

Response of Creeping Bentgrass to Sulfentrazone Herbicide Under Putting Green Maintenance Conditions

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Abstract

Sulfentrazone herbicide was applied to a SR1020 creeping bentgrass putting green (5/32") on October 15, 1996 and again on March 4, 1997 at the rates of 0.125, 0.250 and 0.375 lb. AI/A. Betasan was included at the standard rate of 5.6 ounces of product/1000 ft². Turf response to sulfentrazone was mostly linear with application rate, with higher application rates causing more damage to the turf. Responses occurred quicker in the fall (by 3 DAT) compared to late winter (7DAT). Magnitude of injury was also somewhat less in the late winter than in the fall, although rank responses were still rate dependent for sulfentrazone treated creeping bentgrass turf. Applied rates of 0.250 and 0.375 lb. AI/A were deleterious and not acceptable for putting green quality turf. A marginal (acceptable) response occurred overall at the 0.125 lb. rate. Betasan applied at 5.6 ounces product/1000 ft², caused no visible damage to the turf in the fall and was similar in response to sulfentrazone in the spring at the 0.125 lb. AI/A (repeat) application rate.

Introduction

For a herbicide to be used effectively in the commercial market place, it must possess a minimum of qualities. These include (1) an effective level of weed control and (2) acceptable turfgrass tolerance. Sulfentrazone experimental herbicide was applied in two seasons (Fall 1996 and Spring 1997) at three different rates on a SR1020 creeping bentgrass (*Agrostis palustris*) golf green in order to determine the turfgrass response.

Materials and Methods

A five year old SR1020 creeping bentgrass golf course green received Sulfentrazone herbicide on two application dates; October 15, 1996 (fall) and March 4, 1997 (spring). The greens were mowed 6 x weekly at 5/32" with a walk-behind greens mower. Total applications of N-P-K fertilizer from September 1 to November 15 was 2.0, 1.0 and 1.0 lbs./M, respectively (four applications). Total application of N-P-K from November 30 to March 4 was 1.75, .21 and .42 lbs./M, respectively (7 applications). The green also received seventeen ounces of Ferramec/1000 ft² (in 5 applications) from October 1996 to March 1997. The green was topdressed lightly on a as needed basis to provide an adequate putting green surface. Small micro-plots received herbicide treatments in four replications of a randomized complete block design. Sprayer applications were completed on a standard field basis, and then used under the same conditions for micro-plots using border cut-outs to uniformly spray micro-plots for assessment. Treatments included Sulfentrazone herbicide applied at three levels (0.125, 0.250, and 0.375 lbs. AI/A. Betasan (bensulide) was applied at 5.6 ounces/product/1000 ft² as a commercial comparison (chemical check). Betasan is labeled for use as a pre-emergence herbicide on creeping bentgrass greens. Untreated controls were included in each replication for a total of five field

treatments. Treatments were applied using a CO₂ back pack sprayer with 8004 nozzles. Solution delivery rates were 60 gpa (fall) and 90 gpa (spring). Spray volumes were allowed to dry six hours before an irrigation took place (1/4"). Creeping bentgrass plots received visual post application ratings at various times depending on expression and severity of effect for the following; degree of injury (1-6, 1=none, 4=moderate, 6=severe), percent plot injury (1-100%), turfgrass color (1-9, 1=dead turf, 9=dark green), visual density (1-9, 1=no turf, 9=most dense), and overall turfgrass quality (1-9, 1=dead, 9=best possible).

Results and Discussion

Fall 1996

The fall application was made on October 15, 1996 and the turf received field evaluations at 3, 10, 16 and 28 days after treatment (DAT).

On October 18 (3 DAT), the "herbicide" main effect response was significant for turfgrass injury and percent of the turf affected. SR1020 creeping bentgrass was severely damaged at the higher rates of Sulfentrazone (0.375 and 0.250 lbs. AI/A), with degree of injury scores of 5.8 and 4.8, respectively (Table 1). The 0.125 lbs. AI/A rate scored a mean degree of injury value of 2.5. Sulfentrazone caused the turf to first turn brown in appearance with some light green blotchiness within the canopy. Eventually this progressed to complete brown turf. Scores of 2.5 to 3.0 are marginally acceptable in bentgrass turf maintained under greens conditions. Ideally, any injury induced should be of short duration. Bensulide showed no visual symptoms at the 5.6 oz. product/M rate. The percent plot injured (0-100%) was directly related to the dosage of the applied treatment rates for Sulfentrazone. Percent plot injury at 3 DAT ranged from 24% (0.125 lbs. AI/A), to 65% (0.250 lbs. AI/A), to 84% injury at the high rate (0.375 lbs. AI/A) of Sulfentrazone (Table 2). Both the degree of injury and percent plot injury had significant "linear" responses using orthogonal polynomial contrasts (Table 2).

