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Response of Native Wildflowers and Grasses to Postemergence Herbicides

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ABSTRACT

This study was conducted to examine the effect of postemergence herbicides on wildflowers and native grasses and to determine their usefulness for weed control programs along roadsides and/or in seed production fields. Imazapic and bentazon appeared to be fairly safe for use on wildflowers and imazapic also did not damage the native grasses (bentazon was not applied to any grass species in this study). Dicamba did not injure the native grasses and could be used for post-harvest weed control in seed production fields of annual wildflower species; however, glyphosate could provide the same effect and has a larger spectrum of weeds controlled. Sulfometuron methyl injured many of the wildflower species, but had little effect on the native grasses. MSMA severely to moderately injured the wildflowers and also caused some foliar damage on the grass species.

INTRODUCTION

There is a growing emphasis on using native grasses, legumes, and wildflowers in many types of conservation and roadside plantings. Weed growth is a major impediment to establishing and growing these plants. Herbicides are commonly used to control weeds in many cropland and non-cropland situations; however, the tolerance of most native plants to herbicides is unknown. Also, the diversity of plant types included in many native plantings increases the difficulty of providing adequate weed control without harming one or more of the native plant components (Dickens, 1992). An additional concern is that native plants could be exposed to some herbicides by drift from adjacent application sites; for example, dicamba is especially prone to causing drift injury when applied near sensitive species (Gangstad, ND; Weidenhamer et al., 1989).

Studies have been conducted at the Jamie L. Whitten Plant Materials Center (PMC) to determine herbicide tolerance of several species currently being increased for seed production or used in various research activities (Bloodworth, 1991; Douglas et al., 2000; Grabowski and Billingsley, 1997). Grabowski and Billingsley (1997) examined the tolerance of a variety of native grasses, legumes, and wildflowers to common preemergence herbicides. This is a similar study examining the tolerance of native species listed in Table 1 to postemergence herbicides. Herbicides tested (Table 2) were selected for the following reasons: 1) routine use by the Mississippi Department of Transportation (MDOT) in their vegetation control program (MSMA and sulfometuron methyl); 2) reported success for increasing plant establishment (imazapic) (Beran et al., 1999a, Beran et al., 1999b, Beran et al., 2000; Vollmer and Vollmer, 1999), or 3) potential useful addition to current PMC seed production practices (dicamba and bentazon).

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MATERIALS AND METHODS

Test plots were planted at the Jamie L. Whitten PMC, Coffeeville, Mississippi, on an Oaklimeter silt loam soil. Planting rates used were 2X the recommended rates to ensure a dense stand (Table 1). Plots size was 5' by 8'. Plots were seeded on September 19 and 22, 1997 and September 28 and 29, 1998. Fall planting dates were chosen to optimize the germination of a majority of the species tested (Mueller et al., 2000; USDA, NRCS, 1999). Seeds received no germination enhancing treatments or inoculation prior to planting. Seeds were broadcast on the soil surface of a firm seedbed. Partridge pea and eastern gamagrass plots were raked after planting to incorporate the seeds. No fertilizer or chemical treatments, besides the herbicide treatment being tested, were applied to any plot after planting. Plots were arranged in a randomized complete block with 4 replications.

Table 1. Native species tested for their tolerance to herbicides and the planting rate used for each species.

Common name	Scientific name	Family	Planting rate
Black-eyed susan	*Rudbeckia hirta* L.	Asteraceae	4 lb/ac
Clasping coneflower	*Dracopis amplexicaulis* (Vahl) Cass.	Asteraceae	6 lb/ac
Eastern gamagrass	*Tripsacum dactyloides* (L.) L.	Poaceae	20 lb/ac
Lance-leaf coreopsis	*Coreopsis lanceolata* L.	Asteraceae	12 lb/ac
Lyre-leaf sage	*Salvia lyrata* L.	Lamiaceae	10 lb/ac
Partridge pea	*Chamaecrista fasciculata* (Michx.) Greene	Fabaceae	12 lb/ac
Plains coreopsis	*Coreopsis tinctoria* Nutt.	Asteraceae	4 lb/ac
Purpletop	*Tridens flavus* (L.) A.S. Hitchc.	Poaceae	12 lb/ac
Switchgrass	*Panicum virgatum* L.	Poaceae	20 lb/ac
Virginia wildrye	*Elymus virginicus* L.	Poaceae	26 lb/ac

