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Tolerance of Native Wildflower Seedlings to Imazapic[1]

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Abstract

Plateau (imazapic) at 0.0175 kg ai/ha (0.0156 lb ai/A) to 0.14 kg ai/ha (0.125 lb ai/A) was applied the day after seed of annual phlox (*Phlox drummondii*), black-eyed susan (*Rudbeckia hirta*), blanketflower (*Gaillardia pulchella*), lanceleaf coreopsis (*Coreopsis lanceolata*), scarlet sage (*Salvia coccinea*), standing cypress (*Ipomopsis rubra*), and sundial lupine (*Lupinus perennis*) were sown on a commercial potting medium or a sandy field soil in plastic pots. All seed were from one commercial source, with additional seed of black-eyed susan, lanceleaf coreopsis, and blanketflower from a second source (Florida ecotype). At 28 days after treatment, slight stand thinning was observed on scarlet sage, blanketflower, and black-eyed susan but the major effect of Plateau was stunting on all species. Annual phlox was the most tolerant of Plateau, with only occasional slight stunting and no stand thinning even at the highest rate. Lanceleaf coreopsis and sundial lupine were slightly less tolerant, with scarlet sage, blanketflower, and black-eyed susan being the most susceptible. Planting medium frequently affected Plateau activity, with stunting usually greater in the commercial medium than in a sandy field soil. For the species in which there were two seed sources, seed source affected tolerance of black-eyed susan and lanceleaf coreopsis. The Florida ecotype of lanceleaf coreopsis was more sensitive to Plateau than the commercial source. For black-eyed susan, sensitivity to Plateau depended on the medium in which seedlings were growing. Results for blanketflower were inconclusive.

Index words: native wildflower, ecotype, seed source, Plateau, phytotoxicity, stand establishment.

Species used in this study: annual phlox (*Phlox drummondii* Hook.); black-eyed susan (*Rudbeckia hirta* L.); blanketflower (*Gaillardia pulchella* Foug.); lanceleaf coreopsis (*Coreopsis lanceolata* L.); scarlet sage (*Salvia coccinea* Buc'hoz ex Etl.); standing cypress (*Ipomopsis rubra* (L.) Wherry); sundial lupine (*Lupinus perennis* L.).

Herbicide used in this study: Plateau® (imazapic), ammonium salt of (±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-methyl-3-pyridinecarboxylic acid.

Significance to the Nursery Industry

Susceptibility of native wildflower seedlings to a preemergent application of Plateau herbicide was more accurately assessed by evaluating stunting of seedlings 42 days after application rather than by measuring reductions in number of seedlings (i.e., stand thinning) at 14 or 28 days after application. Plateau caused only minimal stunting to annual phlox, and just slightly stunted lanceleaf coreopsis and sundial lupine. For these species, Plateau could be applied preemergent at 0.035–0.07 kg ai/ha (0.0312–0.0625 lb ai/A; 2–4 oz product per acre), rates recommended on the label for wildflower establishment and maintenance. Scarlet sage, blanketflower, and black-eyed susan were the least tolerant (stunting and occasional stand thinning). Preemergent Plateau rates should not exceed 0.035 kg ai/ha (0.0312 lb ai/A; 2 oz product per acre) for these species, and increased seeding rates (at least 20% greater) should be considered to compensate for possible stand thinning.

Introduction

Controlling weed growth is essential to successful establishment of direct-seeded native wildflower and grass plantings as weeds interfere with stand establishment (2, 5). Weed interference can be substantially reduced by the imidazolinone herbicide Plateau 2AS (imazapic; BASF) (2, 3, 5, 7, 8). Plateau is labelled for weed control in wildflower and grass plantings in noncrop areas, pastures, and rangeland (1). The recommended rate for wildflower establishment is 0.035 to 0.07 kg ai/ha (0.0312 to 0.0625 lb ai/A) (1). A wide array of broadleaf weeds, grasses, and sedges are controlled or suppressed by Plateau, but many native wildflowers exhibit some degree of tolerance (2, 5, 8). Plateau at 0.07 kg ai/ha (0.0625 lb ai/A) improved long-term (14 months) establishment of several direct-seeded native wildflower and grass species compared to nontreated plots when it was applied prior to emergence of wildflower seedlings (2, 3, 5).

