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Effect of glyphosate on introduced and native grasses[1]

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Abstract:

The effect of glyphosate applied alone and with 2,4-D as a commercial mixture on 30 native or introduced grass species was evaluated. Grass yield averaged 98 and 87% of the untreated controls when glyphosate was applied in the fall at 0.2 or 0.4 kg ae ha^{-1}, respectively, alone or with 2,4-D at 0.35 or 0.7 kg ae ha^{-1}. Western wheatgrass production decreased more than any other species present in a native rangeland site following either a spring or fall glyphosate application. In seeded plots, intermediate wheatgrass was the most and 'Fairway' crested wheatgrass the least susceptible to glyphosate plus 2,4-D with average yields of 57 and 97% compared with untreated controls of each species, respectively. Glyphosate reduced the yield of 'Nordan' standard crested wheatgrass more than that of Fairway crested wheatgrass or other diploid cultivars. The greater the spring precipitation following a fall application of glyphosate: the less effect of glyphosate on forage yield. Glyphosate plus 2,4-D can be used for weed control in pasture and rangeland provided some yield reduction is acceptable.

Nomenclature:

Glyphosate, *N*-(phosphonomethyl)glycine; 2,4-D, (2,4-dichlorophenoxy) acetic acid; Fairway crested wheatgrass [*Agropyron cristatum* (L.) Beauv.]; intermediate wheatgrass [*Elymus intermedia* (Host) Nevski]; standard crested wheatgrass [*A. desertorum* (Fisch. ex. Link) Schult]; western wheatgrass [*Pascopyrum smithii* (Rydb.) Love]; leafy spurge, *Euphorbia esula* L. #[2] EPHES.

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[2] Letters following this # symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

Additional index words:

Rangeland, bromegrass, blue grama, *Stipa* spp.

Introduction

Leafy spurge reduces land value and economic return to landowners by reducing both forage production and use by livestock (6, 7, 9). In North Dakota, cattle used 20 and 2% of the forage available in zero- and low- (<20% cover) density leafy spurge, respectively, (4) although leafy spurge canopy cover of 10% or less and shoot control of 90% or more was necessary to achieve 50% forage utilization by cattle in Montana (2). Besides production losses, control costs to manage infested sites and potential for increased infestation each year must be included when assessing the economic impact of leafy spurge (4).

Picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) at 2.2 kg ae ha^{-1} will provide greater than 90% leafy spurge control for at least two growing seasons (5). However, picloram applied at that rate is cost prohibitive for use on large infestations (6, 7). The most cost-effective herbicide treatment for leafy spurge control in North Dakota was picloram plus 2,4-D at 0.28 plus 1.1 kg ha^{-1}. The treatment provided an average net return of 5.5 times the cost and 80% leafy spurge control when applied annually in the spring for 5 yr (7). However, the picloram application rate must be increased to 0.56 kg ha^{-1} when fall-applied to control leafy spurge and then the treatment is not cost-effective (8).

Glyphosate applied in the fall at 0.8 to 2.2 kg ha^{-1} provided 70 to 90% leafy spurge control 12 months after treatment (5). Although glyphosate is useful in cropland, shelterbelts, and as a spot treatment for leafy spurge control, it is nonselective which limits its use in pasture and rangeland. Recently, glyphosate applied with 2,4-D in the fall was shown to provide 70 to 90% leafy spurge control with variable grass injury depending on location (3). The herbicide mixture costs approximately 70% less than picloram plus 2,4-D at 0.56 plus 1.1 kg ha^{-1} and could be an economical treatment for long-term leafy spurge control if grass injury was not severe.

The purpose of this study was to evaluate the effect of glyphosate plus 2,4-D on various introduced pasture and rangeland grass species.

Materials and methods

Field studies to evaluate the effect of glyphosate applied alone and with 2,4-D were conducted on a native rangeland site near Stanton in west-central North Dakota and two seeded forage grass species trials at Fargo and Prosper in eastern North Dakota. A commercial mixture[3] of glyphosate plus 2,4-D was applied at 0.2 to 0.8 plus 0.35 to

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[3] Landmaster BW, Monsanto Co., St. Louis, MO 63167.

1.4 kg ha^{-1}, which is one-half to twice the labeled rate. To decrease the potential for grass injury, no additional surfactant was added. Picloram at 2.2 kg ha^{-1} was included as a standard comparison at the rangeland site.

