

Evaluations of Imazethapyr and Imazapyr for Effective Suppression of Roadside Vegetation

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The objective of these studies was to evaluate rates and mixtures of imazethapyr (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid) and imazapyr (2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl) nicotinic acid with isopropylamine (1:1) plus imazethapyr combinations for growth suppression, seedhead control, and turf discoloration of tall fescue (*Festuca arundinacea* Schreb.) intended for highway roadside turf. Imazethapyr applied alone at rates of 25 to 123 g ha⁻¹ provided effective suppression of height for 4 to 9 weeks, controlled seedheads, and generally failed to discolor turf to unacceptable levels. More discoloration was evident in turf treated with imazethapyr plus imazapyr combinations in comparison with turf treated with imazethapyr alone. Rates of 94 + 5.0 to 123 + 4.4 g ha⁻¹ imazethapyr plus imazapyr, respectively, provided good growth and seedhead suppression, and although discoloration occurred, turf generally recovered following termination of suppression.

For many years, plant growth regulators (PGRs) have been used for turf growth suppression and seedhead control on highway roadsides and other turf areas. With a growing demand for PGRs with improved characteristics, such as decreased turf injury, weed control, and seedhead suppression, many new products are currently being developed by manufacturers.

Two new products, imazethapyr (Pursuit®) and imazapyr (Arsenal®), have recently been developed by the American Cyanamid Company. These materials have been tested for weed control in crops (1, 2), as well as in warm-season grasses (3), cool-season grasses (4–6), and tree nurseries (7). In addition, these materials have been evaluated for turf growth suppression (3, 6–10).

In evaluating new PGR products for suitability to a given market, extensive testing must be performed to determine efficacy of the material in question for growth suppression and seedhead control, and materials must also be evaluated for turf discoloration. These studies were initiated to evaluate rates and mixtures of imazethapyr and imazapyr for growth suppression, seedhead control, and turf discoloration. Tall fescue (*Festuca arundinacea* Schreb.) was selected as the turf species for evaluation because it is one of the most frequently used species on highway roadsides.

MATERIALS AND METHODS

Three studies were conducted in Central Maryland between 1984 and 1987. In 1984 and 1986, studies were conducted at the University of Maryland Turfgrass Research and Education Facility in Silver Spring, Maryland. In 1987 a study was conducted at the United States Department of Agriculture, Beltsville Agricultural Research Center, in Beltsville, Maryland. All treatments in all tests were arranged in a randomized complete block design with three replicates. Data were analyzed by analysis of variance, and means were separated by Bayes least significant difference.

1984 Test

In 1984 turf was a mature Kentucky-31 tall fescue (*Festuca arundinacea* Schreb.) grown on a Chillum silt loam (fine-silty, mixed, mesic typic Hapludult) with a pH of 6.3 and 2.3 percent organic matter. Before PGR application, turf was maintained at 5.4 cm. PGRs were applied with a CO₂ pressurized sprayer at a dilution rate of 467.5 l ha⁻¹ on April 27, 1984 (100 percent greenup). Surfactant (X-77, 0.1% v/v) was added to all PGRs applied. One week after PGR application, all plots were trim mowed to 5.4 cm with a rotary mower. Seedhead emergence occurred on May 4, 1984.

Turf was periodically evaluated for color and canopy height, and seedheads were counted toward the termination of the study. Color was rated visually on a scale of 0 to 9, where 0 represented brown, dead turf; 5 represented turf color acceptable for a highway roadside; 6 represented color acceptable for a home lawn; and 9 represented uniform, dark green coloration. Canopy height was measured with a ruler placed vertically on the soil surface. A lightweight cardboard disc with a 15-cm diameter and a slit in its center was placed over the ruler and allowed to float on the turf canopy. Height measurements were taken on the ruler at the point where the disc stopped. Three measurements were taken per plot. Seedheads were counted on June 1, 1984. Counts were obtained by randomly tossing a square frame (929 cm²) on the plot and counting seedheads within the frame. Three tosses were made per plot.

