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Improving Nursery Crop Weed Control by Assessing Herbicide Movement through Organic Mulch©[a,b]

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SUMMARY

Experiments were conducted in 2018 to assess herbicide movement through organic mulch materials including pinebark, pinestraw, and hardwood. Weed species evaluated were crabgrass (*Digitaria sanguinalis*), garden spurge (*Euphorbia hirta*), and eclipta (*Eclipta prostrata*). Liquid formulations of prodiamine, dimethenamid-P + pendimethalin, and indaziflam were evaluated in

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combination with mulch materials applied at a depth of 5.1 cm (2 in.). Quantification of these herbicides was performed using biological and chemical assays from the soil samples collected from below the mulch layers. Results showed that only 67% eclipta control was observed in pots originally mulched with hardwood, which indicates that indaziflam was more tightly bound to this mulch. Crabgrass data showed that pinebark (65% control) was the only mulch type that caused a significant reduction in prodiamine efficacy. Dimethenamid-P + pendimethalin efficacy on garden spurge was reduced in pots originally mulched with hardwood or pinebark, but all treatments provided ≥94% control. Chemical assays showed that approximately 20% of pendimethalin, prodiamine, and indaziflam that was applied reached the soil surface when mulch was present during the application. More dimethenamid-P reached the soil surface than any other herbicide, with 69% being retained by the pinebark mulch.

INTRODUCTION

Weed management is a costly endeavor in container nursery production as hand weeding can be laborious, time-consuming and expensive. Growers most often rely on preemergence herbicides and supplemental handweeding for control. In some cases, mulch may also be used for weed control in containers, either as a sole means of weed suppression or in addition with preemergence herbicides (Mathers, 2003). When mulch and herbicides are both used for weed control, long-term weed control can be achieved, especially when lower mulch depths are applied (Bartley et al., 2017). Use of these herbicide + mulch combinations can also provide environmental benefits, such as reducing off-target movement of herbicides after application (Chalker-Scott, 2007; Fawcett et al., 1994). However, it is unknown if the efficacy of preemergence herbicides is reduced when they are applied to mulched containers. The objective of this research was to assess herbicide movement through organic mulch to determine the most appropriate mulch type for use with preemergence herbicides.

MATERIALS AND METHODS

Bioassay. Research was conducted at the Mid-Florida Research and Education Center, Apopka, FL in summer 2018. Nursery containers [946 ml (1 qt.)] were filled with a pinebark: peat substrate and amended with Osmocote® Plus 15-9-12 at the rate of 4.7 kg m^{-3} (0.03 lbs. /gal.). After filling containers, twenty seeds of either crabgrass (*Digitaria sanguinalis*), garden spurge (*Euphorbia hirta*) or eclipta (*Eclipta prostrata*) were sown to the surface of each container. Pinebark, pinestraw or hardwood mulch were then applied at a depth of 5.1 cm (2 in.) on top of each container. Liquid formulations of indaziflam (Marengo® 0.622 SC, Bayer Crop Science, Research Triangle Park, NC), prodiamine (Barricade® 4 FL, Syngenta Crop Protection, Greensboro, NC), and dimethenamid-P + pendimethalin (Tower® 6 EC + Pendulum® 3.3 EC, BASF Corp., Research Triangle Park, NC) were applied with a CO_2 backpack sprayer calibrated to deliver 561 liters per hectare (60 gal. per acre) using a 8004 flatfan nozzle (TeeJet Technologies, Wheaton, IL) at a pressure of 30 psi on June 06, 2018 (round 1) and July 12, 2018 (round 2) - at their labeled rates to pots seeded with eclipta, crabgrass, and garden spurge, respectively. A separate group of nontreated pots were maintained for each herbicide and mulch combination. All containers were placed on a full sun container nursery pad and received 3.5 cm (1.4 in.) of irrigation via two irrigation cycles through overhead sprinklers. Following irrigation, mulch was carefully removed from each pot so that only the herbicide reaching the soil surface was available for weed control and the presence of mulch did not confound results. The experiment consisted of a completely randomize design with six replicates per treatment. Data collection included weed counts at 2 and 4 weeks after treatment (WAT). At 4 WAT, all weed species were cut at the soil line and shoot fresh weights were determined for each weed species. Shoot fresh weights were converted to percent control by using the formula [(Nontreated control – treated) / nontreated control) × 100]. All percent control data were subjected analysis of variance using the PROC GLM procedure in SAS® (SAS 9.4, SAS Institute, Inc., Cary, NC). Fisher's Least Significance Difference Test was used to compare between individual means of experimental variables. All differences were considered significant at $p \leq 0.05$ and each weed species was analyzed separately. Significant differences observed in biweekly weed counts were reflected in fresh weight data; therefore, for the sake of brevity only percent control of shoot fresh weight data will be discussed.

