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Goosegrass (*Eleusine indica*) Control with Foramsulfuron in Bermudagrass (*Cynodon* spp.) Turf[1]

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Abstract: Field studies were conducted to evaluate foramsulfuron for postemergence control of goosegrass in bermudagrass turf as a possible replacement for MSMA. In field trials on a golf course and sports fields planted to bermudagrass, mature goosegrass was controlled effectively (>85% goosegrass dead on the basis of canopy area) with two applications of foramsulfuron plus metribuzin. The herbicide rates that were effective varied among studies, e.g., foramsulfuron at 0.029 or 0.044 kg ai/ha mixed with metribuzin at 0.105 to 0.210 kg ai/ha. Goosegrass was often controlled with MSMA at 2.24 kg ai/ha plus metribuzin at 0.105 to 0.210 kg/ha, but foramsulfuron was always as effective, or more effective, than MSMA, in controlling mature goosegrass, at the same rate of metribuzin. Bermudagrass phytotoxicity of foramsulfuron plus metribuzin was temporary and not different from MSMA plus metribuzin. In one location there was noticeable phytotoxicity 4 wk after initial treatment.

Nomenclature: Foramsulfuron, 2-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-4-(formylamino)-*N,N*-dimethylbenzamide; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one; MSMA, monosodium methanearsonate; hybrid bermudagrass, *Cynodon transvaalensis* × *Cynodon dactylon* 'Tifway'; goosegrass, *Eleusine indica* (L.) Gaertn.#[3] ELEIN.

Additional index words: Alternatives to MSMA, arsenic, golf course, turfgrass.

Abbreviations: OM, organic matter; POST, postemergence; WAIT, weeks after initial treatment.

INTRODUCTION

Goosegrass is the most serious weed in golf and sports turf in southern Florida (Busey 2001) and is the third most important weed problem of golf courses in the southeastern United States (Anonymous 1996). Control of mature goosegrass in bermudagrasses (*Cynodon* spp.) is accomplished using the postemergence (POST) herbicide MSMA in combination with triazine herbicides (Murdoch and Ikeda 1974). Two applications of MSMA at 2.24 kg/ha in mixture with metribuzin at 0.14 kg/ha control mature goosegrass (Johnson 1980). A single application of diclofop-methyl is effective in controlling closely mown goosegrass on greens but not large goosegrass plants (McCarty 1991; Murdoch and Nishimoto 1982). As an alternative to MSMA, the combination metribuzin plus diclofop is promising for control of goosegrass, but a high rate of metribuzin, 0.56 kg/ha, is required to achieve 90% goosegrass control (Nishimoto and Murdoch 1999).

Each application of a labeled rate of MSMA at 2.24 kg/ha adds to the landscape 1.04 kg/ha arsenic (As), a Class A human carcinogen. Application of MSMA at 5.6 kg/ha/yr for 7 yr results in average residue levels of 4.6 ppmw As in the top 0 to 15 cm soil (Woolson and Isensee 1981). The accumulation of As in the landscape is a cause for concern regarding water quality. Golf and sports turf areas are often constructed in coastal areas with shallow aquifers. Excess levels of As in soil and water sampled at South Florida golf courses are reported in association with the use of organic arsenical herbicides such as MSMA (Anonymous 2002). Foramsulfuron was registered in 2003 by the U.S. Environmental Protection Agency as the turf herbicide Revolver.[4] The objective of this study was to evaluate foramsulfuron for the POST control of goosegrass in bermudagrass turf as a possible replacement for MSMA.

MATERIALS AND METHODS

Five experiments were conducted on control of mature goosegrass in bermudagrass turf at golf courses and

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

[4] Revolver®, Bayer CropScience LP, Montvale, NJ.

sports fields in Broward County, FL. Goosegrass was ''mature'' on the basis of having three or more tillers per plant. Most plants had at least 10 tillers per plant, and a diameter of 10 to 40 cm. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer in all but the fourth experiment (Bonaventure #9E). In the fourth experiment, a commercial golf course sprayer was used. There was no rain or irrigation during 24 h after treatment. No experimental area was shaded. Mowing was not performed within 2 d before or after herbicide treatments. Visual evaluation of goosegrass control was based on the percentage of goosegrass canopy dead, 0 to 100%, and for purposes of discussion any value greater ($P < 0.05$) than that of the untreated check plots was a significant control, but only treatments causing >85% goosegrass canopy death were considered effective controls.

