in trees. This is the first study confirming that glyphosate with increased surfactant decreases cold tolerance within nursery trees. Much more work is needed to examine the shikimate pathway and its correlation to cracking.

References:

1. Bohnert, H.J., Nelson, D.E., and Jensen, R.G. 1995. Adaptations to Environmental Stresses. The Plant Cell. Vol. 7, 1099-1111.
2. Close, D.C. and McArthur, C. 2002. Rethinking the role of many plant phenolics protection from photodamage not herbivores. OIKOS. 99:166-172.
3. Duke, S.O. and Powles, S.B. 2008. Mini-review Glyphosate: a once-in-a-century herbicide. Pest Management Science. 64:319-325.
4. Knaggs, A.R. 1999. The biosynthesis of shikimate metabolites. Nat. Prod. Rep. 16. pp. 525-560.
5. Kuhns, L.J. 1992. Glyphosate applications to the bark of nine tree species. Proceedings of the annual meeting: Northeastern Weed Science Society. v.46, pp. 23-26.

6. Margna, U., Vainjarv, T., Margna, E. 1988. Glyphosate effects on the biosynthesis of flavonoids from exogenous L-Phenylalanine and L-Tyrosine in buckwheat cotyledons. Biochem. Pysiol. Pflanzen. 183. pp. 329-335.
7. Mathers, H.M. 2008. Take care when using glyphosate around trees. NMPro. July. pp. 43-49.
8. Ossipov, V., Salminen, J.P., Ossipova, S., Haukioja, E., and Pihlaja, K. 2003. Gallic acid and hydrosable tannins are formed in birch leaves from an intermediate compound of the shikimate pathway. Biochemical Systematics and Ecology. 31, 3-16.
9. Rivero, R.M., Ruiz, J.M., Garcia, P.C., Lopez-Lefebre, L.R., Sanchez, E., and Romero, L. 2001. Resistance to cold and heat stress: accumulation of phenolic compounds in tomato and watermelon plants. Plant Science. (160) 315-321.
10. Schmid, J. and Amrhein, N. 1995. Molecular organization of the shikimate pathway in higher plants. Phytochemistry. Vol. 39 No. 4. pp. 737-749.
11. Weaver, L.M. and Herrmann K.M. 1997. Dynamics of the shikimate pathway in plants. Trends in Plant Science. Vol. 2 No. 9. pp. 346-351.

Table 1: Amount of cracking on four species of nursery trees subjected to six sucker removal/injury treatments: Roundup Original Maxx, Roundup Pro, Kleenup Pro, Scythe, Mechanical, and Control. Data is combined over all treatments. Numbers indicate the number of cracks. Letters indicate significance LSMeans α=0.05.

Redbud	Oak	Crabapple	Maple
1.9167 a	1.833 a	2.1667 a	5.333 b

Table 2: Amount of cracking of four genus of nursery trees subjected to six sucker removal/injury treatments: *Cercis canadensis*, *Quercus rubra*, *Malus* 'Prariefire'., and *Acer x freemanii* 'Jeffersred' Data is combined over all genus of trees. Numbers indicate the number of cracks. Letters indicate significance LSMeans α=0.05.

Control	Mechanical	Kleenup Pro	Scythe	Roundup Pro	Roundup Original Maxx
0.625 a	2.375 b	2.375 b	2.75 b	3.875 c	4.875 d

Table 3: Visual browning of four genus of nursery trees subjected to freezing after six field treatments: : *Cercis canadensis*, *Quercus rubra, Malus* 'Prariefire'., and *Acer x freemanii* 'Jeffersred'. Data is combined over all genus of trees. Numbers indicate browning observation: 1=Alive, 5=Dead. Letters indicate significance LSMeans α=0.05.

Control	Mechanical	Kleenup Pro	Scythe	Roundup Orignial Maxx	Roundup Pro
2.271 a	2.632 a	2.797 a	2.862 b	2.88 c	2.911 d