1986 Test

In 1986 turf was a mature "Rebel" tall fescue grown on Chillum silt loam (fine-silty, mixed, mesic Typic Hapludult) with

a pH of 6.2 and 2.4 percent organic matter. Before PGR application, plots were maintained at 5.7 cm with a rotary mower. PGRs were applied with a CO₂ sprayer at a dilution rate of 1402.5 l ha⁻¹ on April 8, 1986 (100 percent greenup). Surfactant (X-77, 0.25% v/v) was added to all PGRs applied. Seedheads emerged on May 3, 1986.

Turf was periodically evaluated for color and canopy height, and seedheads were counted toward the termination of the study. Methods used for evaluating all parameters were the same as in 1984.

1987 Test

Turf was a mature stand of Kentucky-31 tall fescue grown on a Mattapex silt-loam (fine silty, mixed mesic Aqualfic Normudults) with a pH of 6.2 and 2.1 percent organic matter. Before PGR applications, plots were maintained at 5.7 cm with a rotary mower. PGRs were applied with a CO₂ pressurized sprayer at a dilution rate of 467.5 l ha⁻¹ on April 8, 1987 (75 percent greenup). Turf had not been fertilized for at least 5 years before PGR application. Surfactant (X-77, 0.25% v/v) was added to all PGRs applied. Seedhead emergence occurred on May 8, 1987.

Turf was periodically evaluated for color and canopy height, and seedheads were counted toward the termination of the study. Methods used for evaluating all parameters were the same as in 1984.

RESULTS AND DISCUSSION

1984 Test

Imazethapyr applied at 198 g ha⁻¹ discolored turf to unacceptable levels; however, all other PGR treatments resulted

in acceptable turf color (Table 1). Turf treated with imazethapyr generally exhibited more discoloration than mefluidide-treated turf, but it recovered after 4 weeks.

Height and seedhead suppression was evident in all PGR-treated turf (Table 2). Imazethapyr and mefluidide suppressed turf height for at least 4 weeks. Contrary to these results, Duell and Neary (6) and Pennucci and Jagschitz (9) reported that imazethapyr applied at 11, 22, 44 or 88 g ha⁻¹ failed to adequately suppress canopy height of Kentucky bluegrass (*Poa pratensis* L.), red fescue (*Festuca rubra* L.), perennial ryegrass (*Lolium perenne* L.), and tall fescue. The authors did not mention the addition of surfactant to imazethapyr applied to turf, and this omission may have resulted in the lack of adequate turf suppression. The authors also reported minimal turf discoloration with imazethapyr. In addition, the authors reported good tall fescue seedhead suppression with imazethapyr, which agrees with the results obtained herein.

1986 Test

Three weeks after application, color was deleteriously affected by PGR treatments; however, treated turf was still acceptable for a home lawn. There appeared to be a synergistic effect with imazethapyr and imazapyr combinations in terms of discoloration. There was also a rate effect with imazethapyr, with the higher rate causing more discoloration. Eight weeks after treatment, the 185 g ha⁻¹ rate of imazethapyr, the 123 + 3.7 g ha⁻¹ rate of imazethapyr + imazapyr, and the 185 + 3.7 g ha⁻¹ rate of imazethapyr + imazapyr discolored turf to unacceptable levels (Table 3). Turf treated with 123 g ha⁻¹ imazethapyr, amidochlor or mefluidide exhibited acceptable color for a home lawn 8 weeks after treatment. Twelve weeks after application, only mefluidide- and amidochlor-

TABLE 1 EFFECTS OF IMAZETHAPYR ON TALL FESCUE COLOR, 1984

Product	Rate g ha ⁻¹	Color ^a			
		5/9	5/15	5/25	6/3
imazethapyr	25	7.0bcde*	5.8bc	6.3ab	5.7ab
imazethapyr	49	6.8cde	5.7c	6.3ab	5.7ab
imazethapyr	99	6.5e	5.7c	6.3ab	6.0a
imazethapyr	198	6.7de	4.7d	4.7c	4.0de
mefluidide	426	7.0abcd	6.7ab	6.0b	5.7ab
unmowed check		7.7a	7.0a	7.3a	4.3cde
mowed check		7.7a	7.3a	7.3a	5.0abcd

Note: Applications were initiated on April 27, 1984.

