Use of Prodiamine as a Preemergence Herbicide to Control Annual Bluegrass in Kentucky Bluegrass

Peter H. Dernoeden

Department of Natural Resource Sciences and Landscape Architecture,
University of Maryland, College Park, MD 20742-5821

Additional index words. *Poa annua* ssp. *annua*, turfgrass, *Poa pratensis*, crabgrass, *Digitaria ischaemum*

Abstract. Annual bluegrass (*Poa annua* L.) is an intractable weed problem on golf courses. Much has been written about annual bluegrass, but there is little documentation of regional germination period(s) and the proper timing of preemergence herbicides targeted for the control of the annual biotype (*P. annua* ssp. *annua* [L.] Timm. = AB). The objectives of this field study were to determine the optimum prodiamine rate and timing for effective AB control. The turf was a mature stand of 'Kenblue' Kentucky bluegrass (*Poa pratensis* L.) maintained under conditions similar to those imposed for golf course roughs. Three rates of prodiamine (0.36, 0.73, and 1.1 kg·ha⁻¹) were applied on three dates in 1995 (11 Aug., 14 Sept., and 13 Oct.) and 1996 (29 Aug., 16 and 30 Sept.). All rates applied 11 Aug. or 14 Sept. 1995, and 29 Aug. or 16 Sept. 1996 effectively controlled AB. None of the rates applied 13 Oct. 1995 reduced AB cover, and the 0.36 kg·ha⁻¹ rate applied 30 Sept. 1996 provided relatively poor AB control. Data and observations indicated that the major germination period for AB was between late September and early December. Effective AB control was achieved whenever prodiamine, regardless of rate, was applied between mid-August and mid-September. These prodiamine rates and this application window may be effective only in relatively high cut turf (i.e., >5.0 cm) in the mid-Atlantic region. Chemical names used: *O,O*-bis(1-methylethyl) *S*-[2-[(phenylsulfonyl)amino]ethyl] phosphorodithioate (bensulide); *N,N*-di-*n*-propyl-2,4-dinitro-6-(trifluoromethyl)-*m*-phenylenediamine (prodiamine).

Annual bluegrass is an enigmatic weed with diverse annual (*P. annua* ssp. *annua*) and perennial (*P. annua* ssp. *reptans* [Hausskn.] Timm.) biotypes. Several chemical strategies involving pre- and postemergence herbicides and plant growth regulators can reduce annual bluegrass (Beard et al., 1978; Callahan and McDonald, 1992; Dernoeden and Turner, 1988; Goss et al., 1980; Hall and Carey, 1991). Long-term or complete control of the weed, however, is seldom achieved (Branham, 1991; Christians, 1996). Cultural methods, such as increasing mowing height, collecting clippings when seedheads appear, improving drainage and fertility, alleviating soil compaction, applications of iron and magnesium, and flaming reduce the competitiveness of AB (Beard et al., 1978; Bell et al., 1997; Desjardin et al., 1997; Watschke et al., 1995). Among preemergence herbicides, only multiple applications of bensulide consistently reduced AB (Callahan and McDonald, 1992; Goss et al., 1980). Late-summer applications of preemergence herbicides to areas in-play on golf courses, however, are discouraged in the mid-Atlantic region. The use of these herbicides in late summer conflicts with overseeding operations, is

potentially phytotoxic because of generally high air temperatures, and persisting herbicide residues in soil could interfere with successful overseeding should large turf areas be killed during winter due to ice cover, crown hydration, desiccation, disease, or other factors.

Annual bluegrass produces large amounts of seed, and heavily colonized areas in golf course roughs and out-of-bound areas provide a large potential reservoir of seed. The use of a preemergence herbicide in rough areas not adjacent to fairways, greens, and tees would be less risky, assuming turf density was good in late summer. A cursory Maryland study suggested that prodiamine was an effective preemergence AB herbicide (Dernoeden and Krouse, 1994). Annual bluegrass seedling emergence was monitored adjacent to a putting green in Rockville, Md. between 1 Sept. 1994 and 2 May 1995 (Dernoeden, unpublished). Annual bluegrass seedlings were first observed 21 Sept. 1994 in 3- to 4-cm-diameter spots created by a nonselective herbicide. No germination occurred after 14 Dec., but some seedlings did emerge between 12 and 26 Apr. 1995. Hence, the main germination period of AB in the mid-Atlantic region is likely to begin in late summer, but the best timing for an application of a preemergence herbicide for this weed in the region has not been established. Hence, the objectives of this study were to determine the proper timing and rates of prodiamine for preemergence AB control in Kentucky bluegrass maintained under golf course rough conditions.

Treatments were applied to a mature stand of 'Kenblue' Kentucky bluegrass at the Univ. of Maryland Turfgrass Research and Education Facility in Silver Spring, Md. For several years, the test site was heavily infested each spring with *P. annua*, but virtually all of the annual bluegrass died during the summer of each year. Because of its apple-green color, prolific seedhead production in May, and inability to survive summer, the biotype at the site was considered to be *P. annua* ssp. *annua*. There also was a heavy smooth crabgrass [*Digitaria ischaemum* (Schreber) Schreber ex Muhlenb.] infestation at the site when treatments were applied each fall. Soil was a Chillum silt loam (fine silty, mixed mesic typic Hapludult) with a pH of 6.2 and 23 mg organic matter per gram of soil. Turf was mowed to a height of 5 to 6 cm, fertilized with N at 2.2 kg·ha⁻¹ per year, and only irrigated to prevent drought dormancy in the summer. The 1995 and 1996 studies were conducted on separate, but adjacent sites.

