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SOD SEEDED WARM-SEASON GRASS WITH AND WITHOUT SOD SUPPRESSION

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Abstract. Revegetation of deteriorated mixed prairie by sod seeding with a lo-till planter minimizes erosion. Critical periods of inter- and intraspecific competition must be identified to design effective methods of sod suppression and seeding rate. Sod seeding studies were conducted in two counties in south central Nebraska over a 3-year period on a silty range site (fine-silty, mixed, mesic, Typic Argiustolls). Sites were dominated by blue grama [*Bouteloua gracilis* (H.B.K.) Lag. *ex* Steud.] and buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.]. Warm-season native grasses were sod seeded with and without chemical sod suppression. Sod seeding required sod suppression for consistent stand establishment. Sod suppression during the 8-week period following seeding maximized grass seedling emergence. Seedling and stand vigor were more vigorous following sod suppression. Seedling development was independent of seeding rate, and a seeding rate of 20 PLS/0.1 m^2 resulted in an adequate stand. Spring-applied glyphosate [*N* (phosphonomethyl)-glycine] was effective at 0.8 kg/ha using a reduced carrier volume (93 l/ha). August application of glyphosate coupled with a spring application of atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] at the time of seeding was also an effective sod suppression treatment.

Key words. big bluestem, *Andropogon gerardii,* little bluestem, *Schizachyrium scoparium,* indiangrass, *Sorghastrum nutans,* switchgrass, *Panicum virgatum,* sideaots grama, *Bouteloua curtipendula,* glyphosate, mixed prairie, Nebraska

INTRODUCTION

The Loess Hills of south-central Nebraska is part of the mixed prairie (Weaver 1965). Improper management has caused a shift in rangeland vegetation composition from a tall and midgrass bunchgrass community to a shortgrass sod. This shortgrass community is generally considered a disclimax caused by long-term grazing mismanagement. Over 40% of the rangeland in the area was described as poor to fair range condition (Bose 1977).

Seeding native grasses generally requires a period of cropping before seeding into stubble. Erosion hazards and limited moisture often make it impractical to cultivate and grow competitive cover crops by traditional methods when seeding adapted native grasses (Dudley and Holt 1963, Schumacher 1964). Alternative range seeding practices, such as interseeding and sod seeding, have been successfully used to increase forage productivity and improve forage quality in the Great Plains (Schumacher 1964, Robertson and Box 1969, Houston and Adams 1971, Samson and Moser 1982, Hart *et al.* 1985).

The development of lo- or no-till seeding equipment and effective herbicides offers new opportunities to revegetate rangeland. Sod seeding can minimize erosion, maintain species diversity, and expedite recovery. Sod seeding studies were conducted in Furnas and Harlan counties in south central Nebraska to evaluate warm-season grass development and establishment using sod seeding with and without chemical suppression of a shortgrass sod.

METHODS

Study Area

Primary plants in the climax community are big bluestem (*Andropogon gerardii* Vitman), little bluestem [*Schizachyrium scoparium* (Michx.) Nash.], sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], needleandthread (*Stipa comata* Trin. & Rupr.), western wheatgrass (*Agropyron smithii* Rydb.), blue grama [*Bouteloua gracilis* (H.B.K.) Lag. *ex* Steud.], and buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.]. Overgrazing results in a very dense sod of buffalograss and blue grama in the study area.

Experiments were conducted on a silty range site (fine-silty, mixed, mesic, Typic Argiustolls) in two adjacent counties (Furnas and Harlan) in south-central Nebraska. Precipitation is highly variable from season to season and periodic droughts occur. The average annual precipitation is approximately 570 mm with about 80% occurring between April and September. The average growing season is 170 days from May to October. Both sites were grazed annually until initiation of the study. Species composition, based on basal cover, showed that the Furnas County site was dominated by blue grama (54%) and buffalograss (36%). Vegetation at the Harlan County site was also dominated by blue grama (34%) and buffalograss (14%).

