

Seedbed effects on grass establishment on abandoned Nebraska Sandhills cropland

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Abstract

Perennial grass establishment on abandoned cropland in the Nebraska Sandhills is difficult due to low soil fertility, organic matter, and water holding capacity and high potential erodibility. Establishment is further complicated by unpredictable precipitation and weed competition. Two warm-season grasses: sand bluestem [*Andropogon gerardii* var. *paucipilus* (Nash) Fern.] and switchgrass (*Panicum virgatum* L.); and 2 cool-season grasses: smooth brome (*Bromus inermis* Leys.) and intermediate wheatgrass [*Thinopyrum intermedium* (Host) Barkw. & D.R. Dewey subsp. *intermedium*] were evaluated with spring-seeded field trials. Seedbed preparation [untilled, disced, and dead oat (*Avena sativa* L.) cover (DOC)] effect on seeded grass and nonseeded species densities was evaluated in 1985 and 1986 at 2 locations on Valentine sands (Aquic Ustipsamment). In 1985 1 site was irrigated. Both sites were dryland in 1986. Stand failure (< 5 seedlings/m²) occurred on the dryland site in 1985 due to low, erratic precipitation. Stands evaluated in June 1986 on plots established with irrigation in 1985 had 38, 46, and 61 plants/m² for the untilled, disced, and DOC seedbeds, respectively. The disced or DOC seedbeds were required for successful (>10 plants/m²) dryland seedings in 1986 at both locations. Irrigation the establishment year minimized risk of stand failure and allowed the use of any seedbed preparation or grass species studied. Sand bluestem was the only species to establish both years. However, if a dryland seeding of a cool-season species is desired, intermediate wheatgrass appeared more adapted than smooth brome.

Key Words: switchgrass, *Panicum virgatum* L., sand bluestem, *Andropogon gerardii* var. *paucipilus* (Nash) Fern., intermediate wheatgrass, *Agropyron intermedium* (Host) Beauv., *Thinopyrum intermedium* (Host) Barkw. & D.R. Dewey subsp. *intermedium*, smooth brome, *Bromus inermis* Leys., revegetation, seedbed

Upland sites in the Nebraska Sandhills, an edaphic Tallgrass Prairie, are sandy with low organic matter, low water-holding capacity, and low natural fertility while having a high erosion potential. Row crop cultivation under center pivot irrigation became a common practice in the 1970's. Many of these sites have been abandoned due to wind erosion, low crop yields, and/or poor economic conditions (Kocher and Stubbendieck 1986).

Seeding is difficult due to the soil characteristics and the intensity of weed competition. Longspine sandbur [*Cenchrus longispinus* (Hack.) Fern.] is the most prominent weed species on coarse sands. Discing stimulated longspine sandbur establishment on abandoned cropland in the Nebraska Sandhills (Roder et al. 1988, Kocher and Stubbendieck 1986, Oldfather 1984). Longspine sandbur allelopathy reduced switchgrass (*Panicum virgatum* L.) radicle elongation and may influence establishment (Roder et al. 1988). In

Australia, living vegetative cover inhibited longspine sandbur establishment (Twentyman 1974). Irrigation could be used to reduce the moisture competition between weeds and seeded species during the seeding year.

The objectives of this study were to evaluate the effect of seedbed preparation on establishment of 2 warm-, and 2 cool-season grasses and on the weed population.

Materials and Methods

Study Area

Plots were established on 2 abandoned center pivot sites in the Nebraska Sandhills. One site in Custer County, near Milburn, was on a stream terrace of the Middle Loup River with an Ipage-Valentine soil association (mixed, mesic Aquic Ustipsamment and mixed, mesic Typic Ustipsamment). The topography was level to slightly rolling. The second location was 11 km south of Ainsworth in Brown County approximately 50 km north of Milburn. The soil was a Valentine association (mixed, mesic Typic Ustipsamment) with rolling topography (9 to 17% slope).

Average annual precipitation is approximately 565 mm with 80% of this occurring between April and September (Table 1).

