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Turf Herbicide Injury to Landscape Trees as Influenced by Mulch[1]

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Abstract

A two year field study was conducted in 1991 and 1992 to evaluate the sensitivity of landscape trees to certain turf herbicides as affected by mulch. The study included four tree species ('Bradford' callery pear, crape myrtle, Eastern redbud, red maple), four mulch treatments (shredded hardwood bark, pine bark, pine needles, no mulch), and six herbicide treatments [Banvel (dicamba), BAS 514 OOH (quinclorac), Image (imazaquin), Redeem (triclopyr), Stinger (clopyralid)]. Herbicides were applied as directed sprays at the labeled rates for use on turf. Visual injury (%) ratings were measured at 30, 60, 90, 120, and 150 days after treatment. Trunk diameters and total plant fresh weights were measured at the conclusion of the study. In most cases, applying the herbicide over mulch decreased tree injury compared to applications to bare soil (Fig. 3). Red maples were most severely injured by Stinger (clopyralid) (27%) (60 DAT) and BAS 514 OOH (quinclorac) (33%) (60 DAT). Redbuds were most severely injured by the same two herbicides, but at 89% (120 DAT) and 73% (120 DAT), respectively. 'Bradford' pears were injured by Banvel (dicamba) (32%) (120 DAT), and crape myrtles by Image (imazaquin) (10%) (120 DAT).

Index words: root uptake, herbicide, mulch.

Species used in this study: 'Bradford' callery pear (*Pyrus calleryana* Decne. 'Bradford'); crape myrtle (*Lagerstroemia indica* L.); Eastern redbud (*Cercis canadensis* L.); red maple (*Acer rubrum* L.).

Herbicides used in this study: Banvel (dicamba), 3,6-dichloro-2-methoxybenzoic acid; BAS 514 OOH (quinclorac), 3,7-dichloro-8-quinolinecarboxylic acid; Image (imazaquin), 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-y1]-3-quinolinecarboxylic acid; Redeem (triclopyr), [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid; Stinger (clopyralid), 3,6-dichloro-2-pyridinecarboxylic acid.

Significance to the Nursery Industry

Current turf herbicide labels have limited information concerning their application around landscape trees. This study was conducted to evaluate the effects of turf herbicides on off-target tree species. Turf is a significant component of landscapes, primarily lawns and golf courses. Because turf and trees often grow close together, they share a common rooting zone. Turf management practices affect tree health. Injury to trees from turf herbicides is of particular concern. Because tree species vary in sensitivity to herbicides, injury symptoms could appear at different times, and range greatly in severity. Injury from herbicides reduces tree growth, or makes plants aesthetically unacceptable. This study may help to identify some of the potentially interactive relationships between common landscape tree species, herbicides, and mulches.

Introduction

Weeds are unacceptable in most turf situations, especially in highly visible areas such as home lawns, commercial sites, and golf courses. As a result, high intensity maintenance programs are frequently used to manage these areas. This involves considerable expense in terms of labor and herbicide treatments. With the present concern about environmental and health issues, awareness has increased regarding the potential for off-target effects from intense use of herbicides in the landscape. Often, turf areas border plantings that include landscape or shade trees.

Four of the five herbicides used in this study are currently registered for broadleaf weed control in selected turf species. BAS 514 OOH (quinclorac) is undergoing evaluation for possible registration. Redeem (triclopyr) and Banvel (dicamba) are labeled for control of undesirable woody species (13), and Stinger (clopyralid) has been evaluated for brush control (11). Virtually no data are available on root uptake of these herbicides which could be a likely exposure route to trees in a landscape situation.

A limited amount of information exists on the interaction of herbicides with mulches. Root growth, density, and location are directly affected by mulching practices (1, 16). Watson (17) suggested that mulch increased shallow root development. If the herbicides used in a maintenance program are mobile in soil, a tree root system in the upper part of the soil profile is more susceptible to herbicide uptake and subsequent injury. Herbicide adsorption is increased on soils with high organic matter (9, 12, 15). As most mulches are organic, they can adsorb herbicides; decreasing phytotoxicity and longevity of the herbicides (5, 10).