At City of Sunrise Springtree Golf Course (Springtree), there was 30% canopy cover of mature goosegrass in a rough of 'Tifway' (T-419) hybrid bermudagrass turf. The soil was 96% sand, pH 7.2, and 3.5% organic matter (OM). The area was mown three times per week at 13 mm height to accommodate temporary tee surfaces and fertilized with 390 kg N/ha/yr. The experimental design was randomized complete block with six replications. Plots (4.1 by 1.2 m) were assigned to replications to provide similar initial goosegrass densities. Treatments included both an unsafened and a safened (with isoxadifen-ethyl) formulation of foramsulfuron, both at 0.029 and 0.044 kg ai/ha. Treatments included MSMA at 2.24 kg ai/ha, both by itself and tank mixed with metribuzin at either 0.28 or 0.56 kg ai/ha. No surfactant was added. Each herbicide treatment involved two applications made to the same plots on June 18 and 27, 2002. Each application consisted of two spray passes using 11002 flat-fan nozzle tips. Two spray passes were needed to bring the spray volume to an adequate amount with these nozzles. Pressure was 207 kPa in the tubing, and the total spray solution (two passes) was 422 L/ha. There was also an untreated check plot in each replicate. Plots were evaluated visually for goosegrass control, as percent of goosegrass canopy dead, and bermudagrass phytotoxicity, as percent discoloration, 12, 15, 23, 25, and 32 d after the initial application.

At Broward County Brian Piccolo Park, City of Pembroke Pines (Brian Piccolo), there was 55% canopy cover of mature goosegrass plants in a softball outfield with a thin cover of Tifway hybrid bermudagrass mixed with 'Common' bermudagrass turf, *Cynodon dactylon* (L.) Pers. Soil was 94% sand, pH 7.0, and 5.4% OM. The area was mown twice per week at 32 mm height and fertilized with 440 kg N/ha/yr. The experimental design was randomized complete block with four replications, except the foramsulfuron treatments had three replications. Plots (2.4 by 2.4 m) were assigned to replications, to provide similar initial goosegrass densities. Treatment with foramsulfuron (unsafened formulation) at 0.044 kg/ha was compared with MSMA at 2.24 kg/ha, and both were tank mixed with metribuzin at 0.053, 0.105, 0.158, 0.210, and 0.263 kg/ha, and metribuzin was also applied at the same rates by itself, resulting in 18 factorial combinations, including the untreated check plot in each replicate. No surfactant was added. Each herbicide treatment involved two applications made to the same plots, on August 6 and 13, 2002. Each application consisted of two spray passes using 11002 flat-fan nozzle tips. Pressure was 207 kPa in the tubing, and the total spray solution (two passes) was 438 L/ha. Plots were evaluated visually for goosegrass control and percent bermudagrass phytotoxicity, 8, 10, 11, 13, 15, 17, 20, 23, and 26 d after the initial treatment.

At Bonaventure Country Club, City of Weston, on the fifth hole on the East Course (Bonaventure #5E), there was a scattered distribution, average 5% canopy cover, of mature goosegrass plants in Tifway bermudagrass. Soil was 92% sand, pH 7.2, and 5.5% OM. All plots contained golf course rough, and most plots also extended into fairway. The rough was mown three times per week at 38 mm height, the fairway was mown at 17 mm, and all areas were fertilized with 439 kg N/ha/yr. The experimental design was a randomized complete block with six replications. Plots (1.2 by 6.1 m) were assigned to replications, to provide similar initial goosegrass densities. Treatments included foramsulfuron (unsafened formulation) applied at 0.029 and 0.044 kg/ha, by itself and with metribuzin at 0.105 or 0.210 kg/ha; MSMA at 2.24 kg/ha, by itself and with metribuzin at 0.105 or 0.210 kg/ha; diclofop at 1.14 kg/ha, by itself and with metribuzin at 0.105 kg/ha. MSMA treatments contained Meth Oil,[5] a methylated soybean oil mixture as an adjuvant at 0.25% by volume. Foramsulfuron treatments had no adjuvant. The preceding treatments involved two applications made to the same plots, on March 11 and 18, 2003. In addition, foramsulfuron was applied once at 0.087 kg/ha, on March 11, 2003, and was applied three times at 0.029 kg/ha, on March 11, 18, and 25, 2003. Each application consisted of two spray passes using 11015 flat-fan nozzle tips. Pressure was 207 kPa in the tubing, and the total spray solution (two passes) was

[5] Meth Oil®, Terra International, Inc., Sioux City, IA.

