Impacts of preemergence herbicide formulation on cost and weed control efficacy for container nursery crop producers©[a]

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Abstract

This research was conducted to study the impacts of herbicide formulation on the cost and efficacy of common preemergence herbicides. Granular and spray-applied formulations of flumioxazin, indaziflam, pendimethalin + dimethanamid-P, and prodiamine were evaluated for control of four weed species including dove weed (*Murdannia nudiflora*), crabgrass (*Digitaria sanguinalis*), eclipta (*Eclipta prostrata*), and spotted spurge [*Euphorbia maculata* (syn. *Chamaesyce maculate*)].

INTRODUCTION

Research has shown nursery growers often spend up to $4000/acre on hand weeding in containers (Mathers, 2003). In terms of "over-the-top" applications, only certain annual grasses can be controlled selectively (Derr, 1993; Senesac and Neal, 1992), necessitating the need for preemergence herbicides (Derr, 1994).

Preemergence herbicides are available as either granular or spray-applied formulations (dry flowables, liquids, emulsifiable concentrates, etc.). There are advantages and disadvantages associated with each formulation in terms of application, applicator skill needed, and cost. Briefly, spray-applied formulations are more economical, can be applied to wet foliage, can be applied more uniformly, and have been shown to provide superior weed control in certain instances (Bartley et al., 2014). Granular formulations require no special equipment in order to apply, can be applied in areas inaccessible by booms or large sprayers (i.e., shade houses), and more active ingredients are available in granular formulations for over-the-top applications. The objective of this trial was to compare efficacy of four preemergence herbicide active ingredients for control of common summer annual nursery weed species and to determine which species would be most problematic depending upon active ingredient. Average chemical cost savings growers could achieve by selecting spray-applied or granular formulations was also calculated by collecting price data from multiple sources.

MATERIALS AND METHODS

This research was conducted at the Mid-Florida Research and Education Center in Apopka, Florida and at the Gulf Coast Research and Education Center in Wimauma, Florida in 2016 using similar methodology. Nursery containers (1.3 gal, 10 in. diameter, 6 in. depth) were filled with substrate comprised of equal parts pine bark and peat (50:50, v/v) plus standard fertilizer and amendments. After pots were filled, equal amounts of doveweed (*Murdannia nudiflora*), crabgrass (*Digitaria sanguinalis*), and eclipta (*Elipta prostrata*) (in Apopka) or equal amounts of crabgrass, eclipta, and thickhead (*Crassocephalum crepidiodes*) (Wimauma) were hand sown to the surface of each container, ensuring that all seeds were evenly distributed across the container surface. Granular or liquid formulations of flumioxazin, indaziflam, dimethenamid-P + pendimethalin, or prodiamine were applied on 13 and 21 April in Wimauma and Apopka, respectively. Spray-applied formulations were

[a]Second Place – Graduate Student Research Paper Competition

applied using a CO_2 backpack sprayer calibrated to deliver 20 gal. per acre using an 8004 flat fan nozzle (TeeJet Technologies, Glendale Heights, Illinois, USA) at a pressure of 30 psi while granular formulations were applied to each pot separately using a hand-shaker. All pots were irrigated using over-head sprinklers and received 0.5 in. total per day via two separate irrigation cycles. The experiment was designed as a completely randomized design with six single pot replications per treatment at each location. Data collected included weekly counts of each weed species for 12 weeks. At approximately 12 weeks after treatment (WAT), all weeds were cut at the soil line and shoot fresh weights were determined individually for each species. All data were subjected to ANOVA using the PROC GLM statement in SAS (SAS 9.4, SAS Institute, Inc., Cary, North Carolina, USA). Fisher's Least Significance Difference Test was used to separate out the means and all differences considered significant at $p \leq 0.05$. Significant differences observed in weekly weed counts were reflected in fresh weight data; therefore, for the sake of brevity only fresh weight data will be discussed.

RESULTS

Formulation comparisons

1. Crabgrass.

Fresh weights showed prodiamine, pendimethalin + dimethenamid-P, and indaziflam provided similar control of crabgrass and there were no differences observed between formulations (Table 1). Of herbicide treated pots, the highest fresh weights were recorded in pots treated with flumioxazin, but no differences were observed in formulation. In Wimauma, no differences were observed in any herbicide treatment (or formulation).

