Mulching for weed control: influence of type, depth, herbicide formulation and activation irrigation level on germination and growth of three container nursery weed species©[a]

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Abstract

This research was conducted to assess the impact of herbicide formulation, mulch type and depth, and activation moisture on germination and growth of crabgrass (*Digitaria sanguinalis*), garden spurge (*Chamaesyce hirta*), and eclipta (*Eclipta prostrata*). Granular or liquid formulations of indaziflam, prodiamine, and dimethanamid-P + pendimethalin were evaluated for control of these weed species by in combination with either pinestraw, pinebark, or hardwood mulch at depths of 0, 2.5, or 5.1 cm (0, 1 or 2 in.) followed by herbicide activation irrigation levels (one-time irrigation level following treatment) of either 1.3, 2.5, or 5.1 cm (0.5, 1, or 2 in.). Weed seed placement (below or above the mulch layer) and light penetration through different types and depths of 0, 1.3, 2.5, 5.1, and 10.2 cm (or 0, 0.5, 1, 2, and 4 in., respectively) of mulches were also analyzed. Results showed when using herbicides, mulch depth and herbicide formulation had a greater effect on weed control compared with mulch type or herbicide activation irrigation level. Mulch depths of 5.1 cm (2 in.) and liquid formulations generally provided the highest degree of weed control. There were no differences in light penetration or weed counts when mulch was applied at levels of at least 2.5 cm (1 in.).

INTRODUCTION

Mulch can control weed growth, moderate soil temperature, and increase water availability to container-grown plants. Herbicide placement in regards to the mulch layer (i.e., above or below the mulch) is an important factor to be considered because different mulch materials interact differently with various types of herbicides (Marble, 2015). For preemergence herbicides to be effective they must be incorporated into the soil after application; this typically involves application of 0.6 to 1.3 cm (0.3 to 0.5 in.) of irrigation within 3 to 4 days or a few weeks after application to “activate” the herbicide. It is unknown if more irrigation is needed to move the herbicide down to soil when being applied over mulch. No information is available on how different mulch materials and herbicides interact with each other and there is a lack of label recommendations for the use of preemergence herbicides in the mulched nursery containers. The objective of this research was to assess the impact of the mulch type and depth, herbicide formulation, and activation irrigation levels on germination and growth of three container nursery weed species.

MATERIALS AND METHODS

Greenhouse experiment

Research was conducted at the Mid-Florida Research and Education Center, University

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of Florida, in Apopka, Florida in 2016 and repeated in 2017. Nursery containers (946 mL or 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} (or 0.03 lbs $gal.^{-1}$). After filling containers, approximately 35 seeds of either crabgrass (*Digitaria sanguinalis*), garden spurge (*Chamaesyce hirta*) or eclipta (*Eclipta prostrata*) were sown to the surface of each container. Following seeding, three different types of mulch materials including pinestraw, pinebark mini-nuggets, or hardwood chips (*Eucalyptus*) were added on top of each container at depths of 0, 2.5 or 5.1 cm (0, 1 or 2 in.). Liquid or granular formulations of indaziflam (Marengo® 0.622 suspension concentrate and Marengo® 0.0224 G, Bayer Crop Science, Research Triangle Park, North Carolina), prodiamine (Barricade® 4 FL, Syngenta Crop Protection, Greensboro, North Carolina and RegalKade® 0.5 G, Regal Chemical Co., Alpharetta, Georgia), and dimethenamid-P + pendimethalin (Tower® 6 EC + Pendulum® 3.3 EC and Freehand® 1.75 G, BASF Corp., Research Triangle Park, North Carolina) were applied on August 17, 2016 (Round 1) and April 2, 2017 (Round 2) at their labeled rates to eclipta, crabgrass, and garden spurge respectively. Liquid formulations were applied with a CO_2 backpack sprayer calibrated to deliver 178 L ha^{-1} (or 20 gal. $acre^{-1}$) using a 8004 flatfan nozzle (TeeJet Technologies, Wheaton, IL) at a pressure of 30 psi. Granular formulations were applied using a hand-shaker. On the day after treatment, each container was irrigated 1.3, 2.5, or 5.1 cm (0.5, 1, or 2 in.) by hand watering. Following the initial hand watering, pots were kept dry for 3 days inside a greenhouse. After 3 days, all containers were irrigated via overhead sprinkler and received 0.5 cm (0.2 in.) total per day via two separate irrigation cycles. The experiment consisted of a factorial treatment arrangement of the two-herbicide formulations, three types of mulch materials, three types of mulch depths, and three levels of activation moisture levels with eight replications per treatment. Non-mulched, no-herbicide treatment was also included for each weed species for comparison. Data collection included weed counts at 30 and 60 days after treatment (DAT). At 60 DAT, 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 using the formula: Percent control = [((non-treated control – treated)/non-treated control)*100]. All percent control data were subjected to ANOVA using the PROC GLM procedure in SAS® (SAS 9.4, SAS Institute, Inc., Cary, North Carolina). 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 monthly 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.