Furnas County

Plots (4 x 10 m) were sod seeded (30 PLS/0.1 m^2) on 28 April 1981, using a modified John Deere Powr-Till Seeder (20 cm row spacing) with a mixture (% PLS) of 'Kaw' big bluestem (22%), 'Aldous' little bluestem (35%), 'Nebraska 54' indiangrass [*Sorghastrum nutans* (L.) Nash] (9%), 'Blackwell' switchgrass (*Panicum virgatum* L.) (14%), and 'El Reno' sideoats grama (20%). Glyphosate [*N* -(phosphonomethyl)glycine], a non-selective contact herbicide, was used to suppress existing shortgrass sod. Three herbicide rates (0.6, 0.8, and 1.1 kg/ha) and two carrier volumes (93, 186 l/ha) were evaluated with a seeded control and an unseeded reference. Since active growth of the warm-season shortgrass sod is generally after the optimum seeding date for warm-season grasses, it was important to delay herbicide application until after seeding but prior to seedling emergence. Plots were sprayed 6 days after seeding and excluded from grazing.

The experimental design was a randomized complete block with four replications. Blocking criteria was slope and aspect. Ten randomly located segments (1 m) of drill rows were used to estimate stand density. Stand density was evaluated the year of seeding (July 1981) and year following (June 1982). Plant and stand vigor were determined by measuring leaves/tiller, length of longest leaf, tillers/plant and total plants/unit row for each seeded species during the second growing season (June 1982). Sod suppression was determined by hand clipping (2.5 cm) five randomly located quadrats (0.2 m^2) between drill rows in June and November 1981. Treatment comparisons were made using orthogonal contrasts.

Harlan County

Plots (5 x 10 m) were sod seeded with a mixture of debearded Kaw big bluestem and Aldous little bluestem without sod suppression 24 April 1982, using the John Deere Powr-Till seeder. Three seeding rates were used: low (7 PLS/0.1 m^2), medium (20 PLS/0.1 m^2) and high (25 PLS/0.1 m^2). Big bluestem was approximately 80% of the seed mixture (% PLS) for the low rate and about half for the medium and high rates.

A second experiment evaluated the effect of sod suppression. Glyphosate (1.7 kg/ha, 78 l/ha) was applied in late summer (17 August 1982) followed with a spring (23 April 1983) application of atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] (1 kg/ha, 274 l/ha solution), at the time of seeding to control cool-season annuals. A second treatment was summer-applied glyphosate (4 June 1983) following a 31 May 1983, seed-

ing (plots 2.5 x 10 m). Seeding date was delayed to increase the efficacy of the glyphosate treatment. The third treatment was no sod suppression and plots were compared to the 1982 seeding. A mixture (% PLS) of big (81%) and little bluestem (19%) was sod seeded (20 PLS/0.1 m²).

Seedling development was determined using three permanently marked segments (1 m) of drill rows. As seedlings emerged, a 1.9 cm plastic ring was placed around the base of each seedling for permanent identification. Height, number of leaves, and vigor classification (green, wilted, or dead) was recorded. Percentage seedling emergence was based on the number of emerged seedlings as a proportion of the viable seeds planted (PLS/0.1 m²). Measurements began 4 weeks after seeding and were repeated at weekly intervals through mid-July with two readings in August 1982. In 1983, sampling dates were once in June, August, September, and twice in July. Seedling density was determined within 7 randomly located segments (1 m) of drill row. A completely randomized design with four replications was used. Orthogonal contrasts were used to make treatment comparisons.

RESULTS AND DISCUSSION

Furnas County

Sod seeding without sod suppression.

Sod seeding with no sod suppression in 1981 resulted in a complete stand failure at the Furnas County site. However, May and June precipitation (244 mm) was very favorable for seedling development. During the period May through August, plots received about 500 mm of precipitation. Chemical sod suppression resulted in satisfactory stands, suggesting that sod competition rather than equipment, seed, or weather was responsible for seeding failure.

