1-1-1997

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HortScience 32(4):683–686. 1997.

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Additional index words. turfgrass management, weed control

***Abstract.* Field studies were conducted at two sites in Nebraska (NE1 and NE2) and one site in Kansas (KS) in 1994 to determine the influence of selected preemergence herbicides on establishment of seeded 'Sharp's Improved' buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.]. Herbicides were applied within 2 days after seeding. Application of imazethapyr at 0.07 kg·ha^{-1} usually resulted in buffalograss seedling density, vigor, and foliar cover that were superior to buffalograss stands where other herbicides were applied. Buffalograss response to AC 263,222 at 0.07 kg·ha^{-1} was variable and appeared to be influenced by level of weed interference. Seedling density and vigor of buffalograss on areas treated with AC 263,222 were the same or less than on nontreated areas at KS and NE2, where weed infestations were low and moderate [5% and 45% weed foliar cover 12 weeks after treatment (WAT) on nontreated areas]. In contrast, buffalograss establishment was similar in AC 263,222- and imazethapyr-treated plots at NE1 where the weed infestation was high (>70% weed foliar cover 12 WAT on nontreated areas). At 12 WAT, weed foliar cover was ≤25% at NE1 and ≤1% at NE2 where imazethapyr and AC 263,222 were applied. Of all herbicides evaluated, imazethapyr at 0.07 kg·ha^{-1} was superior for suppressing annual grass and broadleaf weeds with no observable deleterious effects on buffalograss establishment from seed. Chemical names used: ±2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-methyl-pyridine carboxylic acid (AC 263,222); 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid (imazethapyr); 6-chloro-*N,N*′-diethyl-1,3,5-triazine-2,4-diamine (simazine).**

Buffalograss is a stoloniferous, warm-season grass native to the Great Plains region of North America and is being increasingly used as an improved turfgrass on low-maintenance sites. Buffalograss can be established by seeding, plugging, or sodding (Feucht and Butler, 1988). Seeding is relatively inexpensive, compared to vegetative propagation, and turf can be established quickly if weed competition is minimized and the seedbed remains moist. In Kansas, complete buffalograss coverage was achieved in 7 to 9 weeks after planting burrs at 49 to 150 kg·ha^{-1} from April through July (Fry et al., 1993).

Selected postemergence herbicides have been applied without injury to buffalograss seedlings in Kansas (Fry and Upham, 1994).

Several preemergence herbicides have been used during vegetative establishment of other warm-season turfgrass species. Oxadiazon [3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one] selectively suppressed weeds in vegetatively established bermudagrass [*Cynodon dactylon* (L.) Pers.] (McCarty and Murphy, 1994) and zoysiagrass (*Zoysia japonica* Steud.) (Fry et al., 1986). Simazine and atrazine [6-chloro-*N*-ethyl-*N*′-(1-methylethyl)-1,3,5-triazine-2,4-diamine] can be used during vegetative establishment of centipedegrass [*Eremochloa ophiuroides* (Munro.) Hack.] and St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] (McCarty and Murphy, 1994). Oxadiazon and isoxaben [*N*-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide] + trifluralin (2,6-dinitro-*N,N*-dipropyl-4-trifluoromethylbenzenamine) did not adversely affect Colorado common buffalograss plug establishment and growth (Harivandi and Elmore, 1993).

There is limited information on preemergence herbicides that can be used at the time of seeding turfgrasses. Siduron [*N*-(2-methylcyclohexyl)-*N*′-phenylurea] can be used to control annual grass weeds during spring seeding of cool-season turfgrass species and zoysiagrass (Watschke and Schmidt, 1992). In a recent Texas study (Dotray and McKenney, 1996), buffalograss treated at the time of seeding was tolerant to cyanazine [2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2methylpropanenitrile], metsulfuron [2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino-sulfonyl]benzoic acid], propazine [6-chloro-*N, N*′-bis(1-methylethyl)-1,3,5-triazine-2,4-diamine], and pyrithiobac [2-chloro-6-[(4,6-dimethoxy-2-pyrimidinyl)thio] benzoic acid]. This study was conducted to evaluate selected preemergence herbicides that could be used to improve seeded buffalograss establishment.

Received for publication 3 Sept. 1996. Accepted for publication 18 Dec. 1996. Kansas Agricultural Experiment Station Pub. 96-25-J. Nebraska Agricultural Research Division and USDA–ARS Journal Series no. 11226. 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.

