Established and Seeded Buffalograss Tolerance to Herbicides Applied Preemergence

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Abstract. Experiments were conducted to evaluate established and seeded buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] tolerance to herbicides applied preemergence at labeled use rates. Established buffalograss tolerated benefin, benefin plus oryzalin, benefin plus trifluralin, DCPA, dithiopyr, isoxaben, oryzalin, pendimethalin, and prodiamine. For established buffalograss treated with atrazine, diuron, or metolachlor, the injury rating was 27% to 71% at 6 weeks after treatment (WAT) and 22% to 84% at 15 WAT. Buffalograss tolerated cyanazine, metsulfuron, propazine, and pyriithiobac applied in the seedbed. Seeded buffalograss stands were reduced by alachlor, atrazine, dicamba, linuron, metolachlor, metribuzin, oryzalin, pendimethalin, and quinclorac. Stand reductions by dicamba (a preplant and postemergence herbicide), up to 100% at 4 WAT and up to 85% at 16 WAT, were those most severe. Seeded and established buffalograss showed excellent tolerance to a few preemergence herbicides that could be used effectively and safely to control weeds during establishment and maintenance of buffalograss. Chemical names used: 2-chloro-*N*-(2,6-diethylphenyl)-*N*-(methoxymethyl)acetamide (alachlor); 6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine (atrazine); *N*-butyl-*N*-ethyl-2,6-dinitro-4-(trifluoromethyl)benzenamine (benefin); 2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile (cyanazine); dimethyl 2,3,5,6-tetrachloro-1,4-benzenedicarboxylate (DCPA); 3,6-dichloro-2-methoxybenzoic acid (dicamba); *S,S*-dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate (dithiopyr); *N'*-(3,4-dichlorophenyl)-*N,N*-dimethylurea (diuron); *N*-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide (isoxaben); *N'*-(3,4-dichlorophenyl)-*N*-methoxy-*N*-methylurea (linuron); 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide (metolachlor); 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one (metribuzin); 2-[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid (metsulfuron); 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide (oryzalin); *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine (pendimethalin); *N*³,*N*³-di-*n*-propyl-2,4-dinitro-6-(trifluoromethyl)-*m*-phenylenediamine (prodiamine); 6-chloro-*N,N'*-bis(1-methylethyl)-1,3,5-triazine-2,4-diamine (propazine); 2-chloro-6-[(4,6-dimethoxy-2-pyrimidinyl)thio]benzoic acid (pyriithiobac); 3,7-dichloro-8-quinolinecarboxylic acid (quinclorac); Team™ [premix of 1.33% benefin and 0.67% 2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine] (trifluralin).

Buffalograss is a stoloniferous, warm-season turfgrass native throughout the short- and mixed-grass prairies of the North American Great Plains (Correll and Johnston, 1979). Buffalograss has greater drought and high-temperature and low-temperature tolerance than common bermudagrass [*Cynodon dactylon* (L.) Pers.], zoysiagrass [*Zoysia japonica* Steud.], tall fescue (*Festuca*

arundinacea Schreb.), or Kentucky bluegrass (*Poa pratensis* L.) (Smith et al., 1991). In addition, buffalograss has a low fertility requirement and moderate wear tolerance (Smith et al., 1991). In subhumid and semiarid regions that receive an average annual rainfall of 300 to 560 mm, these characteristics make buffalograss a desirable turfgrass species (McCarty and Colvin, 1992).

To our knowledge, little research has been conducted to determine buffalograss tolerance to herbicides, and work that has been done was conducted primarily on established turf using postemergence herbicides. McCarty and Colvin (1992) reported that 3-(1-methylethyl)-(1*H*)-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide (bentazon) at 2.24 kg·ha⁻¹ and 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-quinolinecarboxylic acid (imazaquin) at 0.42 kg·ha⁻¹ caused slight but acceptable injury to established buffalograss cultivars Oasis and Prairie. [(3,5,6-Trichloro-2-pyridinyl)oxy]

acetic acid (triclopyr) at 0.56 kg·ha⁻¹, (2,4-dichlorophenoxy)acetic acid (2,4-D) at 1.12 kg·ha⁻¹, 2-[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]benzoic acid (sulfometuron) at 0.017 kg·ha⁻¹, dicamba at 0.56 kg·ha⁻¹, and a three-way mixture of 2,4-D + 2[(4-chloro-*o*-tolyl)oxy]propionic acid (mecoprop) + dicamba (1.2 + 0.13 + 0.54 kg·ha⁻¹) caused marginally acceptable buffalograss quality 20 to 30 days after treatment. 'Prairie' buffalograss needed 20 days to recover from atrazine at 2.24 kg·ha⁻¹, but 'Oasis' buffalograss did not recover from 2,4-D or 2,4-D + dicamba + mecoprop applications. 3-[2,4-Dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one (oxadiazon) and isoxaben plus trifluralin did not cause visible injury to buffalograss plugs, but isoxaben alone affected lateral growth and establishment (Harivandi and Elmore, 1993). Dithiopyr at 0.6 kg·ha⁻¹, quinclorac at 0.8 kg·ha⁻¹, monosodium methanearsonate (MSMA) at 2.2 kg·ha⁻¹, and 3,6-dichloro-2-pyridinecarboxylic acid (clopuralid) at 0.8 kg·ha⁻¹ did not injure 'Sharp's Improved' buffalograss seedlings that had one to three leaves in 1 year and two to four tillers in another (Fry and Upham, 1994).