Herbicide treatments and rates applied are listed in Table 2. Dicamba and bentazon were applied only to selected species as shown in Table 3. Herbicides were applied with a CO_2 powered backpack sprayer, calibrated to deliver 20 gallons per acre of spray solution. No adjuvants were added to any of the herbicide solutions. Application dates are listed in Table 4. The target application dates were chosen to coincide with MDOT spray dates or with critical weed control or native plant growth stages. The dicamba treatment was not applied to the wildflower species in 1998. Visual injury ratings (rating scale: 1 = complete kill; 3 = severe injury; 5 = moderate foliar injury; 7 = slight foliar injury; 9 = no injury.) were made 2 to 4 weeks after spraying, except for the sulfometuron metyl treatment, which was rated in the spring, because the application was made during the dormant season (Table 4). Estimated stand ratings (rating scale: 5 = excellent; 4 = good; 3 = fair; 2 = poor; 1 = none) were also made the following spring, except no stand ratings were made for sulfometuron methyl plots sprayed in 1998. Both sets of ratings were averaged across replications.

A bulk seed sample was taken from herbicide treatment and control plots for each species (not all species and treatments had seeds available for collection). Seeds were stored at room temperature and germination tests were conducted the following year. Switchgrass, Virginia wildrye, and purpletop seeds were prechilled at approximately 5°C for 14 days prior to testing. Germination containers were placed in a germinator set at 20°C/30°C (night/day) with 8 hours of light during the day period. Generally, 2 replications of 100 seeds were tested; however, in some instances sample sizes needed to be reduced because of inadequate seed numbers. Germination percentages were subjected to an analysis of variance (ANOVA) procedure in MSTAT-C (Michigan State Univ., 1988) and a least significant difference (LSD) value was determined for means that differed significantly at $P<0.05$.

Table 2. Herbicides applied and application rates used.

Common name	Trade name(s)	Application rate
Dicamba	Banvel (4 lb ae/gal)	0.5 lb ae/ac
Sulfometuron methyl	Oust (75% ai)	0.5 oz ai/ac
Imazapic	Cadre, Plateau (2 lb ai/gal, both)	2 oz ai/ac
Bentazon	Basagran (4 lb ai/gal)	1 lb ai/ac
MSMA	MSMA (6 lb ai/gal)	3.3 lb ai/ac

Table 3. Herbicides applied to plant species tested.

Species	Dicamba	Sulfometuron methyl	Imazapic	Bentazon	MSMA
Black-eyed susan	X[1]	X	X	X	X
Clasping coneflower	X[1]	X	X	X	X
Eastern gamagrass	X	X	X		X
Lance-leaf coreopsis		X	X	X	X
Lyre-leaf sage		X	X	X	X
Partridge pea		X	X	X	X
Plains coreopsis	X[1]	X	X	X	X
Purpletop	X	X	X		X
Switchgrass		X	X		X
Virginia wildrye	X	X	X		X

[1] Not applied in 1998.

Table 4. Planned herbicide application date (target date), actual application dates, and evaluation dates for herbicide injury ratings and spring stand ratings.

Herbicide	Target date	Appl. date	Eval. Date	Appl. date	Eval. date
		1998		1999	
Dicamba (grasses)	May 15	05/15/98	06/01/98	05/18/99	06/11/99
Dicamba (wildflowers)	August 15	-------------	-------------	08/05/99	09/10/99
Sulfometuron methyl	November 12	11/13/98	05/21/99	11/09/99	05/17/00
Imazapic	June 1	06/08/98	06/22/98	06/03/99	06/18/99
Bentazon	July 1[1]	07/08/98	07/15/98	05/18/99	06/11/99
MSMA	June 15	06/18/98	07/02/98	06/21/99	07/14/99
Spring stand ratings			05/24/99		05/17/00

[1] Target application date was moved to an earlier date in 1999.

