Postemergence Control of Crabgrass in Transition Zone Turf Using MSMA and Fenoxaprop

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ABSTRACT

The objective of this study was to compare the effectiveness of single and sequential applications of monosodium methanearsonate (MSMA) with single applications of fenoxaprop {(±)-2[4-({6-chloro-2-benozoxazolyl}oxy) phenoxy] propanoic acid} for postemergence control of crabgrass (Digitaria spp.). MSMA applied at 2.2 kg ha^{-1} twice on a 14-day interval or 1.1 kg ha^{-1} applied three times on a 7-day interval provided exceptional (99 percent) control of mature (i.e., three or more tillers) crabgrass, but elicited unacceptable levels of discoloration. When MSMA was applied at 0.6 kg ha^{-1} three times on a 7-day interval or at 1.1 kg ha^{-1} twice on a 14-day interval, fair (78 to 79 percent) to good (88 percent) control was achieved without unacceptable discoloration of turf. However, a single MSMA application at 2.2 kg ha^{-1}, did not effectively control crabgrass. Fenoxaprop (0.28 kg ha^{-1}) provided fair (78 percent) to excellent (93 percent) levels of control when applied to mature crabgrass. The erratic performance of fenoxaprop in control of mature crabgrass was attributed to environmental conditions as such conditions affected the vigor of crabgrass. Single applications of fenoxaprop (0.20 and 0.28 kg ha^{-1}) in early summer when crabgrass was relatively immature provided exceptional (91 to 99 percent) control and eliminated weeds as a problem for the remainder of the season. Effective control of mature crabgrass with fenoxaprop (0.28 or 0.56 kg ha^{-1}) can be achieved if rainfall or irrigation is not limiting and crabgrass is growing vigorously.

Weed control in turfgrass is best accomplished by maintaining a dense stand through employment of sound cultural practices. However, because of budget limitations, proper mowing frequency, fertility, and other management inputs in low maintenance, highway turfgrass areas are often neglected. Budget restrictions, as well as mechanical disturbances, environmental and biotic stresses, and poor soil conditions invariably lead to deterioration of turfgrass stand density and weed invasion. For these reasons, herbicides are used to supplement cultural practices in controlling weeds. Weed control in highway turfs is important because it provides the following benefits:

1. Helps improve turfgrass stand density by reducing competition from other plants,
2. Reduces mowing frequency in summer when weed species are growing more rapidly than cool-season turfgrass species,
3. Reduces potential weed problems in adjacent farmland and other property, and
4. Improves aesthetic quality.

Among the most common weeds found in turfgrass areas are smooth [Digitaria ischaemum (Schreb.) Muhl] and hairy [Digitaria sanguinalis (L.) Scop] crabgrass. Crabgrass is particularly troublesome in the transition zone where turfgrass density frequently deteriorates because neither cool- nor warm-season grasses are well adapted to the region. Crabgrass is effectively controlled with preemergence herbicides (1), but these chemicals are often too expensive to use on extensive highway turfgrass areas. When postemergence crabgrass control becomes necessary, methanearsonates such as MSMA are often used. However, effective crabgrass control with these herbicides has been erratic, and their use is normally accompanied by objectionable levels of turfgrass discoloration (2,3). In recent years, fenoxaprop has shown promise as a new, postemergence herbicide (2-8).

In addition to crabgrass, fenoxaprop effectively controls fall panicum (Panicum dichotomiflorum Michx.) and goosegrass [Eleusine indica (L.) Gaertn] (Dernoeden, unpublished data) and was observed to control johnsongrass [Sorghum halepense (L.) Pers.] in a highway demonstration test conducted in Maryland in 1984 (Jesse Crook, unpublished data). The objectives of these studies were to

1. Determine the application rates and sequential application schedules needed to achieve effective crabgrass control with MSMA, and
2. Compare crabgrass control with single and sequential applications of MSMA with single applications of fenoxaprop.

Other important parameters were to determine the influence of rate and timing of applications, as well as to assess the effects of cultural practices on how well fenoxaprop controls crabgrass.