353 L/ha. There was also an untreated check plot in each replicate. Within all plots, there was no discernible difference in goosegrass control or bermudagrass phytotoxicity between fairway and rough, and therefore observations were made for each entire plot. Plots were evaluated visually for goosegrass control and percent bermudagrass phytotoxicity, 8, 10, 12, 14, 17, 21, 28, and 35 d after the initial application.

At Bonaventure Country Club, on the ninth hole on the East Course (Bonaventure #9E), there was a scattered distribution, average 5% canopy cover, of mature goosegrass plants in Tifway bermudagrass golf course rough and adjacent fairway. All plots were split in the middle by the edge of the rough, so that both fairway and rough were represented in each plot. Soil was 90% sand, pH 7.4, and 4.7% OM. The rough was mown three times per week at 38 mm height, the fairway was mown at 17 mm, and all areas were fertilized with 439 kg N/ha/yr. The experimental design was a randomized complete block with three replications. Plots (2.4 by 12.2 m) were assigned to replications, to provide similar initial goosegrass densities. Treatments included foramsulfuron (unsafened formulation) applied at 0.029 kg/ha, mixed with metribuzin at 0.105 or 0.210 kg/ha, and MSMA at 2.24 kg/ha mixed with metribuzin at 0.105 kg/ha. The MSMA treatment contained Meth Oil as an adjuvant at 0.25% by volume. Foramsulfuron treatments had no adjuvant. Treatments received spray applications made to the same plots, on April 7 and 14, 2003, using a commercial golf course sprayer. Each application consisted of a single spray pass using 8004 flat-fan nozzle tips. Pressure was 276 kPa in the tubing, and the spray solution was 323 L/ha. There was also an untreated check plot in each replicate. Plots were evaluated visually for goosegrass control and percent bermudagrass phytotoxicity, 10, 14, 16, 21, and 28 d after the initial application. Because the two areas, fairway and rough, were not assigned randomly, but occurred in all plots, the rough and the fairway were analyzed as separate experiments.

At the American Youth Soccer Organization soccer field at West Broward Community Church, City of Southwest Ranches (AYSO Soccer), there was approximately 20% canopy cover of mature goosegrass plants in Tifway bermudagrass. Soil was 88% sand, pH 7.2, and 32% OM. The area was mown two times per week at 25 mm height and fertilized with 585 kg N/ha/yr. The experimental design was a randomized complete block with four replications. Plots (2.4 by 9.1 m) were assigned to replications, to provide similar initial goosegrass densities. Treatments included foramsulfuron (unsafened formulation) applied at 0.029 kg/ha, by itself and with metribuzin at 0.105 or 0.210 kg/ha, and MSMA at 2.24 kg/ha, with metribuzin at 0.105 kg/ha. MSMA treatments contained Meth Oil, at 0.25% by volume. Foramsulfuron treatments had no adjuvant. The preceding treatments involved two applications made to the same plots, on May 9 and 16, 2003. In addition, foramsulfuron was applied once at 0.058 kg/ha on May 9, 2003, followed by metribuzin applied at 0.210 kg/ha on May 16, 2003 (‘‘foramsulfuron, metribuzin’’). The reverse sequence was also applied, metribuzin on May 9, 2003, followed by foramsulfuron on May 16, 2003 (‘‘metribuzin, foramsulfuron’’). Each application consisted of two spray passes using 11015 flat-fan nozzle tips. Pressure was 276 kPa in the tubing, and the total spray solution (two passes) was 412 L/ha. There was also an untreated check plot in each replicate. Plots were evaluated visually for goosegrass control and percent bermudagrass phytotoxicity, 9, 11, 14, 18, 21, and 25 d after the initial application.