Chemical assay. In addition to the bioassay described previously, chemical assays were performed to quantify herbicide movement through pinebark mulch. Nursery containers (946 ml or 1 qt.) were filled with substrate and amendments as previously described. Pinebark mulch was then applied at a depth of 5.1 cm (or 2 in.) on top of each container. Liquid formulations of indaziflam, prodiamine, and dimethenamid-P + pendimethalin were applied, and pots were irrigated as described above. Following treatment and 3.5 cm (1.4 in.) of irrigation, mulch was removed carefully without disturbing the underlying substrate. The substrate was then sampled to a depth of 2.5 cm (or 1 in.) out from each container. Quantification of each herbicide in the soil layer underneath mulch was determined using previously described methods (EPA 1996; EPA 2007; EPA 2018). All herbicide quantification data were converted to percent retention by pinebark mulch by using the formula [(No mulched control – herbicide treated) / no mulch control) × 100] to determine which herbicide was more tightly bound by the pinebark mulch. Data were analyzed as described previously.

RESULTS

Bioassay. When indaziflam was applied to pots initially mulched with pinebark (89% control) and pinestraw (99% control), eclipta control was similar to that of nonmulched pots (100% control), indicating that these two mulch types had no detrimental effect on indaziflam efficacy of eclipta (Table 1). Only 67% eclipta control was observed in pots originally mulched with hardwood, which indicates that indaziflam was more tightly bound to this mulch. Crabgrass data showed that pinebark (65% control) was the only mulch type that caused a significant reduction in prodiamine efficacy. Prodiamine provided similar crabgrass control when pots were originally mulched with hardwood (80% control), pinestraw (91%), and when no mulch was present. The combination of dimethenamid-P + pendimethalin provided similar control of garden spurge when it was applied to bare soil and pots originally mulched with pinestraw, which both treatments resulting in 100% control. Pots that were originally mulched with either hardwood or pinebark (94 to 95% control) provided commercially acceptable control, but to a less degree than was observed in non-mulched pots or pots originally mulched with pinestraw.

Chemical analysis. Over all three herbicide treatments (four active ingredients), pinebark reduced the amount of herbicide reaching the soil surface by 85% (Table 2). Approximately 20% of pendimethalin, prodiamine, and indaziflam that was applied reached the soil surface and was detected using chemical assay (Table 3). This indicates that 10 to 20% of the herbicide that was applied was available for weed control. More dimethenamid-P reached the soil surface than any other herbicide, with only 69% being retained by the pinebark mulch.

DISCUSSION

Similar to previous findings, herbicides evaluated in these experiments provided a high level of control of each bioassay weed species when applied to the soil surface when no mulch was present at the time of application (Johnson, 1997; Marble, 2011). When mulch was present during the application, results differed by herbicide as some herbicides will bind tighter to organic matter than others. Pinestraw was the only mulch material in which control of the target weed species was similar to control achieved when no mulch was present across all herbicide treatments and weed species evaluated. This indicates that the herbicides evaluated in this study may move more effectively through pinestraw compared with hardwood or pinebark mulch.