MATERIALS AND METHODS

All studies were conducted at the University of Maryland Turfgrass Research Facility in Silver Spring, Maryland, between 1982 and 1984. The turf was a mature stand of Citation perennial ryegrass (Lolium perenne L.) grown on a Chillum silt loam (fine-silty, mixed, mesic Typic Hapludult) with a pH

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of 6.3 and 2.3 percent organic matter. A natural heavy infestation of mostly smooth and some hairy crabgrass existed at the site. Herbicides were applied with a CO_2 pressurized sprayer that delivered 280 L ha^{-1} in 1982 and 468 L ha^{-1} in 1983 and 1984. Turf was maintained at a 4.0- to 7.0-cm height throughout the test years. The plot area was fertilized with a total of 150 kg N ha^{-1} from urea each autumn.

Visual estimates of percent plot area covered by crabgrass were made in September of each year on a scale of 0 to 100 percent. Percent of control was calculated by dividing the percent of crabgrass cover in treated plots by the mean percent of crabgrass cover in untreated plots. An acceptable level of crabgrass control for low-maintenance turf was considered to be greater than 80 percent. Phytotoxicity, in the form of turf discoloration, was visually estimated by using a scale of 0 to 5: 0 = green, healthy turf; 3 = unacceptable discoloration; and 5 = brown turf. All data were analyzed by using the analysis of variance, and significantly different means were separated by using Bayes least significant difference multiple comparison test. Preliminary results of some of these tests were reported previously (2,5-6).

1982 Tests

Two tests conducted in 1982 compared various rates and application intervals of MSMA with a single application of fenoxaprop. Various rates of fenoxaprop applied alone or tank-mixed with crop oil were also evaluated in a separate study. The statistical design used in the first test was a completely randomized block with four replications, and plot size was 1.5 by 1.5 m. A randomized complete block with three replications and 1.5- by 5.0-m plots was used in the second test involving crop oil.

In the first test, MSMA was applied either twice (2.2 kg ha^{-1}) on a 14-day interval or three times (0.6, 1.1, and 2.2 kg ha^{-1}) on a 7-day interval. Fenoxaprop was only applied once. Herbicide applications began July 12 when crabgrass was in the two- to four-tiller stage. Rain showers occurred within 5 hr of the second application of herbicide on July 19; no rain occurred within 72 hr of all other application dates. The area was occasionally irrigated to prevent severe drought stress.

In the second study, various rates of fenoxaprop alone or tank-mixed with crop oil were applied to determine if oil would improve herbicide efficacy. The oil used was AT Plus 411 F (80 percent nonphytotoxic oil plus 20 percent nonionic surfactant) and was tank-mixed at a rate of 2.3 L ha^{-1}. Sprays were applied on August 16 when crabgrass was in the four- to eight-tiller stage. The test area was irrigated before herbicide application and thereafter to prevent drought stress.

1983 Test

Results of 1982 tests suggested that dry soil conditions and mowing within 48 hr of application may adversely affect the performance of fenoxaprop. Because of these observations, turf was not mowed within 72 hr before or after herbicide application, and the 1983 test area was irrigated before herbicide application and thereafter as needed to prevent severe drought stress. No rain or irrigation occurred within the 72-hr period following herbicide application. Herbicide applications were initiated on July 21 when crabgrass was in the three- to six-tiller stage. Fenoxaprop was applied once or sequentially, and MSMA was applied sequentially at intervals and at rates similar to those used in 1982. Plot size was 1.5 by 1.5 m, and the plots were arranged in a randomized complete block with four replications.

1984 Test

Fenoxaprop and MSMA were applied at various rates on three dates (Table 1). On June 13 crabgrass was in the one- to three-leaf stage and was below the turf canopy. On July 2 crabgrass was above the turf canopy and in the two- to four-leaf stage, and on July 16 crabgrass was in the four-leaf to two-tiller stage. No rain occurred within 48 hr of the first two applications, but rain fell 7 hr following application on July 16. In a second 1984 test, only two rates of fenoxaprop (0.28 and 0.56 kg ha^{-1}) were applied on August 7 in an adjacent area. Turf was mowed at each site within 48 hr before or after herbicide applications, and frequent rainstroms during the test period negated any need to irrigate. Plot size and statistical design were the same in both 1984 tests as those used in 1983.