Grass species present at Stanton included needle-and-thread (*Stipa comata* Trin. & Rupr.), green needlegrass (*Stipa viridula* Trin.), western wheatgrass, bluegrasses (*Poa* spp.), blue grama [*Bouteloua gracilis* (Michx.) Torr.], prairie junegrass [*Koeleria pyramidata* (Lam.) Beauv.], and various sedges (*Carex* spp.). The soil was a Temvik Williams silt loam complex (Temvik = fine-silty, mixed, Typic Haploboroll; Williams = fine-loam, mixed, Typic Argiboroll; averaging 4.4% organic matter and pH 6.9).

Herbicides were applied on Sept. 18, 1989 or June 18, 1990 with a tractor-mounted sprayer delivering 80 L ha^{-1} at 240 kPa. The Stanton site had 6% live basal cover as determined by inclined point analysis (1). The plots were 3.1 by 9.1 m and each treatment was replicated four times in a randomized complete block design.

Grass species present at Fargo included 'Nordan' standard crested wheatgrass, four fairway cultivars, the hybrid cultivar 'Hycrest', [*A. desertorum* x *A. cristatum*), 'Orbit' tall wheatgrass [*Elytrigia pontica* (Podp.) Holub], 11 cultivars or experimental lines of intermediate wheatgrass, the experimental pubescent wheatgrass genotype Mandan 759, (*E. intermedia* subsp. *trichophora* A.&D. Love), two cultivars of thickspike wheatgrass [*E. lanceolatus* (Scribn. & Smith) Gould], four cultivars of western wheatgrass, and quackgrass [*Elytrigia repens* (L.) Nevski]. The grasses at Prosper included Orbit tall wheatgrass, 'Oahe' intermediate wheatgrass, 'Rodan' western wheatgrass and 'Lincoln' bromegrass (*Bromus inermis* Leyss.).

Grasses were broadcast seeded at Fargo on June 5, 1985 and seeded in rows 15 cm apart at Prosper on Sept. 1, 1987. Both planting rates were 280 pure live seed m^2. The grasses were fertilized with 150kg ha^{-1} nitrogen every fall except the year of treatment. Herbicides were applied on Sept. 19 and 20, 1989 at Fargo and Prosper, respectively, with a bicycle-wheel plot sprayer delivering 80 L ha^{-1} at 240kPa. Growth at both locations was vigorous when the herbicides were applied.

The soil at Fargo was a Fargo silty clay (fine, Montmorillonitic, frigid, Vertic Haplaquolls; 4.4% organic matter and pH 7.9) and at Prosper, a Barnes clay loam (fine-loamy, mixed, Udic Haploborolls; 5.2% organic matter and pH 7.6). Plots were 1.3 by 1.5 m and treatments were replicated four times in a randomized complete-block design.

Grass stand reduction was estimated visually as compared with the untreated control at Fargo and Prosper in May 1990. Forage production was determined in July, 1990 by clipping two 0.25-m^2 sq. quadrats per plot at Fargo and Prosper or four quadrats at Stanton. Herbage yield of treated grasses was compared with an untreated control for each species and the effect of glyphosate and glyphosate plus 2,4-D on production determined. Herbage was oven-dried 24 hours at 60ºC. Forage data are reported on a dry weight basis. Data were subjected to analysis of variance using the general linear models procedure and the protected LSD mean separation technique.

Results and discussion

Glyphosate plus 2,4-D applied at 0.4 plus 0.7 kg ha^{-1} or less in the fall on native rangeland had no effect or slightly reduced grass yield depending on species (Table 1). Grass yield averaged 98 and 87% of the untreated control averaged over all species when glyphosate was applied at 0.2 or 0.4 kg ha^{-1}, respectively, alone or with 2,4-D. Grass yield declined to an average of 80% when glyphosate was applied at 0.8 kg ha^{-1} alone or with 2,4-D.

Table 1. Influence of glyphosate alone or with 2,4-D, and picloram fall or spring applied on grass forage production in native rangeland near Stanton North Dakota.