On October 25 (10 DAT), the treatment mean effect was highly significant again for both injury scores as well for turfgrass color. The degree of injury did not decrease by 10 DAT. The Sulfentrazone treatments mean injury degree scores were 2.5, 4.8 and 5.8, for the 0.125, 0.250 and 0.375 lbs. AI/A treatments, respectively (Table 1). Bensulide, showed no injurious effects. The percent plot injured from Sulfentrazone did decrease by 10 DAT, but was still unacceptable for the 0.250 and 0.375 lbs. AI/A rates, which exhibited 23% and 44% injury, respectively (Table 2). Overall turfgrass color scores showed that all Sulfentrazone treated creeping bentgrass turf was negatively effected and produced unacceptable color. Turfgrass color was inversely and linearly related to the application rate, with mean color scores of 4.0, 3.0 and 2.0 for Sulfentrazone at the 0.125, 0.250 and 0.375 lbs. AI/A rates, respectively. The Betasan turf was slightly lighter than that of the controls (Table 3).

The same response variables were assigned to plots on November 1 (16 DAT). At this time all three responses had a significant herbicide treatment mean effect. The degree of injury scores were 2.0, 3.5 and 3.8 for the low, medium and high rates of Sulfentrazone, with corresponding percent plot injury of 8%, 14% and 21%, respectively (Tables 1, 2). Overall color scores for Sulfentrazone turfs improved slightly, with only the low applications rate plots (0.125 lbs. AI/A) having a near acceptable color turf score of 5.8 (Table 3). The two higher rate treatments were still unacceptable for color at this time (Table 3). The Betasan treated turf had the darkest color turf (mean value=8.0), while the control had a score of 7.0. The rate response for all three field variables exhibited a significant "linear effect," with turf reaction showing a clear dosage response (Table 3).

On November 12, 1996 (28 DAT) percent plot injury, degree of injury, turfgrass color and visual density scores were assigned to all plots. The degree of injury was still statistically significant for the herbicide main effect, but the percent plot affected was not. Percent plot injury scores were now at low levels (2% plot injury) for Sulfentrazone for the 0.250 and 0.375 lbs (Table 2). AI/A treatments, while all other turfs had no injury by this time (Table 1). Degree of injury was very slight, for the two higher rates of Sulfentrazone, but essentially absent at the low (0.125 lbs. AI/A) rate. Turfgrass color scores ranged from 5.3 (untreated control) to 7.0 for the Betasan treated turf. Sulfentrazone treated turf had color scores similar to that of the untreated turf at this time (Table 3).

Visual density scores ranged from 4.3 to 7.0 on November 12. Decreased stolon density was evident at all rates of Sulfentrazone, which lowered visual density as the application rate increased (Table 4). Density ratings of less than 6.0

exhibit a compromised turf. Sulfentrazone treated turf at 0.375 lbs. AI/A exhibited a noticeably open canopy compared to other turf on the green. Sulfentrazone at 0.125 lbs. AI/A had a mean density score of 5.8. Both the control and the Betasan treated turfs received mean density scores of 7.0 (Table 4).

No further treatments were made until Spring 1997. Basically, from the initial fall application, Sulfentrazone caused significant discoloration of green turf, especially at the rates of 0.250 and 0.375 lbs. AI/A. Turf response at the low rate of 0.125 lbs. AI/A was marginal at best, with fair recovery responses by 16 DAT.

Spring 1997

Repeat spring applications at identical application rates were made to the same plots on March 4, 1997.