This study simulated a landscape situation, with commonly used tree species, mulches and herbicides. The objectives were to examine the potential for non-target injury to landscape trees from root uptake of turf herbicides, and to examine the influence of mulch on herbicide injury severity.

Materials and Methods

The study was conducted over a 2-year period at the Horticultural Crops Research Station in Castle Hayne, NC. The soil was a Stalling fine sand with 0.5% organic matter and pH 5.9. On May 2, 1990, landscape size trees [2.5 cm (1 in) caliper, 2.1 m (7 ft) tall balled and burlapped pears and red maples; 2.5 cm (1 in) caliper, 1.5 m (5 ft) redbuds; and 1.9

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cm (0.75 in) caliper, 3 stem, 1.2 m (4 ft) crape myrtles] were planted in raised beds with plot size 1.8 m by 6.7 m (6 ft × 22 ft). One tree of each species was included in each plot, and each plot was assigned one of four mulch treatments (shredded hardwood bark, pine bark, or pine needle mulch, no mulch). Mulches were spread to a uniform depth of 8 cm (3 in). Two layers of 8 mil black plastic were inserted vertically into 0.6 m (2 ft) deep trenches between plots to prevent root crossover. A one-year establishment period was provided prior to herbicide application. Mulches were replenished to their original depth in February of 1991 and 1992. In early March of 1991, corrective pruning was done and the branches were removed from the lower 45.7 cm (18 in) of trunk to prevent chemical uptake through basal foliage.

On April 11, 1991, and April 9, 1992, Banvel, Image, BAS 514 OOH, Stinger, and Redeem, were applied as directed sprays in 271 L/ha (29 GPA) with a CO_2 backpack sprayer at 69 kPa (10 psi) with a K-5 flooding nozzle in a 91cm (36 in) band on each side of the plot. The herbicides, Banvel, Image, Stinger, and Redeem, were applied at medium labeled rates for turf: 0.14, 0.56, 0.28, 0.43 kg ai/ha (0.125, 0.5, 0.25, 0.38 lb ai/A), respectively. Because of research protocol, BAS 514 OOH was applied at 0.84 kg/ha (0.75 lb ai/A), with a second directed application at the same rate 30 days later on half the initially treated plots. All plots, including the control, were maintained weed-free by using Paraquat at 0.56 kg ai/ha (0.5 lb ai/A) and hand weeding. Overhead irrigation was used as needed the first year while trees became established.

The experiment was a randomized complete block design consisting of 28 treatments and five replications. A rating (%) of visual damage was taken at 30, 60, 90, 120, and 150 days after treatment (DAT). A rating scale of 0% to 100% was used with 0% and 100% representing no damage and plant death, respectively. A rating of 10% represented visible but not aesthetically unacceptable injury. A rating of 50% represented visible and commercially unacceptable injury. Trunk diameters were measured at 45 cm (18 in) above bare ground prior to treatment each year, and at the conclusion of the study. Fresh weights of the above ground plant parts were also measured at the conclusion of the study. Results were consistent over the two years. The data were averaged over the two years and analyzed using analysis of variance (ANOVA). Means were separated using the LSD test at the five percent significance level.