		Yield of grasses			
Application month and treatment	Rate	Western wheat-grass	Blue gama	Stipa, spp.[a]	Total[b]
	kg ha^{-1}	% of untreated control			
September					
Glyphosate + 2,4-D	0.2 + 0.35	105	135	90	97
Glyphosate + 2,4-D	0.4 + 0.7	88	78	98	84
Glyphosate + 2,4-D	0.8 + 1.4	64	68	110	84
Glyphosate	0.2	57	103	123	99
Glyphosate	0.4	71	77	111	90
Glyphosate	0.8	44	93	116	77
Picloram	2.2	68	209	31	68
June					
Glyphosate + 2,4-D	0.2 + 0.35	56	144	84	101
Glyphosate + 2,4-D	0.4 + 0.7	49	117	88	92
Glyphosate + 2,4-D	0.8 + 1.4	33	120	102	85
Glyphosate	0.2	96	121	109	100
Glyphosate	0.4	64	64	80	93
Glyphosate,	0.8	22	56	65	54
Picloram	2.2	78	75	106	99
LSD (0.10)		30	65	30	14

[a]Needle-and-thread and green needlegrass.
[b]Total also includes bluegrasses, prairie junegrass, and *Carex* spp.

Western wheatgrass production was decreased more than any other grass species at the rangeland site near Stanton by glyphosate, especially at 0.8 kg ha^{-1}, regardless of application date (Table 1). Grass injury from the fall treatments was higher than expected since the grasses were dormant at application following a dry summer in which precipitation was below normal every month of the growing season (Table 2). Also, precipitation had been 22.4 cm below normal the previous growing season, so only a minimum amount of herbicide would have been expected to translocate in the slow-growing grasses.

Picloram at 2.2 kg ha^{-1} similarly reduced needle-and-thread and green needlegrass production to 31% of the control (Table 1). Western wheatgrass production was reduced to 68% of the control following picloram application and blue grama yield increased to 209% of the control. The large increase in blue grama yield may be due to decreased competition from shrubs and the *Stipa* spp. Although picloram generally is not applied at 2.2 kg ha^{-1} in large areas for leafy spurge control, it is used at this rate for control of small infestations and thus may alter species composition.

Glyphosate applied alone or with 2,4-D in June reduced western wheatgrass production at all application rates except glyphosate plus 2,4-D at 0.2 plus 0.35 kg ha^{-1} (Table 1). Glyphosate applied alone at 0.8 kg ha^{-1} reduced *Stipa* spp. production but not when applied with 2,4-D. Blue grama production was variable but was not reduced by glyphosate plus 2,4-D regardless of application rate. Picloram at 2.2 kg ha^{-1} did not affect grass production the year of treatment.

Table 2. Precipitation amounts and deviation from normal at the three experiment sites.

	Location/precipitation					
	Fargo		Prosper		Stanton	
Year/month.	Total	Dev.[a]	Total	Dev.	Total	Dev.
	cm					
1988						
January-December	36.9	-12.9	27.4	-17.3	24.2	-22.4
1989						
January-April	11.6	2.2	4.9	-2.1	8.9	0.3
May	6.6	0.9	7.4	1.7	6.2	-0.2
June	3.8	-3.9	3.2	-5.0	2.7	-6.9
July	1.6	-6.9	2.1	-4.6	2.3	-4.6
August	15.4	8.6	19.6	12.9	4.4	-0.8
September	5.3	0.6	2.3	-2.8	2.3	-2.6
October-December	4.4	-2-5	1.7	-3.5	2.5	-2.6
1990						
January-April	10.2	0.8	8.7	1.6	4.0	-4.6
May	3.9	-1.8	1.8	-3.9	3.4	-3.0
June	15.4	7.6	15.0	6.8	18.5	8.9
July	2.0	-6.5	3.3	-3.4	4.0	-2.9

[a]Deviation from normal.

Table 3. Influence of fall-applied glyphosate plus 2,4-D on forage production of cultivars or genotypes of several wheatgrass species and quackgrass the following growing season, Fargo, North Dakota.

Species/ cultivar or genotype	Glyphosate + 2,4-D rate (kg ha^{-1})		
	0.4 + 0.7	0.8 + 1.4	Mean
	% of untreated control		
Western wheatgrass			
Flintlock	82	70	76
Rodan	68	59	64
Rosana	78	86	82
Walsh	90	85	88
Created wheatgrass			
Nordan. (standard tetraploid)	76	67	70
Fairway (diploid)	129	102	115
Parkway	91	93	92
Ruff	127	98	113
S-7317	112	89	100
Hycrest[a]	93	86	89
Tell wheatgrass			
Orbit	60	78	69
Intermediate wheatgrass			
Oahe	49	32	40
Clarke	68	58	63
Mandan 759R	103	43	73
MI-1811	68	55	62
MI-1812	71	58	65
MI-1813	46	56	51
MI-1814	62	47	54
MI-1815	62	50	56
MI-1821	74	57	66
SD-54	53	51	52
Slate	46	49	48
Pubescent wheatgrass			
Mandan 759	64	82	73
Thickspike wheatgrass	68	61	64
Critana			
Sodar	135	67	101
Quackgrass	63	69	66
Mean	78	67	
LSD (0.05)	Rate 9; species/cultivar = 32		

