DETERMINING DISLODGEABLE FOLIAR RESIDUE LEVELS FOLLOWING THE APPLICATION OF TWO PESTICIDES USED TO MANAGE SPORTS TURF, 2017

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INTRODUCTION

The use of pesticides on athletic fields is often a contentious issue due to concerns regarding human health. Due to this concern, Connecticut has banned all pesticides on school grounds from Kindergarten through 8th grade to reduce the risk of exposure to children (State of Connecticut, 2009). Pesticide fate post application largely determines the potential for human exposure (Clark, 2007). In an effort to limit exposure to field users, pesticide labels may designate reentry time periods or state to keep unprotected persons or pets out of the treated area until sprays have dried. However, many are still concerned for field user safety. Quantification of residues post application will provide lawmakers with science-based information when drafting future legislation to minimize pesticide exposure.

The objective of this research was to quantify foliar residues on playing surfaces following the application of two herbicides in two formulations sampled at post application time intervals of 0, 1, 3, 5, 7, 9 & 14 days after treatment. Initial samples were collected prior to herbicide treatments.

MATERIALS AND METHODS

A two-year field study was conducted at the University of Connecticut Plant Science Research and Education Facility in Storrs, CT. The experiment was initiated on 12 July 2016 and repeated on 8 August 2017. The first year the study was performed on a three-year-old monostand of 'Granite' Kentucky bluegrass (*Poa pratensis* L.) on a Woodbridge, fine sandy loam soil. The following year the site was renovated and re-sodded with a blend of Kentucky bluegrass cultivars including; 'Everest' (40%), 'Wildhorse' (20%), 'Corsair' (20%), and 'Award' (20%). Turfgrass was actively growing and not under stress prior to applying the treatments. Nitrogen was applied at 24 kg ha^{-1} as urea (45-0-0) on 8 June 2016 and 49 kg ha^{-1} as Methex (40-0-0) on 27 July 2017. The study was mowed at 6.35 cm twice weekly and the clippings were returned. The last mowing occurred the morning before herbicides treatments were applied. Thereafter, entry into the research area was restricted and no mowing or irrigation occurred.

The study was arranged in a split-split plot design as a 2 × 2 × 8 factorial with three blocks measuring (1.8 m × 29.3 m). The main plot factor, formulation, included granular and liquid (1.8 m × 14.6 m). The subplot factor, herbicide, included a 3-way combination broadleaf herbicide (2,4-D, dicamba and mecoprop) and dithiopyr (1.8 m × 7.3 m). The sub-subplot factor was herbicide residue collected days after treatment (DAT), which included an initial, 0, 1, 3, 5, 7, 9, and 14 (0.9 m × 1.8 m). The combination herbicide was applied as a granular formulation of Ferti-lome Weed Out Broadleaf Control (PBI/Gordon Corporation, Kansas City, MO) or liquid formulation of Trimec Classic (PBI/Gordon Corporation, Kansas City, MO). Both formulations were applied at a rate of 1.5 kg ai ha^{-1}. Dithiopyr was applied as granular Dimension 0.1 G; plus fertilizer (0-0-7) (Dow AgroSciences, Indianapolis, IN) or liquid Dimension 2EW (Dow AgroSciences, Indianapolis, IN). Both formulations were applied at a rate of 0.2 kg ai ha^{-1}.

Granular herbicides were applied to plots using a hand-held shaker. Prior to the application of the granular 3-way combination herbicide, the plots were watered with 6.4 mm of irrigation to improve adhesion of the herbicide granules to the foliage. Granular and liquid dithiopyr were watered in after application with 12.7 mm of irrigation. All watering was in accordance to their respective labels and measured using a flow meter (Figure 1).

Figure 1. Wetting surface before the application of granular 2,4-D.