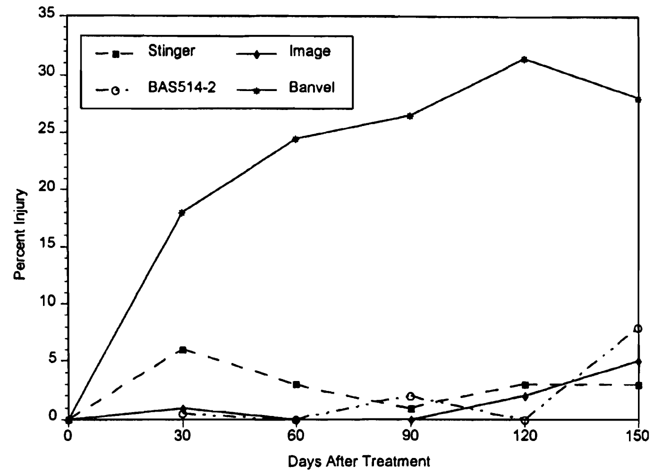

Fig. 1. Visible foliar injury as a result of postdirected applications of selected turf herbicides on 'Bradford' callery pear with no mulch. Injury was rated on a percent scale with 0% and 100% representing no injury and plant death, respectively. Data were combined over 1991–1992. LSD = 3.1 for comparing herbicides at a given date.

Results and Discussion

'Bradford' pear. In general, trees in mulched plots had less herbicide injury compared to plots with no mulch. Most herbicides did not affect trunk diameter or fresh weight; excluding Image which reduced fresh weight compared to the control (Table 1). No visible injury was observed on 'Bradford' pear from Redeem (Fig. 1). Injury from Image and BAS 514 OOH DIR1 and DIR2 appeared 150 DAT. The injury from Image occurred on the no mulch plots and was visible only in the shortening of internodes which, while affecting tree growth, did not cause the trees to be aesthetically unacceptable. Injury from BAS 514 OOH DIR1 occurred on hardwood bark plots. Injury from BAS 514 OOH DIR2 occurred on pine needle plots and no mulch plots. Injury from Stinger appeared 30 DAT on no mulch plots (Fig. 1). The visual injury symptoms were < 10% for all herbicide/mulch treatments (data not shown) with the exception of Banvel on no mulch. Injury from Banvel was most severe on the no mulch plots; 32% at 120 DAT with reduced symptoms at 150 DAT (Fig. 1). 'Bradford' pear is reportedly sensitive to Banvel (3, 4). Even though tree growth was

Table 1. Mean trunk diameter (mm) and total fresh weight (kg) of landscape trees across groundcovers at conclusion of study.

	Rates	'Bradford' pear		Eastern redbud		Red maple	
Treatment	kg/ha	diam.[z]	tot.wt.	diam.	tot.wt.	diam.	tot.wt.
Control	—	49.37	14.31	35.30	2.61	44.02	6.11
BAS 514 D1	0.84	50.02	13.83	33.52	2.14	39.60	4.37*
Redeem	0.43	48.18	13.12	37.26	2.60	45.83	6.67
Image	0.56	48.37	11.36*	35.55	2.22	45.32	6.19
Banvel	0.14	47.92	12.92	37.62*	2.68	43.27	5.64
Stinger	0.28	49.25	13.64	30.74*	1.40*	45.25	6.36
BAS 514 D2	0.84	49.73	14.99	34.39	1.62*	39.08*	3.65*
LSD (0.05)		NS	1.76	2.11	0.64	3.01	1.59

[z]Abbreviations: diam. = diameter (mm); tot.wt. = total fresh weight (kg); D1 = directed once; D2 = directed twice.

*Significant difference at 0.05 level.

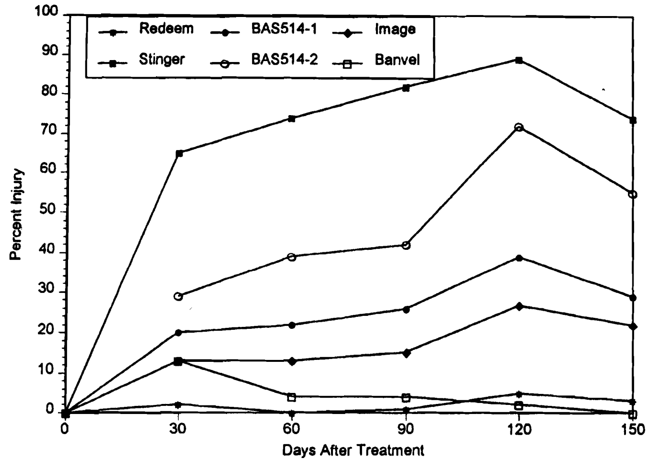

Fig. 2. Visible foliar injury as a result of postdirected applications of selected turf herbicides on Eastern redbud with no mulch. Injury was rated on a percent scale with 0% and 100% representing no injury and plant death, respectively. Data were combined over 1991–1992. LSD = 8.6 for comparing herbicides at a given date.