Materials and Methods

One experiment was conducted at the Rocky Ford Turfgrass Research Center in Manhattan, Kan. (KS), and two at the John Seaton Anderson Turfgrass Research Facility near Ithaca, Neb. (NE1 and NE2), in 1994. Sites were rototilled to a 10-cm depth and rolled within 2 d of planting. The sites were treated with a starter fertilizer (19N–26P–5K) to provide N at 49 kg·ha^{-1} at planting. 'Sharp's Improved' buffalograss burrs were seeded at 74 kg·ha^{-1} (pure live seed, 63 kg·ha^{-1}) and lightly raked 1-cm deep into the surface.

Preemergence herbicides were applied to 1 × 2-m plots at all sites within 2 d after seeding. An irrigation of ≈8 mm was applied within 24 h after seeding. Seeded plots were irrigated, as needed during the summer, to enhance seed germination and seedling growth and development. Herbicides included in the study were: imazethapyr; AC 263,222; DCPA (dimethyl 2,3,5,6-tetrachloro-1,4-benzenedicarboxylate); simazine; pronamide, 3,5-dichloro (*N*-1,1-dimethyl-2-propynyl) benzamide; dithiopyr, [*S,S*-dimethyl 2-(difluromethyl)-4-(2-methylpropyl-6-trifluoromethyl)-3,5-pyridinedicarbothioate]; prodiamine [N^3,N^3-di-n-propyl-2,4-dinitro-6-(trifluoromethyl)-m-phenylenediamine]; pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine]; benefin [*N*-butyl-*N*-ethyl-2,6-dinitro-4-(trifluoromethyl)benzenamine]; bensulide [*O,O*-bis(1-methylethyl)*S*-[2-[(phenylsulfonyl) amino]ethyl]phosphorodithioate]; siduron; oxadiazon; benefin + trifluralin; oryzalin [4-(dipropylamino)-3,5-dinitrobenzene-sulfonamide]; and benefin + oryzalin. Application rates (Tables 1–4) were based upon label recommendations, with the exception of simazine. Turfgrass managers have traditionally applied simazine to newly seeded buffalograss stands at 1.1 kg·ha^{-1}, ≈50% of the standard application rate. Thus, this lower application rate was evaluated herein.

Buffalograss was seeded on 15 June 1994 at KS in a Chase silt loam (Aquic Argiudoll). Liquid herbicides were applied in water at 93 mL·m^{-2} at 246 kPa. Granular herbicides (benefin, bensulide, oxadiazon, trifluralin, and oryzalin) were applied with a shaker can to achieve uniform distribution. Broadleaf weeds were observed within 3 weeks of planting and included spotted spurge (*Euphorbia maculata* L.), curly dock (*Rumex crispus* L.), redroot pigweed (*Amaranthus retroflexus* L.), and carpetweed (*Mollugo verticillata* L.). Grassy weeds were observed at the same time, and included fall panicum (*Panicum dichotomiflorum* Michx.), yellow foxtail [*Setaria pumila* (Poir.) Roem. and Schult.], and stinkgrass [*Eragrostis cilianensis* (All.) E. Mosher].

Buffalograss was seeded on 9 June 1994 at NE1 and on 17 June 1994 at NE2. The soil at each site was a Sharpsburg silty clay loam (Typic Argiudoll). Liquid herbicides were diluted in water and applied at 120 mL·m^{-2} at 240 kPa. Granular herbicides were applied as previously described. Weed composition and density differed between NE1 and NE2. Yellow foxtail and large crabgrass [*Digitaria sanguinalis* L. (Scop.)] were the dominant weeds at NE1, whereas prostrate spurge and redroot pigweed were the dominants at NE2.

Buffalograss seedling density and vigor at 4 weeks after treatment (WAT) and buffalograss and weed foliar cover were measured at 8 and 12 WAT to determine buffalograss and weed response to herbicide treatments at all sites. Buffalograss seedling densities were determined by counting the seedlings within a 30 × 30-cm quadrat randomly placed within each plot. Seedling vigor was visually rated using a 0 to 9 scale, where 0 = dead seedlings or no seedlings present and 9 = vigorously growing seedlings. Buffalograss and weed foliar cover in plots were rated visually on a 0% to 100% scale where 0% represented no foliage and 100% represented complete coverage of the soil with foliage. Herbage mass of buffalograss and weeds was measured 12 WAT at NE1 and NE2. Herbaceous vegetation was clipped to a 1-cm stubble height within a 0.25-m^2 quadrat that was randomly placed in each plot. Vegetation samples were separated into buffalograss, broadleaf, and grass weeds components, dried at 60 °C for 72 h, and weighed.

