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Seeding of Abandoned Croplands in the Central Great Plains[1]

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Highlight

Crested wheatgrass and Russian wildrye were successfully established by late-summer planting in summer-fallowed strips using a double-disc depth-band drill. Crested wheatgrass was also established by spring planting. Blue grama and side-oats grama were not established.

Extensive acreages of abandoned cropland in the Central Great Plains produce only a fraction of their potential as rangeland. Seeding, as a method of realizing this potential, has been generally expensive and subject to frequent failures. The risk of failure in the 10- to 15-inch precipitation zone has deterred seeding on many areas which are in low stages of productivity. It is estimated that 5 million acres of stabilized, abandoned croplands in the lower precipitation zones of the Central Great Plains would be revegetated if dependable and economically feasible methods of stand establishment were known.

In 1956 a study was initiated at the Central Plains Experimental Range 38 miles northeast of Fort Collins, Colorado, to determine the cultural practices required to establish stands of crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.), Russian wildrye (*Elymus junceus* Fisch.), blue grama (*Bouteloua gracilis* (H.B.K.) Lag.), and side-oats grama (*Bouteloua curtipendula* (Michx.) Torr.).

Methods

The experiment was conducted on a half-section of land described by Klipple and Retzer (1959) as belonging to the Ascalon series. The sandy-loam soil was cultivated for bean production for several years, severely eroded by wind, and subsequently abandoned in 1935. In 1956, twenty years after abandonment, this land was in the Aristida-stage of secondary succession (Costello, 1944). The stand of low-value perennial vegetation protected the soil from blowing.

The 20-year (1939-1958) average annual precipitation at the experimental site was 11.84 inches with an average of 8.51 inches during the period May 1 to September 30. Average annual wind velocity was 6.1 miles per hour. The highest average wind velocity recorded for a 24-hour period was 21.1 miles per hour. The mean high and low temperatures during the growing season were 78° F. and 47° F., respectively. The average frost-free period was 133 days.

The study evaluated three dates of planting, three methods of seedbed preparation, five kinds of drills with various row spacings, and four species as outlined in Table 1. Plantings were made during three successive years to test results under the highly variable year-to-year climatic conditions. Treatments were replicated twice in each of three year-blocks.

Seedbed Preparation. — The three methods of seedbed preparation were summer fallow, spring cultivation, and direct seeding. Cultural methods to be practical for this area must provide features that are effective in combating wind erosion. Therefore, summer-fallowed and spring-cultivated seedbeds were confined to narrow strips approximately two rods wide leaving undisturbed strips of equal width between the cleared ones.

The most intensive method of seedbed preparation was summer fallow. Fallowed strips were cultivated initially in May, using 15-inch sweep blades mounted on a tractor tool bar. The strips were cultivated twice more during the summer, usually in June and July, depending upon weed growth. These operations

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Table 1. Treatment combinations showing planting time, seedbed preparation, drills, and species used.

Planting time	Spring									Late Summer				Fall				
Seedbed preparation	Summer fallow			Spring cultivated			Direct			Summer fallow				Direct				
Drill	Depth band	Single disc	Hoe type	Depth band	Single disc	Hoe type	Depth band	Single disc	Hoe type	Depth band	Single disc	Hoe type	Lister type	Depth band	Single disc	Hoe type	Lister type	Sweep type
Species:[1]																		
Agde	x[2]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Elju	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bogr	x	x	x	x	x	x	x	x	x									
Bocu	x	x	x	x	x	x	x	x	x									

[1]Agde = crested wheatgrass
Elju = Russian wildrye
Bogr = blue grama
Bocu = side-oats grama
[2]x indicates that the species was used in the treatment.

left the strips in the rough condition shown in Figure 1. Just prior to planting, the seedbed was prepared with a spike-toothed harrow and a cultipacker. The resulting seedbed is shown in Figure 2, top.

The second most intensive method of seedbed preparation was spring cultivation. The strips were cultivated initially with sweeps followed by the harrow and cultipacker. Tillage was also confined to narrow strips in this method of preparation. All tillage operations in the spring cultivation method took place just before planting.

The least intensive method of land preparation was direct seeding. In this method a narrow band of the native vegetation was removed with either a lister or sweep blade. The seed was drilled directly behind the blades.

The three types of land preparation were set up in adjacent strips. Fallow and spring-cultivated strips were always flanked by direct-seeding strips.

Drills.—The five drills used were a double-disc depth-band, a single-disc, a hoe-type, a lister-type, and a sweep-type drill. The most precise planting was done with a special grass drill equipped with cotton hoppers, double-disc furrow openers with depth bands, and packer wheels (Figure 2, top). This depth-band drill which placed the seed at a 1-inch depth was developed by the Agricultural Engineering Section of the Colorado Agricultural Experiment Station. An ordinary single-disc grain drill without depth bands and a hoe-type or deep-furrow wheat drill were also used. In this light soil an attempt was made to obtain a planting depth of approximately one inch with each drill. When the depth-band, single-disc, or hoe-type drills were used in direct-seeding plots, a properly spaced band of vegetation was first removed with sweeps mounted on a tractor tool bar.

