Effect of Pesticide-treated Grass Clippings Used as a Mulch on Ornamental Plants

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Abstract. With increasing pressure to reduce disposal of yard waste in landfills, many homeowners are seeking alternative methods for grass clipping disposal. When turf is treated with pesticides, the collected grass clippings become a potential source of injury to susceptible plants that come in contact with the clippings. In this study, grass clippings were collected at 2, 7, and 14 days after pesticide treatment from a turf treated with chlorpyrifos, clopyralid, 2,4-D, flurprimidol, isoxaben, or triclopyr. The clippings were used as a mulch around *Lycopersicon esculentum* Mill. (tomato), *Phaseolus vulgaris* L. (bush bean), *Petunia ×hybrida* Hort. Vilm.-Andr. (petunia), and *Impatiens wallerana* Hook. f. (impatiens). Beans were planted 4 weeks prior to mulching, whereas the other plants were grown in the greenhouse for 6 weeks and transplanted into the field 2 weeks prior to mulching. Clippings containing residues of clopyralid, 2,4-D, or triclopyr killed tomato, bean, and petunia plants when used 2 days after pesticide treatment (DAPT) and severely injured these same species when mulched 7 and 14 DAPT. Flurprimidol injured tomato, impatiens, and bean plants when present on mulch collected 2, 7, and 14 DAPT, but was not lethal. Flurprimidol slowed plant growth, caused darker green leaf color, and reduced flowering when mulched at 2 DAPT. Isoxaben injured tomato and bean plants when present on mulch used 2, 7, and 14 DAPT but was not lethal. Injury was not as severe in the second year of the study, indicating different environmental stresses and climatic conditions make predicting pesticide injury for all growing seasons difficult; however, grass clippings from a turf treated with herbicides or plant growth regulators should not be used for mulch around sensitive plants for at least 14 DAPT. Chemical names used: O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosphorothioate (chlorpyrifos); 3,6-dichloro-2-pyridinecarboxylic acid, triethylamine salt (clopyralid); 2,4-dichlorophenoxyacetic acid, dimethylamine salt (2,4-D); α -(1-methylethyl)- α -[4-(trifluoromethoxy)phenyl]-5-pyrimidinemethanol (flurprimidol); N-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide and isomers (isoxaben); 3,5,6-trichloro-2-pyridinyloxy acetic acid, triethylamine salt (triclopyr).

With diminishing landfill capacity in the United States (Campbell and Tripepi, 1991), many turfgrass managers and homeowners are seeking alternative methods for disposing of yard waste such as turfgrass clippings. Whitmore et al. (1993) estimated that 79% of all households have private lawns and 21% to 32% grow ornamentals, vegetables, or fruit each year. They also reported that anywhere from 9.4% to 14.6% of all households treated their lawns with pesticides, thereby generating pesticide-treated turfgrass clippings. Although returning clippings to the turf is the best option, other disposal options are avail-

able.

Along with the composting of grass clippings, many home gardeners have used grass clippings for a mulch around their ornamental and vegetable plants. The mulch conserves soil moisture (Gicheru, 1994), buffers temperature extremes (Ashworth and Harrison, 1983; Bristow, 1988; Teasdale and Mohler, 1993) and suppresses weed germination.

Few researchers have determined the impact of pesticide-treated mulch and compost on plants that are mulched with these materials. Bahe and Peacock (1995) studied the effects of mulching two vegetable and two flower species with turf treated with a mixture of three postemergence broadleaf herbicides. This study was conducted in the greenhouse and showed significant growth reduction in the four species tested. Mulch depth and harvest date (number of days after herbicide application) were factors in the Bahe and Peacock study.

Pesticide half-lives vary markedly in soil and little is known about pesticide degradation on leaf surfaces. For instance, the average half-life for triclopyr and 2,4-D in soil (no

light, constant temperature, and water potential) was 138 and 21 d, respectively, indicating that these compounds can be persistent under certain conditions (Johnson et al., 1995). However, triclopyr and 2,4-D both have very short photolysis half-lives of only 1 to 12 h in aqueous solutions (Call and Gavit, 1986; Crosby and Tutgrass, 1966). Norris et al. (1987) observed a soil half-life of 80 d for triclopyr, while Stephenson et al. (1990) observed a soil half-life of 14 d on several different soils in northern Ontario. The half-life for clopyralid (salt) is 12–70 d, while the half-life for 2,4-D is 10 d (Wauchope et al., 1992).