^aColor was rated visually using a 0 to 9 scale: 0 = brown turf; 5 = color acceptable for highway roadside turf; 6 = color acceptable for home lawn; 9 = uniform, dark green.

*Means within a column and followed by the same letter are not significantly different at $p = 0.05$ level according to Bayes LSD.

TABLE 2 EFFECTS OF IMAZETHAPYR ON TALL FESCUE CANOPY HEIGHT AND SEEDHEADS

Product	Rate g ha ⁻¹	Canopy Height				Seedheads
		5/24	6/8	6/21	7/16	5/15
		- - - - -	- - - - -	- - - - -	- - - - -	no. m ⁻²
imazethapyr	25	8.6cd	14.3ab	14.5a	20.8a	0.0b
imazethapyr	49	8.3de	14.9a	15.3a	18.5a	2.1b
imazethapyr	99	7.5ef	12.4abc	14.0a	18.7a	0.0b
imazethapyr	198	6.8f	11.7bc	12.9a	16.9a	0.0b
mefluidide	426	9.0bcd	11.3bc	14.1a	19.2a	4.3b
unmowed check		11.4a	13.9ab	15.7a	19.4a	170.1a
mowed check		-				

Note: Applications were initiated on April 27, 1984.

*Means within a column and followed by the same letter are not significantly different at p = 0.05 level according to Bayes LSD.

TABLE 3 EFFECTS OF IMAZETHAPYR AND IMAZETHAPYR PLUS IMAZAPYR COMBINATIONS ON TALL FESCUE COLOR, 1986

Product	Rate g ha ⁻¹	Color ^a			
		4/28	5/19	6/9	7/2
imazethapyr + imazapyr	94 + 5.0	7.0b*	5.3bc	4.0c	4.3a
imazethapyr + imazapyr	123 + 3.7	6.0c	4.5d	3.3d	3.0a
imazethapyr + imazapyr	185 + 3.7	6.0c	4.7cd	2.7e	2.7a
imazethapyr	123	7.0b	5.8b	6.0b	3.8a
imazethapyr	185	6.0c	4.3d	3.3d	3.0a
mefluidide	426	8.7a	8.3a	8.0a	6.0a
amidochlor	2800	8.8a	8.5a	7.6a	5.0a
unmowed check		8.9a	8.3a	6.3ab	3.3a

Note: Applications were initiated on April 8, 1986.

^aColor was rated visually using a 0 to 9 scale: 0 = brown turf; 5 = color acceptable for highway roadside turf; 6 = color acceptable for home lawn; 9 = uniform, dark green.

*Means within a column and followed by the same letter are not significantly different at p = 0.05 level according to Bayes LSD.

TABLE 4 EFFECTS OF IMAZETHAPYR AND IMAZAPYR COMBINATIONS ON TALL FESCUE CANOPY HEIGHT AND SEEDHEADS

Product	Rate g ha ⁻¹	Canopy Height				Seedheads
		4/28	5/13	5/27	7/2	6/2
		cm				no. m ⁻²
imazethapyr + imazapyr	94 + 5.0	9.1b*	9.2c	9.4c	7.9bc	0.0b
imazethapyr + imazapyr	123 + 3.7	9.2b	8.9c	8.6c	6.0c	0.0b
imazethapyr + imazapyr	185 + 3.7	9.2b	9.3c	10.0c	6.2c	0.0b
imazethapyr	123	9.2b	9.5c	10.2c	8.7bc	0.0b
imazethapyr	185	9.9b	8.7c	9.1c	6.0c	2.1b
mefluidide	426	10.0b	9.8c	11.8c	11.6b	8.6b
amidochlor	2800	11.1a	11.6b	15.6b	12.3a	17.2b
unmowed check		14.6a	20.1a	20.1a	14.5a	185.1a

Note: Applications were initiated on April 8, 1986.