2. Eclipta.

In Apopka, there was no difference in eclipta fresh weights between formulations of flumioxazin, indaziflam, or prodiamine; however, pots treated with the granular formulation of pendimethalin + dimethenamid-P contained significantly higher fresh weights (35.4 g) than pots treated with the spray-applied formulation (5.0 g). Treatments of pendimethalin + dimethenamid-P (EC), indaziflam (both formulations), and flumioxazin (both formulations) resulted in lower fresh weights than pots treated with prodiamine (either formulation). In Wimauma, the spray-applied formulation of flumioxazin provided better control of eclipta when compared to the granular formulation while the reverse was true for prodiamine.

3. Doveweed.

In terms of formulation comparison, the only difference observed was that pots treated with the granular formulation of indaziflam had lower fresh weights when compared to pots treated with the spray-applied formulation of indaziflam. No other differences in formulation were observed between any of the herbicides. Flumioxazin (both formulations), indaziflam (G), and pendimethalin + dimethenamid-P (both formulations) provided significantly greater doveweed control compared to prodiamine.

4. Thickhead.

No differences were observed in formulations of any herbicide with the exception of prodiamine in which application of the granular formulation resulted in lower fresh weights than the spray-applied formulation.

Table 1. Efficacy of granular and spray-applied herbicides for preemergence control of selected weed species.

Herbicide	Formulation[1]	Rate (lbs ai/A)[2]	Example cost/A[3] ($)	Weed shoot fresh weight (g)			
				Crabgrass	Eclipta	Doveweed	Total fresh wt (g)
				Apopka			
Flumioxazin	G	0.37	300	136.3 bA[4]	14.2 bcB	0.8 cC	151.3 ab
Flumioxazin	DF	0.37	106	119.2 bA	16.0 bcB	0.0 cC	135.2 b
Indaziflam	G	0.04	385	26.0 cA	0.0 cB	11.2 cA	37.2 c
Indaziflam	SC	0.04	200	0.0 cB	0.0 cB	32.1 bA	32.1 c
Pendimethalin + dimethanamid-P	G	2 + 1.5	365	1.7 cB	35.4 bA	0.1 cB	37.2 c
Pendimethalin + dimethanamid-P	EC	2 + 1.5	112	0.0 cB	5.0 cA	0.0 cB	5.0 c
Prodiamine	G	1.5	440	1.7 cC	88.1 aA	51.4 aB	141.8 b
Prodiamine	L	1.5	60	0.4 cC	99.7 aA	42.4 abB	142.5 b
Control	-	-	-	174.7 aA	6.2 cB	4.9 cB	186.2 a
LSD $_{0.05}$	-	-	-	36.4	24.8	15.2	35.6
				Wimauma			
				Crabgrass	Eclipta	Thickhead	Total fresh wt (g)
Flumioxazin	G	0.37	300	0.1 bA	1.2 abA	1.1 bcA	2.4 bc
Flumioxazin	DF	0.37	106	0.0 bA	0.1 cA	0.0 cA	0.1 d
Indaziflam	G	0.04	385	0.2 bB	0.9 abcAB	1.0 bcA	2.1 bc
Indaziflam	SC	0.04	205	0.0 bA	0.0 cA	0.0 cA	0.0 d
Pendimethalin + dimethanamid-P	G	2 + 1.5	365	0.0 bA	0.8 abcA	0.2 cA	1.0 cd
Pendimethalin + dimethanamid-P	EC	2 + 1.5	112	0.0 bA	0.0 cA	0.0 cA	0.0 d
Prodiamine	G	1.5	440	0.0 bB	1.3 abA	2.0 bA	3.3 ab
Prodiamine	L	1.5	60	0.0 bB	0.3 bcB	3.2 aA	3.5 ab
Control	-	-	-	1.4 aA	1.5 aA	1.7 bA	4.6 a
LSD $_{0.05}$	-	-	-	0.8	1.0	1.2	1.6

[1]G = granular; DF = dry flowables; SC = suspension concentration; EC = emulsifiable concentrates; L = liquid.

[2]Rate (lbs ai/A) = pounds of active ingredient per acre.

[3]Example cost was derived by calculating average price of leading brand names sold by multiple distributors and calculated on a cost per acre basis using the highest recommended label rate of each product. Prices will vary considerably based upon distributor, brand name or generic, location, shipping, tax rates, and quantity purchased. Price information is included for educational purposes only and should not be considered an advertised price by any entity.