Table 1. Precipitation (mm) patterns for 1985 and 1986 at Milburn and Ainsworth, Nebraska¹.

Month	1985		1986		Long-term Average	
	Milburn	Ainsworth	Milburn	Ainsworth	Milburn	Ainsworth
	(mm)					
January	6	10	0	4	11	11
February	4	1	33	21	15	19
March	15	19	22	33	35	29
April	84	38	87	98	57	56
May	94	70	110	67	88	89
June	72	35	48	95	94	101
July	121	100	106	71	91	76
August	70	81	123	84	72	62
September	129	73	125	202	52	51
October	32	12	52	55	29	29
November	22	56	12	11	19	19
December	11	8	5	0	12	13
TOTAL	660	503	723	741	575	555

¹U.S. Department of Commerce. 1985. 1986. Climatol. Data. Nebraska. Nat. Oceanic Atmos. Admin. Environ. Data Information Service, Asheville, NC. The Anselmo, NE, records were used for Milburn. The long-term average is based on 1951-1980.

Snowfall occurs frequently from November to April, but snow-cover is not continuous. The number of frost-free days ranges from 110 to 142 (U.S. Department of Agriculture 1982). The last spring frost (0° C) can occur as late as 17 May with the first fall frost occurring as early as 5 September.

The principal annual weed at Milburn was longspine sandbur. Other problem weeds were spotted beebalm (*Monarda pectinata* L.), common lambsquarter (*Chenopodium album* L.), narrowleaf goosefoot, (*Chenopodium desiccatum* A. Nels.), redroot pigweed

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(*Amaranthus retroflexus* L.), smooth pigweed (*Amaranthus hybridus* L.), and common sunflower (*Helianthus annuus* L.). Long-spine sandbur and green foxtail [*Setaria viridis* (L.) Beauv.] were the major weeds at Ainsworth, although horseweed [*Conyza canadensis* (L.) Cronq.] became a major problem the year following seeding.

The dominant climax species for both areas include sand bluestem [*Andropogon gerardii* var. *paucipilus* (Nash) Fern.], little bluestem [*Schizachyrium scoparium* (Michx.) Nash], prairie sandreed [*Calamovilfa longifolia* (Hook.) Scribn.], and needleand-thread (*Stipa comata* Trin & Rupr.). Switchgrass is often present, although it normally comprises less than 5% of the species composition by weight.

Experiment Design

A randomized complete block design with 4 replications was used within each location year combination. A split block treatment arrangement was used with seedbed treatments as whole plots and grass species as subplots within seedbeds. Four large (36 × 72 m) uniform areas were identified at each location. Each area was divided in half (block, 36 × 36 m) and seeding year, 1985 or 1986, was randomly allotted. Within blocks, 3 seedbed treatments (12 × 36 m) were randomly assigned. Seeded species were drilled in strips randomly assigned across all seedbeds, resulting in 6 × 12 m subplots. Experimental errors were tested for normality. Data with experimental errors that were not normally distributed and could not be transformed were excluded from the analysis of variance. Treatment main effects were tested using F tests and orthogonal contrasts when interactions were not significant.

Treatments

Seedbed Preparations

Untilled (control), disced, and dead oat (*Avena sativa* L.) cover (DOC) were the seedbed treatments. At Milburn, the untilled treatment had a mixture of annual and perennial grasses and broadleaf forbs from the previous year's growth. At Ainsworth, the untilled treatment had corn (*Zea mays* L.) residue and the previous year's fall-seeded, no-till rye (*Secale cereale* L.). Corn residue was heavy in low spots and interfered with seeding. The 1986 seedlings used the same cover weathered for a year. Most of the weeds at both locations were actively growing at spring planting.

The disced seedbed treatment provided initial, temporary weed control. A tandem disc set to till at approximately 10 cm depth was used to partially incorporate plant residues. Residues were incorporated enough to reduce interference with seeding and seedling emergence while leaving enough cover to reduce the risk of wind and water erosion. Partial incorporation of corn residues was difficult on the lower areas at Ainsworth due to the large amounts present. Discing was done on 1 May 1985 and 1986.