Most preemergence herbicides can be applied only to established turfgrass (Murphy, 1994). Few studies have been conducted to determine buffalograss establishment from seed and its tolerance to herbicides applied preemergence. Buffalograss seed germination was not affected by clopyralid at rates up to 9.0 kg·ha⁻¹, but was suppressed by 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid (picloram) and triclopyr at 1.1 kg·ha⁻¹ and 2,4,5-T at 9.0 kg·ha⁻¹ (Huffman and Jacoby, 1984). Fermanian et al. (1980) determined that seeded bermudagrass was moderately tolerant to 4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4*H*)-one (metribuzin) at 0.42 kg·ha⁻¹ and 2-(*tert*-butylamino)-4-(ethylamino)-6-(methylthio)-*s*-triazine (terbutryn) at 1.36 kg·ha⁻¹, but highly sensitive to 2-*tert*-butyl-4(2,4-dichloro-5-isopropoxyphenyl)-Δ²-1,3,4-oxadiazolin-5-one (oxadiazon) at 0.79 kg·ha⁻¹ and 1-(2-methylcyclohexyl)-3-phenylurea (siduron) at 0.23 kg·ha⁻¹. Bovey and Voigt (1983) reported that of 23 herbicides applied in the seedbed, 'Morpa' and 'Renner' weeping lovegrass [*Eragrostis curvula* (Schrad.) Nees] were tolerant to propazine and *S*-ethyl bis(2-methylpropyl) carbamothioate (butylate) at 2.2 kg·ha⁻¹. 'Renner' was tolerant to atrazine, diuron, and 2-chloro-*N*-(1-methylethyl)-*N*-phenylacetamide (propachlor) applied in the seedbed at 0.6 kg·ha⁻¹. In cool-season grasses, Fermanian and Haley (1994) reported that prodiamine applied to juvenile (<1 year old) Kentucky bluegrass at 1.4 kg·ha⁻¹ caused a significant loss of quality. In 3 years of research, fall applications of prodiamine at 0.8 and 2.2 kg·ha⁻¹ and DCPA at 23.5 kg·ha⁻¹ significantly reduced overseeded Kentucky bluegrass populations 2 years after planting.

The objective of this research was to determine established and seeded buffalograss tolerance to herbicides applied preemergence.

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Materials and Methods

Established buffalograss tolerance. Field experiments were conducted in 1994 near Bronco (1155 m altitude), Texas [Portales fine sandy loam (fine-loamy, mixed, thermic Aridic Calciustoll)], and at the Texas Tech Univ. greenhouse facility in Lubbock (960 m altitude) [Amarillo fine sandy loam (fine-loamy, mixed, thermic Aridic Paleustalf)]. All experimental sites had <1.4% organic matter in the topsoil and a pH of 8.1 to 8.4. Buffalograss ('Comanche') caryopses were broadcast by hand at 27 kg·ha⁻¹ in May 1992 at Bronco under a center-pivot sprinkler irrigation system. Buffalograss was maintained with supplemental water and fertilized according to soil test recommendations (A&L Agricultural Laboratories, Lubbock, Texas) for grass seed production. In 1994, on-site rainfall in Bronco was 280 mm and supplemental irrigation was 500 mm. Individual 2.0 × 7.3-m plots under the center-pivot sprinkler irrigation system were developed in this established buffalograss area.

At Lubbock, buffalograss ('Comanche' and 'Texoka') caryopses were planted in May 1992 in 2 × 2-m plots as described above. Above-ground sprinklers with micro-spinner emitters provided supplemental irrigation. The buffalograss was maintained with supplemental water (500 mm) and fertilized midseason with sulfur-coated urea (39 kg·ha⁻¹) according to soil test recommendations.

Herbicides (see Table 1) were applied to established dormant buffalograss in March at both experimental sites. Applications were made using a CO₂-pressurized backpack sprayer that delivered a carrier volume of 140 liters·ha⁻¹. Teejet (Spraying Systems Co., Wheaton, Ill.) 8002 nozzle tips were used at 207 kPa pressure.