Three rates of prodiamine were applied on three dates in 1995 and 1996 (Tables 1 and 2). The site was irrigated within 24 h of each application with at least 1.0 cm of water. Prodiamine was applied in 467 L·ha⁻¹ of water with a CO₂-pressurized (262 kPa) backpack sprayer equipped with a 8004E flat-fan nozzle. Plots were 1.5 × 1.5 m and were arranged in a randomized complete block with four replications. Percentage of plot area covered by AB or smooth crabgrass was assessed visually on a 0% to 100% linear scale where 0 = no weeds and 100 = entire plot area covered by weeds. Rating for AB cover was facilitated by the presence of seedheads between mid-May and early June. Subjectively, AB cover ≤ 5.0% was considered to be commercially acceptable control for a golf course rough. Data were subjected to analysis of variance and means were separated at *P* ≤ 0.05 using the Duncan's multiple range test.

Results and Discussion

1996. Large numbers of AB seedlings were first noted emerging at the site on 3 Oct. 1995. The AB coverage trends evident on 27 Nov. 1995 remained relatively unchanged on subsequent rating dates, including the final rating on 24 May 1996 (Table 1). All rates applied on either 11 Aug. or 14 Sept. significantly reduced annual bluegrass and produced statistically similar levels of control. Complete control was only provided by 1.1 kg·ha⁻¹ applied 14 Sept. None of the treatments applied 13 Oct., however, reduced AB significantly when compared with control plots. Using a subjective AB cover threshold of ≤ 5.0%, the following prodiamine treatments provided for commercially acceptable control for golf course roughs: 0.36 kg·ha⁻¹ applied 14 Sept., and 0.73 or 1.1 kg·ha⁻¹ applied on 11 Aug. and 14 Sept.

Smooth crabgrass was highly invasive and weed cover was rated on 20 Aug. 1996 (Table 1). Ratings showed that 0.73 kg·ha⁻¹ prodiamine applied on 13 Oct. and 1.1 kg·ha⁻¹ applied on

Received for publication 9 Dec. 1997. Accepted for publication 24 Mar. 1998. Contribution of the Maryland Agricultural Experiment Station, College Park, Md. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

Table 1. Influence of rate and time of application of prodiamine on preemergence control of annual bluegrass and smooth crabgrass in 'Kenblue' Kentucky bluegrass, 1995–96.

Rate (kg·ha ⁻¹)	Date applied (1995)	% plot area covered				
		1995	1996			Smooth crabgrass 20 Aug.
		27 Nov.	3 Apr.	1 May	24 May	
0.36	11 Aug.	2 b ^z	3 bcd	4 bc	7 bc	90 a
	14 Sept.	2 b	2 bcd	3 bc	4 bc	46 bc
	13 Oct.	23a	31a	33 a	40 a	39 c
0.73	11 Aug.	2 b	3 bcd	3 bc	4 bc	61 b
	14 Sept.	<1 b	1 cd	2 bc	2 c	24 cd
	13 Oct.	19 a	15 abcd	16 abc	18 abc	4 d
1.10	11 Aug.	<1 b	1 cd	1 c	1 c	33 c
	14 Sept.	0 b	0 d	0 c	0 c	6 d
	13 Oct.	22 a	18 abc	21 ab	25 ab	1 d
Untreated	---	16 a	19 ab	34 a	38 a	96 a

^zMean separation within columns by Duncan's multiple range test; $P \leq 0.05$.

Table 2. Influence of rate and time of application of prodiamine on preemergence control of annual bluegrass and smooth crabgrass in 'Kenblue' Kentucky bluegrass, 1996–1997.

Rate (kg·ha ⁻¹)	Date applied (1996)	% plot area covered				
		1996	1997			Smooth crabgrass 5 Sept.
		17 Dec.	28 Apr.	16 May	2 June	
0.36	29 Aug.	2 b ^z	1 c	3 c	3 c	2 b
	16 Sept.	0 b	4 c	4 c	5 c	<1 b
	30 Sept.	4 b	11 b	20 b	17 b	1 b
0.73	29 Aug.	0 b	1 c	2 c	3 c	<1 b
	16 Sept.	0 b	1 c	<1 c	1 c	0 b
	30 Sept.	3 b	6 bc	8 c	8 bc	<1 b
1.10	29 Aug.	0 b	0 c	<1 c	<1 c	0 b
	16 Sept.	0 b	0 c	0 c	0 c	0 b
	30 Sept.	2 b	3 c	4 c	3 c	0 b
Untreated	---	8 a	21 a	33 a	35 a	5 a

^zMean separation within columns by Duncan's multiple range test; $P \leq 0.05$.