The DOC seedbed treatment was disced (10 cm depth) to partially incorporate residues on 23 March 1985 and 1986. Oats were planted 2 days later to stabilize the soil surface and suppress emergence of annual grasses and broadleaf weeds, providing a firm, relatively trash-free seedbed. Certified 'Ogle' oats were planted (54.5 kg PLS/ha) using a 3.7-m grain drill with 18 cm row spacings. On 1 May in both years, prior to perennial grass seeding, the oat standing crop was sprayed with glyphosate [N-(phosphonomethyl) glycine] at the rate of 1.1 kg ai/ha in a carrier volume of 187 l/ha. A CO₂-powered backpack sprayer equipped with a hand-held spray boom (8002 flat-fan spray tips) operated at 193 kPa was used.

Grass Species

Two warm-season grasses: 'Goldstrike' sand bluestem and 'Trailblazer' switchgrass, and 2 cool-season grasses: 'Lincoln' smooth brome (*Bromus inermis* Leyss.) and 'Slate' intermediate wheatgrass [*Thinopyrum intermedium* (Host) Barkw. & D.R.

Dewey subsp. *intermedium*] were seeded (<2.5 cm depth, 18 cm row spacing) in monocultures using a 3.7-m Miller NoTill grass drill (3-point hitch) equipped with coulters, double-disc openers with depth bands and packer wheels. Seedings (430 PLS/m²) were made on 3, 4 May 1985 and on 3 May 1986. Optimum seeding time for warm-season grasses is approximately 1 April to 15 May. Development of the oat cover determined the date of grass seeding resulting in a relatively late date for cool-season grass seeding considering 1 March to 30 April as optimum.

The Milburn site was not irrigated. The Ainsworth site was irrigated (25 mm/week) in 1985 from 1 June to 15 August. In 1986, the center pivot system was removed by the cooperators. No weed control was practiced after planting in either year of the study at either location. Results were analyzed as 4 environments.

Sampling

The sampling area (3 × 9 m) excluded a 1.5-m border of each subplot. Density of seeded species in drill rows was determined on 10 randomly located 1-m row lengths. Total seeded plants/m was converted to density using row spacing to define area. Stand criteria were: failure (<5 seedlings/m²), marginal (5–10 seedlings/m²), successful (>10 seedlings/m²) (Launchbaugh 1966, Launchbaugh and Owensby 1978). Density of 3 nonseeded species categories (annual grasses, perennial grasses, and broadleaf forbs) was determined using 20 randomly located square frames (0.1 m²) in each subplot. Weed density data were not normally distributed and a natural logarithm transformation was used to normalize the data for treatment comparison. Areas seeded 3 May 1985 were sampled 9 June and 12 August 1985 and 15 June 1986. Areas seeded 3 May 1986 were sampled 15 June and 12 August 1986 and 10 June 1987.

Results

Annual precipitation at the Milburn site was above-normal both years (Table 1). However, during a 3-week period at the end of June and beginning of July 1985, environmental conditions were extreme. Generally, precipitation patterns in 1985 were characterized by intense rainfall events separated by long, dry periods; 1986 had a better precipitation distribution. Annual precipitation at Ainsworth was below normal in 1985 and above normal in 1986. Irrigation at the Ainsworth site in 1985 made it a much more moderate environment compared to Milburn. Both sites had similar annual precipitation in 1986. Grasshopper (*Tettigoniidae* sp.) damage to seedlings, especially smooth brome and intermediate wheatgrass was observed at both locations in both years of the study, particularly at Milburn in 1985 under water stress conditions.

Milburn

Dryland-1985

Broadleaf weed population was greater on the untilled seedbed, measured on 19 June, compared to tilled seedbeds (Table 2); however, the untilled seedbed had the lowest population of annual grasses present. The DOC seedbed preparation suppressed broadleaf weeds compared to discing while discing resulted in fewer nonseeded perennial grasses. Both seedbeds had high annual grass populations due to disturbance. These relationships among treatments were consistent during the growing season.

