Selective Removal of Creeping Bentgrass from Kentucky Bluegrass with Sulfosulfuron

Marcus A. Jones¹ and Nick E. Christians^{2,5}

Department of Horticulture, Iowa State University, Ames, IA 50011

Daniel Weisenberger³ and Zachary J. Reicher⁴

Department of Agronomy, Purdue University, West Lafayette, IN 47907

Additional index words. acetolactate synthase inhibitors, sulfonylurea herbicides, perennial grass control, weed management

Abstract. Creeping bentgrass (*Agrostis stolonifera* L.) is well adapted to golf course greens, tees, and fairways but may become a weed in Kentucky bluegrass (*Poa pratensis* L.) roughs and lawns. The objectives of this study were to determine effects of sulfosulfuron rate and application date on control of creeping bentgrass and safety on Kentucky bluegrass. Field experiments were initiated in 2003 and 2004 in Ames, IA, and West Lafayette, IN. Single applications of sulfosulfuron at 0.011 or 0.022 kg·ha⁻¹ were applied over a 9-week period during the fall of each year. Phytotoxicity on Kentucky bluegrass was recorded weekly and control of creeping bentgrass was determined in the spring after fall treatments. No treatment provided greater than 31% control, and there were few differences in control between the two rates of sulfosulfuron. In West Lafayette, late fall applications were the most effective providing up to 31% control of creeping bentgrass. Sulfosulfuron provided less than 18% control in Ames in either year. Kentucky bluegrass was tolerant of all sulfosulfuron applications. Late fall applications of sulfosulfuron may be useful in partially removing creeping bentgrass from a heavily contaminated sward of Kentucky bluegrass.

Chemical names used: 1-(4,6-dimethoxypyrimidin-2-yl)-3-(2-ethylsulfonylimidazo[1,2-a]pyridin-3-yl)sulfonylurea (sulfosulfuron)

Creeping bentgrass (*Agrostis stolonifera* L.) is a cool-season grass well adapted to golf course greens, tees, and fairways that forms a dense, smooth surface ideal for golf when maintained at mowing heights less than 1.25 cm. However, creeping bentgrass is competitive with other cool-season turfgrasses at higher mowing heights (7.5 to 10 cm) and often spreads into surrounding areas of Kentucky bluegrass (*Poa pratensis* L.) (Davis, 1958). Creeping bentgrass is considered a weed in these situations because it disrupts turfgrass uniformity (Beard, 1973).

Perennial grasses are often the most difficult weeds to control because they possess characteristics similar to the desired turf species (Christians, 2004). Cultural weed management practices are ineffective and herbicides currently labeled to control creeping bentgrass are nonselective (Dernoeden, 1999).

Sulfosulfuron is a sulfonylurea herbicide that provides selective control of annual and perennial grassy and broadleaf weeds in wheat (*Triticum aestivum* L.; Maverick, 75% a.i.; Monsanto Co., St. Louis), noncrop areas (Outrider, 75% a.i.; Monsanto Co.), and in highly managed turfgrass areas (Certainty, 75% a.i.; Monsanto Co.). The herbicide inhibits the acetolactate synthase enzyme, which aids in the synthesis of the branch chain amino acids leucine, isoleucine, and valine (Schloss, 1995). A number of sulfonylurea herbicides have shown selective herbicidal activity against grassy weeds in grass crops (Bruce and Kells, 1997; Larocque and Christians, 1985; Maloy and Christians, 1986; Rabae and Harvey, 1997).

Recent studies demonstrate that sulfosulfuron exhibits herbicidal activity on annual bluegrass (*Poa annua* L.) (Lycan and Hart, 2002; Taylor et al., 2002) and tall fescue (*Festuca arundinacea* Schreb.) (Lycan and Hart, 2004), but Kentucky bluegrass and perennial ryegrass (*Lolium perenne* L.) are tolerant of the herbicide at low application rates (Lycan and Hart, 2004). Although these reports reveal the differential responses of cool-season grasses to sulfosulfuron, its

activity on creeping bentgrass is not understood at this time. In addition, the efficacy of herbicides is often dependent on environmental conditions and target species (Malefyt and Quakenbush, 1991; Miller et al., 1978; Nalewaja and Woznica, 1985). Therefore, the objectives of this study were to determine 1) the effect of sulfosulfuron rate and application date on control of creeping bentgrass, and 2) the effect of sulfosulfuron applications on Kentucky bluegrass safety.