Before statistical analysis, goosegrass control and bermudagrass phytotoxicity evaluations were averaged within weeks after the initial treatment (WAIT), that is, any two or more evaluations within a week were pooled as subsamples before analysis. Data were analyzed by ANOVA, using treatment by replication interaction for comparison of treatment means, and means were separated by the Waller-Duncan Bayesian *k*-ratio *t* test, $k = 100$, $P \approx 0.05$, a multiple significant difference test. Single-degree contrasts involving linear and quadratic effects and interactions among herbicide rates in the Brian Piccolo experiment were determined by the general linear model (Sokal and Rohlf 1981).

RESULTS AND DISCUSSION

Foramsulfuron treatments at Springtree (Table 1) caused slight (up to 52%) temporary control of mature goosegrass ($P < 0.05$). Most often, foramsulfuron treatments were not different from MSMA in goosegrass control. Effective (>85%) control of goosegrass was only achieved with MSMA plus metribuzin at 0.56 kg/ha, from 2 to 5 WAIT. MSMA and foramsulfuron by themselves caused no significant phytotoxicity to bermudagrass, but MSMA plus metribuzin caused significant phytotoxicity, from 2 to 5 WAIT. Because the unsafened formulation of foramsulfuron caused no bermudagrass phytotoxicity, the safened formulation was dropped from subsequent experiments. Because foramsulfuron by itself was not effective in goosegrass control, it was subsequently mixed with metribuzin.

Table 1. Herbicide treatments, goosegrass control, and bermudagrass phytotoxicity at Springtree Golf Course, Sunrise, FL.[a,b]

Treatment	Rate	Goosegrass control				Bermudagrass phytotoxicity			
		2 WAIT	3 WAIT	4 WAIT	5 WAIT	2 WAIT	3 WAIT	4 WAIT	5 WAIT
	kg/ha	%							
Foramsulfuron	0.029	27	38	17	0	0	3	0	0
Foramsulfuron	0.044	40	52	25	15	0	0	0	0
Foramsulfuron (safened)	0.029	18	22	18	7	0	0	0	7
Foramsulfuron (safened)	0.044	35	45	18	8	0	0	3	0
MSMA	2.24	42	37	15	7	0	0	0	0
MSMA + metribuzin	2.24 + 0.28	82	92	92	65	52	40	41	22
MSMA + metribuzin	2.24 + 0.56	100	100	100	100	70	67	60	57
Untreated check	—	0	0	0	0	0	0	0	0
MSD		11	11	11	25	8	18	19	19
P		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[a] Means of six replications. Each treatment involved two applications, 9 d apart.

[b] Abbreviations: MSD, minimum significant difference ($P \approx 0.05$); WAIT, weeks after initial application.

At Brian Piccolo (Table 2), foramsulfuron at 0.044 kg/ha caused moderate control of goosegrass from 2 WAIT to 4 WAIT, but the control 4 WAIT, 76%, was considered ineffective because it was ≥85%. MSMA at 2.24 kg/ha controlled goosegrass slightly, between 26 and 36%, but only through 3 WAIT. Mixture of metribuzin with either foramsulfuron or MSMA strongly increased goosegrass control, depending on the rate of metribuzin. Effective (>85%) goosegrass control 4 WAIT required a minimum of 0.105 kg/ha metribuzin, in the mixture with foramsulfuron at 0.044 kg/ha, and required a minimum of 0.210 kg/ha metribuzin, in the mixture with MSMA at 2.24 kg. Effect of MSMA, foramsulfuron, and metribuzin (linear) were all highly significant ($P < 0.01$) for goosegrass control. The linear effect of metribuzin was consistently the strongest effect on goosegrass control.

Table 2. Herbicide treatments, goosegrass control, and bermudagrass phytotoxicity at Broward County Brian Piccolo Park softball field, Pembroke Pines, FL.[a,b]