Liquid herbicides were applied with a Toro Multi Pro 1250 sprayer (The Toro Company, Bloomington, MN). The sprayer was calibrated to deliver the herbicides at 774 L ha^{-1} with AI11008 nozzles at 241 kPa traveling at 4.8 km h^{-1}. To prevent driving on treated turfgrass and contaminating adjacent plots, the sprayer traveled in a 1.8 m wide alleyway between blocks. Additionally, plywood boards were positioned to prevent spraying into adjacent plots. In 2016, all blocks were treated with a single herbicide before sampling was initiated. In 2017, treatment applications and samplings were completed for each subplot factor (herbicide) before moving to subsequent subplots to minimize variations between blocks associated with drying of the herbicide on the foliage.

Samples were collected to determine how persistent herbicide residues were on foliage over time. Initial samples were collected a week before herbicide treatments were applied. Day 0 samples were taken immediately following the application. On day 1, 3, 5, 7, 9, and 14 sample collection occurred between 5:00 am and 6:30 am. This timing has been determined to corresponds with peak daily residue recovery (Gannon and Jeffries, 2014).

Residue samples were collected on a percale cotton cloth covered with a 4 mm thick plastic sheet that was clamped by a Polyvinyl chloride (PVC) frame with internal dimensions of 0.9 m × 0.6 m, and placed on the turf canopy (Figure 2). A modified California roller was rolled twenty passes on top of the plastic; down and back counted as two separate passes (Williams et al., 2008). After each sample was rolled, the plastic was discarded and the frame was cleaned to minimize cross-contamination. The roller (13.6 kg) was 60 cm wide, 10 cm in diameter and foam-wrapped to help conform to small undulations on the surface of the ground. After collection, the cloth was carefully placed in an amber colored jar (500 mL, Fisher Scientific, Hampton, NH), and placed into a cooler. Samples were transferred to a -4º C freezer to minimize degradation of the active ingredients during storage.

Figure 2. Cloth sample after being rolled. Dew moisture visible on cloth.

The laboratory testing was conducted by the University of Massachusetts Pesticide Laboratory, Amherst, MA. Trimec Classic and Ferti-lome Weed-Out samples were tested for all three active ingredients; 2,4-D, dicamba and mecoprop. Both Dimensions formulations were tested for dithiopyr only.

An analysis of variance was completed to test for significant treatment effects (P <0.05) using the Mixed procedure in SAS statistical software 9.4 (SAS Institute. Cary, NC. 2004). Least square means were separated based on Fisher's protected least significant difference (LSD) test.

RESULTS AND DISCUSSION

The average dislodgeable pesticide residues extracted from each treatment are summarized in Table 1. Significant main effects were observed across all three factors for both years; active ingredient, formulation, and DAT. Significant interactions were also observed across all combinations of the three factors for 2016 and 2017. The results of the mean separation test are shown in Figures 3 - 10 and Table 1. In 2016, liquid 2,4-D and dicamba residues for Day 1 were significantly higher than Day 0, and no differences were observed between the remaining days after treatment. In 2017, Day 1 also had slightly higher values than Day 0, but were not statistically different. After Day 3, no differences were observed between DAT. Table 1 shows that in both years, the liquid formulation of the 3-way combination broadleaf herbicide had some of the highest levels of residues during the 14-day period. Rain events may have resulted in the sharp decline of residue on Day 3 in 2016, and Day 5 in 2017.

Generally, the granular formulations resulted in less residue retained in the canopy and/or non-detectable (ND) levels of the active ingredient sooner after application (Table 1). The exception was mecoprop (MCPP) in 2017 where no differences were observed between formulations after 0 DAT. In 2016, regardless of active ingredient, the granular formulation resulted in significantly less residue retained in the canopy immediately following application on Day 0 (Figures 3-6). In 2017, a similar trend was observed with the granular formulations of 2,4-D, MCPP, and dicamba all resulting in less residue in the canopy on Day 0 (Figures 7-9). The exception was dithiopyr where no differences were detected between formulations (Figure 10). During both years, the study was conducted, plots treated with granular formulations of 2,4-D and dicamba had significantly less residue compared to those treated with the liquid formulations one day after application (Table 1). During the first year of the study with a detection limit of 1.95 µg sample^{-1}, dithiopyr was ND as soon as one day after application regardless of formulation. In 2017, with a much lower detection limit (0.035 µg sample^{-1}), the granular formulation was ND 5 DAT and liquid formulation at 9 DAT (Table 1). However, following three consecutive ND, 0.4 µg was recovered on 14 DAT in the granular formulation.