Materials and Methods

Experiments were established in 2003 and 2004 in both Ames, IA, and West Lafayette, IN (Table 1). Research in Ames was conducted at Coldwater Golf Links on a mixed sward of creeping bentgrass and Kentucky bluegrass. Research in West Lafayette was conducted at the W. H. Daniel Turfgrass Research and Diagnostic Center on adjacent creeping bentgrass and Kentucky bluegrass areas.

Treatments at both locations were arranged in a 2 × 9 factorial with two application rates and nine application timings. Application rates were 0.011 or 0.022 kg·ha⁻¹ of sulfosulfuron. In 2003, sulfosulfuron was applied weekly beginning the fourth week of August and concluding the fourth week of October. Because early applications of sulfosulfuron had little effect in 2003, applications in 2004 started the third week of September and ended the third week of November. Sulfosulfuron was mixed with a nonionic surfactant (MON 0818; Monsanto Co.) at 0.25% v/v for all applications.

Visual quality ratings of Kentucky bluegrass were assessed weekly on a scale of 1 to 9 with 1 = poorest, 6 = acceptable, and 9 = best. In Ames, percentage creeping bentgrass control was determined by using a grid described by Patton et al. (2004) and modified from Tinney et al. (1937). A 1.5 × 1.5-m polyvinyl chloride frame was placed over each plot. The frame contained an interval filament grid with 81 intersections. The total number of times creeping bentgrass was present under each intersection was recorded for each plot and percentage cover was calculated. Initial creeping bentgrass coverage was determined before initiation of fall treatments. Percentage creeping bentgrass coverage was again determined the next spring and compared with initial coverage to quantify changes in creeping bentgrass populations. Percentage control of creeping bentgrass was calculated by subtracting changes in creeping bentgrass populations in untreated control plots from population changes in treated plots.

Because solid and separate stands of bentgrass and bluegrass were used in West Lafayette, creeping bentgrass coverage was visually estimated on a 0% to 100% linear scale the spring after fall applications. Percentage control of creeping bentgrass was calculated by subtracting populations of creeping bentgrass in untreated control plots from population changes in treated plots.

Received for publication 9 Feb. 2007. Accepted for publication 20 Mar. 2007.

This manuscript is a portion of a thesis submitted by Marcus Jones in fulfilling a degree requirement. We thank the Iowa Turfgrass Institute, the Iowa Golf Course Superintendents Association, Midwest Regional Turf Foundation, and Monsanto for their support. We also thank Brian Maloy, Superintendent of Coldwater Golf Links, for providing area to conduct the experiment.

Mention of a trademark, proprietary product, or vendor does not constitute a guarantee of warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products of vendors that also may be suitable.

¹Graduate research assistant.

²University professor.

³Research agronomist.

⁴Professor/extension turfgrass specialist.

⁵To whom reprint requests should be addressed; e-mail nchris@iastate.edu

Experiments at both locations were arranged in a randomized complete block and all data were analyzed using the MIXED models procedure of SAS (SAS Institute, 1999–2001). Years and locations were considered fixed, because trends in the efficacy of the herbicide were expected to vary with environmental conditions between years and locations. Means of Kentucky bluegrass quality and percentage creeping bentgrass control were compared by using Fisher's *F*-protected least significant difference test. All tests of significance were made at $P \leq 0.05$.

Results and Discussion

Kentucky bluegrass quality. Kentucky bluegrass quality remained above acceptable levels throughout the duration of each experiment (data not shown), and quality ratings of Kentucky bluegrass were similar in treated plots like in the untreated plots ($P \geq 0.2235$). These results agree with Lycan and Hart (2004) who demonstrated that Kentucky bluegrass was tolerant to sulfosulfuron and exhibited only temporary discolorations at application rates 0.034 kg·ha⁻¹ or less.