On March 11 (7 DAT), plots were rated for degree of injury, percent plot injury and turf color. The herbicide treatment main effect was statistically significant for all three field responses at 7 DAT. Percent injury ranged from (2% control) to 48%, for Sulfentrazone at the 0.375 lbs. AI/A rate (Table 2). Percent injury was 27% and 5% for Sulfentrazone at the 0.250 and 0.125 lbs. AI/A rates, respectively (Table 2). Betasan turf had 4% damage. All damage was in the form of brown leaf blades and/or leaf tips. The degree of injury ranged from 2.0 to 5.0 (moderate-severe injury) for Sulfentrazone at the 0.375 lbs. AI/A. Values of 2.0 or less are desirable, especially for putting green turf. Sulfentrazone at the 0.250 lbs. AI/A rate had moderate injury (4.3), which was unacceptable (Table 1).

Mean turfgrass color scores were low, including that of the control (untreated check plots). SR1020 is lighter green in color (compared to 'Pennncross') and prefers warmer temperatures to 'Pennncross' as well. A 'lean' winter fertilization program may have also contributed to the low color scores, as well. Mean color scores ranged from 5.5 (Betasan and untreated turf) to 3.0 for Sulfentrazone at the high rate of 0.375 lbs. AI/A. Once again, rate response was evident for color among Sulfentrazone treated turf (which ranged from 3.0 to 5.5)(Table 3).

On March 17 (14 DAT) plots were rated for the last time for percent plot and degree of injury, turfgrass color and overall quality. Percent plot injury mean scores ranged from 4% (control) to 20% (Sulfentrazone treated turf). Percent injury generally increased with application rate (Table 2). Sulfentrazone at the 0.250 and 0.375 lbs. AI/A rates averaged 20% and 18% injury, respectively, at 14 DAT. Betasan now had 7% injury, while Sulfentrazone at the low rate (0.125 lbs. AI/A) had 4% injury (Table 2).

Degree of injury scores ranged from 1.5 to 3.8, among Sulfentrazone treated bentgrass turf (Table 1). Betasan had a mean degree of injury score of 2.3. Sulfentrazone had a mean injury score of 1.50 (barely noticeable) at the low rate (0.125 lbs. AI/A). At the two higher rates, injury was again noticeable at both the 0.250 and 0.375 lbs. AI/A rates of Sulfentrazone, which had mean scores of 3.8 and 3.5, respectively.

Final color evaluations ranged from 3.8 to 5.8 (Table 3). Turfs treated with the lowest amounts of herbicide had the highest turf color scores at 14 DAT. These treatments included Sulfentrazone at the low rate of 0.125 lbs. AI/A and Betasan at 5.6 oz. product/1000 ft². These turfs had mean color scores of 5.8 and 5.5, respectively. The control had a mean color score of 5.3. Again, Sulfentrazone at 0.250 and 0.375 lb. AI/A rate caused a noticeable and somewhat lengthy negative response when applied to SR1020 creeping bentgrass.

Finally, overall turfgrass quality scores were assigned at the final evaluation (14 DAT) as an assessment of overall turfgrass appearance and visual performance. Mean scores ranged from 3.5 to 6.0, with the lowest rate of Sulfentrazone (0.125 lbs. AI/A) having the highest numerical score (mean=6.0)(Table 4). This was followed by Betasan (mean=5.5), and next by the control (mean=5.3). This is often typical in that low rates of herbicides often cause a latent increase in color/quality within 2-3 weeks after a treatment. This occurred previously in the fall for Betasan and here in the spring for both Betasan and the low rate of Sulfentrazone. By 14 DAT, turfgrass quality was low for Sulfentrazone at the medium and high rates, with final quality scores of 4.0 and 3.5, respectively (Table 4).

Compared to fall applications, it appeared that the expression of symptoms took longer to appear in the late winter, early spring (March), than that in the fall (October). This may be due to several factors; (1) decreased soil temperatures and much lower night temperatures in March vs. October, (2) overall decreased growth of SR1020 in the winter than in the warmer fall, (3) enhanced microbial decomposition rates (unmeasured) present at the 2nd application and (4) plant uptake rates which may be greater in the warmer fall, than in cooler winter conditions. Both factors (3) and (4) are speculative since no information was/is available on these attributes relative to Sulfentrazone at that time.