Detection limits were improved for the active ingredients used in the experiment from 2016 to 2017. Dithiopyr had a detectable residue level of 1.95 µg sample^{-1} and 0.035 µg sample^{-1} in 2016 and 2017 respectively. The improved detection limits are likely the reason why dithiopyr residues were found through Day 14 in 2017. 2,4-D and MCPP had a detection limit of 0.39 and 0.035 µg sample^{-1} in 2016 and 2017 respectively. Dicamba had a detection limit of 3.9 and 0.35 µg sample^{-1} in 2016 and 2017. Any residue recovered below these limits was labeled ND. For statistical analysis purposes, all ND's were considered half the detection limit.

Additional research is needed to determine how the solubility of 2,4-D and dicamba can lead to residues dislodging into solution multiple days and weeks after treatment. According to these data (Table 1), the granular formulation of the 3-way combination broadleaf herbicide had lower residues recovered than liquid formulations. This was also observed in 2016 with the dithiopyr herbicides. This suggests that granular formulation of the 3-way combination broadleaf herbicide would be preferred over liquid formulation to minimize field closure times following the use of pesticides; however, this suggestion does not consider the efficacy of the herbicides tested, which is an important component to sports turf maintenance. These results can help improve recommendations for minimizing potential exposure risks and help lawmakers make science-based decisions concerning future legislation.

LITERATURE CITED

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Table 1. Average dislodgeable residues in Kentucky bluegrass following the application of herbicides in both formulations in 2016 and 2017.

			Days After Treatment						
Year	Formulation	a.i.	0	1	3	5	7	9	14
			µg sample⁻¹						
2016	L	2,4-D	703.6b[f]	1251.9a	18.5c	4.3c	2.1c	8.1c	7.3c
	G	2,4-D	6.7c	4.0c	2.1c	ND	ND	ND	0.4c
	L	MCPP	210.1a	176.1a	3.9b	1.2b	0.4b	1.1b	1.8b
	G	MCPP	4.3b	ND	1.52b	ND	ND	ND	ND
	L	Dicamba	689.5b	1279.2a	14.2c	ND	ND	5.6c	6.7c
	G	Dicamba	5.8c	4.5c	ND	ND	ND	ND	ND
	L	Dithiopyr	26.4a	ND	ND	ND	ND	-[e]	-
	G	Dithiopyr	3.9b	ND	ND	ND	ND	-	-
2017	L	2,4-D	391.4a	433.7a	210.3b	2.50c	3.87c	1.15c	0.33c
	G	2,4-D	2.38c	16.13c	4.60c	0.43c	0.41c	0.25c	0.04c
	L	MCPP	127.3a	77.5ab	15.0b	0.21b	0.50b	0.15b	0.04b
	G	MCPP	0.56b	3.7b	1.16b	0.06b	0.19b	0.06b	0.04b
	L	Dicamba	371.5a	450.4a	209.2b	2.13c	4.13c	1.0c	ND
	G	Dicamba	1.90c	18.5c	4.01c	ND	ND	ND	ND
	L	Dithiopyr	24.9a	1.46b	0.11b	0.04b	0.04b	ND	ND
	G	Dithiopyr	14.5a	1.09b	0.11b	ND	ND	ND	0.04b

[a]Abbreviations: DAT, Days after treatment; G/L, Granular/Liquid; a.i., active ingredient; ND, Non-detectable
[b]Dithiopyr samples had a detection limit of 1.95 µg sample^{-1} (2016) and 0.035 µg sample^{-1} (2017).
[c]2,4-D and MCPP had a detection limit of 0.39 µg sample^{-1} (2016) and 0.035 µg sample^{-1} (2017).
[d]Dicamba had a detection limit of 3.9 µg sample^{-1} (2016) and 0.35 µg sample^{-1} (2017).
[e]Dashes '-' indicate no laboratory sampling took place because of four consecutive non-detects
[f] Statistical comparison within years and active ingredients; grouped within shaded rows. Data points with the same letter are not statistically different according to Fisher's protected LSD (P<0.05).