Application rate and date. Sulfosulfuron at 0.011 kg·ha⁻¹ and 0.022 kg·ha⁻¹ were equally effective at controlling creeping bentgrass except applications made the third and fourth weeks of October in 2003 in West Lafayette. This was likely the result of an interaction between application rate and date (Table 2). Sulfosulfuron applied at 0.022 kg·ha⁻¹ the third and fourth weeks of October reduced creeping bentgrass up to 16% more than 0.011 kg·ha⁻¹. Similarly, Lycan and Hart (2004) found that turfgrass injury of tall fescue increased as sulfosulfuron rates increased from 0.006 to 0.067 kg·ha⁻¹. With the exception of West Lafayette in 2003, poor control was likely the result of low application rates. Preliminary data indicate that single applications of sulfosulfuron at rates of 0.035 to 0.105 kg·ha⁻¹ controlled 37% to 80% of creeping bentgrass during the fall (Reicher and Weisenberger, 2004).

Applications of sulfosulfuron later in the fall were more effective at controlling creeping bentgrass compared with earlier applications. Sulfosulfuron applied at either rate during the fourth week of August through the second week of Oct. 2003 resulted in 8% or less creeping bentgrass control in West Lafayette, but provided an average of 20% and 17% control when applied in the third or fourth week of October, respectively (Table 2). In 2004, creeping bentgrass control increased with later applications, and applications made the first week of November provided an average of 30% control of creeping bentgrass in West Lafayette (Table 3). Sulfosulfuron applications occurring after the first week of November in 2004 provided 18% or less control of creeping bentgrass in West Lafayette regardless of rate.

The inconsistent efficacy of sulfosulfuron is likely the result of variations in environmental conditions. Soil moisture levels and air temperatures can alter herbicide efficacy

Table 1. Site, application, and management information of two locations used to determine the effect of sulfosulfuron rate and timing on creeping bentgrass control in Kentucky bluegrass turf.

Site information	Location	
	Ames, IA	W. Lafayette, IN
Replications	3	4
Plot size (m)	1.5	1.5
Kentucky bluegrass variety	Sure shot ^z	Columbia
Creeping bentgrass variety	L-93	L-93
Mowing height (cm)	2.54	6.35/3.81 ^y
Mowing frequency	1×/week	2×/week
Irrigation frequency	To prevent drought stress	To prevent drought stress
Soil texture	Silty clay loam	Silt loam
Soil series	Zook	Stark
Soil family	Fine montmorillonitic mesic Cumulic Haplaquolls	Fine-silty mixed mesic Aerlic Ochraqualls
Soil pH	7.2	6.9
Soil mg·kg ⁻¹ potassium	5	112
Soil mg·kg ⁻¹ phosphorus	143	303
Soil organic matter (%)	4.0	5.7
Spray volume (L·ha ⁻¹)	1218	824
Spray pressure (kPa)	262	241
Nozzle type	#8002	#80015

^zSure shot is a Kentucky bluegrass blend containing Nuglade, Bluemoon, Award, Rugby II, and Rambo cultivars.

^yAdjacent areas of Kentucky bluegrass and creeping bentgrass were mowed at 6.35 and 3.81 cm, respectively.

Table 2. Sulfosulfuron application timing and rate affects creeping bentgrass populations.^z

Timing	Ames, IA ^y			West Lafayette, IN		
	11 g·ha ⁻¹ ai	22 g·ha ⁻¹ ai	Mean	11 g·ha ⁻¹ ai	22 g·ha ⁻¹ ai	Mean
	Percent change					
August wk 4	-2 ^x	4	1	3	2	3
September wk 1	-5	-12	-9	-5	-5	-5
September wk 2	7	12	10	-3	-5	-4
September wk 3	-9	-17	-13	-2	-6	-4
September wk 4	-14	0	-7	-4	-2	-3
October wk 1	8	1	5	-4	-4	-4
October wk 2	1	5	3	2	8	5
October wk 3	11	16	14	12	28	20
October wk 4	17	7	12	13	20	17
Mean	2	2		1	4	
ANOVA						
Rate		0.00 NS			7.56* (6)	
Date		3.37* (22) ^w			43.33* (7)	
Rate × date		0.63 NS			4.74* (5)	

^zAll treatments were mixed and applied with the nonionic surfactant MON 0818 at 0.25% v/v. Change in creeping bentgrass coverage was determined the spring of 2004 after treatments applied during the fall of 2003.