Field experiment

In addition to the above experiment, another study was conducted in Summer 2017 where weed seed placements (above or below mulch layer) and light penetration through the different types and depths of mulches were evaluated. Nursery containers (11.4 L or 3 gal.) were filled with substrate and amendments as previously described. Approximately 35 seeds of crabgrass or garden spurge were sown to the surface of one-half of each container (representing seeds below the mulch layer). Following seeding, three different types of mulch materials including pinestraw, pinebark or hardwood chips were added on top of each container at depths of 0, 1.3, 2.5, 5.1, and 10.2 cm (0, 0.5, 1, 2, and 4 in.). Containers without mulch (control) were also included. Another 35 seeds of crabgrass or garden spurge were sown to the surface of mulch layer on the other half of each container (representing seeds above the mulch layer). Square transparent plastic tube of 30.5 cm (12 in.) × 3.8 cm (1.5 in.) × 3.8 cm (1.5 in.) (Sinclair & Rush Inc.) was inserted at the middle of each container containing the crabgrass seeds, below the mulch layer. All the containers were kept under full sun condition and received 1.3 cm (0.5 in.) of irrigation per day via overhead sprinkler. Data collection included biweekly weed counts and light intensity measurements in terms of photosynthetic photon flux density (PPFD) under the mulch layers at different depths using a light measuring sensor (LI-191R Line Quantum Sensor, LICOR®, Inc. Environmental, 4421 Superior Street, Lincoln, Nebraska 68504) by inserting into the transparent plastic tubes.

The experiment was a randomized complete block design with four different mulch types, five different mulch depths, with four replicates in each treatment. Light measurements data and weed counts data were analyzed (in SAS®) similarly as discussed in the previous experiment. Data from both years were combined for analysis. Due to minimal interactions between the treatment variables and for the sake of brevity, only treatment main effects are discussed.

RESULTS

Greenhouse experiment

There was no significant difference in the percent control of crabgrass, eclipta and garden spurge at three different irrigation levels (data not shown). In crabgrass and garden spurge, there was no difference in percent control among mulch types. For eclipta, the hardwood chips provided greater control (81.1%) compared to pine bark (67.5%) and pinestraw (64.8%) (Table 1). Mulch depth of 5.1 cm (2 in.) provided greater control than depths of 0 or 2.5 cm (1 in.) for all three weed species (Table 1). Liquid formulations provided greater control of all three weed species compared with granular formulations (Table 1).

Table 1. Main effects of mulch types, depths and herbicide formulations on three container weed species.

Mulch type	Percent control[1]	Mulch depth (cm)	Percent control	Herbicide formulations	Percent control
		Crabgrass			
None	84.5b[2]	0.0	84.5b	None	27.7c
Pinestraw	87.5ab	2.5	84.6b	Granular	91.1b
Pinebark	87.2ab	5.1	91.3a	Liquid	98.2a
Hardwood	89.1a				
		Eclipta			
None	54.3c	0.0	54.3b	None	41.3c
Pinestraw	64.8b	2.5	55.4b	Granular	60.3b
Pinebark	67.5b	5.1	86.8a	Liquid	80.9a
Hardwood	81.1a				
		Garden spurge			
None	89.3b	0.0	89.3b	None	66.5c
Pinestraw	96.1a	2.5	92.1b	Granular	94.8b
Pinebark	93.2a	5.1	97.5a	Liquid	99.1a
Hardwood	95.1a				

[1]Percent control = converted shoot fresh wt using the formula: [((non-treated control - treated)/non-treated control)*100].

[2]Means followed by the same letter are not significantly different based upon Fisher's protected LSD test ($p<0.05$).

Field experiment

Pinebark and pinestraw provided greater crabgrass control than hardwood as shown by weed counts (Table 2). In pots seeded with garden spurge, all mulch types provided at least a 40% reduction in weed counts up until week 6 (17.4 weeds per pot or less in mulched pots compared with 29.5 in non-mulched pots). After week 6, pinebark and pinestraw continued to provide greater spurge control than the hardwood mulch. For both crabgrass and garden spurge, seeds placed below the mulch showed less germination from week 2 until week 12, with the exception of crabgrass seeds placed below pinestraw mulch (Table 2). Mulch depths of 2.5, 5.1, and 10.2 cm (1, 2, and 4 in.) excluded over 99.5% of light and there was no difference in mulch type at depths greater than 1.3 cm (0.5 in.) (data not shown).

Table 2. Weed counts for crabgrass and garden spurge.