Buffalograss injury was rated visually 6 and 15 weeks after treatment (WAT) using a 0% to 100% scale and comparing herbicide-treated turf to nontreated turf for greenup, density, living ground cover, and quality. All plots were hand-weeded to minimize weed competition. At the end of the growing season, when the buffalograss was no longer green, a 10-cm-diameter area was randomly selected and hand-clipped at the soil surface in each plot. The resulting above-ground biomass was oven-dried at 60°C for 72 h and weighed. Dry weight values are presented as a percentage of the nontreated control.

The design was a randomized complete block with four replications at Bronco and a randomized complete block, split-plot design with five replications at Lubbock. At Lubbock, main plots were cultivars and subplots were herbicide treatments. All data were subjected to analysis of variance (ANOVA). Means were separated using Fisher's Protected LSD test at $P \leq 0.05$ (Steel and Torrie, 1980).

Seeded buffalograss tolerance. Field experiments were conducted in 1993 and 1994 at the Texas Tech Univ. Erskine Research facility in Lubbock. The Amarillo fine sandy loam (fine-loamy, mixed, thermic Aridic Paleustalf) had a pH of 7.6 and 1.3% organic matter.

Buffalograss ('Comanche') caryopses were broadcast by hand at 27 kg·ha⁻¹ in individual 2.0 × 7.3-m plots. Soil was moist at germination and supplemented with 1000 mm irrigation during the study using above-ground sprinklers with micro-spinner emitters.

Herbicides (see Table 2) were soil-applied within 24 h after seeding, as described above, and followed by ≈25 mm of irrigation. Buffalograss stand density was evaluated 4 WAT and 10 to 16 WAT. A visual estimation of turf density, based on a scale of 0% (bare ground) to 100% (complete coverage), was recorded at each observation date. All plots were hand-weeded to minimize weed competition. Above-ground biomass was harvested at the end of the growing season as described previously.

The design was a randomized complete block with four replications. All data were subjected to ANOVA. Means were separated using Fisher's protected LSD test at $P \leq 0.05$ (Steel and Torrie, 1980).

Results and Discussion

Established buffalograss tolerance. At Lubbock, cultivar × treatment interactions were nonsignificant; therefore, cultivars were combined within treatments. Treatment × location interactions also were nonsignificant; thus, data from Bronco and Lubbock were combined.

Established buffalograss treated with atrazine, diuron, or metolachlor was rated ≥27% for injury 6 WAT (Table 1). Buffalograss injury was greatest with atrazine and diuron. None of the other herbicides or herbicide combinations caused serious buffalograss injury.

At 15 WAT, buffalograss treated with atrazine, diuron, or metolachlor was rated ≥22% for injury (Table 1). Buffalograss injury was greatest with diuron, followed by atrazine and metolachlor. Buffalograss injury by 6-chloro-*N,N'*-diethyl-1,3,5-triazine-2,4-diamine (simazine) increased from 7% at 6 WAT to 11% at 15 WAT. No other herbicides caused objectionable buffalograss injury.

Table 1. Established buffalograss injury following preemergence herbicide treatments, 1994; data for Bronco and Lubbock, Texas, combined.

Herbicide		Buffalograss injury ^z (%)		Biomass ^y (%)
	Rate	Weeks after treatment		
Compound(s)	(kg·ha ⁻¹)	6	15	30
Atrazine	2.2	71	62	48
Benefin	3.4	4	2	110
Benefin + oryzalin	1.7 + 1.7	1	0	105
Benefin + trifluralin	2.3 + 1.1	2	1	106
DCPA	16.8	1	0	125
Dithiopyr	0.6	1	2	96
Diuron	2.8	67	84	41
Isoxaben	1.1	1	0	109
Metolachlor	4.5	27	22	81
Oryzalin	2.2	1	0	109
Pendimethalin	3.4	1	0	108
Prodiamine	1.7	1	0	107
Simazine	2.2	7	11	83
Nontreated	---	0	0	100
LSD _(0.05)	---	10	4	15

^zBuffalograss injury using a 0% to 100% scale was based on greenup, density, living ground cover, and quality as compared to a nontreated control.

^yAbove-ground buffalograss tissue was harvested after it was no longer green and then was oven-dried. Biomass yield is expressed as a percentage of the nontreated control.

Table 2. Seeded buffalograss stand following preemergence herbicide treatments, Lubbock, Texas.