Sod seeding with sod suppression.

Plots treated with the higher glyphosate rates (0.8 and 1.1 kg/ha) had greater seedling density than the 0.6 kg/ha rate (Table 1). The lower carrier volume was more effective than the higher. Buhler and Burnside (1983) determined that decreasing carrier volume reduced or eliminated inhibition of glyphosate phytotoxicity due to high ion content of carrier water. The highest glyphosate rate used with the lowest carrier volume resulted in a successful (> 1.0 seedling/0.1 m², Launchbaugh and Owensby 1978) stand (1.4 seedlings/0.1 m²). Stand counts in 1982 were generally higher than the 1981 counts, primarily due to tillering.

Above-ground sod biomass in the untreated area was greater in June (1970 kg/ha, P = 0.01) and November (1850 kg/ha, P = 0.03) than the average of the treated areas. Above-ground sod biomass was not significantly different between rates or carrier volumes in June of the seeding year (Table 2). In November, the medium glyphosate rate had less sod biomass than the highest rate (1090 and 1530 kg/ha, respectively). An inverse relationship existed between seedling density and June sod biomass (r = -0.41, P = 0.07). Spring-applied glyphosate suppressed rather than killed the sod. Treated plots were suppressed for approximately 8 weeks

Table 1. Seedling density (number/0.1 m²) of a warm-season grass mixture sod seeded April 28, 1981, at Furnas County, Nebraska, and evaluated July 1981 and June 1982. Glyphosate was applied at three rates in two carrier volumes 6 days after seeding.

		Carrier volume (l/ha)			*Glyphosate rate (kg/ha)*			*Contrasts (PR > F)*[2]	
Species	*Year*	*93*	*186*	*PR > F*[1]	*0.6*	*0.8*	*1.1*	*0.6 vs. 0.8, 1.1*	*0.8 vs. 1.1*
		----------no./0.1 m²----------			----------no./0.1 m²----------				
Big bluestem	1981	3.4	2.4	.18	1.5	3.0	4.2	.02	.20
	1982	6.4	5.1	.25	2.5	7.1	7.6	<.01	.74
Sideoats grama	1981	0.2	0.3	.53	0.1	0.2	0.6	.12	.03
	1982	0.5	0.1	.05	0.2	0.4	0.3	.65	.70
Switchgrass	1981	2.3	1.4	.06	0.7	2.4	2.4	<.01	.93
	1982	2.4	1.7	.35	0.5	2.2	3.4	<.01	.16
Little bluestem	1981	2.7	1.1	<.01	0.7	1.9	3.1	<.01	.06
	1982	3.0	2.1	.20	0.9	3.4	3.4	<.01	.95
Indiangrass	1981	0.8	0.6	.06	0.1	0.7	0.9	<.01	.28
	1982	1.3	1.5	.54	0.4	1.7	2.1	<.01	.40
Total	1981	9.4	5.6	<.01	3.2	8.1	11.1	<.01	.06
	1982	13.6	10.6	.21	4.6	14.9	16.7	<.01	.51

[1]PR > F is the significance probability value for the F value for the comparison of carrier volume within year.
[2]Orthogonal contrasts of the lowest glyphosate rate with the average of the two higher rates and the comparison of the medium rate with the highest rate.

Table 2. Above-ground sod biomass (kg/ha) of plots sod seeded 28 April 1981, at Furnas County, Nebraska. Glyphosate was applied at three rates in two carrier volumes 6 days after seeding and yields were determined in June and November of the seeding year.