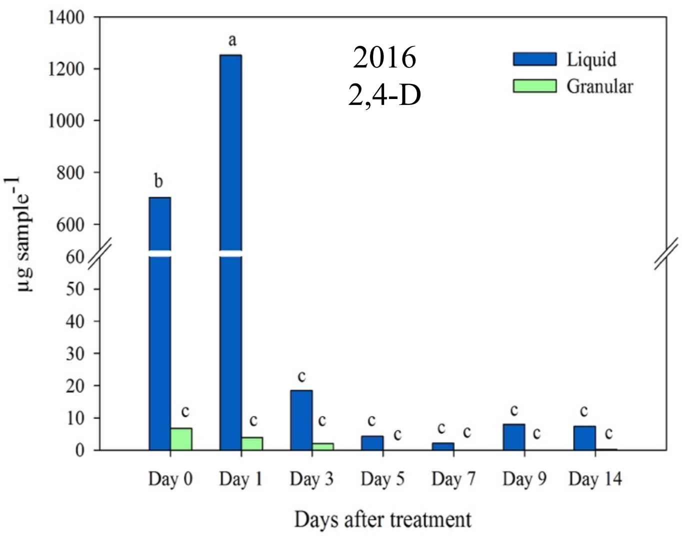

Figure 3. The effect of formulation and time on dislodgeable foliar residue levels of 2,4-D. Data points with the same letter are not statistically different according to Fisher's protected LSD ($P<0.05$).

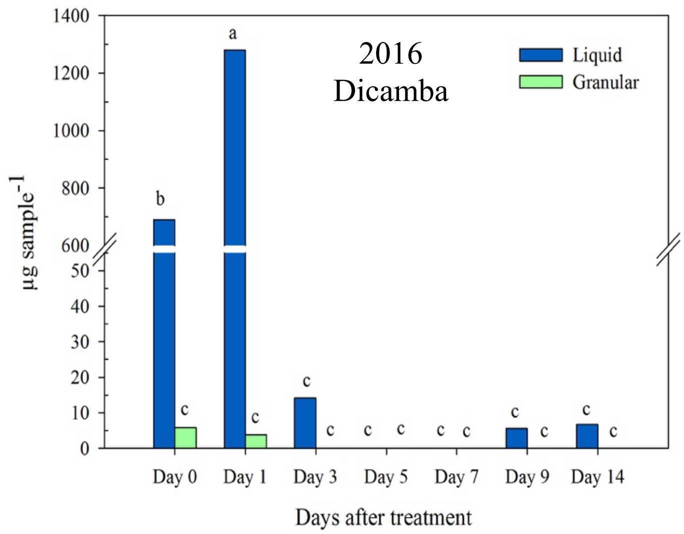

Figure 4. The effect of formulation and time on dislodgeable foliar residue levels of Dicamba. Data points with the same letter are not statistically different according to Fisher's protected LSD ($P<0.05$)