^yValues presented for Ames, IA, and W. Lafayette, IN, represent means of three and four replications, respectively.

^xNegative values represent an increase in creeping bentgrass cover.

^wFisher's *F*-protected least significant difference values.

NS, *Nonsignificant or significant $P = 0.01$, respectively.

by influencing absorption, translocation, or metabolism. Malefy and Quakenbush (1991) found that greater soil moisture levels increased control of slender meadow foxtail (*Alopecurus myosuroides* Huds.) receiving applications of imazamethabenz-methyl. Similarly, Nalewaja and Woznica (1985) reported green foxtail (*Setaria viridis* L.) susceptibility to chlorsulfuron increased as air temperatures decreased. Increased efficacy of sulfosulfuron applications later in fall might be the result of creeping bentgrass' inability to metabolize the herbicide. The rate at which plants metabolize sulfonylurea herbicides has been cited as the major selectivity mechanism between species (Gallaher et al., 1999). In addition, Olson et al., (2000) reported that cooler air temperatures decreased the metabolism rate of sulfosulfuron in jointed goatgrass (*Aegilops cylindrical* Host.),

wild oat (*Avena fatua* L.), and downy brome (*Bromus tectorum* L.). An attempt was made to relate soil moisture levels and air temperature to sulfosulfuron efficacy, but trends were not apparent.

Sulfosulfuron provided 17% or less control of creeping bentgrass in Ames in either year (Tables 2 and 3). The ineffectiveness of sulfosulfuron in Ames and the discrepancies between the two locations in 2004 may be related to the general inconsistent performance of sulfosulfuron. Other research with sulfosulfuron indicates variable results in different years (Lycan and Hart, 2004) and between locations (Taylor et al., 2002).

Control of creeping bentgrass in this study was dependent on proper application timing. Late fall applications were the most effective providing up to 31% control of creeping bentgrass. Single applications of

Table 3. Sulfosulfuron application timing and rate affects creeping bentgrass populations.^z

Timing	Ames, IA ^y			West Lafayette, IN		
	11 g·ha ⁻¹ ai	22 g·ha ⁻¹ ai	Mean	11 g·ha ⁻¹ ai	22 g·ha ⁻¹ ai	Mean
	% change					
September wk 4	9	0	5	-9	-9	-9
September wk 5	-1 ^x	5	2	-4	-2	-3
October wk 1	-16	2	-7	-14	-10	-12
October wk 2	11	2	7	-8	10	1
October wk 3	-15	-10	-13	7	5	6
October wk 4	-14	1	-7	11	7	9
November wk 1	-1	-13	-7	28	31	30
November wk 2	-9	-12	-11	12	8	10
November wk 3	-15	-13	-14	0	18	9
Mean	-6	-4		3	6	
Analysis of variance						
Rate		0.11 NS			1.72 NS	
Date		1.26 NS			7.37* (21) ^w	
Rate × date		2.24 NS			0.86 NS	

^zAll treatments were mixed and applied with the nonionic surfactant MON 0818 at 0.25% v/v. Change in creeping bentgrass coverage was determined the spring of 2005 after treatments applied during the fall of 2004.

^yValues presented for Ames, IA, and W. Lafayette, IN, represent means of three and four replications, respectively.

^xNegative values represent an increase in creeping bentgrass cover.

^wFisher's *F*-protected least significant difference value.

^{NS}, *Nonsignificant or significant *P* = or 0.01, respectively.

sulfosulfuron late in the fall may be useful in partially removing creeping bentgrass in a heavily contaminated sward of Kentucky bluegrass. However, the capability of sulfosulfuron at completely removing creeping bentgrass is questionable unless greater control can be achieved. Preliminary data indicate that three fall applications of sulfosulfuron at 0.053 kg·ha⁻¹ provided 93% control of creeping bentgrass (Reicher and Weisenberger, 2004). Future research examining the effect of increased rates and multiple applications in addition to investigating how environmental factors affect the herbicidal efficacy on different turfgrass cultivars will be needed to determine the future application of sulfosulfuron for turfgrass managers.