Tolerance to Plateau can vary depending on growth stage, seed source, genotype, or variety (1) as well as soil properties (4). For example, Plateau at 0.105 kg ai/ha (0.094 lb ai/A) severely injured a field-grown Florida ecotype of blanketflower (*Gaillardia pulchella*) (6) even though this species should be relatively tolerant to this rate (equivalent to 6 oz product per acre) according to label information (1). There are also statements on the label to let users know that some stand thinning or loss (as well as stunting and chlorosis) could occur (1). Beran et al. (2) reported that Plateau at 0.07 kg ai/ha (0.0625 lb ai/A) reduced emergence of black-eyed susan (*Rudbeckia hirta*) and upright prairie coneflower (*Ratibida columnifera* (Nutt.) Woot. and Standl.) 4 weeks after seed were sown and Plateau applied. At 14 months, plant density of black-eyed susan, upright prairie coneflower, Indian blanket (*Gaillardia aristata* Pursh), and purple coneflower (*Echinacea purpurea* (L.) Moench.) in Plateau-treated plots was less than in nontreated plots. The variable effects Plateau can have on stand thinning were reported by Beran et al. (3). They observed that seedling stands of crown vetch (*Coronilla varia* L.) about 4 weeks after Plateau was applied (seeds sown 1–2 days before Plateau application) were greater in Plateau-treated plots compared to nontreated plots, but the following year the same Plateau treatment had no effect. Similarly, purple prairie clover (*Dalea purpurea* Vent.) seedling stands (4 weeks after seed was sown) were not affected by

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Plateau in 1994 and 1995 studies but in 1996 Plateau reduced seedling stands by about 44% (3).

Seedling stand density, as noted above, is one indicator of tolerance to Plateau. Measuring the effect of Plateau on seedling density can be a relatively quick method of evaluating wildflower tolerance to Plateau that does not require much space if pot experiments are conducted in a greenhouse. The objective of this experiment was to evaluate tolerance of seven native wildflower species (and two seed sources for three of the species) to Plateau applied preemergence. Substrate effects on species tolerance were also evaluated to determine if tolerance of these species to Plateau was affected by media characteristics.

Materials and Methods

On April 12 (Expt. 1) and May 15, 2001 (Expt. 2), 50 seed (per species per pot) of the following species were sown in plastic pots [7.3 × 7.3 × 7.9 cm (2.9 × 2.9 × 3.1 in); 378 ml (12.8 oz)] containing pre-moistened MetroMix 200 (pH 5.8; 16.4% organic matter [OM]) (The Scotts Co., Marysville, OH) or Fuquay fine sand (pH 5.2, 1.0% OM): annual phlox (*Phlox drummondii*), black-eyed susan, blanketflower, lanceleaf coreopsis, scarlet sage (*Salvia coccinea*), standing cypress (*Ipomopsis rubra*), and sundial lupine (*Lupinus perennis*). Fuquay fine sand was obtained on-site; however, the topsoil [~5–7.5 cm (2–3 inches)] was removed to eliminate most of the weed seed, and remaining soil was screened to remove root fragments. The University of Florida's Soil and Water Science Department Analytical Research Laboratory conducted tests for media characteristics. Seed of all species was purchased from Wildseed Farms (Fredericksburg, TX), which will hereto after be referred to as TEX. In addition, seed of Florida ecotypes of black-eyed susan, blanketflower, and lanceleaf coreopsis were included in the study, and will be referred to as NFL. Seed of these Florida ecotypes were derived from plants grown from seed collected in upland habitats of the Florida panhandle and extreme south Georgia (AHS Heat Zone 9; USDA Hardiness Zone 8b). All seed was lightly covered with the respective substrates after the seed was sown.

The day after the seed were sown, Plateau 2AS at 0.0175, 0.035, 0.07, or 0.14 kg ai/ha (0.0156, 0.0312, 0.0625, and 0.125 lb ai/A, respectively) was broadcast applied over the seeded media; a nontreated control was included. Plateau was applied outdoors using a compressed air backpack sprayer that delivered 374 liters/ha (40 gal/A) at 138 kPa (20 psi) through a single flat fan nozzle (Teejet XR8002 VS; Spraying Systems Co., St. Petersburg, FL). Conditions at the time of application on April 13 were: 96% relative humidity (RH); 21C (70F) air and substrate temperature; calm wind; moist substrate. On May 16, application conditions were: 91% RH; 14C (57F) air temperature; 16C (61F) substrate temperature; calm wind; moist substrate. About 1 hr after application on each date, pots were overhead irrigated with 0.63 cm (0.25 in) water, and then moved to a greenhouse. Conditions in the greenhouse were as follows: light level 80% of outdoor PPF; average minimum/maximum temperatures for Expts. 1 and 2 were 15.5/34.5C (59.9/94.1F) and 17.6/32.1C (63.6/89.8F); pots were overhead irrigated once per day with 0.43 cm (0.17 in) water.