TABLE 1 Timing of Postemergence Treatments for the Control of Crabgrass With a Single Application of Fenoxaprop and MSMA in 1984

Herbicide	Rate (kg ai ha^{-1})	Date Applied	Crabgrass,[a] %	
			Cover	Control
Fenoxaprop	0.13	June 13	49cd[b]	37
Fenoxaprop	0.20	June 13	30ef	62
Fenoxaprop	0.20	July 2	7gh	91
Fenoxaprop	0.28	July 2	1h	98
Fenoxaprop	0.28	July 16	1h	99
Fenoxaprop	0.44	July 16	0h	100
MSMA	1.1	June 13	64bc	18
MSMA	2.2	June 13	72ab	7
MSMA	2.2	July 2	44de	44
MSMA	2.2	July 16	45de	42
Untreated	–	–	78a	–

Note: ai = active ingredient.

[a]Crabgrass cover was visually rated on September 11, 1984.
[b]Means in the column followed by the same letter are not significantly different at the p = 0.05 level according to the Bayes LSD.

RESULTS AND DISCUSSION

Results of 1982 Test

Data collected on September 10 indicated that one application of fenoxaprop (0.28 kg ha^{-1}), two applications of MSMA at 22.2 kg ha^{-1} on a 14-day interval, and three applications of MSMA at 1.1 or 2.2 kg ha^{-1} on a 7-day interval provided effective crabgrass control (Table 2). Phytotoxicity ratings collected on July 19, 1 week after the first application revealed that 2.2 kg ha^{-1} of MSMA provided an unacceptable level of discoloration. The 0.6 kg ha^{-1} and 1.1 kg ha^{-1} rates of MSMA applied three times on a 7-day interval provided fair and excellent crabgrass control, respectively, without causing unacceptable levels of discoloration. Fenoxaprop (0.17 kg ha^{-1}) provided fair control, and neither rate tested caused turf discoloration.

All rates of fenoxaprop applied alone or tank-mixed with oil and applied to mature crabgrass on August 16 provided excellent crabgrass control (Table 3). The improved effectiveness of fenoxaprop from the August 16 application compared with the July 12 application (Table 2) was not immediately understood. Fenoxaprop appears to be a slow-acting, systemic herbicide. About 10 days after application of fenoxaprop, crabgrass begins to turn yellow and

TABLE 2 Postemergence Crabgrass Control and Phytotoxic Effects of MSMA and Fenoxaprop

Herbicide	Rate (kg ai ha^{-1})	Applications: Interval (days)	Applications: No.	Phytotoxicity[a] July 19	Crabgrass,[b] %: Cover	Crabgrass,[b] %: Control
MSMA	2.2	14	2	3.0c[c]	1a	99
MSMA	0.6	7	3	1.0a	11b	78
MSMA	1.1	7	3	2.4bc	1a	99
MSMA	2.2	7	3	3.6d	0a	100
Fenoxaprop	0.17	–	1	1.2ab	11b	76
Fenoxaprop	0.28	–	1	1.0a	8ab	85
Untreated control	–	–	–	1.2ab	50c	–

Note: Applications were initiated on July 12, 1982, when crabgrass was in the two- to 4-tiller stage.

[a]Phytotoxicity was visually determined using a 0 to 5 scale: 0 = green, healthy turf; 3 = unacceptable discoloration; and 5 = brown turf.

[b]Crabgrass cover was visually rated on September 10, 1982.

[c]Means following the same letter in the same column are not significantly different at p = 0.05 level according to the Bayes LSD.

TABLE 3 Postemergence Crabgrass Control With Various Rates of Fenoxaprop Applied Alone or Tank-Mixed With Crop Oil

Herbicide	Rate (kg ai ha^{-1})	Crabgrass,[a] %: Cover	Crabgrass,[a] %: Control
Fenoxaprop	0.17	1a[c]	94
Fenoxaprop	0.17 + oil[b]	1a	96
Fenoxaprop	0.28	<1a	99
Fenoxaprop	0.28 + oil	<1a	99
Fenoxaprop	0.56	<1a	99
Untreated control	–	23b	–

Note: Herbicide treatments were applied August 16, 1982, when crabgrass was in the four- to eight-tiller stage.

[a]Crabgrass cover was visually rated on September 17, 1982.

[b]Crop oil was applied at a rate of 2.3 L ha^{-1}.