Conclusion

1. Sulfentrazone herbicide applied to SR1020 bentgrass putting green turf caused significant damage to the turf.
2. Both degree of injury and percent plot injury increased with application rates of 0.125, 0.250 and 0.375 lbs. AI/A of Sulfentrazone.
3. Injury responses occurred sooner and lasted longer with the first application (Fall 1996), than when the same plots were treated with the same rates in the late winter of 1997 (March).
4. Betasan, applied at 5.6 ounces of product/1000 ft² caused no visible damage to the turf when applied in the fall and only slight, temporary damage when applied in the spring as a second application at the same rate.

Table 1. Mean degree of injury scores¹ of SR1020 creeping bentgrass putting green turf after applications² of Sulfentrazone herbicide, 1996 and 1997. University of Arizona.

TREATMENTS	RATE LB. AI/A	10/18/96 (3 DAT)	10/25/96 (10 DAT)	11/1/96 (16 DAT)	11/12/96 (28 DAT)	3/11/97 (7 DAT)	3/17/97 (14 DAT)
Sulfentrazone	0.125	2.5	2.5	2.0	1.0	--	--
Sulfentrazone	0.250	4.8	4.8	3.5	1.8	--	--
Sulfentrazone	0.375	5.8	5.3	3.8	1.3	--	--
Betasan	5.6	1.0	1.0	1.0	1.0	--	--
Control	none	1.0	1.0	1.0	1.0	--	--
Sulfentrazone	0.125+0.125	--	--	--	--	2.0	1.5
Sulfentrazone	0.250+0.250	--	--	--	--	4.3	3.8
Sulfentrazone	0.375+0.375	--	--	--	--	5.0	3.5
Betasan	5.6+5.6 (ounce/M)	--	--	--	--	2.0	2.3
Control	none+none	--	--	--	--	1.0	1.3
TEST MEAN ³		3.0	2.9	2.3	1.2	2.9	2.5
LSD VALUE ⁴		0.5	0.5	0.7	0.5	0.7	0.9

Orthogonal Contrast⁵ P Level=

-Sulfentrazone Linear	0.01	0.01	0.01	1.00	1.00	0.08
-Sulfentrazone Quadratic	0.01	0.01	0.09	1.00	0.01	0.09
-All Sulfentrazone vs. Betasan	0.01	0.01	0.01	0.01	0.01	0.01

¹Degree of injury (1-6), 1=no, 4=moderate, 6=severe. Values are the average of four replications.

²First application (all treatments) applied 10/15/96. Second application (all treatments) applied on March 4, 1997.

³Test Mean = mean of all treatments on each evaluation date.

⁴LSD Value = Mean separation statistic. Treatment means which differ in amount greater than the LSD value are statistically different from each other.

⁵Orthogonal contrasts for determining significance of effect of rate responses. Statistical significance occurs at 0.05, or less.

Table 2. Mean percent plot injury¹ of SR1020 creeping bentgrass putting green turf after applications² of Sulfentrazone herbicide, 1996 and 1997. University of Arizona.

TREATMENTS	RATE LB. AI/A	10/18/96 (3 DAT)	10/25/96 (10 DAT)	11/1/96 (16 DAT)	11/12/96 (28 DAT)	3/11/97 (7 DAT)	3/17/97 (14 DAT)
Sulfentrazone	0.125	24%	9%	8%	1%	--	--
Sulfentrazone	0.250	65%	23%	14%	2%	--	--
Sulfentrazone	0.375	84%	44%	21%	2%	--	--
Betasan	5.6	1%	1%	1%	1%	--	--
Control	--	1%	1%	1%	1%	--	--
Sulfentrazone	0.125+0.125	--	--	--	--	5%	4%
Sulfentrazone	0.250+0.250	--	--	--	--	27%	20%
Sulfentrazone	0.375+0.375	--	--	--	--	48%	18%
Betasan	5.6+5.6 (ounce/M)	--	--	--	--	4%	7%
Control	-- --	--	--	--	--	2%	4%
TEST MEAN ³		35%	16%	9%	1%	17%	11%
LSD VALUE ⁴		7%	9%	5%	NA	10%	7%

Orthogonal Contrast⁵ P Level=

-Sulfentrazone Linear	0.01	0.11	0.02	1.00	1.78	0.43
-Sulfentrazone Quadratic	0.01	0.29	0.14	1.00	0.50	0.58
-All Sulfentrazone vs. Betasan	0.01	0.01	0.01	0.07	0.01	0.01

¹Percent plot injury (0-100%). Values are the average of four replications.