Experiments were set up as separate 2 × 5 factorials (or 2 × 2 × 5 factorials for the three species that had two seed sources) within each species, with four single pot replications per treatment arranged in a completely random design. Number of living seedlings (out of 50 possible seedlings) was recorded 14 and 28 days after treatment (DAT). The degree of stunting was evaluated 42 DAT to determine the effect Plateau would have at a time when greater root uptake of Plateau was likely. Stunting was rated on a scale of 0 to 100 (increments of 10), with 0 = no stunting, 10–30 = slight stunting, 40–60 = moderate stunting, 70–90 = severe stunting, and 100 = completely stunted, internodes extremely compressed. Seedling number data were transformed by arcsine square root before analysis but retransformed means are presented. An *F*-test was conducted on seedling number data to determine if differences among nonzero rates existed. If the observed *F* was significant, the conservative Newman-Keuls multiple comparison ($\alpha = 0.05$) was applied. This approach was used since, in general, Plateau means rarely exhibited a response consistent with a simple polynomial model. In addition, the zero rate (i.e., the nontreated control) was compared with nonzero rates using Dunnett's test ($\alpha = 0.05$). For the stunting data, the nontreated control was omitted since every observation for this treatment over both experiments was zero except for two, and one of these was a missing value. Using these observations would have seriously underestimated experimental error.

Results and Discussion

Stunting ratings at 42 DAT were a much better indicator of species tolerance to Plateau compared to seedling numbers because number of seedlings per pot (that is, stand density) was rarely dependent on the rate of Plateau (as noted above). No other injury symptoms typically caused by Plateau (chlorosis, necrosis, reddish/purplish foliage [1, 6]) were observed. Given that any reductions in seedling number were rarely rate-dependent, only the 28 DAT results are reported for each species.

Lanceleaf coreopsis. Plateau, seed source, and medium in Expt. 1 affected stunting but there were no interactive effects. Plateau caused more stunting to NFL seedlings than to TEX seedlings (29.1 vs. 15.7; $P < 0.001$), with stunting of all seedlings greater in the MetroMix than in the field soil (31.2 vs. 13.5; $P < 0.002$). In Expt. 1, the 0.0175 kg ai/ha (0.0156 lb ai/A) rate caused the least amount of stunting, and the higher rates caused slightly greater stunting (Table 1). In Expt. 2, the only significant effect was that of Plateau. Stunting was minimal at the low rate but only slight at the higher rates.

For seedling number, the Plateau × medium × seed source interaction was highly significant ($P < 0.001$). Plateau did not reduce seedling number (results not shown), but in two cases seedling number in Plateau treatments were greater than the controls: for both TEX and NFL seedlings growing in MetroMix in Expt. 1, the greatest number of seedlings 28 DAT occurred with Plateau at 0.14 kg ai/ha (0.125 lb ai/A) (TEX: 36.4 vs. 25.0 for the control; and NFL: 42.8 vs. 6 for control; $P < 0.05$). Number of TEX seedlings in Expt. 1 was greater in MetroMix than in the field soil for all Plateau rates, including the control; however, the number of NFL seedlings was greater for MetroMix compared to field soil only for the two high Plateau rates (Table 2).

Blanketflower. Stunting in Expt. 1 was affected by Plateau, seed source, and medium but there were no interactive effects. There was equivalent slight to moderate stunting at

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Table 1. Stunting of native wildflower species seedlings 42 days after a preemergence application of Plateau. Stunting was rated on a scale of 0 to 100 (increments of 10), with 0 = no stunting, 10–30 = slight stunting, 40–60 = moderate stunting, 70–90 = severe stunting, and 100 = completely stunted, internodes extremely compressed. Results only shown for species in which there were significant differences among the nonzero rates of Plateau in Experiments 1 or 2.