Excavation of seed and seedlings suggested that seed planted in the untilled treatment germinated, but most of the seedlings dried up before shoot emergence. The disced seedbed resulted in the highest seedling emergence measured on 19 June 1985 for all species planted compared to the DOC (Table 3). Seedling losses were high (90% of 19 June stand) during the year of establishment. Overwinter losses reduced seedling stand density to less than 5 plants/m² by 15 June 1986 for both disced and DOC seedbeds.

Initial warm-season grass (sand bluestem and switchgrass) density was lower than cool-season grass (smooth brome and interme-

Table 2. Effect of seedbed preparation on the density (plants/m²) of annual grasses, perennial grasses, and broadleaf weeds at 2 sampling dates in 2 seeding years at Milburn and Ainsworth¹.

Seedbed preparation	Plant type	Planting dates			
		3, 4 May 1985		3 May 1986	
		Sampled			
		19 June 1985	12 Aug 1985	15 June 1986	12 Aug 1986
		—————(plants/m ²)—————			
		Milburn			
		dryland			
Untilled	Annual grasses	3	7	65	24
Disced		81	62	219	87
Dead oat cover (DOC)		83	86	156	63
Contrasts (P>F)					
Untilled vs. tilled ²		<.01	<.01	<.01	<.01
Disced vs. DOC		.96	.18	.11	.15
Untilled	Perennial grasses	61	122	98	162
Disced		20	34	59	174
DOC		63	108	83	233
Contrasts (P>F)					
Untilled vs. tilled		<.01	.01	.11	.24
Disced vs. DOC		<.01	<.01	.11	.15
Untilled	Broadleaf weeds	340	76	43	17
Disced		67	45	82	53
DOC		24	19	57	40
Contrasts (P>F)					
Untilled vs. tilled		<.01	.03	.21	<.01
Disced vs. DOC		<.01	.01	.37	.36
		—————(plants/m ²)—————			
		Ainsworth			
		—irrigated—	—dryland—		
Untilled	Annual grasses	128	125	556	399
Disced		189	169	1075	837
DOC		137	125	854	578
Contrast (P>F)					
Untilled vs. tilled		.31	.41	<.01	<.01
Disced vs. DOC		.23	.19	.11	.05
Untilled	Broadleaf weeds	1	<1	255	200
Disced		<1	<1	15	17
DOC		<1	<1	24	18
Contrast (P>F)					
Untilled vs. tilled		.31	.63	<.01	<.01
Disced vs. DOC		.60	.94	.42	.88

¹Orthogonal comparison were made on the natural log transformations.

²Tilled is the average response of the disced and dead oat cover (DOC) seedbed treatments.

diate wheatgrass) density on 19 June 1985 (Table 4). However, by 1 July 1985 (data not shown) few cool-season seedlings could be found, and by 12 August 1985 none were observed while sand bluestem seedlings were abundant (23/m²). By June 1986, seedling density of warm- and cool-season grasses was not different and only sand bluestem met the requirement for a marginal stand.

Dryland-1986

In contrast to the 1985 seeding, the untilled seedbed had fewer broadleaf weeds than the disced or DOC seedbed preparations in June (Table 2). Few annual grasses were found on the untilled seedbed in June and August.

The untilled seedbed had a lower seedling emergence than the disced or DOC seedbeds (Table 3). Emergence on the untilled seedbed was nearly 15-fold better than in 1985; however, summer mortality was severe. At the end of the first growing season only the

Table 3. The effect of seedbed preparation averaged over seeded species¹ on stand density (plants/m²) at 3 sampling dates at Milburn and Ainsworth for plots seeded 3, 4 May 1985 and 3 May 1986.