Treatment	Rate	Goosegrass control			Bermudagrass phytotoxicity		
		2 WAIT	3 WAIT	4 WAIT	2 WAIT	3 WAIT	4 WAIT
	kg/ha	%					
Foramsulfuron	0.044	49	65	76	9	3	9
Foramsulfuron + metribuzin	0.044 + 0.053	58	82	82	29	21	30
Foramsulfuron + metribuzin	0.044 + 0.105	61	91	98	33	28	37
Foramsulfuron + metribuzin	0.044 + 0.158	68	90	92	38	29	32
Foramsulfuron + metribuzin	0.044 + 0.210	78	97	98	39	41	30
Foramsulfuron + metribuzin	0.044 + 0.263	81	98	100	44	43	40
MSMA	2.24	36	26	1	4	3	0
MSMA + metribuzin	2.24 + 0.053	50	50	21	33	18	21
MSMA + metribuzin	2.24 + 0.105	64	72	48	35	29	35
MSMA + metribuzin	2.24 + 0.158	71	90	83	42	30	29
MSMA + metribuzin	2.24 + 0.210	74	90	94	39	25	23
MSMA + metribuzin	2.24 + 0.263	80	95	99	38	33	30
Metribuzin	0.053	33	24	18	18	6	0
Metribuzin	0.105	46	53	36	26	17	23
Metribuzin	0.158	56	63	43	31	21	29
Metribuzin	0.210	64	89	65	41	37	38
Metribuzin	0.263	68	83	64	38	38	40
Untreated check	—	3	0	0	0	0	0
MSD		7	15	31	8	9	14
Contrasts P values less than							
MSMA		0.0001	0.0001	0.01	0.01	NS	NS
Foramsulfuron		0.0001	0.0001	0.0001	0.001	0.01	0.05
Metribuzin (linear)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Metribuzin (quadratic)		0.05	0.05	NS	0.0001	0.05	0.05
MSMA by metribuzin (linear)		0.001	NS	0.05	NS	0.01	0.05
MSMA by metribuzin (quadratic)		NS	NS	NS	NS	0.05	NS
Foramsulfuron by metribuzin (linear)		0.0001	0.0001	0.05	NS	NS	0.0001
Foramsulfuron by metribuzin (quadratic)		0.001	NS	NS	NS	NS	NS

[a] Means of four replications except only three replications of foramsulfuron treatments. Each treatment involved two applications, 7 d apart.

[b] Abbreviations: MSD, minimum significant difference ($P \approx 0.05$); NS, not significant; WAIT, weeks after initial application.

Table 3. Herbicide treatments, goosegrass control, and bermudagrass phytotoxicity at Bonaventure Country Club East Course #5, Weston, FL.[a,b]

Treatment	Rate	Applications	Goosegrass control				Bermudagrass phytotoxicity	
			2 WAIT	3 WAIT	4 WAIT	5 WAIT	2 WAIT	3 WAIT
	kg/ha	no.	%					
Foramsulfuron	0.029	2	30	36	10	0	0	0
Foramsulfuron + metribuzin	0.029 + 0.105	2	55	75	66	72	6	2
Foramsulfuron + metribuzin	0.029 + 0.210	2	80	93	88	98	5	0
Foramsulfuron	0.044	2	36	43	13	15	0	1
Foramsulfuron + metribuzin	0.044 + 0.105	2	65	84	76	73	8	1
Foramsulfuron + metribuzin	0.044 + 0.210	2	77	97	93	93	13	3
Foramsulfuron	0.029	3	33	54	42	38	0	2
Foramsulfuron	0.087	1	25	19	0	0	0	0
MSMA	2.24	2	25	2	0	0	0	0
MSMA + metribuzin	2.24 + 0.105	2	54	66	53	49	6	2
MSMA + metribuzin	2.24 + 0.210	2	76	88	82	88	11	2
Diclofop	1.145	2	2	2	12	18	0	0
Diclofop + metribuzin	1.145 + 0.105	2	65	84	74	77	13	3
Untreated check	—	0	3	5	7	8	0	0
MSD			11	14	19	24	5	6
P			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[a] Means of six replications, applications made 7 days apart.

[b] Abbreviations: MSD, minimum significant difference ($P \approx 0.05$); WAIT, weeks after initial application.

The MSMA by metribuzin (linear) interaction was highly significant ($P < 0.01$) for goosegrass control, only 2 WAIT, whereas the foramsulfuron by metribuzin (linear) interaction was very highly significant ($P < 0.0001$) both 2 WAIT and 3 WAIT. There was moderate bermudagrass phytotoxicity ($P < 0.05$) at Brian Piccolo 4 WAIT, associated with metribuzin, and this was hypothesized to be due to a relatively thin turfgrass cover. By 41 d after initial treatment (data not presented), there was no phytotoxicity. Others have reported the phytotoxicity of higher rates of metribuzin to bermudagrass (Johnson et al. 1990; Murdoch and Nishimoto 1982; Wiecko 2000). There was no effect of MSMA on bermudagrass phytotoxicity after 2 WAIT, the effect of foramsulfuron was significant through 4 WAIT, and the effect of metribuzin (linear) was very highly significant ($P < 0.0001$) through 4 WAIT.