*Means within a column and followed by the same letter are not significantly different at $p = 0.05$ level according to Bayes LSD.

TABLE 5 EFFECTS OF IMAZETHAPYR PLUS IMAZAPYR COMBINATIONS ON TALL FESCUE COLOR, 1987

Product	Rate g ha ⁻¹	Color*				
		4/20	4/29	5/5	5/19	5/29
imazethapyr + imazapyr	74 + 2.7	5.7b*	4.7b	4.7ab	6.3a	5.0a
imazethapyr + imazapyr	99 + 3.7	5.3b	3.7b	3.7b	5.6a	6.0a
imazethapyr + imazapyr	123 + 4.4	5.7b	4.7b	4.0b	5.3a	5.7a
mefluidide	426	6.3ab	4.3b	4.7ab	5.7a	6.0a
unmowed check		7.0a	6.7a	6.0a	7.0a	6.0a

Note: Applications were initiated on April 8, 1987.

*Color was rated visually using a 0 to 9 scale: 0 = brown turf; 5 = color acceptable for highway roadside turf; 6 = color acceptable for home lawn; 9 = uniform, dark green.

*Means within a column and followed by the same letter are not significantly different at $p = 0.05$ level according to Bayes LSD.

treated turf exhibited acceptable color for roadside turf; however, no treatment was significantly different from untreated turf.

Height suppression was present in all treated plots, with the exception of amidochlor, for at least 9 weeks (Table 4). Growth suppression was still evident in imazethapyr and imazapyr treated turf 12 weeks after application. All PGRs tested effectively controlled seedheads (Table 4).

1987 Test

Applications made at 75 percent greenup on April 8, 1987, resulted in turf discoloration that lasted for at least 4 weeks, and recovery occurred by 6 weeks after application (Table 5). Prinster and Watschke (8) also reported discoloration and recovery with imazethapyr and imazapyr combinations. No significant turf color differences were evident among PGRs

TABLE 6 EFFECTS OF IMAZETHAPYR PLUS IMAZAPYR COMBINATIONS ON TALL FESCUE CANOPY HEIGHT AND SEEDHEADS

Product	Rate g ha ⁻¹	Canopy Height				Seedheads
		4/28	5/13	5/27	7/2	6/2
		cm				no. m ⁻²
imazethapyr + imazapyr	74 + 2.7	7.8b*	9.1b	14.8a	18.0a	57.1b
imazethapyr + imazapyr	99 + 3.7	8.0b	9.7b	14.7a	17.5a	38.8b
imazethapyr + imazapyr	123 + 4.4	8.4b	8.6b	12.9a	20.4a	35.5b
mefluidide	426	8.5b	9.1b	14.8a	21.6a	29.1b
unmowed check		12.7a	14.6a	16.7a	20.8a	222.8a

Note: Applications were initiated on April 8, 1987.

*Means within a column and followed by the same letter are not significantly different at $p = 0.05$ level according to Bayes LSD.

applied. Height suppression lasted at least 5 weeks (Table 6). Tall fescue seedhead suppression was evident in all imazethapyr and imazapyr combinations and mefluidide-treated plots (Table 6).

CONCLUSION

More discoloration was evident in turf treated with higher rates of imazethapyr and with imazethapyr plus imazapyr combinations than with imazethapyr used alone. Turf, however, generally recovered from discoloration toward the end of the suppression period. The suppression period lasted between 4 and 9 weeks on tall fescue. Suppression appeared to be better than mefluidide and amidochlor. Tall fescue seedhead control was excellent for all rates tested.

On the basis of the results of these studies, it appears that imazethapyr applied alone or in combination with imazapyr will be an effective PGR for use on roadside tall fescue turf. The range of rates providing effective height and seedhead control and acceptable color is quite broad, that is, imazethapyr (25 to 123 g ha⁻¹); imazethapyr plus imazapyr (94 + 5.0 to 123 + 3.7 g ha⁻¹, respectively). Consequently, the safety margin for this material is quite broad.

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