Seedbed preparation	Planting dates					
	3, 4 May 1985			3 May 1986		
	19 June 1985	12 Aug 1985	15 June 1986	15 June 1986	12 Aug 1986	10 June 1987
	—————(plants/m ²)—————					
Milburn						
dryland						
Untilled	4	<1	<1	55	3	2
Disced	151	14	3	174	24	14
Dead oat cover (DOC)	122	12	2	175	31	19
Contrasts (P>F)						
Untilled vs. tilled ²						
Disced vs. DOC	.05	.87	.37	.92	.19	.54
Ainsworth						
irrigated						
Untilled	92	57	38	52	5	3
Disced	117	64	46	56	25	11
DOC	106	86	61	67	31	13
Contrasts (P>F)						
Untilled vs. tilled						
Disced vs. DOC	.07	.15	.03	.01	—	—
dryland						
Untilled	.07	.15	.03	.01	—	—
Disced vs. DOC	.37	.14	.04	.02	.18	.49

¹Species seeded were sand bluestem, switchgrass, smooth brome, and intermediate wheatgrass.

²Tilled is the average response of the disced and dead oat cover (DOC) seedbed treatments.

³The untilled seedbed was not included in the analyses of variance due to non-normal distributions.

disced and DOC seedbeds had successful stands. Winterkill reduced the stands about 50%, but stands were rated successful. Due to the high rate of switchgrass emergence, warm-season grasses had a higher seedling density in June than cool-season grasses (Table 4). Summer mortality was severe, especially for cool-season grasses. Following the first winter there was no difference in cool- and warm-season grass densities due to some apparent winterkill of warm-season grasses and tillering of cool-season grasses. Sand bluestem had a higher second-year stand than switchgrass while the 2 cool-season grasses were similar with all 4 species having successful stands.

Ainsworth

Irrigated-1985

Irrigation was applied during the growing season at approximately 25 mm/week from June to August 1985. Annual grasses, primarily foxtail, were the dominant nonseeded species on all seedbeds (Table 2). Broadleaf weeds were not important and the nonseeded species density remained unchanged during the growing season.

Seedling emergence data were variable on the untilled seedbed due to heavy crop residues which interfered with seed placement and seedling emergence (Table 3). Seedling emergence was greater and more uniform on the disced and DOC than on the untilled seedbed. By August 1985, 38, 45, and 18% of the original seedling stand had died on the untilled, disced, and DOC seedbeds, respectively. Overwinter survival was good on all seedbeds with all second year stands rated successful.

Both warm- and cool-season grasses established at acceptable densities with irrigation (Table 4). Average cool-season grass density was greater than warm-season grass density on all sample dates. Seedling density for all species declined to less than 50% of June 1985 stands by June 1986. There was no significant difference between sand bluestem and switchgrass seedling density. However, sand bluestem plants appeared to be more vigorous than the switchgrass plants. Average cool-season grass density was about 3-fold greater than warm-season grasses after the first winter.

Table 4. Seedling density (plants/m²) over seedbed preparations at 3 sampling dates for grasses seeded at Milburn and Ainsworth for plots seeded 3, 4 May, 1985 and 3 May 1986.

Seeded species	Planting dates					
	3, 4 May 1985			3 May 1986		
	19 June 1985	12 Aug 1985	15 June 1986	15 June 1986	12 Aug 1986	10 June 1987
	(plants/m ²)					
	Milburn					
	dryland			dryland		
Sand bluestem	163	24	6	132	37	24
Switchgrass	83	3	1	171	58	10
Smooth brome	158	<1	2	126	6	14
Intermediate wheatgrass	141	<1	2	110	9	18
Contrasts (P>F)						
Sand bluestem vs. switchgrass	<.01 ¹	.05 ¹	<.01 ¹	.05	.10	<.01 ¹
Smooth brome vs. intermediate wheatgrass	.29	— ²	.75	.40	.80	.27
Warm-season vs. cool-season ³	.03	— ²	.18	.03	<.01	.75
	Ainsworth					
	irrigated			dryland		
Sand bluestem	77	70	33	49	49	16
Switchgrass	40	33	17	44	28	9
Smooth brome	143	61	56	79	26	9
Intermediate wheatgrass	159	113	88	94	85	12
Contrasts (P>F)						
Sand bluestem vs. switchgrass	.04	.03	.28	.49	.01	.27 ¹
Smooth brome vs. intermediate wheatgrass	.31	<.01	.04	.05	.03	.65
Warm-season vs. cool-season	<.01	<.01	<.01	<.01	<.01	.69

¹The untilled seedbed was not included in the analyses of variance due to non-normal distributions.