The objectives of this research were to determine the effects of pesticide-treated turfgrass clippings when used as a mulch around ornamental and vegetable plants. Additionally, if those clippings were phytotoxic, we wished to determine how many mowings would be necessary to reduce pesticide residue concentrations below phytotoxic levels.

Materials and Methods

Four plant species were chosen based on their popularity and range of sensitivity to pesticide injury. In 1991, 'Advantage' tomato, 'Dwarf Cranberry' bush bean, 'Peppermint Daddy' petunia, and 'Impulse Red' impatiens were used. In 1992, 'Lady Luck Hybrid' tomato, 'Etna' bush bean, 'Accent Rose Star Hybrid' impatiens, and 'Primetime Salmon' petunia were used. The tomato, impatiens, and petunia plants were all started in the greenhouse for 6 weeks, then transplanted to the field 2 weeks prior to treatment initiation. The bush beans were started from seed in the field 4 weeks prior to treatment initiation.

The garden site was a Marlette sandy loam soil (fine-loamy, mixed, mesic Glossoboric Hapludalfs) and was fertilized with bovine waste and then tilled 15 cm deep in the autumn prior to spring planting each year. The soils were tested each year to ensure fertility levels were adequate, and irrigation was supplied to assure normal growth of the annuals under full sun. The four species were planted into four separate blocks and analyzed separately, as there was no interest in quantifying the differences between species. For 1991, the study was a factorial design with two factors (pesticide and mulch date) in a randomized complete block. For each species, there were 75 plants per block, three blocks, and five plants for each pesticide/mulch date treatment combination. This design was modified in 1992 into a split-block design in which the mulch date factor (subplot of five plants) was split on the pesticide treatment factor (row). There were 80 plants for each block, three blocks, and 20 plants for each pesticide treatment (row), and five plants for each pesticide/mulch date treatment combination. Within each plot, only the center three of the five plants were rated for injury to lessen border effects from adjacent treatments.

The pesticides (all values as a.i.) chosen for this study included an insecticide, chlorpyrifos at 1.5 kg·ha⁻¹; a combination application of triclopyr at 0.4 kg·ha⁻¹ and 2,4-D at 1.1 kg·ha⁻¹;

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a combination application of clopyralid at 0.2 kg·ha⁻¹ and triclopyr at 0.6 kg·ha⁻¹; isoxaben at 1.1 kg·ha⁻¹; and flurprimidol at 1.7 kg·ha⁻¹. Chlorpyrifos was excluded in 1992 based on the results obtained in 1991. A control plot with clippings from untreated turf was included in both years.

All pesticides were applied using a research plot sprayer calibrated to 375 L·ha⁻¹ at 0.21 MPa. The pesticides were applied to separate 390 m² plots of an old stand of *Festuca* spp. (fine), *Lolium perenne*, and *Poa pratensis* L. (varieties unknown) on 12 June 1991 and 15 June 1992. The turf was watered and fertilized prior to pesticide applications to ensure adequate clippings would be available on the dates of mulch. Dates of mulching were 2, 7, and 14 d after pesticide treatment (DAPT) in 1991 and 2, 7, 14, and 28 DAPT in 1992. The plots treated with the preemergence herbicide isoxaben received 0.5 cm of irrigation immediately following application in accordance with label recommendations.

The turf was mowed from 7 cm down to 3.5 cm on each date of mulching with a 51 cm rotary mower. The clippings were collected and transported immediately to the plant mulching site (≈1 km away). A layer of approximately 10 cm of the grass clipping mulch was deposited around the base of each plant extending outward 15 cm from the base. Irrigation was supplied within 24 h after mulching.

A visual rating scale from 0 to 100 was devised to quantify injury to the plants, and injury ratings were taken about every 7 d until

90 DAPT (Table 1). An analysis of variance was performed using the SuperAnova statistical package (Abacus Concepts, Berkeley, Calif.). Injury ratings were analyzed for differences between years using a split-block model.

Results and Discussion

Years were found to be a significant source of variation and, therefore, the mean injury ratings for each year were analyzed and tabulated separately (Tables 2–4). None of the pesticide treatments caused as severe injury in 1992 as in 1991.