	Below[2]	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above
	2WAS[1]		4WAS		6WAS		8WAS		10WAS		12WAS	
Crabgrass												
Mulch type												
Pinebark	1.3c	1.7c	1.6c	1.8c	1.5c	2.1c	1.1c	1.9c	1.1c	1.7c	1.1c	1.6c
Pinestraw	1.5c	1.2c	2.1c	1.4c	2.1c	2.0c	1.9c	1.9c	2.0c	1.8c	2.0c	1.6c
Hardwood	4.8b	6.0b	5.1b	7.4b	5.1b	7.9b	5.1b	7.4b	4.6b	6.8b	4.6b	6.2b
Control	8.5a	12.5a	8.8a	12.8a	10.0a	12.8a	10.0a	13.0a	10.0a	13.0a	10.0a	13.0a
Mulch depth (cm)												
1.3	7.9a	7.1b	8.3a	7.6b	8.3a	8.1b	7.9a	7.6b	7.3b	7.1b	7.2b	6.7b
2.5	2.0b	2.1c	2.6b	2.8c	2.8b	3.4c	2.8b	3.3c	2.8c	3.7c	2.8c	2.9c
5.1	0.2b	1.6c	0.5c	2.1c	0.3c	2.6c	0.1c	2.3c	0.1d	1.4c	0.1d	1.3c
10.2	0b	1.1c	0.3c	1.6c	0.3c	1.8c	0.1c	1.8c	0.1d	2.1c	0.1d	1.7c
0.0	8.5a	12.5a	8.8a	12.8a	10.0a	12.8a	10.0a	13.0a	10.0a	13.0a	10.0a	13.0a
Garden Spurge												
Mulch type												
Pinebark	2.5b	5.0b	2.6b	6.3b	4.1c	7.4c	11.9c	17.4c	13.2b	19.4c	54.5c	69.9b
Pinestraw	3.6b	3.4b	5.1b	7.1b	5.7bc	7.5c	15.9c	20.0c	18.4b	22.8c	64.3c	79.9b
Hardwood	4.1b	3.8b	4.5b	5.1b	9.6ab	17.4b	40.4b	52.3b	53.2a	68.1b	174.8b	223.1a
Control	18.0a	34.0a	14.5a	29.5a	14.5a	29.5a	60.8a	97.0a	60.8a	97.0a	245.3a	254.8a
Mulch depth (cm)												
1.3	11.8b	15.0b	13.0a	17.2b	13.8a	17.8b	43.4a	56.3b	44.4ab	59.1b	166.0b	199.3b
2.5	0.8c	1.1c	1.2b	5.3c	5.3b	11.3bc	24.2b	31.6c	32.1bc	40.5bc	107.5c	137.3c
5.1	1.0c	0c	2.0b	2.2cd	4.9b	9.0c	13.7b	20.3cd	19.6c	26.8c	60.8d	93.6d
10.2	0c	0c	0b	0d	1.9b	5.1c	9.8b	11.4d	17.0c	20.7c	57.1d	67.1d
0.0	18.0a	34.0a	14.5a	29.5a	14.5a	29.5a	60.8a	97.0a	60.8a	97.0a	245.3a	254.8a

[1]WAS = Weeks after seeding.

[2]Weed counts followed by the same letter are not significantly different based upon Fisher's protected LSD test ($p<0.05$).

DISCUSSION

Herbicides need to be irrigated after application to be incorporated or "activated" (Altland et al., 2003), but very little research has been conducted to examine whether more irrigation is needed to improve efficacy in mulched areas (Marble, 2015). The result from this trial showed that when using herbicides, activation irrigation levels of 1.3, 2.5, and 5.1 cm (0.5, 1, or 2 in.) had no impact on efficacy when applied on mulched surfaces. Mulch type had no impact in crabgrass and garden spurge control. However, hardwood performed better than pinebark and pinestraw in controlling eclipta. Placement of herbicides (above or below a mulch layer) can be an important aspect to examine along with the different mulch types. Case and Mathers (2006) showed oryzalin provided better weed control when applied under hardwood bark while flumioxazin performed better when applied on top of the pinebark nuggets (Case and Mathers, 2006). A mulch depth of 5.1 cm (2 in.) improved weed control efficacy in all the three weed species. This result is in accordance with previous findings of Somireddy (2012) where mulch depth alone can provide sufficient weed control. Our data also showed that liquid-formulations performed better than granulars. Further examination of how these formulations move and bind with organic mulch is needed, but previous research suggests that liquid formulations typically provide greater control than granulars due to increased coverage (Wehtje et al., 2015).

Mulch can reduce weed seed germination and growth near the soil surface by reducing photosynthetic capability due to light exclusion (Crutchfield et al., 1986; Teasdale and Mohler, 2000). Additionally, many mulch materials such as pinebark nuggets have hydrophobic properties and quickly dry following rainfall or irrigation, which reduces water availability to germinating weeds (Richardson et al., 2008). Data suggest that an application of mulch at a depth of 5 cm (2 inches) or more can effectively control the weeds by acting as a physical barrier to the weed seed germination and growth. Based upon results from this trial, it can be concluded that mulch depth and herbicide formulation will affect weed control efficacy to a greater degree than activation moisture or mulch type. Future work will be conducted in field soils and will utilize different weed genera. We are also currently investigating the water holding capacity of various mulches to determine which type(s) may be more suitable in a nursery environment. Additional research will also focus more closely on herbicide formulation and movement through various mulch types.

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