Plateau (kg ai/ha)	Lanceleaf coreopsis	Standing cypress	Sundial lupine	Scarlet sage	Blanketflower
			Experiment 1		
0.0175	15.2b[z]	32.5a	7.5b	28.8a	31.7b
0.035	22.5a	43.8a	13.8b	42.5a	31.7b
0.07	25.6a	40.0a	20.0b	45.0a	31.5b
0.14	26.2a	48.3a	36.2a	43.8a	53.8a
			Experiment 2		
0.0175	3.8d	12.5c	0.0a	29.7b	—[y]
0.035	11.2c	13.8c	8.8a	41.2a	—[y]
0.07	18.1b	31.2b	7.5a	46.2a	—[y]
0.14	24.4a	43.8a	13.3a	51.2a	—[y]

[z]Means, within species and Experiments, followed by different letters are significantly different at the 5% level as determined by the Newman-Keuls test.
[y]The three factor interaction in Experiment 2, Plateau × medium × seed source, was significant ($P = 0.005$), so results are presented in Table 3.

the three low rates, and moderate stunting at 0.14 kg ai/ha (0.125 lb ai/A) (Table 1). Plateau caused more stunting to NFL seedlings than to TEX seedlings (47.6 vs. 26.7; $P < 0.001$), with stunting to all seedlings greater in the MetroMix than in the field soil (51.5 vs. 22.8; $P < 0.001$). In Expt. 2, the Plateau × medium × seed source interaction was significant ($P = 0.005$) (Table 3). Plateau caused slight stunting to TEX seedlings ($P = 0.026$), with the worst stunting at 0.14 kg ai/ha rate (22.5). Also, stunting was greater with MetroMix than with field soil (20.6 vs. 11.9; $P = 0.002$). For NFL seedlings, the Plateau × medium interaction was significant ($P = 0.009$). Stunting in the field soil was less than in MetroMix for all but the lowest rate of Plateau (Table 3).

Table 2. Effect of medium on number of native wildflower seedlings 28 days after 50 seeds (per pot) were sown on two media and grown under greenhouse conditions.

	Experiment 1		Experiment 2	
Wildflower taxa	Field soil	MMix	Field soil	MMix
Lanceleaf coreopsis				
TEX	8.2	29.8*[z]	5.6	29.7*
NFL	15.3	22.2[y]	12.5	28.1*
Blanketflower				
TEX	35.2	40.4	35.6	46.2*
NFL	4.3	4.2	5.5	4.6
Standing cypress	11.3	21.8*	23.1	27.7*
Sundial lupine	17.5	24.9*	19.9	27.5[x]
Annual phlox	26.0	24.3	20.6*	10.4
Black-eyed susan				
TEX	28.2	27.2	26.8	35.9*
NFL	6.8	7.9	18.4*	7.4
Scarlet sage	24.6	30.9*	31.8	37.3[w]

[z]*Mean number of seedlings per pot (n = 4) for one medium significantly greater than the other medium within a species (and seed source) and experiment.
[y]Mean number of seedlings per pot significantly greater in MetroMix than in field soil only for Plateau at 0.07 and 0.14 kg ai/ha; number of seedlings greater in field soil for 0.0175 kg ai/ha.
[x]Mean number of seedlings per pot significantly greater in MetroMix than in field soil only for Plateau at 0, 0.0175, and 0.14 kg ai/ha.
[w]Mean number of seedlings significantly greater in MetroMix than in field soil only for Plateau at 0 and 0.035 kg ai/ha.

At 28 DAT in Expt. 1 and Expt. 2, seed source × Plateau was significant ($P = 0.002$ and 0.004, respectively). This was probably due to the low germination rate of NFL seed compared to TEX seed (4.1 vs. 37.9 seedlings per pot averaged over all treatments in Expt. 1, and 5.0 vs. 41.7 in Expt. 2). With such low numbers of NFL seedlings and four replications per treatment, differences among treatments were not possible to detect for NFL seedlings. For the TEX seedlings, Plateau at 0.14 kg ai/ha (0.125 lb ai/A) reduced number of TEX seedlings compared to the control (41.8 vs. 30.1) in Expt. 1. In Expt. 2, TEX seedling number for all Plateau rates except 0.035 kg ai/ha (0.0312 lb ai/A) were significantly greater than the control (34.8 vs. 42.2–45.4 for the three rates).

Standing cypress. Plateau caused slight to moderate stunting in Expt. 1 but there were no differences among Plateau treatments (Table 1). In Expt.2, stunting was slight at 0.0175 kg ai/ha (0.0156 lb ai/A) and 0.035 kg ai/ha (0.0312 lb ai/A) but moderate at the two highest rates. Medium had no effect.

Plateau had no effect on seedling number in Expt. 1 or 2. However, in both experiments seedling number was greater in MetroMix than in the field soil (Table 2).