		Carrier volume (l/ha)			*Glyphosate rate (kg/ha)*			*Contrasts (PR > F)*[2]	
Month	*Year*	*93*	*186*	*PR > F*[1]	*0.6*	*0.8*	*1.1*	*0.6 vs. 0.8, 1.1*	*0.8 vs. 1.1*
		----------kg/ha----------							
June	1981	1,190	1,090	.64	1,280	990	1,160	.38	.54
November	1981	1,300	1,354	.75	1,360	1,090	1,530	.79	.04

[1]PR > F is the significance probability value for the F value for the comparison of carrier volume within year.
[2]Orthogonal contrasts of the lowest glyphosate rate with the average of the two higher rates and the comparison of the medium rate with the highest rate.

and then the sod recovered. The herbicide treatment resulted in a more vigorous sod than in controls at the end of the treatment year, apparently due to the chemical fallow. The timing and completeness of sod suppression was critical for seedling establishment rather than total biomass reduction.

Higher rates of glyphosate and lower carrier volume generally resulted in more vigorous seeded plants the year after seeding. Sprague *et al.* (1962) demonstrated that germination and emergence of seeded species were not affected by sod suppression but growth and development were. The response of little bluestem was representative of all seeded species (Table 3). Tiller and plant vigor was greater following application of the higher glyphosate rates and lower carrier volume.

Harlan County

Sod seeding without sod suppression.

The 1982 sod seeding without sod suppression at Harlan County was successful (Table 4). Despite differences in seeding mixture, end-of-season stand density and seedling vigor were not affected by seeding rate. Seedling mortality probably resulted from interspecific competition with existing sod during periods of low soil moisture rather than intraspecific competition. The 1982 precipitation pattern was favorable and minimized sod competition. May and June precipitation (220 mm) was adequate for seedling growth. The summer precipitation (May-August) was 294 mm.

Approximately 90% of big and little bluestem emergence occurred by the eighth week after seeding (Figure 1). Big and little bluestem seedling mortality increased sharply 8 weeks after seeding to approximately 80 and 60% survival, respectively (Fig. 2).

Stand persistence was determined by comparing the number of tillers in 1983 (mid-July) with live seedlings at the end of the seeding year (1982). Big bluestem had 87% stand persistence for the low seeding rate, 82% for the medium and 89% for the high seeding rate. Little bluestem had 39% stand persistence for the low seeding rate, 54% for the medium rate and 23% for the high rate.

Stand establishment in 1983 failed (Table 5, untreated). Little bluestem had minimal establishment in plots seeded in April and May (Table 4). Big bluestem did not survive the growing season with either seeding date. Plots seeded 23 April received about 130 mm of precipitation during May. Plots seeded 31 May only received 50 mm during June. July was extremely dry (< 10 mm) with high temperatures which resulted in seedling mortality.

Table 3. Effect of carrier volume and glyphosate rate on tiller and plant vigor of seed seeded little bluestem determined June 1982. Seeding was done 28 April 1981, at Furnas County, Nebraska.

	Carrier volume (l/ha)			*Glyphosate rate (kg/ha)*			*Contrasts (PR > F)*[2]	
Variable	*93*	*186*	*PR > F*[1]	*0.6*	*0.8*	*1.1*	*0.6 vs. 0.8, 1.1*	*0.8 vs. 1.1*
Tiller vigor								
Leaves/tiller (number)	3.6	3.5	.92	2.1	4.2	4.3	.01	.89
Longest leaf/tiller (cm)	19.7	16.4	.41	11.0	20.6	22.7	.02	.66
Plant vigor								
Tillers/plant (number)	5.6	3.3	.06	1.4	4.9	7.1	<.01	.13

[1]PR > F is the significance probability value for the F value for the comparison of carrier volume within year.
[2]Orthogonal contrasts of the lowest glyphosate rate with the average of the two higher rates and the comparison of the medium rate with the highest rate.

Table 4. Seedling density (number/0.1 m²) of big bluestem (6, 9, and 11 PLS/0.1 m²) and little bluestem (1, 11, and 13 PLS/0.1 m²) sod seeded in a mixture at three seeding rates (low, medium, high) on 24 April 1982, in Harlan County, Nebraska, without sod suppression.