[c]Means following the same letter in the same column are not significantly different at p = 0.05 level according to the Bayes LSD.

subsequently crabgrass plants develop a purple-red color, and die 2 to 3 weeks after application. Following the July 12 application (Table 2), however, some of the purple-colored plants recuperated by producing new tillers from axillary buds. Failure to achieve more effective control after the July 12 application was attributed to treated plants having been mowed within 48 hr of application; this possibly reduced the translocation of sufficient amounts of herbicides to meristematic tissues to provide effective control. Reduced efficacy, however, may also have between caused by dry soil conditions throughout the period before and following the July 12 application.

Results of 1983 Test

In this test the effectiveness of single and sequential applications of various rates of MSMA and fenoxaprop to mature crabgrass (i.e., three- to six-tiller stage) was again assessed (Table 4). The results of MSMA use were similar to those observed in 1982 (Table 2). MSMA applied at 1.1 kg ha^{-1} two to three times on a 7- or 14-day interval or 2.2 kg ha^{-1} MSMA applied twice on a 14-day interval effectively controlled mature crabgrass. Turf treated with 2.2 kg ha^{-1} MSMA exhibited unacceptable levels of discoloration for 2 weeks (i.e., July 28 and August 4) following application (Table 4). Unacceptable discoloration was also observed 1 week following the second application (7-day interval) of 1.1 kg ha^{-1} MSMA on August 4. As was observed in 1982 (Table 2), 0.6 kg ha^{-1} MSMA (applied three times on a 7-day interval) and 1.1 kg ha^{-1} (applied two times on a 14-day interval) provided 79 and 88 percent crabgrass control without causing an unacceptable level of discoloration.

Single and sequential applications of fenoxaprop significantly reduced crabgrass populations, but the level of control was unacceptable (Table 4). During July 1983 only 2.3 cm of precipitation occurred, and

TABLE 4 Postemergence Crabgrass Control and Phytotoxic Effects of MSMA and Fenoxaprop

Herbicide	Rate (kg ai ha^{-1})	Applications: Interval (days)	Applications: No.	Phytotoxicity[a]: July 28	Phytotoxicity[a]: August 4	Crabgrass,[b] %: Cover	Crabgrass,[b] %: Control
MSMA	0.6	7	3	0.0a[c]	1.5c	13a	79
MSMA	1.1	7	3	1.0ab	3.8ef	<1a	99
MSMA	1.1	14	2	0.8ab	1.2bc	8a	88
MSMA	2.2	14	2	3.1b	3.2de	<1a	99
Fenoxaprop	0.09	14	2	0.0a	0.5ab	17a	73
Fenoxaprop	0.17	–	1	0.0a	0.2ab	46cd	26
Fenoxaprop	0.17	14	2	0.0a	0.2ab	16ab	74
Fenoxaprop	0.28	–	1	0.2a	0.2ab	17ab	73
Untreated control	–	–	–	0.0a	0.0a	62de	–

Note: Applications were initiated on July 21, 1983, when crabgrass was in the three- to six-tiller stage.

[a]Phytotoxicity was visually determined using a 0 to 5 scale: 0 = green, healthy turf; 3 = unacceptable discoloration; and 5 = brown turf.

[b]Crabgrass cover was visually rated on September 13, 1983.

[c]Means following the same letter in the same column are not significantly different at p = 0.05 level according to the Bayes LSD.

during July and August, the mean daily maximum temperature was 33°C. Despite irrigating the plot area 24 hr before herbicide application, it is believed that the stressful environmental conditions before and during the test period prevented effective uptake and translocation of fenoxaprop in the crabgrass. Watschke (8) also has observed a marked reduction in the efficacy of crabgrass control by fenoxaprop when applied under conditions of drought stress. These and other data (Table 3) therefore indicate that rates exceeding 0.28 kg ha^{-1} of fenoxaprop will be needed to effectively control mature crabgrass (i.e., three or more tillers), particularly during periods of high-temperature stress and limited rainfall.

Results of 1984 Test

Previous testing substantiated that sequential applications of MSMA (1.1 and 2.2 kg ha^{-1}) effectively controlled mature crabgrass, but fenoxaprop performed erratically (Tables 2-4). The objective of tests conducted in 1984 was to determine if a single application of MSMA and fenoxaprop in early summer would eliminate crabgrass for the remainder of the season.