Sundial lupine. Plateau caused slight to moderate stunting in both experiments (Table 1). In Expt. 1, stunting was greatest at 0.14 kg ai/ha (0.125 lb ai/A) but the only significant difference was between the highest rate (moderate stunting) and the other rates (slight stunting). In Expt. 2, stunting was minimal (and none at 0.0175 kg ai/ha [0.0156 lb ai/A]), with no differences among Plateau rates. Potting medium had a significant effect ($P = 0.044$), with stunting greatest in field soil (23.8 vs. 15.0).

Seedling number was not reduced by Plateau in Expt. 1 (results not shown). Seedling number in MetroMix was about 40% greater than in field soil in both experiments, although in Expt. 2 differences were only significant at 0.0175 kg ai/ha (0.0156 lb ai/A) and 0.14 kg ai/ha (0.125 lb ai/A) (Table 2).

Annual phlox. Among all the species (or seed sources), Plateau caused the least amount of stunting with phlox. The medium × Plateau interaction was significant ($P = 0.010$) in

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Table 3. Stunting of blanketflower and black-eyed susan seedlings (42 days after a preemergence application) as affected by Plateau, medium and seed source. Stunting was rated on a scale of 0 to 100 (increments of 10), with 0 = no stunting, 10–30 = slight stunting, 40–60 = moderate stunting, 70–90 = severe stunting, and 100 = completely stunted, internodes extremely compressed. Results are only shown for which there was a significant Plateau × medium × seed source interaction among the nonzero rates of Plateau (only occurred in Experiment 2).

Plateau (kg ai/ha)	Blanketflower	Black-eyed susan
	Seed Source – TEX; Medium – Field Soil	
0.0175	—[z]	5.0b[y]
0.035	—	13.3b
0.07	—	35.0a
0.14	—	36.7a
	Seed Source – NFL; Medium – MetroMix 200	
0.0175	15.0c	7.5c
0.035	53.3b	25.0b
0.07	62.5ab	77.5a
0.14	75.0a	85.0a
	Seed Source – NFL; Medium – Field Soil	
0.0175	7.5b	0.0c
0.035	10.0ab	5.0b
0.07	20.0ab	7.5b
0.14	30.0a	20.0a

[z]Results not shown since there were only significant main effects for Plateau and medium in Experiment 2.

[y]Means, within a species, seed source, and medium, followed by different letters are significantly different at the 5% level as determined by the Newman-Keuls test.

Expt. 1, with differences in stunting among Plateau rates only for MetroMix; however, only slight stunting occurred at the two highest rates (20.0 and 10.0, respectively). In Expt. 2, stunting (20.0) was only observed at 0.07 kg ai/ha (0.0625 lb ai/A).

Seedling number was not reduced by Plateau in either experiment. In Expt. 2, there were nearly twice as many seedlings in the field soil compared to the MetroMix (Table 2).

Black-eyed susan. Plateau caused slight to moderate stunting in Expt. 1 but there were no differences among the Plateau rates. The medium × seed source interaction was highly significant ($P < 0.001$). Seedlings of TEX exhibited more stunting in MetroMix than in field soil (44.0 vs. 8.1) while the level of stunting for NFL seedlings was relatively high on field soil and MetroMix (48.1 and 39.4, respectively); however, the difference in stunting between TEX and NFL seedlings on MetroMix was not significant. In Expt. 2, stunting was also greater with MetroMix than with field soil for both seed sources. Stunting was moderate (55.0–65.0) on all TEX seedlings (no differences among rates) growing in MetroMix but only slight to moderate in field soil (Table 3). For NFL seedlings, stunting at 0.07 kg ai/ha (0.0625 lb ai/A) and 0.14 kg ai/ha (0.125 lb ai/A) was moderate to severe on MetroMix but only slight to moderate on field soil (Table 3).

Seedling number was not reduced by Plateau except for TEX seedlings at 0.07 kg ai/ha (0.0625 lb ai/A) (16.6 vs. 34.3) in Expt. 1 and at 0.14 kg ai/ha (0.125 lb ai/A) in Expt. 2 (24.6 vs. 20.1). Seedling number was greater for TEX than for NFL for all treatments in both experiments except Plateau at 0.07 kg ai/ha (0.125 lb ai/A) in Expt. 1. The seed source × medium interaction was highly significant in Expt. 2 ($P < 0.001$), with highest seedling number for NFL occurring with field soil, and with MetroMix for TEX.