[4]Means within each column followed by the same lower-case letter and means within each row followed by the same upper-case letter are not significantly different based upon Fisher's Protected LSD test (P=<0.05).

No significant differences were observed when comparing spray-applied and granular formulations of the same active ingredients in Apopka. Of herbicide treated pots, pots treated with flumioxazin and prodiamine had greater total fresh weights compared with pots treated with indaziflam or pendimethalin + dimethenamid-P. In Wimauma, pots treated with spray-applied formulations of flumioxazin and indaziflam had lower fresh weights compared with pots treated with granular formulations of the same active ingredient. Of all herbicide treatments, lowest total fresh weights were recorded in pots treated with spray applied formulations of flumioxazin, indaziflam, and both formulations of pendimethalin + dimethenamid-P.

Weed prevalence by active ingredient

1. Apopka.

For pots treated with flumioxazin, crabgrass was the most prevalent weed species, followed by eclipta and doveweed. Indaziflam provided very effective control of eclipta (0.0 g fresh weight) and the predominate weed species in pots treated with indaziflam was crabgrass and doveweed for the granular formulation; doveweed was the only species in the spray-applied formulation as all crabgrass and eclipta were completely controlled (Table 1; Figure 1). Eclipta was the predominate weed in pots that were treated with pendimethalin + dimethenamid-P. Similarly, for pots treated with prodiamine, eclipta was the predominate species followed by doveweed and lastly crabgrass.

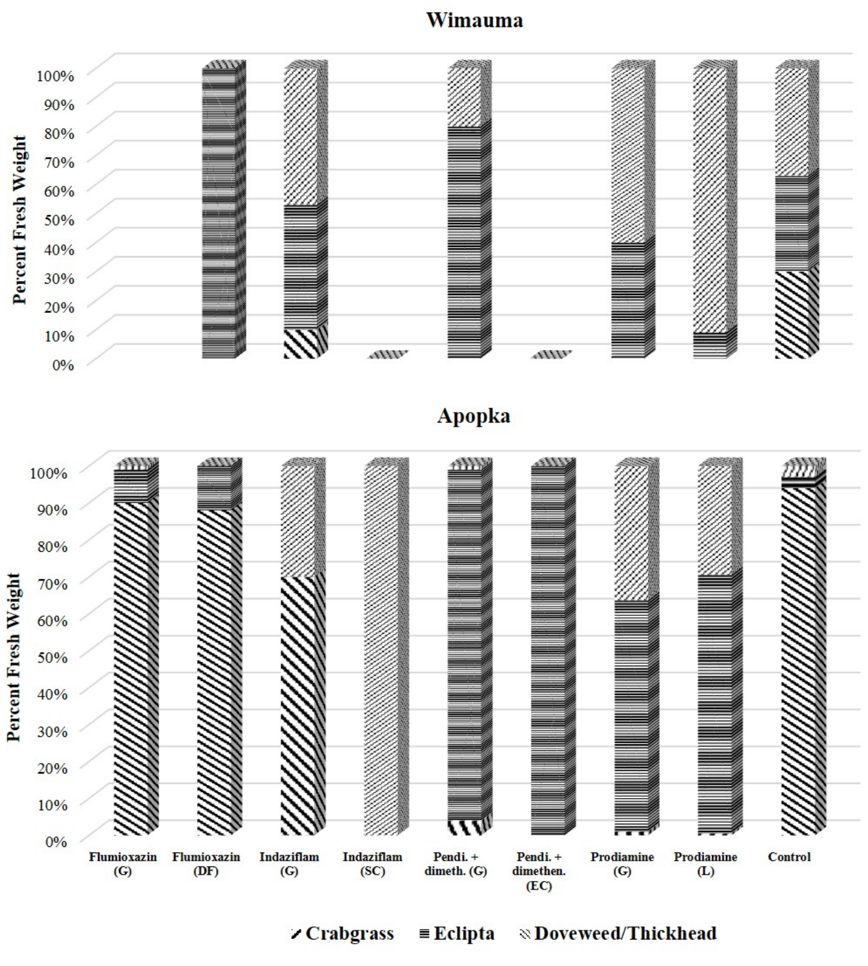

Figure 1. Weed prevalence by species in each herbicide treatment (percentage of each weed species).