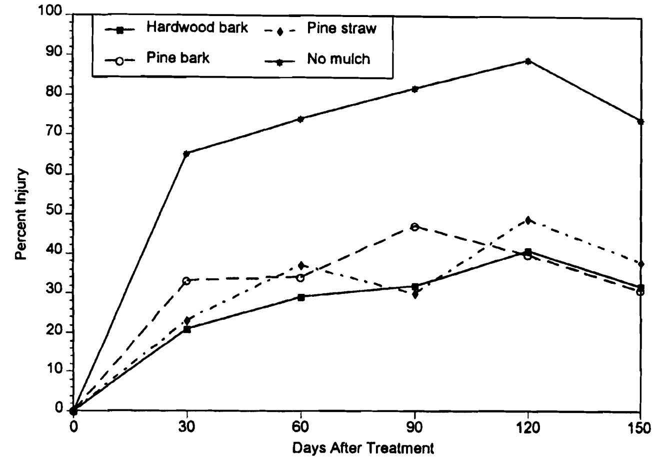

Fig. 3. Influence of groundcover on visible foliar injury as a result of postdirected applications of Stinger on Eastern redbud. Injury was rated on a percent scale with 0% and 100% representing no injury and plant death, respectively. Data were combined over 1991–1992. LSD = 8.6 for comparing mulches at a given date.

not affected, the injury observed at 30 DAT persisted over the growing season. The uninjured foliage that was produced later in the season was insufficient to reduce the overall appearance of injury. The trees remained aesthetically unacceptable. Injury was typical of auxin-type growth regulator herbicides: stem and petiole twisting and bending, and leaf curling and upward cupping (6, 14).

Crape myrtle. No injury was observed on crape myrtle from Redeem, BAS 514 OOH DIR2, or Banvel. Injury to crape myrtle from Stinger was observed on pine bark, pine needle, and no mulch plots, while injury from BAS 514 OOH DIR1 and Image was observed only on no mulch plots (data not shown). In most cases the observed injury occurred late in the season, was < 10%, and was transient. Tree growth was not affected (data not shown).

Eastern redbud. Eastern redbud showed injury significant at the 0.05 level from all herbicide treatments. Generally, injury was reduced by mulch (data not shown). With no mulch (Fig. 2), injury from all herbicides except Banvel and Redeem increased through 120 DAT before the trees showed new growth with no injury at 150 DAT. Injury from Redeem occurred late in the season, on plots with pine bark, with ratings < 18% (data not shown). Injury from BAS 514 OOH DIR1 occurred only on no mulch plots, while injury from BAS 514 OOH DIR2 occurred on pine needle (< 21%) (data not shown) and no mulch plots. BAS 514 OOH DIR2 and Stinger did reduce tree growth. With Banvel, an increase in trunk diameter was detected with no other visible effects (Table 1). Injury from Image occurred only on no mulch plots, and injury from Banvel occurred only on pine needle plots (≤ 11%) (data not shown). Figure 3 best illustrates the difference in magnitude of injury as it relates to mulch type in this study. Leguminous plants are highly sensitive to Stinger (19). Injury to Eastern redbud from Stinger was severe regardless of mulch treatment; most severe on bare ground. Injury appeared 30 DAT, and persisted through 150 DAT. Tree growth was significantly reduced (Table 1), and trees were aesthetically unacceptable. Typical growth regulator symptoms were observed: stem and petiole twisting, leaf cupping and curling, and necrosis. Leaves also thickened and wrinkled interveinally.