At Bonaventure #5E (Table 3), two applications of foramsulfuron, at either 0.029 kg/ha or 0.044 kg/ha, caused ineffective goosegrass control, 30 to 43%, through 3 WAIT. Two applications of MSMA at 2.24 kg/ha caused only 25% goosegrass control 2 WAIT. Three applications of foramsulfuron at 0.029 kg/ha controlled goosegrass 42% through 4 WAIT, but this was possibly an artifact of the attenuated duration of applications. A single application of 0.087 kg/ha foramsulfuron only controlled goosegrass 19%, 3 WAIT. Mixtures of foramsulfuron applied twice at either 0.029 or 0.044 kg/ha, with metribuzin at 0.210 kg/ha, controlled goosegrass effectively (>85%), from 3 WAIT to 5 WAIT. Foramsulfuron plus metribuzin at 0.105 kg/ha controlled goosegrass, 55% to 84%, through 5 WAIT but was considered ineffective because it was <85%. Effective goosegrass control was achieved with two applications of MSMA at 2.24 kg/ha plus metribuzin at 0.210 kg/ha, 3 WAIT and 5 WAIT, but was ineffective when metribuzin was only 0.105 kg/ha. Diclofop by itself had no effect on goosegrass, whereas diclofop plus metribuzin provided as high as 84% control of goosegrass, 3 WAIT. No treatment at Bonaventure #5E caused more than slight (13%) phytotoxicity to bermudagrass 2 WAIT. By 4 WAIT and 5 WAIT, there was no observable phytotoxicity to bermudagrass from any treatment.

At Bonaventure #9E (Table 4), which used the commercial sprayer, goosegrass was controlled 90 to 97%, from 2 WAIT to 4 WAIT, in both the rough and the fairway, with foramsulfuron at 0.029 kg/ha plus metribuzin at 0.210 kg/ha (Table 4). Phytotoxicity to bermudagrass was minimal, no more than 13% in the rough, although the results were not significant statistically. By 4 WAIT, there was no observable phytotoxicity to bermudagrass from any treatment. Foramsulfuron as well as MSMA mixed with the lower rate of metribuzin, 0.105 kg/ha, controlled goosegrass 89 to 100% in the fairway, but the control in the rough, 71 to 83%, was ineffective.

At AYSO Soccer (Table 5), two applications of foramsulfuron at 0.029 kg/ha, mixed with 0.210 kg/ha metribuzin, caused effective goosegrass control, between 90 and 98%, from 2 WAIT to 4 WAIT. Phytotoxicity to bermudagrass (18%) was noticeable and significant only 2 WAIT. Other split application treatments, foramsulfuron by itself; and foramsulfuron plus metribuzin at 0.105

Table 4. Herbicide treatments, goosegrass control, and bermudagrass phytotoxicity at Bonaventure Country Club East Course #9, Weston, Florida.[a,b]

Treatment	Rate	Location	Goosegrass control			Bermudagrass phytotoxicity	
			2 WAIT	3 WAIT	4 WAIT	2 WAIT	3 WAIT
	kg/ha		%				
Foramsulfuron + metribuzin	0.029 + 0.105	Fairway	90	97	100	2	0
Foramsulfuron + metribuzin	0.029 + 0.210	Fairway	95	95	95	4	1
MSMA + metribuzin	2.24 + 0.105	Fairway	89	97	97	4	2
Untreated check	—	Fairway	0	0	0	0	0
MSD	—	—	11	13	11	4	3
P	—	—	<0.0001	<0.0001	<0.0001	NS	NS
Foramsulfuron + metribuzin	0.029 + 0.105	Rough	83	82	83	8	0
Foramsulfuron + metribuzin	0.029 + 0.210	Rough	90	93	97	13	3
MSMA + metribuzin	2.24 + 0.105	Rough	77	71	73	4	0
Untreated check	—	Rough	0	0	0	0	0
MSD	—	—	10	16	17	10	5
P	—	—	<0.0001	<0.0001	<0.0001	NS	NS

[a] Means of three replications. Each treatment involved two applications 7 d apart.