		Buffalograss stand ^z (%)				Biomass ^y (%)
Herbicide		1993		1994		
	Rate	Weeks after treatment				
Compound	(kg·ha ⁻¹)	4	10	4	16	21
Alachlor	3.4	22	25	49	85	78
Atrazine	2.2	28	34	0	17	28
Cyanazine	1.7	77	79	72	95	108
Dicamba	0.3	9	5	0	15	14
Linuron	1.1	9	17	44	25	0
Metolachlor	3.4	11	15	4	25	37
Metribuzin	1.1	9	16	0	36	22
Metsulfuron	0.017	95	100	73	88	125
Oryzalin	1.7	43	45	56	72	112
Pendimethalin	1.7	44	48	2	19	44
Propazine	1.7	76	81	83	99	114
Pyrithiobac	0.07	78	84	72	96	105
Quinclorac	0.6	22	29	19	32	19
Nontreated	---	100	100	100	100	100
LSD _(0.05)	---	28	26	29	29	45

^zBuffalograss stand based on a scale of 0% (bare ground) to 100% (complete coverage) was rated visually as compared to a nontreated control.

^yAbove-ground buffalograss tissue was harvested after it was no longer green and then was oven-dried. Biomass yield is expressed as a percentage of the nontreated control.

Buffalograss biomass reduction relative to the control ranged from 17% to 59% where atrazine, diuron, metolachlor, or simazine were applied (Table 1). Biomass reductions were greatest with atrazine and diuron followed by metolachlor and simazine. No other herbicide treatment induced a reduction in biomass.

Seedling buffalograss tolerance. Treatment $\times$ year interactions were significant and data from 1993 and 1994 are reported separately.

In 1993, cyanazine, metsulfuron, propazine, and pyriithiobac did not reduce seeded buffalograss stand compared to nontreated buffalograss at 4 and 10 WAT (Table 2). Buffalograss stand was reduced 56% by pendimethalin and 57% by oryzalin at 4 WAT. Similar stand reductions were observed at 10 WAT where these herbicides were applied. Alachlor, atrazine, and quinclorac reduced buffalograss stand 72% to 78% at 4 WAT and 66% to 75% at 10 WAT. Stand reductions were 89% to 91% at 4 WAT and 83% to 95% at 10 WAT with dicamba, linuron, metolachlor, and metribuzin.

In 1994, as in 1993, cyanazine, metsulfuron, propazine, and pyriithiobac did not reduce seeded buffalograss stand compared to nontreated buffalograss (Table 2). Buffalograss stand was reduced 44% to 81% with alachlor, linuron, oryzalin, and quinclorac at 4 WAT and 15% to 75% at 16 WAT. Stand reductions of 96% to 100% at 4 WAT and 64% to 85% at 16 WAT with atrazine, dicamba, metolachlor, metribuzin, and pendimethalin were those most severe.

There was a significant loss in above-ground biomass for buffalograss harvested 21 WAT following several herbicide treatments in 1994 (Table 2). Biomass losses were 56% and 63% with pendimethalin and metolachlor, respectively. Atrazine, dicamba, metribuzin, and quinclorac reduced buffalograss biomass by 78% to 86%. No buffalograss biomass was measured where linuron was applied.

There was some commonality among herbicides that caused buffalograss injury and among herbicides that caused no objectionable injury. In general, photosynthetic inhibi-

tors (atrazine and diuron), a shoot inhibitor (metolachlor), and a growth regulator (dicamba) were more injurious than mitotic inhibitors (benefin, oryzalin, pendimethalin, and proflaminate) and amino acid biosynthesis inhibitors (metsulfuron and pyriithiobac). The photosynthetic inhibitors propazine and simazine were exceptions because buffalograss injury caused by these herbicides was less severe than injury caused by other photosynthetic inhibitors.

Weed control was not evaluated in these studies. Weed control by these herbicides has been well-documented in established turfgrass (Fermanian et al., 1980; Liskey, 1995; Menn and Hall, 1994; Menn et al., 1994; Smith et al., 1991), in turfgrass grown from vegetative plugs (Harivandi and Elmore, 1993), and in other horticultural and agronomic crops (Weed Science Society of America, 1994). All herbicides, except diuron (Table 1) and alachlor, cyanazine, linuron, propazine, pyriithiobac, and quinclorac (Table 2), are currently labeled for use in established turfgrass. However, these herbicides are not labeled for use in the seedbed because of the perceived turfgrass sensitivity to all herbicides at seedling emergence. Turfgrass tolerance to herbicides at seedling emergence would lead to a more rapid and uniform turfgrass stand.

At two locations on the Southern High Plains, where low soil organic matter and high-pH soils predominate, established buffalograss tolerated benefin, benefin plus oryzalin, benefin plus trifluralin, DCPA, dithiopyr, isoxaben, oryzalin, pendimethalin, and proflaminate. Atrazine, diuron, and metolachlor treatments caused significant injury and these herbicides should be avoided. Seeded buffalograss was sensitive to most of the herbicides applied preemergence, but tolerated cyanazine, metsulfuron, propazine, and pyriithiobac.

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