²Smooth brome and intermediate wheatgrass were not included in the analysis of variance to non-normal distributions.

³Warm-season is the average response of sand bluestem and switchgrass. Cool-season is the average response of smooth brome and intermediate wheatgrass.

Intermediate wheatgrass appeared to be more vigorous than smooth brome; however, a higher percentage of smooth brome survived the winter. Intermediate wheatgrass plants produced abundant reproductive tillers in the spring of 1986 while very few smooth brome plants produced reproductive tillers.

Dryland-1986

The untilled seedbed had lower annual grass population than the tilled seedbeds (Table 2). However, broadleaf weeds (primarily horseweed) had a much higher density on the untilled seedbed compared to the tilled seedbeds. Generally, nonseeded species densities were greater in 1986 than in 1985.

Seedling emergence was highest on the DOC seedbed (Table 3). However, emergence on both the untilled and the disced seedbeds exceeded 50 seedlings/m². Approximately 50% of the original seedling stand had died by August 1986 on the disced and DOC seedbeds compared to a 90% loss of seedlings on the untilled seedbed. By 10 June 1987, seedling density on the untilled seedbed was low and variable. Seedling densities on the disced and DOC seedbeds were rated successful.

Warm-season grass emergence was lower than cool-season grass in June 1986 (Table 4). There was no difference in emergence between the warm-season grasses. Intermediate wheatgrass had

greater emergence than smooth brome. Summer mortality was most evident in switchgrass and smooth brome. There were no significant differences in seedling density between sand bluestem and switchgrass, or between smooth brome and intermediate wheatgrass by June 1987.

Discussion and Conclusions

Dryland establishment of forage grasses was inconsistent, supporting the findings of McGinnies (1960), Barnes et al. (1952), and Sumner and Love (1961). In 1985 forage grasses did not establish on the dryland seeding at Milburn, regardless of seedbed treatment. Apparently low precipitation, moisture competition from an actively growing nonseeded species population at the time of seeding, and crop residue interfering with seed placement resulted in stand failure. However, in 1986 when moisture was more favorable for emergence, dryland seedings at both Milburn and Ainsworth were successful.

Successful grass stands were obtained at Ainsworth in 1985 with irrigation on all seedbed treatments, even though nonseeded species populations were high (>100 plants/m²). Irrigated grass seedlings were more competitive with nonseeded species. Oldfather (1984) also noted improved seedling establishment with supplemental irrigation the year of establishment.

Dryland seedings using the untilled treatment were not successful. Improved seedling emergence on the shallow-tilled seedbeds was apparently due to a firmer seedbed, better seed placement and removal of weedy competition compared to the untilled seedbed. This compensated for the subsequent flush of annual grasses following disturbance. The DOC seedbed should be used under dryland conditions in preference to the disced seedbed. The DOC seedbed is the most expensive of the 3 seedbeds used, but apparently the combination of chemically killed mulch which protected against wind erosion and the additional equipment passes which resulted in a firmer seedbed provided better seedling establishment.

Dryland seeding of switchgrass, smooth brome, or intermediate wheatgrass resulted in stand failure at Milburn in 1985. Most seedling mortality occurred from 20 June to 10 July when temperatures were near 38° C with windy conditions and no precipitation. Sand bluestem was the only species with a marginal stand (5–10 seedlings/m²). The dryland seedings of 1986 were successful for all species at both locations due to a more favorable year.

With irrigation, sand bluestem, switchgrass, smooth brome, and intermediate wheatgrass stands were successful 1 year after planting. Smooth brome and intermediate wheatgrass seedling emergence with irrigation was greater than sand bluestem and switchgrass, which agreed with earlier observations by Deput et al. (1982). Intermediate wheatgrass, the most successful species, developed a canopy which shaded out weeds such as longspine sandbur and green foxtail, which appeared to support research by Twentyman (1974). In addition, intermediate wheatgrass was the only 1 of the 4 species to produce reproductive tillers 1 year after seeding.

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