RESULTS AND DISCUSSION

Growth of competing plants and the target species was very dense by mid-summer in most plots and may have prevented complete spray penetration. For this reason, some of the injury ratings (Table 5) are not as severe as anticipated, especially for shorter-growing species such as lyre-leaf sage, lance-leaf coreopsis, and black-eyed susan. It may also explain why injury ratings for some herbicides varied between treatment years. Plains coreopsis plots could not be evaluated in 1998 because an unidentified stem-boring insect (Order: Coleoptera) killed all plants in the plots before the herbicide application dates.

Injury and Stand Ratings

Dicamba (grasses): Dicamba did not injure the grass species treated (Table 5). This result was expected because its activity is targeted to broadleaf species and it generally does not injure grasses (Gangstad, ND). It also did not affect plant stands compared to those in the control plots when rated the following spring (Table 6).

Dicamba (wildflowers): Dicamba was only applied to the wildflowers in 1999. Clasping coneflower and plains coreopsis are both annual species that had died back before the chemical was applied. The injury ratings presented (Table 5) are for seedlings that germinated after the application date. Dicamba had no adverse effect on subsequent germination of these species within the plots. Black-eyed susan is a short-lived perennial and dicamba did injure the established plants that were sprayed, as indicated by the first rating number listed (Table 5). This rating is higher than expected, probably due to plant cover in the plots hindering spray coverage as mentioned previously; however, hairs on the leaves may also have prevented thorough coverage. The second rating shows that dicamba had no adverse effect on later seedling establishment for this species either. No clear effect on stand ratings the following spring could be determined for black-eyed susan or plains coreopsis (Table 6). The low stand rating for clasping coneflower was probably due more to plant residue on the plots preventing germination and seedling survival than to the herbicide application.

Sulfometuron methyl: Sulfometuron methyl injured several of the wildflower species. This herbicide has significant activity against many broadleaf weeds, affecting both germinating seeds and established plants (DuPont, 1999). Injury ratings for lyre-leaf sage and lance-leaf coreopsis (both perennial species) were lower, with the exception of lance-leaf coreopsis in 1998. They probably escaped some of the spray because of their short stature; however, lyre-leaf sage also has many hairs on the leaves that might have prevented spray coverage and lance-leaf coreopsis has highly glabrous leaves that may have affected spray retention. Partridge pea is an annual species that had senesced prior to the application date; there was no injury noted on seedlings that germinated the spring following treatment. Seedlings of the other wildflower species germinate in the fall and therefore seedlings or perennial plants would have been present during the application. All native grass species tested are perennials. Sulfometuron methyl did not injure eastern gamagrass or switchgrass. This is not unexpected because these two grasses formed fairly large crowns prior to the application, which would decrease their susceptibility to herbicide injury. Some injury was noted on the smaller Virginia wildrye and purpletop. This chemical will provide control of certain grasses (Meister Publishing Co., 1996) and therefore may have some activity against these two species. Spring stand ratings for the 1999 treated plots indicate that sulfometuron methyl did not appear to decrease stands of any of the grass species, but may have had some affect on those wildflower species that displayed visual injury symptoms.