Results from this study show that many of the most commonly used preemergence herbicides are bound in organic mulch materials. Only 10 to 30% of the herbicide that was applied reached the soil surface, at least following only approximately 3.8 cm (1.5 in.) of irrigation over a short time period. As most herbicide labels indicate that 0.6 to 1.3 cm (0.25 to 0.5 in.) of irrigation is needed to water in herbicides following application, more irrigation may be needed with preemergence herbicides applied to mulched nursery containers or landscape beds. While only a small portion of the total herbicide applied reached the soil surface. In most instances, commercially acceptable weed control resulted over a 4 week evaluation period. It is unknown, however, how efficacy would be affected over a longer period and/or if weed seed were sown on multiple dates.

While this data shows a high degree of herbicide binding to mulch, use of preemergence herbicides to mulched containers or landscape beds would still offer significant advantages. In many cases, weed germination and growth significantly increase when seeds are placed on top of mulch compared to seeds below mulch (Richardson et al., 2008). Therefore, herbicide that is retained in the mulch layer would be available to prevent growth from weed seeds introduced on top of the mulch layer that may germinate/growth within that mulch layer. Weed control from these different herbicide + mulch combinations (when mulch was left on the soil surface) was not determined in the current study - but these combinations have been shown to provide season long weed control in previous studies (Bartley et al., 2017; Somireddy, 2012). While this data shows that pinestraw may be the most compatible mulch for use with the preemergence herbicides evaluated here, more data is needed to evaluate long-term control with this combination in a variety of environments. Cost, aesthetics, availability, and consumer acceptance should also be considered when evaluating mulch either with or without the use of preemergence herbicides.

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Table 1. Percent control of three herbicides applied to different mulch materials.

Weed Species	Herbicide	Mulch types[z]	Percent control[y]
Eclipta	Indaziflam	Hardwood	67 b[x]
		Pinebark	89 a
		Pinestraw	99 a
		No-mulch	100 a
Crabgrass	Prodiamine	Hardwood	80 ab
		Pinebark	65 b
		Pinestraw	91 ab
		No-mulch	100 a
Garden spurge	Dimethanamid-P + pendimethalin	Hardwood	94 b
		Pinebark	95 b
		Pinestraw	100 a
		No-mulch	100 a

[z]Liquid formulations of each herbicide (or combination) were to applied to pots mulched with hardwood, pinebark, pinestraw, or contained no mulch. Two days after application, mulch was removed prior to bioassay.

[y]Percent control was calculated as a percent decrease in shoot fresh weights in pots receiving no herbicide or mulch treatment by using the formula:
[((nontreated control - treated)/ nontreated control)*100)]

[x]Means within each weed species followed the same letter are not significantly different in based upon Fisher's Protected LSD test ($P \leq 0.05$).

Table 2. Average amount of herbicide[y] detected in soil samples following application to pots mulched with pinebark and those containing no mulch.	
Mulch type	Herbicide detected (mg/Kg)
Pinebark	49.4 b[z]
No-mulch	321.7 a

[z]Means followed the same letter are not significantly different in a column ($P \leq 0.05$).

[y]Herbicides applied were indaziflam, prodiamine, and dimethenamid-P + pendimethalin. The amount of herbicide presented in this table is the average of all four herbicides.

Table 3. Percent of preemergence herbicides retained by pinebark.

Mulch type	Herbicides	% Retained in mulch[z]
Pinebark	Pendimethalin	88 a[y]
	Prodiamine	84 a
	Indaziflam	80 a
	Dimethenamid-P	69 b

[z]Percent retention in mulch was calculated as a percent decrease in herbicide amount in soil samples receiving no mulch treatment by using the formula:

[((no mulch control - treated)/ no mulch control)*100)]

[y]Means followed the same letter are not significantly different based upon Fisher's Protected LSD test ($P \leq 0.05$).