	Weeks after seeding										
Seeding rate	*4*	*5*	*6*	*7*	*8*	*10*	*11*	*12*	*14*	*16*	*18*
	----------big bluestem----------										
Low	0.6	0.2	0.5	0.5	1.0	0.9	0.8	0.2	0.1	0.2	0.4
Medium	0.4	0.2	0.9	1.3	1.7	0.8	0.7	0.9	0.8	0.3	0.6
High	0.3	0.5	1.0	1.5	1.2	1.7	0.8	0.4	0.6	0.5	0.2
Contrasts (PR > F)[1]											
Low *vs.* medium, high	0.37	0.13	0.05	0.04	0.37	0.04	0.93	0.15	0.02	0.28	0.98
Medium *vs.* high	0.74	0.02	0.41	0.70	0.43	<0.01	0.67	0.21	0.35	0.30	0.20
	----------little bluestem----------										
Low	0.6	0.5	0.5	0.4	1.0	1.0	0.6	0.1	0.3	0.1	0.5
Medium	1.4	1.1	1.1	1.4	3.0	1.6	1.8	1.7	1.7	1.5	1.7
High	1.9	1.1	1.2	1.4	1.9	1.9	1.3	1.0	1.0	0.6	0.8
Contrasts (PR > F)											
Low *vs.* medium, high	0.04	0.04	0.2	<0.01	0.05	0.09	0.01	0.01	0.02	0.03	0.22
Medium *vs.* high	0.42	0.96	0.80	1.0	0.17	0.59	0.19	0.11	0.10	0.06	0.21

[1]PR > F is the significance probability value for the F value for the comparisons of seeding rate by species within a sampling date. The lowest seeding rate was compared to the average of the highest two and the medium seeding rate was compared to the highest seeding rate.

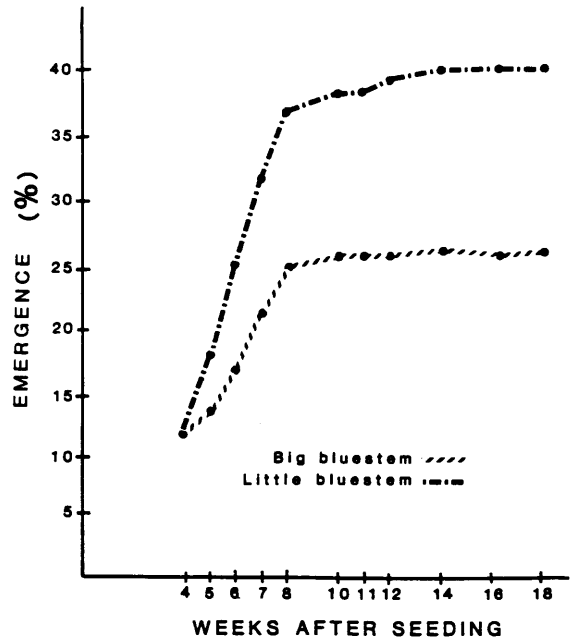

FIG. 1. Emergence (%) during the growing season of big and little bluestem, averaged over seeding rate at Harlan County, Nebraska. Emergence was based on a percent of PLS sod seeded on 24 April 1982.

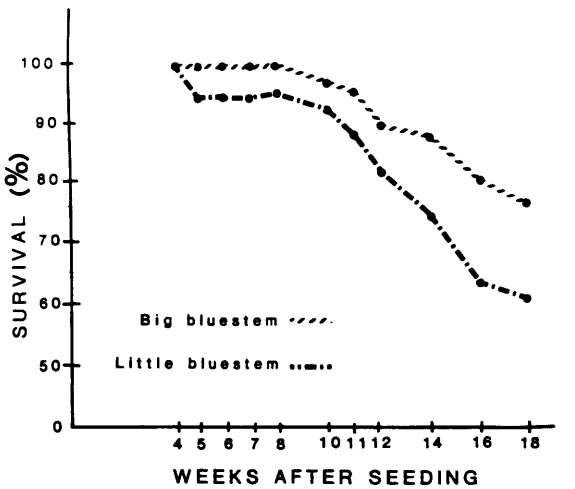

FIG. 2. Survival (%) for big and little bluestem averaged over the medium and high seeding rates at Harlan County, Nebraska. Percent survival was based on emerged seedlings following an 24 April 1982, sod seeding.