Tomato. Tomato plants were the most sensitive of the four species studied and clopyralid + triclopyr and 2,4-D + triclopyr killed all plants in the 2 DAPT mulch treatments in 1991; however, only clopyralid + triclopyr caused severe injury in 1992 (Table 2). Clopyralid + triclopyr and 2,4-D + triclopyr-treated clippings collected 2 DAPT caused plant wilting within hours after the tomato plants were mulched. Even when clippings were collected at 7 or 14 DAPT, clopyralid + triclopyr residues were present at sufficient levels to cause significant plant injury in both years.

The isoxaben treatment caused significant injury to tomato plants when clippings were mulched at 2 and 7 DAPT in both years, but this injury was more severe in 1991 (Table 2). The isoxaben injury was slower to develop than the postemergence herbicide injury.

The plant growth regulator flurprimidol

caused significant injury when plants were mulched 2 DAPT, but this injury was delayed and did not become significant until 20 DAPT in 1991 and 31 DAPT in 1992. In both years, flurprimidol-treated clippings caused injury when collected 2, 7, and 14 DAPT but the injury was less for the later mulching dates. The injury caused by flurprimidol was very different than that caused by herbicides, resulting in stunting of plant growth, darker green leaf color, and less flowering and fruit production relative to the control plants (data not shown). Similar results were observed by Wainwright and Bithell (1986) when they applied paclobutrazol {(±) - (R*,R*)-β[(4-chlorophenyl)methyl]-x-(1,1 dimethyl)-1H-1,2,4-triazole-1-ethanol} as a soil drench to tomato plants.

Bean. Beans were also very sensitive to clopyralid + triclopyr; the 2 and 7 DAPT mulch treatments in 1991 and the 2 DAPT treatment in 1992 killed all plants (Table 3). Clopyralid + triclopyr and 2,4-D + triclopyr-treated clippings collected 2 DAPT caused wilting within hours after the plants were mulched. Triclopyr + 2,4-D and clopyralid + triclopyr caused severe injury in 1991 when clippings were collected 14 DAPT. Clopyralid + triclopyr residues caused significant plant injury in both years when clippings were applied 2, 7, and 14 DAPT.

Isoxaben caused injury when clippings were applied 2 and 7 DAPT in 1991, but this treatment was not injurious in 1992 on any of the mulching dates (Table 3). The isoxaben injury was also slower to develop than the postemergence herbicide injury in 1991.

Flurprimidol caused significant injury, but this injury was delayed and did not become significant until 20 DAPT in 1991 and 31 DAPT in 1992 (Table 3). The clippings from these plots were safe to use for mulch by 7 DAPT in 1992 but not until 14 DAPT in 1991.

Petunia. Clopyralid + triclopyr and 2,4-D + triclopyr residues were lethal to petunias when mulch was applied 2 DAPT in 1991, while only clopyralid + triclopyr residues caused severe injury in 1992 (Table 4). Clopyralid + triclopyr and 2,4-D + triclopyr-treated clippings collected 2 DAPT in 1991 caused wilting within hours after the plants

Table 1. Plant injury rating scale (0–100).

0–9	No injury
10–19	Slight discoloration of leaves but no distortion of leaves and stems
20–29	Discoloration of leaves and wrinkling of leaf margins
30–39	Discoloration of leaves and injury to leaf surface
40–49	Discoloration of leaves and moderate to severe injury to the leaves
50–59	Discoloration of leaves, entire leaf moderately to severely injured, slight twisting of the stem, and slight callus tissue development.
60–69	Discoloration of leaves, entire leaf severely injured, moderate callus tissue development, and moderate twisting of the stems.
70–79	Discoloration of the leaves, entire leaf severely injured, severe callus tissue development, and severe twisting, swelling and splitting of the stem
80–89	Leaves nearly nonexistent, stems severely twisted, swollen, discolored and splitting open.
90–99	Leaves nonexistent, stems nearly nonexistent.
100	Completely dead

Table 2. Tomato plant injury^a after mulching with pesticide-treated grass clippings.