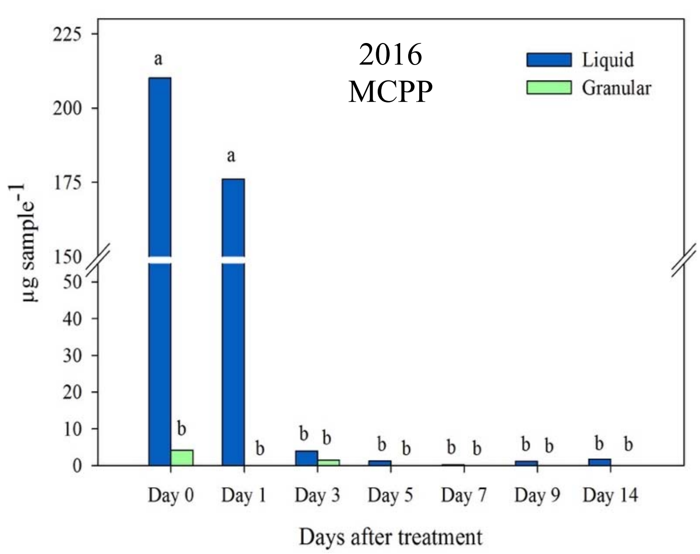

Figure 5. The effect of formulation and time on dislodgeable foliar residue levels of MCPP. Data points with the same letter are not statistically different according to Fisher's protected LSD ($P<0.05$).

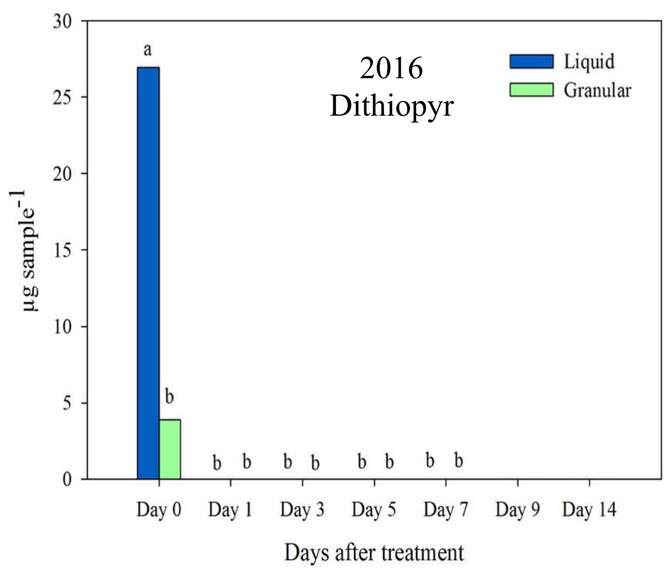

Figure 6. The effect of formulation and time on dislodgeable foliar residue levels of Dithiopyr. Data points with the same letter are not statistically different according to Fisher's protected LSD ($P<0.05$).

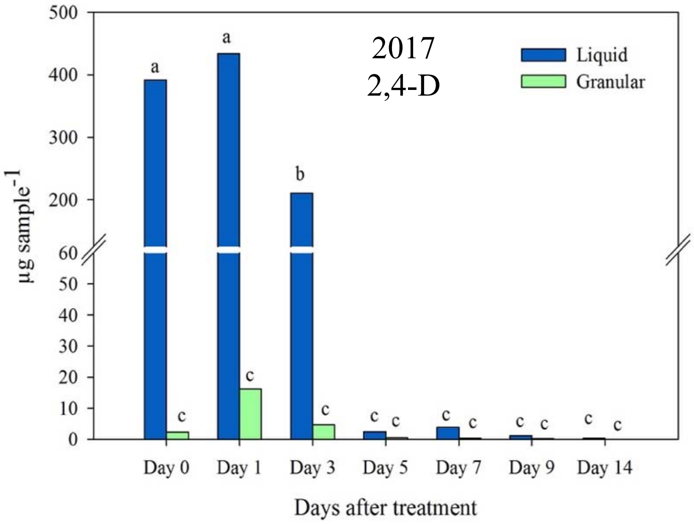

Figure 7. The effect of formulation and time on dislodgeable foliar residue levels of 2,4-D. Data points with the same letter are not statistically different according to Fisher's protected LSD (P<0.05).