Red maple. In no mulch plots, injury to red maple was detected from all herbicide treatments except Redeem, (Fig. 4). Injury from Redeem appeared on hardwood and pine bark plots, 30 DAT and again 120 DAT. Injury from Image appeared on pine bark plots 150 DAT and on pine needle plots 60 DAT. Injury from Banvel was observed on hardwood plots at 30 DAT and 120 DAT. For Redeem, Image, and Banvel on mulched plots, injury ratings were ≤ 10% (data not shown). Injury from Stinger, BAS 514 OOH DIR1 and DIR2, occurred across all mulch treatments. Injury on no mulch plots was observed at 60 DAT and remained significant through 150 DAT for all three herbicide treatments (Fig. 4). Injury from Stinger peaked on hardwood plots 150 DAT, on pine bark plots 60 DAT, and on pine needle plots 90 DAT. For those herbicide treatments, ratings were < 11% (data not shown). Injury from BAS 514 OOH DIR1 occurred; on hardwood mulch plots 30 DAT and again 90 DAT to persist through 150 DAT, on pine bark plots 90 DAT to persist 150 DAT, and on pine needle plots 30 DAT to persist 150 DAT. For those treatments, the ratings were < 15% (data not shown).

Injury from BAS 514 OOH DIR2 was observed on hardwood and pine needle plots at all dates, and on pine bark plots from 60 DAT through 120 DAT. In all cases, the ratings were ≤ 22% (data not shown). Injury from BAS 514 OOH DIR1 and DIR2 was severe enough to reduce tree growth (Table 1). Typical growth regulator symptoms that were observed included: twisting and bending of stem petioles, and cupping and curling of leaves. Leaves were also stunted and strap-like in appearance. Overall, trees were aesthetically unacceptable.

Herbicide injury was species dependant. In general, trees in mulched plots had less herbicide injury compared to trees in plots with no mulch. This is consistent with research which

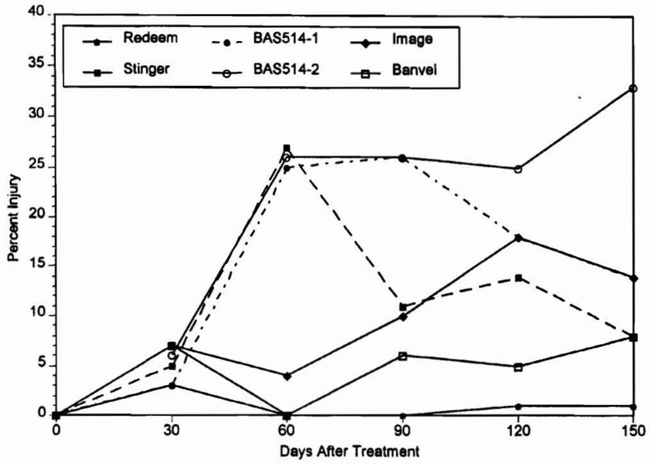

Fig. 4. Visible foliar injury as a result of postdirected applications of selected turf herbicides on red maple with no mulch. Injury was rated on a percent scale with 0% and 100% representing no injury and plant death, respectively. Data were combined over 1991–1992. LSD = 6.8 for comparing herbicides at a given date.

shows that herbicide adsorption to mulch can reduce availability, persistence and phytotoxicity (8, 9). Several factors may be involved in the timing of injury observed. Rainfall, measured at the research station, exceeded 43 cm (17 in) in July 1991 and exceeded 30 cm (12 in) in August 1992. Considering the differential mobility of the herbicides (2, 19), and the properties of a Stalling fine sand, excessive rainfall could cause leaching through the root zones of the trees. Mulch influences tree root distribution and density (7, 16). Herbicide that is adsorbed to the mulch remains in close proximity to the shallow roots growing in the interface zone; thus, increasing the potential for uptake. Alternately, mulch is an excellent environment for increased microbe activity (17, 18), which could increase the rate and amount of herbicide degradation. In many cases in this study, injury symptoms appeared later in the season and had lower % values on plots with mulch. Some tree species may be more efficient at metabolizing herbicides than others. Based on the data from this study, concern over off-target effects of herbicides is warranted, particularly in landscape situations where high maintenance programs and proximity plantings are common.