Pesticide	Date mulched (DAPT) ^b	Days after pesticide treatment									
		1991					1992				
		8	12	20	30	55	4	12	19	31	53
Clopyralid + triclopyr	2	81	90	100	100	100	55	74	82	94	100
2,4-D + triclopyr	2	68	63	94	100	100	22	10	5	8	0
Flurprimidol	2	0	11	40	39	28	3	0	0	13	40
Isoxaben	2	13	60	76	80	67	7	0	14	0	0
Control	2	3	5	0	7	0	0	0	0	0	0
Clopyralid + triclopyr	7	2	60	73	92	93	0	10	7	37	67
2,4-D + triclopyr	7	1	33	29	40	0	0	0	0	0	0
Flurprimidol	7	1	15	23	46	20	0	0	0	27	40
Isoxaben	7	5	23	48	55	33	0	0	0	13	0
Control	7	2	3	3	10	0	0	0	0	0	0
Clopyralid + triclopyr	14	0	13	30	36	49	0	0	0	23	5
Flurprimidol	14	2	3	3	18	0	0	0	0	0	20
Control	14	0	3	0	10	0	0	0	0	0	0
LSD _{0.01}		10	26	32	37	49	13	19	14	26	20

^aInjury was rated on a scale from 0 to 100, with 0 as no injury and 100 representing completely dead plants (See Table 1).

^bDAPT = days after treatment with pesticide.

Table 3. Bean plant injury^a after mulching with pesticide-treated grass clippings.

Pesticide	Date mulched (DAPT) ^b	Days after pesticide treatment									
		1991					1992				
		8	12	20	30	55	4	12	19	31	53
Clopyralid + triclopyr	2	66	83	100	100	100	37	77	86	100	100
2,4-D + triclopyr	2	53	48	52	40	13	31	18	13	0	0
Flurprimidol	2	3	13	42	41	38	0	41	40	18	25
Isoxaben	2	17	27	45	46	17	7	5	0	0	0
Control	2	0	0	0	15	0	7	0	0	0	0
Clopyralid + triclopyr	7	0	48	79	93	100	0	13	43	55	68
2,4-D + triclopyr	7	6	12	32	13	0	0	0	0	0	0
Flurprimidol	7	6	6	32	35	15	0	0	0	0	0
Control	7	0	5	13	12	0	0	0	0	0	0
Clopyralid + triclopyr	14	3	3	38	68	48	0	0	0	28	52
2,4-D + triclopyr	14	5	2	21	11	0	0	0	0	0	13
Flurprimidol	14	7	6	0	10	0	0	0	0	0	0
Control	14	1	5	0	5	0	0	0	0	12	5
LSD _{0.01}	15	15	26	26	NS	19	14	12	11	19	23

^aInjury was rated on a scale from 0–100, with 0 as no injury and 100 representing completely dead plants (See Table 1).

^bDAPT = days after treatment with pesticide.

^{NS}Nonsignificant.

were mulched. Even when clippings were collected at 7 DAPT, clopyralid + triclopyr caused significant injury in both years. In 1992, the injury caused by clopyralid + triclopyr was much slower to develop and was not evident until 25 DAPT (10 July), which may indicate that the plants were injured initially, but injury was not evident until the midsummer climate conditions added additional stress to the plants. Flurprimidol caused only minor injury to the petunia plants. Isoxaben did not injure petunias in either year.

Impatiens. None of the pesticides were lethal to *impatiens*, but injury was significant for the postemergence herbicides in 1991 (data not shown). None of the postemergence herbicides caused significant injury in 1992. Isoxaben was not injurious to this species in either year. Flurprimidol caused a stunting of plant growth and a darker green leaf color than the control plants, but this injury was only minor relative to the tomato and bean plants (data not shown).

As expected, chlorpyrifos residues did not cause significant injury to any plant species in 1991, so this treatment was not included in 1992. In 1992, pesticide-treated clippings used 28 DAPT caused no injury, indicating pesticide-treated clippings are safe for use as mulch 28 DAPT.

Not all postemergence broadleaf herbicides caused the same level of injury. Clopyralid +

triclopyr was significantly more injurious than triclopyr + 2,4-D, suggesting that clopyralid was the primary cause of the injury. Clopyralid persists in spearmint hay (Boydston, 1994) and other crops (Thorsness and Messersmith, 1991). Boydston (1994) showed that clopyralid could injure potatoes when processed spearmint hay, treated with clopyralid in the fall, was disked into potato fields the following spring.

The injury observed from isoxaben residues was less severe in 1992 than in 1991. In 1992, plants receiving isoxaben-treated mulch took nearly 8 weeks to express maximum injury. Over time, pesticides can become more strongly sorbed to the mulch, making them less available for volatilization, microbial degradation, or leaching (Whang et al., 1993). Isoxaben residues may have been released in 1992 as microorganisms degraded the grass clippings, but leaching of the residues did not occur during rain or irrigation events.