[a]Hybrid of induced tetraploid *A. cristatum* and *A. desertorum.*

Susceptibility of wheatgrasses to glyphosate plus 2,4-D varied among species and cultivars (Table 3). In general, intermediate wheatgrass was the most and fairway cultivars of crested wheatgrass the least susceptible to injury from glyphosate plus 2,4-D. Herbage yields averaged 57 and 106% of the untreated controls for intermediate and fairway crested wheatgrass, respectively, averaged over all rates and cultivars. Walsh and ‘Rosana’ western wheatgrass averaged 85% yield of the control compared with only 64% for the cultivar Rodan. ‘Sodar’ thickspike wheatgrass was less susceptible to glyphosate plus 2,4-D than the cultivar ‘Critana’ when the herbicides were applied at 0.4 plus 0.7 kg ha^{-1}, respectively.

The most dramatic difference in glyphosate susceptibility was between species of crested wheatgrass (Table 3). Forage yield of ‘Nordan’ standard crested wheatgrass, a tetraploid, averaged 70% of the unsprayed control, whereas Fairway, a diploid, averaged 115% of the untreated control. ‘Ruff’ and ‘S-7317’ are genotypes derived from Fairway and their production averaged 107% of the control. Also, ‘Parkway’ and the hybrid ‘Hycrest’ tended to be less susceptible to glyphosate than Nordan. Quackgrass yield was reduced to 66%, averaged over both application rates, of the control by fall applied glyphosate plus 2,4-D.

Grass injury at Fargo was less than expected. Following a generally dry growing season, the grasses were growing vigorously when the herbicides were applied due to above-average precipitation received in August (Table 2). Despite the rapid lush growth, glyphosate injury was not severe to most species even when applied at twice the labeled rate. Visual observation indicated grasses treated with glyphosate in the fall began growing later the following spring than the untreated controls (data not shown). However, following normal to above-normal precipitation early in the growing season, the grasses produced the same or only slightly less herbage than the untreated controls.

Table 4. Influence of fall-applied glyphosate plus 2,4-D on forage production of cultivars of several wheatgrass species and bromegrass the following growing season, Prosper, North Dakota.

	Glyphosate + 2,4-D rate (kg ha^{-1})		
Species/cultivar	0.4+ 0.7	0.8 + 1.4	Mean
		% of untreated control	
Bromegrass/Lincoln	97	86	92
Tell wheatgrass/Orbit	92	91	91
Intermediate wheatgrass/Oahe	84	78	81
Western wheatgrass/Rodan	81	68	72
Mean	87	76	
LSD (0.05) Rate = NS			
LSD (0.10) Species = 15			

At Prosper, Rodan western wheatgrass yield was reduced more than Lincoln bromegrass and Orbit tall wheatgrass by glyphosate plus 2,4-D (Table 4). The average yield of Rodan western wheatgrass was 72% of the control, which was similar to the 64% production in the wheatgrass trial at Fargo. However, Orbit tall wheatgrass and Oahe intermediate wheatgrass averaged 91 and 81% yield of the controls, respectively, which was higher than the 69 and 40%, respectively, found in the Fargo wheatgrass trial. In general, the grass species in the trial at Prosper recovered from the initial glyphosate injury more rapidly than at Fargo and produced higher total yields (data not shown). This may be due to the higher rainfall received at Prosper compared with Fargo during the spring and early summer, which helped the grasses overcome glyphosate injury (Table 2).

Glyphosate reduced forage production of most grass species when applied in the fall at 0.4 kg ha^{-1} whether applied alone or with 2,4-D. The amount of reduction depended on the amount of rainfall received the year following treatment and not the year of treatment. The greater the spring precipitation the less effect glyphosate had on yield. Glyphosate plus 2,4-D could be used in a long-term leafy spurge control program as well as control of other perennial weeds in pasture and rangeland provided some reduction in yield is acceptable. The combination treatment would be most useful when the landowner is beginning a control program on heavily infested land. The treatment is more economical than picloram plus 2,4-D and the reduction in yield would be minimal because forage production is decreased approximately 50% by the leafy spurge alone (7).

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