Experiments at each site were designed as randomized complete blocks with four replications per herbicide treatment. Each experiment was analyzed separately using analysis of variance procedures. Hartley's F-max test was used to evaluate homogeneity of the error variances for each variable (Lentner and Bishop, 1993). Error variances of buffalograss seedling density, buffalograss foliar cover, weed foliar cover, and annual grass herbage mass were determined to be heterogeneous and data from these variables were analyzed separately for each site. Error variances associated with buffalograss seedling vigor, buffalograss herbage mass, and broadleaf herbage mass were determined to be homogeneous and data for these variables were pooled for analysis across sites. Significant herbicide × site interactions were detected for all variables with homogeneous error variances. Means of response variables were compared using Fisher's protected least significant difference ($P \leq 0.05$).

Results and Discussion

Buffalograss responses. At all sites, buffalograss seedling density, vigor, and foliar cover were consistently high on areas treated with imazethapyr. At KS, seedling densities in plots treated with imazethapyr, AC 263,222, simazine, pronamide, and benefin + trifluralin were similar to those in nontreated plots (Table 1). Buffalograss seedling density was 216 plants/m^2 where imazethapyr was applied as compared to <104 plants/m^2 where all other herbicides, except AC 263,222 and simazine, were applied. At NE1 and NE2, buffalograss seedling density was greater where imazethapyr was applied than where other herbicides or none were applied. At NE1, seedling density in plots where AC 263,222 and simazine were applied was greater than that in nontreated plots. In contrast, seedling density in AC 263,222-treated plots at NE2 was lower than in nontreated plots.

Buffalograss seedling vigor at KS was similar in nontreated plots and imazethapyr-treated plots (Table 1). At NE1, seedlings in plots treated with imazethapyr were more vigorous than those in the nontreated control, possibly due to greater weed abundance in the latter. Seedling vigor in plots treated with AC 263,222, simazine, pronamide, prodiamine, benefin, bensulide, oxadiazon, or benefin + trifluralin was similar to that in the nontreated control. At NE2, seedling vigor in plots treated with imazethapyr, simazine, pronamide, benefin, and oxadiazon was similar to that in the nontreated control.

Buffalograss foliar cover at 8 WAT in KS was similar in nontreated plots and those treated with imazethapyr or simazine (Table 2). At NE1, there was an increase in buffalograss foliar cover from 2% in the nontreated plots to 53%, 40%, and 20% in plots treated with imazethapyr, AC 263,222, or simazine, respectively. Severe annual grass competition (54% weed foliar cover 8 WAT) in nontreated plots may have been the primary cause for the low buffalograss foliar cover. At NE2, buffalograss foliar cover at 8 WAT was >28% where imazethapyr or simazine had been applied (Table 2).

By 12 WAT in Kansas, buffalograss cover in imazethapyr-treated plots was >90%, and similar to simazine, pronamide, prodiamine, benefin, oxadiazon, benefin + trifluralin, and the nontreated control (Table 3). By 12 WAT at NE1, buffalograss cover was >50% in plots treated with imazethapyr or AC 263,222. Buffalograss foliar cover at NE2 12 WAT was 70% in imazethapyr- and 43% in simazine-treated plots, while cover was 28% in nontreated plots. Foliar cover in plots treated with AC 263,222, pronamide, benefin, siduron, or oxadiazon was similar to that in nontreated plots at NE2 12 WAT.

Buffalograss herbage mass in plots treated with imazethapyr exceeded that in nontreated plots at the Nebraska sites (Table 4). At NE1, only the herbage mass in AC 263,222-treated plots was similar to that in imazethapyr-treated plots. Buffalograss herbage mass in plots treated with all other herbicides was similar to that in the nontreated plots. Plots treated with dithiopyr, prodiamine, pendamethalin, and oryzalin produced less buffalograss herbage mass than nontreated plots at NE2.

Table 1. Buffalograss seedling density and vigor 4 weeks after application of preemergence herbicides at Manhattan, Kan. (KS), and at two locations near Ithaca, Neb. (NE1 and NE2), in 1994.

		KS		NE1		NE2	
Herbicide	Rate (kg·ha^{-1})	Density (no/m^2)	Vigor[z]	Density (no/m^2)	Vigor	Density (no/m^2)	Vigor
Imazethapyr	0.07	216	6.8	100	8.5	127	8.3
AC 263, 222	0.07	165	2.5	71	5.5	39	4.0
DCPA	11.8	12	2.0	8	2.0	2	1.0
Simazine	1.1	156	4.3	68	6.8	66	6.8
Pronamide	1.1	94	4.8	42	5.3	54	6.8
Dithiopyr	0.6	9	1.0	3	1.8	1	0.3
Prodiamine	0.8	50	2.8	12	4.0	2	1.0
Pendimethalin	2.2	1	0.8	14	2.5	3	0.3
Benefin	1.7	83	4.5	22	5.3	45	5.0
Bensulide	8.4	70	3.5	10	5.0	12	4.8
Siduron	13.4	0	0.5	13	1.0	37	3.8
Oxadiazon	2.2	68	2.8	39	5.0	38	5.5
Benefin + trifluralin	1.5	104	3.5	24	4.8	13	3.0
		0.7					
Oryzalin	1.7	2	0	0	0	1	0
Benefin + oryzalin	1.1	27	1.3	7	1.3	5	3.0
		1.1					
Nontreated	0	162	7.0	43	4.8	76	6.8
$LSD_{0.05}$		69	1.9	18	1.9	34	1.9