Imazapic: Most of the wildflower and grass species were tolerant of imazapic. Black-eyed susan has been shown to have good tolerance to imazapic when applied at 1 oz ai/ac (Beran et al., 1999a). Although the rate used in this study was twice as much, there was still no damage to black-eyed susan plants. Beran et al. (1999a) found that some injury did occur to black-eyed susan when weed densities were low, which was not a consideration in this study. Lyre-leaf sage showed some foliar injury. Partridge pea also showed slight damage, which is not unexpected because the label states that legumes are somewhat susceptible to injury from postemergence applications. Beran et al. (1999b) found that partridge pea showed good tolerance to imazapic, but the rate used (1 oz ai/ac) was lower. The maximum rate listed on the Plateau label for partridge pea is 12 oz of the product per acre (3 oz ai/ac) in mixed grass and forb stands, with the caveat that some stand thinning of the legume might occur. Imazapic is not labeled for preemergence applications on switchgrass due to the potential for plant injury, but it did not appear to cause any damage when applied postemergence in this study. Purpletop injury ratings were high in 1999 and stands appeared to be reduced by the treatment in both years. Since this study was conducted, we have sprayed imazapic at a rate of 10 oz of the product per acre (2.5 oz ai/ac) on established purpletop plants. The plants initially showed signs of injury, but eventually recovered. The ratings may have been taken too early in 1999 to allow for recovery. Further testing may be required to determine if imazapic is safe for use on purpletop. Lyre-leaf sage stands may also have been impacted by imazapic. Effects on stands of other species were not detected; however, the black-eyed susan stands and plot appearance were highly impressive in both years.

Bentazon: None to very slight injury was noted for any of the wildflower species treated with bentazon. This herbicide has been used for many years on PMC production fields of partridge pea. It is not known if the plant canopy on the plots affected penetration to the shorter-growing species, but plains coreopsis, partridge pea, and probably clasping coneflower would definitely have been sprayed. Black-eyed susan was the only species where some injury was noted in both study years and there may have been some impact on spring stand ratings in the first year, but none was noted in the second.

MSMA: MSMA severely injured black-eyed susan, clasping coneflower, and plains coreopsis. Lance-leaf coreopsis and lyre-leaf sage were injured, but not as severely, probably because the spray did not penetrate the canopy to reach the plants. The injury rating for partridge pea was higher in 1999 than in 1998. Foliar injury was also noted on the grass species. It was difficult to determine a definite trend in spring stand ratings for most species; however, stands of black-eyed susan did appear to be reduced by the herbicide.

Table 5. Visual injury ratings for herbicide treatments.

Herbicide	Species	Injury[1]	
		1998	1999
Dicamba	Eastern gamagrass	9	7
	Purpletop	9	9
	Virginia wildrye	9	9
Dicamba[2]	Black-eyed susan	---	4/9[3]
	Clasping coneflower	---	9
	Plains coreopsis	---	9
Sulfometuron methyl	Black-eyed susan	7	6
	Clasping coneflower	1	5
	Eastern gamagrass	9	9
	Lance-leaf coreopsis	3	6
	Lyre-leaf sage	8	8
	Partridge pea	9	9
	Plains coreopsis[4]	---	5
	Purpletop	9	6
	Switchgrass	9	9
	Virginia wildrye	5	8
Imazapic	Black-eyed susan	9	9
	Clasping coneflower	9	9
	Eastern gamagrass	8	9
	Lance-leaf coreopsis	9	9
	Lyre-leaf sage	8	9
	Partridge pea	8	7
	Plains coreopsis	---	9
	Purpletop	8	3
	Switchgrass	9	9
	Virginia wildrye	9	9
Bentazon	Black-eyed susan	7	8
	Clasping coneflower	9	8
	Lance-leaf coreopsis	9	9
	Lyre-leaf sage	9	9

	Partridge pea	9	9
	Plains coreopsis	---	9
MSMA	Black-eyed susan	2	3
	Clasping coneflower	2	---[5]
	Eastern gamagrass	7	8
	Lance-leaf coreopsis	6	4
	Lyre-leaf sage	6	7
	Partridge pea	7	4
	Plains coreopsis	---	1
	Purpletop	7	9
	Switchgrass	8	8
	Virginia wildrye	6	7

[1] Average rating for all replications rated (some replications for some species could not be rated). Rating scale: 1 = complete kill; 3 = severe injury; 5 = moderate foliar injury; 7 = slight foliar injury; 9 = no injury.
[2] Not applied in 1998.
[3] First rating for new seedlings; second is for perennating plants present at the time of application. Other two species in this treatment are annuals and ratings are for new seedlings only.
[4] All plains coreopsis plants were killed by insects.
[5] Plants had senesced and could not be evaluated.