Scarlet sage. Plateau caused slight to moderate stunting in Expt. 1 but there were no differences among the Plateau rates. In Expt. 2, Plateau caused slight stunting at the low rate, and an equivalent level of moderate stunting at the three higher rates. Stunting was greater in MetroMix than in field soil in both experiments (Expt. 1 — 52.5 vs. 27.5; $P < 0.001$; Expt. 2 — 53.1 vs. 30.8; $P < 0.001$).

Plateau reduced seedling number in Expt. 1 but only at 0.07 kg ai/ha (0.0625 lb ai/A). Seedling number was greater in MetroMix than in field soil in Expt. 1 (Table 2). In Expt. 2, seedling number tended to be higher on MetroMix than on field soil but the difference was significant only for the control and Plateau at 0.035 kg ai/ha (0.0312 lb ai/A). Compared to the control, seedling number was reduced by Plateau at 0.07 kg ai/ha (0.0625 lb ai/A) and 0.14 kg ai/ha (0.125 lb ai/A).

Plateau applied prior to emergence of seven native wildflower species usually caused some degree of stunting by 42 DAT but no other foliar injury symptoms typical of Plateau were noted. Plateau at 0.07 kg ai/ha (0.0625 lb ai/A) and 0.14 kg ai/ha (0.125 lb ai/A) reduced seedling numbers (i.e., caused stand thinning) of blanketflower (TEX only), black-eyed susan (TEX only), and scarlet sage at 28 DAT compared to the control. However, the level of stand thinning did not consistently occur in both experiments. It is not unusual for the activity of Plateau to vary within a species in replicated experiments. For example, Plateau at 0.07 kg ai/ha (0.0625 lb ai/A) had no effect on percentage of emerged black-eyed susan or Indian blanket (*Gaillardia aristata*) seedlings at 4 weeks after treatment (WAT) during one year but Plateau reduced percentage of emerged seedlings when the experiment was repeated the following year under similar conditions (2).

Medium frequently affected Plateau activity, with stunting usually greater in MetroMix 200 than in a sandy field soil. Given that organic matter will adsorb Plateau (4) and the MetroMix had much more OM than the field soil (16% vs. 1%), stunting of seedlings in the field soil would have been expected to be greater. However, what may have occurred was that the Plateau in the sandy field soil leached below the root zone (neither medium ever dried out during either study) because of the relatively low moisture holding capacity of the field soil compared to the MetroMix (Jeff Birk, BASF; personal communication).

Annual phlox was clearly the species most tolerant of a preemergence application of Plateau at rates up to 0.14 kg ai/ha (0.125 lb ai/A), which is twice the rate recommended on the label for wildflower establishment. This rate could be used to provide a broad spectrum of weed control when establishing a phlox planting from seed. In a previous experiment, Plateau at rates up to 0.28 kg ai/ha (0.25 lb ai/A) caused no stunting to annual phlox at 6 WAT when applied preemergence (7).

A preemergence application of Plateau at up to 0.07 kg ai/ha (0.0625 lb ai/A) could be used with lanceleaf coreopsis

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and sundial lupine. Only slight stunting at the three lowest rates occurred in both experiments on both species, and this level of stunting was deemed acceptable based on the level of acceptable injury defined by Vollmer and Vollmer (7). They also reported only slight injury to these species 6 weeks after a preemergence application. In that study, no stunting was caused by postemergence application; however, we observed that Plateau delayed reblooming of NFL lanceleaf coreopsis when it was applied to flowering plants (6).

Scarlet sage, blanketflower, and black-eyed susan were the least tolerant based on the moderate level of stunting that often occurred at the label rate of 0.07 kg ai/ha (0.0625 lb ai/A), the stand thinning that Plateau occasionally caused, and the increased stunting of seedlings growing in MetroMix. Results about the tolerance of NFL blanketflower seedlings were inconclusive because of poor germination. In a previous study (7), Plateau applied preemergence severely injured blanketflower at 0.07 kg ai/ha (0.0625 lb ai/A) while black-eyed susan was slightly injured at rates up to 0.28 kg ai/ha (0.25 lb ai/A). There are no other reports of scarlet sage tolerance to Plateau. Based on the results of this study and previous work (6), use of Plateau on these species should be limited to 0.0175–0.035 kg ai/ha (0.0156–0.312 lb ai/A; 1–2 oz product per acre) when applied preemergence. Moreover, seeding rates could be increased by at least 20% to compensate for thinning that might occur.

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