A single application of MSMA (1.1 and 2.2 kg ha^{-1} on June 13 or 2.2 kg ha^{-1} on July 2 or 16) did not effectively control crabgrass (Table 1). However, the July 2 and 16 applications of fenoxaprop were extremely effective in eliminating crabgrass for the remainder of the growing season. When fenoxaprop was applied on June 13, the 0.20 kg ha^{-1} rate effectively controlled the existing crabgrass, although crabgrass plants were below the perennial ryegrass canopy. On August 24 it was observed that crabgrass in the plots treated with fenoxaprop (0.20 kg ha^{-1}) on June 13 generally possessed three to five tillers, whereas crabgrass plants in the untreated plots were in the eight- to ten-tiller stage (data not given). Hence, crabgrass developing in the plots treated at the 0.20 kg ha^{-1} rate germinated following the June 13 application, which resulted in what appeared to have been ineffective (62 percent) control (Table 1).

Fenoxaprop was also applied to an adjacent perennial ryegrass test area on August 7, 1984. At that time, crabgrass was in the three- to five-tiller stage. Crabgrass coverage was rated on September 11, 1984, and the 0.28 kg ha^{-1} rate provided 93 percent control; the 0.56 kg ha^{-1} rate provided 97 percent control (data not given). In past studies (Tables 2-4), however, late July applications of fenoxaprop failed to provide satisfactory crabgrass control. Late-season failures were attributed to drought hardening of crabgrass, which reduced herbicide effectiveness, particularly against mature crabgrass with three or more tillers. In 1984 environmental conditions in Maryland were less stressful; that is, there was a generally lower daytime temperature (mean maximum = 29.6°C) and above average rainfall in July (11.4 cm). Hence, it appears that environmental conditions, as they affect the vigor of crabgrass, will influence the performance of fenoxaprop in late summer.

SUMMARY

In summary, MSMA applied twice at 1.1 or 2.2 kg ha^{-1} on a 14-day interval provided effective control of mature crabgrass (i.e., three or more tillers), but may cause an unacceptable level of discoloration. However, a single application of MSMA (2.2 kg ha^{-1}) in early summer did not effectively control crabgrass. A single application of fenoxaprop provided erratic control when applied to mature crabgrass. When fenoxaprop was applied at 0.20 or 0.28 kg ha^{-1} in early summer, extremely effective control was achieved. Fenoxaprop may effectively control mature crabgrass at 0.28 or 0.56 kg ha^{-1}, but only when rainfall is not limiting and crabgrass is growing vigorously.

REFERENCES

1. P.H. Dernoeden. Management of Preemergence Herbicides for Crabgrass Control in Transition Zone Turf. HortScience, Vol. 19, 1984, pp. 443-445.
2. P.H. Dernoeden and J.D. Fry. Crabgrass Control in Turf with Fenoxaprop-Ethyl, MSMA, Tridiphane and UC 77892. Proc., Northeastern Weed Science Society, Vol. 39, 1985, pp. 282-287.
3. R.E. Engel. Complementary Action of Postemergence and Preemergence Herbicide Combinations for Control of Digitaria Ischaemum Muhl. and D. sanguinalis (L.) Scop. (crabgrass). In Proc., Fifth International Turf Research Conference, Avignon, France (F. Lemaire, ed.), 1985, pp. 691-698.
4. P.C. Bhowmik. New Herbicides for Crabgrass Control in Turfgrass. Proc., Northeastern Weed Science Society, Vol. 38, 1984, pp. 282-288.
5. P.H. Dernoeden and J.D. Fry. Developing Crabgrass and Goosegrass Control Strategies in Turf with HOE-A2501. Proc., Northeastern Weed Science Society, Vol. 38, 1984, pp. 289-294.
6. P.H. Dernoeden and J.A. Grande. Postemergence Control of Crabgrass in Turf with MSMA and HOE-581. Proc., Northeastern Weed Science Society, Vol. 37, 1983, pp. 384-388.
7. J.A. Jagschitz. Crabgrass Control in Turfgrass with Herbicides. Proc., Northeastern Weed Science Society, Vol. 39, 1985, pp. 274-278.
8. T.L. Watschke. Pre- and Postemergence Crabgrass Control in 1983 and 1984. Proc., Northeastern Weed Science Society, Vol. 39, 1985, pp. 279-281.

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