²First application (all treatments) applied 10/15/96. Second application (all treatments) applied on March 4, 1997.

³Test Mean = mean of all treatments on each evaluation date.

⁴LSD Value = Mean separation statistic. Treatment means which differ in amount greater than the LSD value are statistically different from each other.

⁵Orthogonal contrasts for determining significance of effect of rate responses. Statistical significance occurs at 0.05, or less.

Table 3. Mean turfgrass color¹ of SR1020 creeping bentgrass putting green turf after applications² of Sulfentrazone herbicide, 1996 and 1997. University of Arizona.

TREATMENTS	RATE LB. AI/A	10/25/96 (10 DAT)	11/01/96 (16 DAT)	11/02/96 (28 DAT)	3/11/97 (7 DAT)	3/17/97 (14 DAT)
Sulfentrazone	0.125	4.0	5.8	5.5	--	--
Sulfentrazone	0.250	3.0	4.8	6.0	--	--
Sulfentrazone	0.375	2.0	3.5	5.7	--	--
Betasan	5.6	6.8	8.0	7.0	--	--
Control	none	7.0	7.0	5.3	--	--
Sulfentrazone	0.125+0.125	--	--	--	5.5	5.8
Sulfentrazone	0.250+0.250	--	--	--	4.3	4.5
Sulfentrazone	0.375+0.375	--	--	--	3.0	3.8
Betasan	5.6+5.6 (ounce/M)	--	--	--	5.5	5.5
Control	none+none	--	--	--	5.5	5.3
TEST MEAN ³		4.6	5.8	5.9	4.8	5.0
LSD VALUE ⁴		0.4	0.7	0.9	0.7	1.1

Orthogonal Contrast⁵ P Level=

-Sulfentrazone Linear	0.01	0.01	0.01
-Sulfentrazone Quad ratio	0.01	0.66	0.01
-All Sulfentrazone vs. Betasan	0.01	0.01	0.80

¹Turfgrass color (1-9), 1=dead, 9=darkest possible. Values are the average of four replications.

²First application (all treatments) applied 10/15/96. Second application (all treatments) applied on March 4, 1997.

³Test Mean = mean of all treatments on each evaluation date.

⁴LSD Value = Mean separation statistic. Treatment means which differ in amount greater than the LSD value are statistically different from each other.

⁵Orthogonal contrasts for determining significance of effect of rate responses. Statistical significance occurs at 0.05, or less.

Table 4. Mean turfgrass density¹ and quality scores² of SR1020 creeping bentgrass putting green turf after applications³ of Sulfentrazone herbicide, 1996 and 1997. University of Arizona.

DENSITY			QUALITY		
TREATMENT	RATE LB AI/A	11/12/96 (24 DAT)	TREATMENT	RATE LB AI/A	03/17/97 (14 DAT)
Sulfentrazone	0.125	5.8	Sulfentrazone	0.125+0.125	6.0
Sulfentrazone	0.250	5.5	Sulfentrazone	0.250+0.250	4.0
Sulfentrazone	0.375	4.3	Sulfentrazone	0.375+0.375	3.5
Betasan	5.6	7.0	Betasan	5.6+5.6	5.5
Control	--	7.0	Control	-- --	5.3
TEST MEAN ⁴		5.9			4.9
LSD VALUE ⁵		1.2			1.4

Orthogonal Contrast⁶

-Sulfentrazone Linear	0.03		0.44
-Sulfentrazone Quadratic	0.19		0.38
-All Sulfentrazone vs. Betasan	0.02		0.01

¹Density (1-9), 1=no turf, 9=most dense. Values are the mean of four replications.

²Quality (1-9), 1=dead turf, 9=best possible. Values are the mean of four replications.

³First application (all treatments) applied 10/15/96. Second application (all treatments) applied on March 4, 1997.

⁴Test Mean = mean of all treatments on each evaluation date.

⁵LSD Value = Mean separation statistic. Treatment means which differ in amount greater than the LSD value are statistically different from each other.

⁶Orthogonal contrasts for determining significance of effect of rate responses. Statistical significance occurs at 0.05, or less.