Literature Cited

- Beard, J.B. 1973. Turfgrass: Science and culture. Prentice Hall, Englewood Cliffs, NJ. p. 545–551.
- Bruce, J.A. and J.J. Kells. 1997. Quackgrass (*Elytrigia repens*) control in corn (*Zea mays*) with nicosulfuron and primisulfuron. Weed Technol. 11:373–378.
- Christians, N.E. 2004. Fundamentals of turfgrass management. 2nd ed. John Wiley and Sons, Inc., Hoboken, NJ. p. 219.
- Davis, R.R. 1958. The effect of other species and mowing height on persistence of lawn grasses. Agron. J. 50:671–673.
- Dernoeden, P.H. 1999. Perennial grass weeds and their control in turf. Univ. of Maryland Coop. Ext Agr. mimeo 73.
- Gallagher, K., T.C. Mueller, R.M. Hayes, O. Schwartz, and M. Barrett. 1999. Absorption, translocation, and metabolism of primisulfuron and nicosulfuron in broadleaf signalgrass (*Brachiaria platyphylla*) and corn. Weed Sci. 47:8–12.
- Larocque, D.J. and N.E. Christians. 1985. Selective control of tall fescue in Kentucky bluegrass with chlorsulfuron. Agron. J. 77:86–89.
- Lycan, D.W. and S.E. Hart. 2002. MON 44940: A potential new herbicide for weed management in turfgrass species. Proc. Northeast Weed Sci. Soc. 56:111–112.
- Lycan, D.W. and S.E. Hart. 2004. Relative tolerance of four cool-season turfgrass species to sulfosulfuron. Weed Technol. 18:977–981.
- Malefyt, T. and L. Quakenbush. 1991. Influence of environmental factors on the biological activity of the imidazolinone herbicides, p. 103–127. In: Shaner, D.L. and O'Conner, S.L. (eds.). The imidazolinone herbicides. CRC Press, Boca Raton, FL.
- Maloy, B.M. and N.E. Christians. 1986. Tolerance of tall fescue and Kentucky bluegrass to chlorsulfuron under field conditions. Weed Sci. 34:431–434.
- Miller, S.D., J.D. Nalewaja, A. Dobrzanski, and J. Pudelko. 1978. Temperature effect on barban phytotoxicity. Weed Sci. 26:132–134.
- Nalewaja, J.D. and Z. Woznica. 1985. Environment and chlorsulfuron phytotoxicity. Weed Sci. 33:395–399.
- Olson, B.L.S., K. Al-Khatib, P. Stahlman, and P. Isakson. 2000. Efficacy and metabolism of MON 37500 in *Triticum aestivum* and weedy grass species as affected by temperature and soil moisture. Weed Sci. 48:541–548.
- Patton, A.J., D.W. Williams, and Z.J. Reicher. 2004. Renovating golf course fairways with zoysiagrass seed. HortScience 39:1483–1486.
- Rabaey, T.L. and R.G. Harvey. 1997. Annual grass control in corn (*Zea mays*) with primisulfuron combined with nicosulfuron. Weed Technol. 11:171–175.
- Reicher, Z.J. and D. Weisenberger. 2004. Post-emergence control of creeping bentgrass with fall applications of MON 44951. Purdue Univ., West Lafayette, IN. 28 Aug. 2005. <<http://www.agry.purdue.edu/turf/report/2004/p137.pdf>>.
- SAS Institute. 1999–2000. Software release 8.02. SAS Inst., Cary, NC.
- Schloss, J.V. 1995. Recent advances in understanding the mechanism and inhibition of acetolactate synthase, p. 4–11. In: Setter, J. (ed.). Herbicides inhibiting branch chain amino acid biosynthesis. Springer-Verlag, New York, NY.
- Taylor, J.M., G.E. Coats, and K.C. Hutto. 2002. Pre and post control of annual bluegrass. Proc. South. Weed Sci. Soc. 55:69.
- Tinney, F.W., O.S. Aamodt, and H.L. Ahlgren. 1937. Preliminary report of a study on methods used in botanical analysis of pasture swards. Agron. J. 29:835–840.