[z]Seedling vigor was rated visually on scale of 0 (dead seedlings) to 9 (seedlings with no evidence of herbicide injury).

Table 2. Buffalograss (BG) and weed foliar cover 8 weeks after application of preemergence herbicides at Manhattan, Kan. (KS), and at two locations near Ithaca, Neb. (NE1 and NE2), in 1994.

Herbicide	Rate	Cover (%)[z]					
		KS		NE1		NE2	
	(kg·ha^{-1})	BG	Weed[y]	BG	Weed	BG	Weed
Imazethapyr	0.07	45	2	53	21	48	0
AC 263, 222	0.07	10	0	40	9	9	0
DCPA	11.8	10	2	3	24	1	25
Simazine	1.1	36	2	20	38	29	2
Pronamide	1.1	25	18	6	59	15	26
Dithiopyr	0.6	1	1	1	23	0	4
Prodiamine	0.8	12	1	2	40	0	2
Pendimethalin	2.2	1	0	4	18	1	4
Benefin	1.7	29	9	2	50	8	28
Bensulide	8.4	12	14	4	48	7	54
Siduron	13.4	1	8	2	21	8	41
Oxadiazon	2.2	18	1	7	31	10	8
Benefin + trifluralin	1.5	13	0	5	46	3	18
		0.7					
Oryzalin	1.7	0	2	0	2	0	4
Benefin + oryzalin	1.1	6	1	3	30	1	13
		1.1					
Nontreated	0	46	13	2	54	15	33
$LSD_{0.05}$		10	10	10	16	10	15

[z]Buffalograss and weed cover were rated visually on a 0 to 100 scale.
[y]At KS, weeds were prostrate spurge, curlydock, redroot pigweed, carpetweed, fall panicum, yellow foxtail, and stinkgrass. Yellow foxtail and large crabgrass were the dominant weeds at NE1, whereas prostrate spurge and redroot pigweed were the dominants at NE2.

Table 3. Buffalograss (BG) and weed foliar cover 12 weeks after application of preemergence herbicides at Manhattan, Kan. (KS), and at two locations near Ithaca, Neb. (NE1 and NE2), in 1994.

Herbicide	Rate	Cover (%)[z]					
		KS		NE1		NE2	
	(kg·ha^{-1})	BG	Weed[y]	BG	Weed	BG	Weed
Imazethapyr	0.07	95	1	64	25	70	1
AC 263, 222	0.07	58	1	54	14	16	0
DCPA	11.8	63	4	6	36	3	34
Simazine	1.1	93	1	22	49	43	5
Pronamide	1.1	80	2	9	66	30	31
Dithiopyr	0.6	8	1	2	30	0	9
Prodiamine	0.8	73	1	3	51	0	5
Pendimethalin	2.2	10	4	11	28	1	8
Benefin	1.7	89	4	7	68	18	38
Bensulide	8.4	62	17	7	60	10	69
Siduron	13.4	18	1	4	24	17	51
Oxadiazon	2.2	89	1	9	45	23	15
Benefin + trifluralin	1.5	81	2	6	55	6	28
	0.7						
Oryzalin	1.7	3	10	0	8	0	5
Benefin + oryzalin	1.1	35	5	4	40	3	16
	1.1						
Nontreated	0	89	5	3	74	28	45
$LSD_{0.05}$		20	7	11	18	14	15

[z]Buffalograss and weed cover were rated visually on a 0 to 100 scale.
[y]At KS, weeds were prostrate spurge, curlydock, redroot pigweed, carpetweed, fall panicum, yellow foxtail, and stinkgrass. Yellow foxtail and large crabgrass were the dominant weeds at NE1, whereas prostrate spurge and redroot pigweed were the dominants at NE2. All four weed species were observed at both Nebraska sties, however.