In 1991, very little rainfall (0.1 cm at 2 DAPT) occurred within the first 8 DAPT, and it was during this time that the first two harvests were completed. On 9 and 10 DAPT the turf received a combined 3.2 cm of rainfall. The higher levels of injury observed in 1991 may have resulted from more of the pesticide residues being present on the leaf at the time of clipping harvest 2 and 7 DAPT, but injury was still more pronounced in 1991 when clippings were used as mulch 14 DAPT. Since very little

rainfall occurred in 1991 for the first 8 DAPT, yet clippings harvested 14 DAPT still caused significant injury, pesticide residues may have been sorbed by the grass leaves and then released when the clippings began decomposing. In 1992, 1.5 cm of rain fell 2 DAPT, but after the 2 DAPT clippings were collected. This rain event probably washed a significant quantity of the pesticide from the grass, accounting for the lower injury levels observed from the 7, 14, and 28 DAPT harvests. However, this would not explain the lower injury observed at 2 DAPT in 1992. Several possible explanations for the lower injury can be offered. The plant material could have been more mature and thus less susceptible to herbicide injury. The density of the treated turf could have been higher in 1992, particularly since this was a nonirrigated site, and an increase in leaf area index would lead to a lower concentration of pesticide per unit of leaf area.

Herbicide uptake by ornamental or vegetable plants can occur in one of three ways. Since the mulch is placed in direct contact with the stem of the plants, herbicide can be absorbed directly from the mulch through the plant stem. Second, herbicide can be released from the mulch into the underlying soil, either by leaching or during decomposition of the mulch, and taken up by the root systems of the desirable plants. Products such as isoxaben and flurprimidol are probably taken up in this

Table 4. Petunia plant injury^a after mulching with pesticide-treated grass clippings.

Pesticide	Date mulched (DAPT) ^b	Days after pesticide treatment									
		1991					1992				
		8	12	20	30	55	4	12	19	31	53
Clopyralid + triclopyr	2	10	19	26	93	100	10	7	10	57	92
2,4-D + triclopyr	2	13	29	26	100	100	0	0	0	0	0
Control	2	3	0	0	0	0	5	0	0	0	20
Clopyralid + triclopyr	7	0	3	12	18	58	0	0	0	40	72
2,4-D + triclopyr	7	3	20	17	40	0	0	0	0	0	0
Control	7	0	0	0	0	0	0	0	0	0	0
Clopyralid + triclopyr	14	5	0	3	12	12	0	0	0	13	20
2,4-D + triclopyr	14	10	0	0	0	0	0	0	0	0	0
Control	14	0	0	0	5	0	0	0	0	13	7
LSD _{0.01}		NS	NS	NS	31	22	5	NS	1	NS	31

^aInjury was rated on a scale from 0 to 100, with 0 as no injury and 100 representing completely dead plants (See Table 1).

^bDAPT = days after treatment with pesticide.

^{NS}Nonsignificant.

manner. However, Schneegurt et al. (1994) did observe limited foliar uptake and activity of isoxaben on a wide variety of weed species. A third possible route of entry is for the herbicide residues to volatilize from the mulch and be absorbed in the vapor phase by the desirable plants. However, the pesticides evaluated in this study would be considered to have very low volatility.

This study confirms the earlier results of Bahe and Peacock (1995) on the potential for plant injury when using clippings obtained from a turf that has been recently treated with a pesticide. Bahe and Peacock (1995) collected clippings at 1, 5, 10, and 15 d after application of one herbicide. Our study was conducted in the field and differed in that collections were made sequentially at 2, 7, and 14 DAPT so that the clippings harvested at 7 d represented the second harvest from the plot. Our studies indicated that even after two mowings, clippings still contained enough herbicide residue to cause significant plant injury. If herbicides or plant growth regulators are used on a turf, the clippings subsequently collected should not be used as a mulch for at least 2 weeks after pesticide application or until three mowings have occurred.

As was expected, postemergence broad-leaf herbicides were quite injurious, but other herbicides or plant growth regulators can also cause plant injury. Rainfall or irrigation after application can reduce the injury potential. Mulching ornamentals with grass clippings is an excellent way of disposing of yard waste

and improving the performance of a home garden; however, returning grass clippings to the turf is still the best option for their disposal (Haley et al., 1985).

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