14 Sept. or 13 Oct. 1995, provided an excellent level (1% to 6% crabgrass cover) of season-long smooth crabgrass control in 1996. These findings were similar to those reported previously for November applications of prodiamine in Maryland (Dernoeden, 1993).

1997. Treatments were initiated later than in 1996, and prodiamine was applied at 2-week intervals to better pinpoint the application window for the herbicide and germination time of AB. Annual bluegrass seedlings were first observed in the test site on 30 Sept. 1996. Except for the 0.36 kg·ha⁻¹ rate applied on 30 Sept. 1996, all treatments provided a similar level (0% to 8% cover) of AB control. The only treatments not within the $\leq 5\%$ cover threshold were the 0.36 and 0.73 kg·ha⁻¹ rates applied on 30 Sept. On all rating dates in 1997, AB control was better with the high vs. the low prodiamine rate applied 30 Sept. These data suggested that the high rate may have had some early postemergence activity on AB. During the summer there was very little rainfall and only a modicum of irrigation water was applied. As a result, smooth crabgrass levels were very low and all treatments signifi-

cantly reduced crabgrass cover.

Annual bluegrass seed germinates during cool, moist periods in late summer and fall, but in some regions seed may germinate in the spring (Beard et al., 1978). According to Branham (1991), AB germinates so profusely in spring and fall in Michigan that three annual applications of preemergence herbicides are needed to effectively control the weed. In Tennessee, the annual subspecies germinates from mid-November to early January (Callahan and McDonald, 1992). Observations and data from this study indicated that the major germination period of AB in central Maryland was from late September to early December. The view that germination occurs after mid-September is supported in part by the relatively poor level of control provided by 0.36 kg·ha⁻¹ prodiamine applied 30 Sept. 1996, relative to that obtained with the 29 Aug. and 16 Sept. applications in 1996. There was little change in AB cover ratings between 27 Nov. 1995 and 3 Apr. 1996, indicating that most of the AB emerged by late November in 1995 (Table 1). Annual bluegrass seed may have germinated at the site in April, but seedling emergence was

not noted. Field observation indicated that the rapid increases in AB cover ratings during April and May in both years were largely due to aggressive tillering of overwintering AB in the spring. Hence, as reported in Tennessee (Callahan and McDonald, 1992), the annual biotype appears to have one major germination period between late summer and early winter in central Maryland. As previously noted, however, there may be a brief spring germination period in April. Results from this study also showed that AB could be controlled effectively with as little as 0.36 kg·ha⁻¹ prodiamine applied during the first two weeks of September. This timing and rate may only be appropriate for central Maryland in a nondisturbed (i.e., no core cultivation, verticutting, etc.) turf maintained at a mowing height above 5.0 cm.

Literature Cited

- Beard, J.B., P.E. Rieke, A.J. Turgeon, and J.M. Vargas. 1978. Annual bluegrass (*Poa annua* L.) description, adaptation, culture and control. Michigan Agr. Expt. Sta. Res. Rpt. 352.
- Bell, G.E., E. Odorizzi, and T.K. Danneberger. 1997. Controlling annual bluegrass and rough bluegrass in creeping bentgrass fairways: A nutritional approach. Agron. Abstr. 122.
- Branham, B. 1991. Dealing with *Poa annua*. Golf Course Mgt. 59(9):46, 48, 52, 54, 58, 60.
- Callahan, L.M. and E.R. McDonald. 1992. Effectiveness of bensulfide in controlling two annual bluegrass (*Poa annua*) subspecies. Weed Technol. 6:97–103.
- Christians, N. 1996. A historical perspective of annual bluegrass control. Golf Course Mgt. 64(11):49–57.
- Dernoeden, P.H. 1993. November applied preemergence herbicides for smooth crabgrass control the following summer. Intl. Turfgrass Soc. Res. J. 7:291–297.
- Dernoeden, P.H. and J.M. Krouse. 1994. Preemergence smooth crabgrass, annual bluegrass, woodsorrel and prostrate spurge control. Proc. Northeastern Weed Sci. Soc. 40:120. (Abstr.)
- Dernoeden, P.H. and T.R. Turner. 1988. Annual bluegrass control and tolerance of Kentucky bluegrass and perennial ryegrass to ethofumesate. HortScience 23:565–567.
- Desjardins, Y., M. Tardif, J. Gill, and C. Lague. 1997. *Poa annua* war calls for scorched-earth policy. Golf Course Mgt. 65(10):49–54.
- Goss, R.L., T.W. Cook, S.E. Brauen, and S.P. Orton. 1980. Effects of repeated applications of bensulfide and tricalcium arsenate on the control of annual bluegrass and on quality of Highland colonial bentgrass putting green turf. Proc. Third Intl. Turfgrass Res. Conf. 3:247–255.
- Hall, C.S. and C.K. Carey. 1991. Control of annual bluegrass (*Poa annua*) in Kentucky bluegrass (*Poa pratensis*) turf with linuron. Weed Technol. 6:852–857.
- Watschke, T.L., P.H. Dernoeden, and D.J. Shetlar. 1995. Managing turfgrass pests. CRC Press, Boca Raton, Fla.