Weed control. Weed infestations as estimated by weed foliar cover at 8 and 12 WAT were low at KS and moderate to high at NE1 and NE2 (Tables 2 and 3). At 12 WAT at KS, weed foliar cover in all herbicide-treated plots, except those treated with bensulide, was similar to that in nontreated plots (Table 3). At NE1, plots treated with imazethapyr and AC 263,222 had lower weed cover at 12 WAT than simazine-treated plots (Table 3). At NE2, there was <10% weed foliar cover in plots treated with imazethapyr, AC 263,222, simazine, dithiopyr, prodiamine, pendamethalin, and oryzalin at 12 WAT (Table 3).

Annual grass weed herbage mass at NE1 was lower in plots treated with imazethapyr, AC 263,222, DCPA, pendimethalin, siduron, and oryzalin than in plots than in nontreated plots (Table 4). All herbicide-treated plots at NE2 had lower grass weed herbage mass than nontreated plots. Broadleaf weed herbage mass at NE2 was similar in herbicide-treated plots and nontreated plots, except where bensulide had been applied.

Imazethapyr at 0.07 kg·ha^{-1} provided good buffalograss establishment at all sites. Where weed infestations were severe in Nebraska, imazethapyr provided good weed control. The effectiveness of AC 263,222 in facilitating establishment of buffalograss was variable. At NE1, where annual grass weeds dominated, buffalograss establishment was enhanced by AC 263,222. In contrast, buffalograss establishment was reduced by AC 263,222 where weed infestations were at a low or moderate. The relatively high weed abundance at NE1 may have resulted in increased uptake and more rapid removal of the herbicide from the soil and decreased the amount of AC 263,222 to which buffalograss seedlings were exposed. Masters et al. (1996) observed a similar response where imazapyr [(±)-2-[4,5-dihydro-4-methyl-4-(1-methyl-ethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid] improved stand establishment of seeded switchgrass (*Panicum virgatum* L.) at a site with severe annual grass weed pressure, but reduced stand establishment at a site with low weed pressure.

Buffalograss establishment was variable where simazine at 1.1 kg·ha^{-1} was applied. As

Table 4. Buffalograss (BG), annual grass (G) and broadleaf (B) weed herbage mass 12 weeks after application of preemergence herbicides at two locations near Ithaca, Neb. (NE1 and NE2), in 1994.

		Herbage composition ($g \cdot m^{-2}$)[z]					
	Rate	NE1			NE2		
Herbicide	($kg \cdot ha^{-1}$)	BG	G	B	BG	G	B
Imazethapyr	0.07	106	63	14	78	0	1
AC 263,222	0.07	82	43	1	16	0	0
DCPA	11.8	2	47	15	14	6	37
Simazine	1.1	29	151	8	52	0	0
Pronamide	1.1	10	149	22	43	8	30
Dithiopyr	0.6	3	82	41	0	0	6
Prodiamine	0.8	8	150	38	1	0	7
Pendimethalin	2.2	18	55	9	0	0	23
Benefin	1.7	2	121	30	21	3	69
Bensulide	8.4	2	82	35	11	0	184
Siduron	13.4	1	34	32	32	27	38
Oxadiazon	2.2	20	100	1	31	0	21
Benefin + trifluralin	1.1 0.7	6	145	4	4	1	47
Oryzalin	1.7	0	0	7	0	0	3
Benefin + oryzalin	1.1 1.1	5	116	16	11	0	15
Nontreated	0	0	160	0	27	95	23
$LSD_{0.05}$		30	94	30	25	31	43

[z]Herbage composition was determined by clipping herbaceous vegetation within a randomly placed 0.25 m^{-2} quadrate in each plot, drying at 60 °C for 7 h, and weighing. Yellow foxtail and large crabgrass were the dominant weeds at NE1, whereas prostrate spurge and redroot pigweed were the dominants at NE2. All four weed species were observed at both Nebraska sites, however.

with imazethapyr, simazine did not adversely affect buffalograss seedling count, vigor, or foliar cover compared to nontreated turf. Unlike imazethapyr, simazine provided poor annual grass control at NE1 at 12 WAT (Table 3). The simazine rate we used in this study may have been too low to provide adequate grass weed control at NE1 during buffalograss establishment..

Imazethapyr applied at 0.07 $kg \cdot ha^{-1}$ within 2 d of seeding had no negative effects on buffalograss seedling density, vigor, foliar cover, or herbage mass. This herbicide reduced weed cover at NE1 where large crabgrass and yellow foxtail were the dominant weeds and at NE2 where prostrate spurge and redroot pigweed dominated. Of all herbicides evaluated in this study, imazethapyr at 0.07 $kg \cdot ha^{-1}$ was most effective for suppressing annual grass and broadleaf weeds with no detrimental effects on buffalograss establishment.

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