[b] Abbreviations: MSD, minimum significant difference (P ≈ 0.05); NS, not significant; WAIT, weeks after initial application.

kg/ha; foramsulfuron at 0.058 kg/ha followed by metribuzin at 0.210 kg/ha, and the reciprocal, caused effective control of goosegrass 3 WAIT, but not 2 WAIT or 4 WAIT. MSMA plus metribuzin was not effective and controlled goosegrass no more than 75%.

In conclusion, goosegrass was effectively (>85%) and consistently controlled with two applications of foramsulfuron plus metribuzin at 0.210 kg/ha in six out of six combinations of experiment and treatment (Brian Piccolo and Bonaventure #5E, both with foramsulfuron at 0.044 kg/ha; and Bonaventure #5E and #9E, both fairway and rough, and AYSO Soccer, all with foramsulfuron at 0.029 kg/ha). These results from foramsulfuron were comparable with those from MSMA at 2.24 kg/ha, which was also effective in goosegrass control when applied in mixture with metribuzin at 0.210 kg/ha at Brian Piccolo and Bonaventure #5E.

Goosegrass was effectively (>85%) controlled with two applications of foramsulfuron plus metribuzin at 0.105 kg/ha in three out of six combinations of experiment and treatment (Brian Piccolo with foramsulfuron at 0.044 kg/ha; and Bonaventure #9E fairway and AYSO Soccer, both with foramsulfuron at 0.029 kg/ha) but not in the other three combinations (Bonaventure #5E with foramsulfuron at 0.044 kg/ha; and not at Bonaventure #5E nor in the rough at Bonaventure #9E, both with foramsulfuron at 0.029 kg/ha). These results from foramsulfuron were more often effective than those from MSMA at 2.24 kg/ha when applied in mixture with metribuzin at 0.105 kg/ha, effective in only one of five evaluations (fairway at Bonaventure #9E) but not in the other four (Brian Piccolo, Bonaventure #5E, rough at Bonaventure #9E, nor AYSO Soccer).

Although there may have been growing height and

Table 5. Herbicide treatments, goosegrass control, and bermudagrass phytotoxicity at American Youth Soccer Organization (AYSO) field, Southwest Ranches, Florida.[a,b]

Treatment	Rate	Goosegrass control			Bermudagrass phytotoxicity
		2 WAIT	3 WAIT	4 WAIT	2 WAIT
	kg/ha	%			
Foramsulfuron	0.029	74	89	68	3
Foramsulfuron + metribuzin	0.029 + 0.105	85	89	83	9
Foramsulfuron + metribuzin	0.029 + 0.210	94	98	90	18
Metribuzin, foramsulfuron	0.210, 0.058	72	90	77	7
Foramsulfuron, metribuzin	0.058, 0.210	83	86	64	6
MSMA + metribuzin	2.24 + 0.105	73	75	73	12
Untreated check	—	5	0	13	0
MSD		13	11	27	5
P		<0.0001	<0.0001	<0.0001	<0.0001

[a] Means of four replications. Treatments ''metribuzin, foramsulfuron'' and ''foramsulfuron, metribuzin'' involved separate applications of the two chemicals. Other herbicide treatments involved tank mixtures that were applied successively in two applications on separate dates, 7 d apart.

[b] Abbreviations: MSD, minimum significant difference (P ≈ 0.05); WAIT, weeks after initial application.

other environmental factors affecting goosegrass control and phytotoxicity to bermudagrass, the rate of metribuzin is the most important factor in goosegrass control using foramsulfuron mixtures. The consistently effective rate of metribuzin, 0.210 kg/ha, may cause phytotoxicity under some conditions. Metribuzin can cause phytotoxicity to bermudagrass turf at 0.2 kg/ha (McCarty et al. 1991) and even at rates as low as 0.07 kg/ha (Murdoch and Nishimoto 1982). Net photosynthesis of bermudagrass ceases temporarily, depending on bermudagrass cultivar, from metribuzin applied at 0.25 kg/ha (Yang and Bingham 1984). In all evaluations, foramsulfuron was as effective, or more effective, than MSMA at the same rate of mixture of metribuzin, in controlling mature goosegrass.

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