Table 6. Stand ratings made the spring following herbicide application.

Herbicide	Species	Stand ratings[1]	
		1998	1999
Control	Black-eyed susan	5	5
	Clasping coneflower	4	3
	Eastern gamagrass	3	3
	Lance-leaf coreopsis	3	3
	Lyre-leaf sage	5	5
	Partridge pea	2	2
	Plains coreopsis[2]	---	1
	Purpletop	3	4
	Switchgrass	3	3
	Virginia wildrye	4	4
Dicamba	Eastern gamagrass	3	5
	Purpletop	3	4
	Virginia wildrye	4	4
Dicamba[3]	Black-eyed susan	---	3
	Clasping coneflower	---	4
	Plains coreopsis	---	1
Sulfometuron methyl[4]	Black-eyed susan	---	3
	Clasping coneflower	---	1
	Eastern gamagrass	---	5
	Lance-leaf coreopsis	---	3
	Lyre-leaf sage	---	4
	Partridge pea	---	1
	Plains coreopsis	---	1
	Purpletop	---	3

	Switchgrass	---	3
	Virginia wildrye	---	3
Imazapic	Black-eyed susan	5	5
	Clasping coneflower	2	3
	Eastern gamagrass	2	3
	Lance-leaf coreopsis	3	1
	Lyre-leaf sage	2	3
	Partridge pea	3	1
	Plains coreopsis	---	1
	Purpletop	2	2
	Switchgrass	3	2
	Virginia wildrye	3	5
Bentazon	Black-eyed susan	3	5
	Clasping coneflower	4	3
	Lance-leaf coreopsis	2	2
	Lyre-leaf sage	5	5
	Partridge pea	2	1
	Plains coreopsis	---	1
MSMA	Black-eyed susan	2	4
	Clasping coneflower	3	4
	Eastern gamagrass	2	2
	Lance-leaf coreopsis	1	3
	Lyre-leaf sage	4	4
	Partridge pea	2	1
	Plains coreopsis	---	1
	Purpletop	3	3
	Switchgrass	4	3
	Virginia wildrye	4	4

[1] Stand ratings taken the spring following application. Rating scale: 5 = excellent, 4 = good, 3 = fair, 2 = poor, 1 = none.
[2] All plains coreopsis seedlings were killed by insect feeding in the previous year.
[3] Not applied in 1998.
[4] No stand ratings were taken for this treatment in the spring of 1999.

Germination Testing

Due to the late application date, germination testing was not conducted for the wildflower species treated with dicamba or any species treated with sulfometuron methyl. Eastern gamagrass did not produce sufficient seed for testing in a single growing season and lance-leaf coreopsis and lyre-leaf sage produced seed prior to any of the herbicide applications and were therefore not tested. Partridge pea seed was lost to an early frost in 1999.

There were no significant differences in germination percentages between any of the herbicide treatments for seed collected in 1998 (Table 7); however germination of all species except purpletop was very poor. It is not known if this poor germination can be attributed to environmental conditions during seed set or to conditions during germination testing. Germination of black-eyed susan, clasping coneflower, switchgrass, and Virginia wildrye was significantly lower for seed collected from the imazapic treatment in 1999 (Table 8). Beran et al. (1999a) noted that imazapic reduced flowering of black-eyed susan, but did not test the effect of this herbicide on seed germination. Sample sizes used in the germination test were small due to the limited amount of seed collected and the difficulty of manually separating and counting seeds for testing. For this reason, it cannot be definitively stated that imazapic reduced germination of these species, but further testing may be warranted. Germination of 1999 black-eyed susan was also similarly reduced by the MSMA treatment.

Table 7. Germination percentages for seed collected in 1998 (germination test conducted in 1999).