Table 5. Seedling density (number/0.1 m²) of big bluestem and little bluestem sod seeded (20 PLS/0.1 m²) in a mixture at Harlan County, Nebraska. Plots seeded 23 April 1983, had received glyphosate (1.7 kg/ha) the preceding late summer and atrazine (1 kg/ha) at the time of seeding. Plots seeded 31 May 1983, received glyphosate June 4.

	Date after seeding									
Species/Treatment	*July 5*	*PR > F*[1]	*July 18*	*PR > F*	*Aug 5*	*PR > F*	*Aug 18*	*PR > F*	*Sept 18*	*PR > F*
	Seeded April 23									
Big bluestem										
Untreated	0.1		0.0		0.1		0.0		0.0	0.11
		0.35		0.02		0.07		0.05		
Late summer glyphosate spring atrazine	0.2		0.7		1.0		0.2		0.3	
Little bluestem										
Untreated	0.1		0.0		0.0		0.0		0.0	
		0.37		0.01		0.02		0.08		0.07
Late summer glyphosate spring atrazine	0.2		0.4		0.3		0.2		0.2	
	Seeded May 31									
Big bluestem										
Untreated	—[2]		0.0		0.0		0.0			
						0.77		0.56		0.87
Early summer glyphosate	0.1		0.0		0.2		0.1		0.0	
Little bluestem										
Untreated	—		—		0.1		0.0		0.1	
						0.52		0.54		0.86
Early summer glyphosate	0.3		0.0		0.2		0.1		0.1	

[1]PR > F is the significance probability value for the F value for the comparison of with and withoutchemical sod suppression by species.
[2]No seedlings emerged.

Sod seeding with sod suppression.

Seedling development in 1983 was poor and inconsistent. However, stand density 18 September of the seeding year was greater ($P = 0.09$) with an August application of glyphosate plus an April application of atrazine (0.5 seedlings/0.1 m^2) compared to June applied glyphosate (<0.5 seedlings/0.1 m^2) (Table 5). The success of the early May applied glyphosate (1.1 kg/ha) at Furnas County and results of a 1979 sod seeding (Hart *et al.* 1985) suggested that other factors influenced glyphosate efficacy at Harlan County. The residue accumulation resulting from 1 year of non-use could have interfered with herbicide activity or been detrimental to seedling development. Andrews *et al.* (1974) determined that summer and fall glyphosate applications were more effective than spring for perennial weed control.

CONCLUSIONS

Sod seeding without sod suppression was not successful in 1981 at Furnas County nor 1983 at Harlan County using two different seeding dates. While a stand was established without sod suppression in 1982 at Harlan County, the risk of stand failure warrants the use of sod suppression. In both cases where stands failed without sod suppression, stands were established with chemical sod suppression. Approximately 90% of the warm-season seedlings emerged within 8 weeks of seeding, defining a critical period for sod suppression. Stand vigor increased with increased sod suppression. Glyphosate was an effective herbicide for control of the warm-season shortgrass sod. It should be applied in a minimum carrier volume (93 l/ha) and the rate should be at least 0.8 kg/ha for a spring application. Timing of spring-applied glyphosate was a problem because the warm-season sod did not green-up appreciably until after the optimum seeding date for warm-season grasses. A late summer glyphosate application the year prior to seeding was a feasible alternative. It provided better sod suppression due to sod mortality which was apparently associated with the downward carbohydrate translocation during this period. However, in this study (50% shortgrass sod) a spring application of atrazine was required to control cool-season annuals, limiting the warm-season seeded species to big bluestem and switchgrass. Dense sods may not require a follow-up spring application of atrazine.

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