(*Ed. note*: This paper reports the results of research only and does not imply registration of a pesticide and/or growth regulent under amended FIFRA. Therefore; using any of the products mentioned in this report, be certain of their registration by appropriate state and/or federal authorities.)

Literature Cited

1. Appleton, B.L., J.F. Derr, and B.B. Ross. 1990. The effect of various landscape weed control measures on soil moisture and temperature, and tree root growth. J. Arboriculture. 16:264–268.

2. Ashton, F.M. and T.J. Monaco. 1991. Weed Science: Principles and Practices. John Wiley & Sons, Inc., NY, pp. 466.

3. Decker, H.F. and J. Decker. 1988. Lawn Care, Handbook for Professionals. Prentice-Hall, Englewood Cliffs, NJ, pp. 270.

4. Fraedrich, S.W. and E.T. Smiley. 1991. Herbicides and Trees. Grounds Maint. 26(6):26–30.

5. Gold, A.J., T.G. Morton, W.M. Sullivan, and J. McClory. 1988. Leaching of 2,4-D and dicamba from home lawns. Water, Air, and Soil Pollution 37:1-2, 121–129.

6. Gunsolus, J.L. and W.S. Curran. 1991 (revised). Herbicide Mode of Action and Injury Symptoms. North Central Regional Ext. Pub. 377.

7. Green, T.L. and G.W. Watson. 1989. Effects of turfgrass and mulch on the establishment and growth of bare-root sugar maples. J. Arboriculture. 15:268–272.

8. Grover, R. 1971. Adsorption of picloram by soil colloids and various other adsorbents. Weed Sci. 19:417–418.

9. Hance, R.J. and K. Holly. 1990. Weed Control Handbook: Principles. Blackwell Scientific Publications, Cambridge, MA, pp. 582.

10. Hodges, L. and R.E. Talbert. 1990. Adsorption of the herbicides diuron, terbacil and simazine to blueberry mulches. HortScience. 25:401–402.

11. Meyer, R.E. and R.W. Bovey. 1990. Influence of sulfonylurea and other herbicides on selected woody and herbaceous species. Weed Sci. 38:249–255.

12. Rhodes, R.C., I.J. Belasso, and H.L. Pease. 1970. Determination of mobility and adsorption of agrichemicals on soils. J. Agr. Food Chem. 18:524–528.

13. Sassman, J., R. Pienta, M. Jacobs, and J. Cioffi. 1984. Pesticide background statements. Vol. 1. Herbicides. U.S. Dep.Agr., Forest Service. Agr. Hdbk. 633.1271

14. Sharma, M.P. 1988. Recognizing Herbicide Action and Injury. Second Edition. Alberta Environmental Centre, Vegreville, Alberta, Canada, pp. 138.

15. Walker, A. and D.V. Crawford. 1968. The role of organic matter in adsorption of the triazine herbicides by soils, p. 91–108. *In*: International Atomic Energy Agency (ed.). Isotopes and radiation in soil organic matter studies. Proc. Second Symp. Intl. Atomic Energy Agency, Vienna.

16. Watson, G.W. 1988. Organic mulch and grass competition influence tree root development. J. Arboriculture. 14:200–203.

17. Watson, G.W. 1989. Competition between trees and turf. Grounds Maint. 24:30, 59, 61.

18. Watson, G.W. and G. Kupkowski. 1991. Effects of a deep layer of mulch on the soil environment and tree root growth. J. Arboriculture. 17:240–245.

19. Weed Science Society of America. 1989. Herbicide Handbook. 6th ws. Weed Sci. Soc. Am., Champaign, IL, pp. 301.