Herbicide	Black-eyed susan	Clasping coneflower	Partridge pea	Purpletop	Switchgrass	Virginia wildrye
	-------------------	-------------------	---------%	---------	-------------------	-------------------
Control	31	4	29	57	17	3
Imazapic	28	4	27	72	13	0
MSMA	14	9	32	68	10	0
Dicamba	----	----	----	60	----	0
Bentazon	----	----	40	----	----	----
LSD (0.05)[1]	NS	NS	NS	NS	NS	NS
Mean	24	5	39	64	13	1

[1] NS indicates treatment means in columns are not significantly different according to ANOVA at P<0.05.

Table 8. Germination percentages for seed collected in 1999 (germination test conducted in 2000).

Herbicide	Black-eyed susan	Clasping coneflower	Plains coreopsis	Purpletop	Switchgrass	Virginia wildrye
	-------------------	-------------------	---------%	---------	-------------------	-------------------
Control	85	78	65	83	42	33
Imazapic	55	20	71	----	8	0
MSMA	56	48	45	95	79	28
Dicamba	----	----	----	91	----	22
Bentazon	91	64	55	----	----	----
LSD (0.05)[1]	14	34	NS	NS	20	19
Mean	71	53	59	89	43	21

[1] NS indicates treatment means in columns are not significantly different according to ANOVA at P<0.05.

CONCLUSIONS

Dicamba is a suitable broadleaf herbicide for the grass species tested; however, the same effect could probably be obtained with 2,4-D or other broadleaf herbicides. The dicamba treatment on the wildflowers was included mainly as a field preparation option that could be used to treat some difficult-to-control broadleaf weeds such as goldenrods (*Solidago* spp.). It does not appear that this treatment would have any advantage over the current PMC practice of spraying glyphosate (Roundup) following harvest. Whether dicamba or glyphosate were sprayed, perennial black-eyed susan plants would be damaged or killed by the application.

Suflometuron methyl injured several wildflower species and stands also appeared to be affected. This herbicide is routinely used by MDOT to control weeds and bahiagrass (*Paspalum notatum* Flueggé) along the roadsides. Spraying this chemical could have a significant impact on the establishment and persistence of wildflower species that may be planted in these areas. Although the decumbent lance-leaf coreopsis and lyre-leaf sage were not as severely injured in this study, this result cannot also be expected along roadsides that are regularly mowed. None of the grass species appeared to be greatly affected by this herbicide, which could have been inferred by the common presence of these grasses along roadsides that are regularly sprayed.

Imazapic had little impact on a majority of the species, with the exception of partridge pea, lyre-leaf sage, and purpletop where slight injury was noted. It controls several troublesome weeds such as crabgrass (*Digitaria* spp.), which improved the appearance of many of the plots. Imazapic is labeled for roadside use, but MDOT was not widely using this herbicide when the study began. The increased tolerance to this herbicide means that it could be utilized on roadsides where wildflowers are planted; however, it will not control grasses such as bahiagrass and johnsongrass [*Sorghum halepense* (L.) Pers.] at the lower rates labeled for most forb species. The possible effect on flower production and seed germination suggest that further research should be conducted before imazapic is used routinely on wildflower seed production fields.

Bentazon appeared to be a fairly safe herbicide for use on the wildflowers treated. This indicates that it could be used postemergence on both roadsides and seed production fields, although application to small areas of the production fields containing the shorter-growing species may be recommended to confirm tolerance before spraying the entire field. Addition of this herbicide to weed control options is especially promising because bentazon can control yellow nutsedge (*Cyperus esculentus* L.).

MSMA severely injured most of the wildflowers and slightly to moderately injured the grasses. Routine use of this chemical by MDOT may contribute to the lack of persistence of wildflower stands along the roadsides. Foliar burning is also usually visible on native grasses after the road crews spray; however, the plants usually recover from this injury. This recovery coupled with the weed control the herbicide provides may explain why there are large stands of many of these native grasses along some roadsides. Current public acceptance is moving away from continued use of organic arsenicals, such as MSMA, due to the concern that arsenic residues may be accumulating in soils and plant tissues.

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