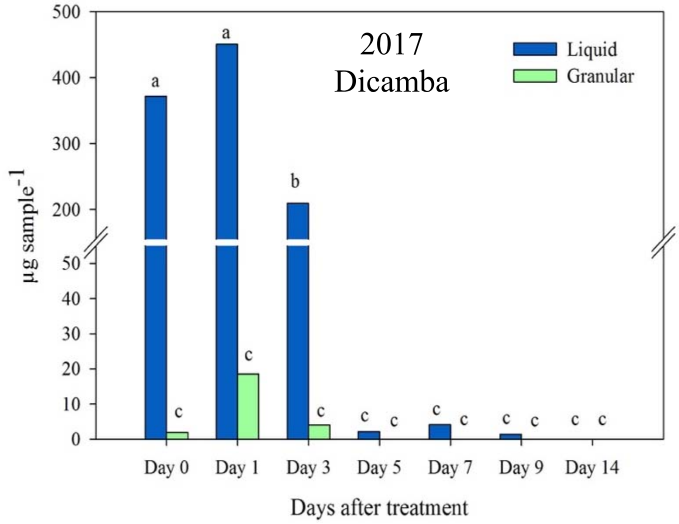

Figure 8. The effect of formulation and time on dislodgeable foliar residue levels of Dicamba. Data points with the same letter are not statistically different according to Fisher's protected LSD (P<0.05).

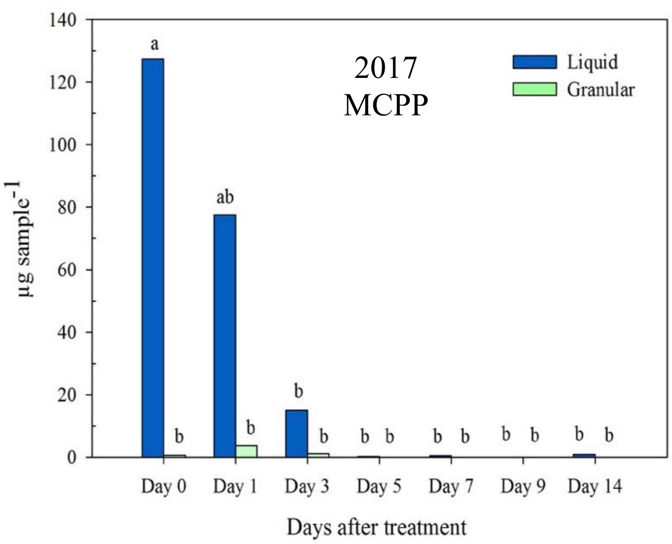

Figure 9. The effect of formulation and time on dislodgeable foliar residue levels of MCPP. Data points with the same letter are not statistically different according to Fisher's protected LSD (P<0.05).

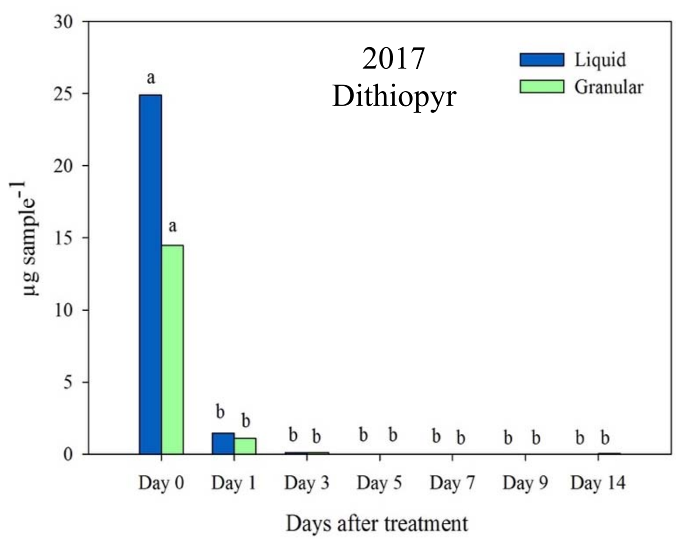

Figure 10. The effect of formulation and time on dislodgeable foliar residue levels of Dithiopyr. Data points with the same letter are not statistically different according to Fisher's protected LSD (P<0.05).