2. Wimauma.

Few differences were observed in weed fresh weights between the herbicide treatments and weed growth was considerably less for all species in Wimauma when compared to weed growth in Apopka. Species distribution similar among most treatments with the exception of indaziflam granular in which thickhead grew larger than crabgrass, prodiamine granular in which eclipta and thickhead grew larger than crabgrass and the spray-applied prodiamine in which thickhead grew larger than both eclipta and crabgrass.

DISCUSSION

Results from this trial indicate that in general, granular and spray-applied preemergence herbicides provided similar control. However, it should be noted that in this study granular products were applied to each pot individually and carefully distributed across the container surface. Research has shown that in real-world scenarios, granular preemergence herbicides typically result in high variability (up to 250%) from one pot to another within a container block (Barker and Neal, 2016), and if the application is not made correctly, poor weed control will result. It should also be noted that all weed species evaluated in this trial have relatively large seeds. Previous research evaluating the impact of herbicide formulation for small-seeded broadleaf weeds (*Euphorbia maculata* or spotted spurge) has shown increased levels of control from spray-applied formulations of flumioxazin compared to granular (Bartley et al., 2014). Results of this study also illustrate how weed species prevalence will change depending upon active ingredients that are applied for control. For example, prodiamine, a dinitroaniline herbicide is highly effective on grass weeds. Crabgrass grew poorly in pots treated with prodiamine but as this active ingredient is also largely ineffective for eclipta or doveweed, those species became prevalent. The reverse was true for pots treated with pendimethalin + dimethenamid-P; in these pots, crabgrass was controlled with pendimethalin (also a dinitroaniline herbicide) and doveweed was controlled well by dimethenamid-P which has a different mode of action. Dimethenamid-P also has activity on eclipta, but typically does not result in complete control of high infestations. As evidenced in part by this study, it is important to rotate through various modes of action throughout the year in order to achieve desired results.

Given that few differences were noted in this study, growers should consider several factors which choosing between herbicide formulations. First, crop safety and tolerance should be the primary concern. While granular herbicides may provide increased safety in certain cases, there are several liquid preemergence herbicides which are labeled for over-the-top applications to hundreds of ornamental plants including isoxaben and dithiopyr (Gallery®SC and Dimension®, Dow AgroSciences), dimethenamid-P and pedimethalin (Tower® and Pendulum® 3.3 EC, BASF Corp.), and prodiamine and s-metolachlor (Barricade® and Pennant Magnum®, Syngenta). For field crops and in situations where directed applications could be made (as well as non-crop areas), flumioxazin (SureGuard®, Valent Corp., USA) and indaziflam (Marengo®, OHP Inc.) could be used. A standard 50 lb. bag of granular preemergence herbicide could cost approximately $75; in this case, treating an acre at the highest label rate (ex., 200 lbs.) would cost $300. To treat the same acre with a comparable liquid herbicide could be expected to cost approximately $55. For a 50-acre nursery making three applications per year, switching to spray-applied herbicides would be estimated to result in savings of $36,750 ($45,000 annual cost for granular vs. $8,250 cost for liquid) which does not include labor cost savings associated with liquid applications.

Literature cited

Barker, A., and Neal, J.C. (2016). Using a hand-cranked, hand-held spreader to apply herbicides in container nurseries. http://www4.ncsu.edu/~jcneal/Extension%20Publications/Spreader%20Tips%20Fact%20Sheet%20jcn.pdf (accessed August 25, 2016).

Bartley, P., Wehtje, G., Gilliam, C., Foshee, W., and Murphy, A.M. (2014). South. Nurs. Res. Conf. *59,* 278–81.

Derr, J.F. (1993). Weed control in nursery crops. In Pest Management Guide for Horticultural and Forest Crops, E.S. Hagood, ed. (Virginia Coop. Ext. Serv., Blacksburg. Publ.), p.102–113.

Derr, J.F. (1994). Weed control in container-grown herbaceous perennials. HortScience *29*, 95–97.

Mathers, H.M. (2003). Novel methods of weed control in containers. HortTechnology *13*, 28–34.

Senesac, A., and Neal, J. (1992). Weed management guide for herbaceous ornamentals. In Weed Facts (Ithaca, New York: Cornell Univ. Coop, Ext.).