Two machines were designed to plant with no prior seedbed preparation. One was a lister-type experimental grass planter developed by the Colorado Agricultural Experiment Station (Davis and Barmington 1957). It had listers to clear the weedy vegetation and press wheels to firm the soil over the seed after it had been placed in the bottom of the furrow (Figure 2, bottom). The second machine was a sweep-type drill equipped with 18-inch sweeps to clear the vegetation. It planted the seed in the center of a flat, cleared band and covered the seed by drag chains.

Row spacings in inches were as follows:

Drill	Prepared Seedbed	Direct Seeding
Depth-band	12, 24*	12, 24
Single-disc	7, 14, 28*	14, 28
Hoe-type	14, 28*	14, 28
Lister-type		24
Sweep-type		34

Spacings with asterisks were not used in spring plantings.

Dates of Seeding.—Spring plantings with blue grama, side-oats grama, crested wheatgrass, and Russian wildrye were made between March 18 and April 15 in each of the three successive years—1956, 1957, and 1958. Summer-fallowed strips planted in the spring had been fallowed since May of the previous year. Crested wheatgrass and Russian wildrye were planted in late summer in strips that had been fallowed approximately four months.

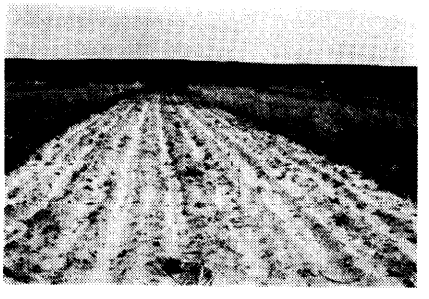

FIGURE 1. Summer-fallowed strip prior to seedbed preparation.

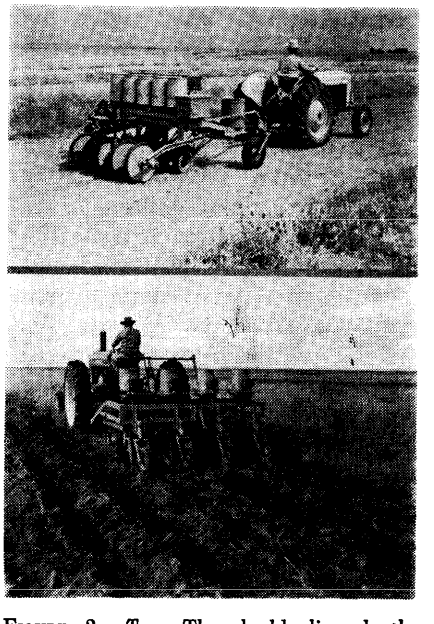

FIGURE 2. *Top*—The double-disc depth-band drill on a prepared seedbed. *Bottom*—The lister-type grass planter on a direct-seeding plot.

Late-summer planting was done between August 27 and September 10 in each of the three years. Fall seedings of crested wheatgrass and Russian wildrye were made only in direct-seeding plots between October 14 and 18 each year, after the competing warm-season vegetation had become dormant.

Rates of Seeding. — Seeding rate adjustments were made on each drill to give the desired number of pure live seed per foot of row. These resulted in approximately 16 pure live crested wheatgrass seeds, 15 Russian wildrye, 32 blue grama, and 45 side-oats grama seeds per foot of seeded row.

Measurements and Data Analysis. —Counts of the number of plants per foot of seeded row were made in July of each year from 1956 through 1960. In 1961 sample plots were clipped in each strip to determine herbage production of the seeded species. Analyses of variance of the number of plants per foot of seeded row two years after seeding and of herbage production in 1961 were performed to evaluate the observed differences. Duncan's Multiple Range Test was applied to specific interesting comparisons.

Table 2. Average number of seeded grass plants established per foot of row with spring planting in 1956, 1957, and 1958, using three methods of seedbed preparation. Counts made two years after planting.

Species	Preparation: Summer fallow	Spring cultivated	Direct	Mean
	(Number[1])			
Crested wheatgrass	0.78	0.52	0.17	0.49[a]
Russian wildrye	0.40	0.22	0.02	0.21[b]
Blue grama	0.12	0.11	0.09	0.11[b]
Side-oats grama	0.16	0.04	0.03	0.08[b]
Mean	0.36[a]	0.22[b]	0.08[c]	0.22

[1]Values are averages of three drills. Border means with different superscripts are diffrent at the 5% level.

Table 3. Russian wildrye and crested wheatgrass plants established per foot of row, seeded on summer-fallowed land.

Species	Time of planting	Drill used: depth band	single disc	hoe type	lister type	Mean omitting lister type
		(Number[1])				
Russian wildrye	spring	0.64	0.30	0.26	—	0.40[b]
	late summer	1.32	0.44	0.45	0.23	0.74[a]
Crested wheatgrass	spring	1.16	0.72	0.47	—	0.78[a]
	late summer	1.00	0.55	0.58	0.27	0.71[a]
Mean		1.03[a]	0.50[b]	0.44[b]		0.66

[1]Values are averages of three years. Counts were made two years after planting. Border means with different superscripts are different at the 5% level.

Results

A planting was considered successful if one or more plants were established per two feet of row two years after the date of seeding. Blue grama and side-oats grama were not established successfully with any seeding method. Direct seeding was unsuccessful at all times and with all species.

Seedbed Preparation. — Seedling establishment improved as control of the competing vegetation increased. In spring plantings summer fallow gave the best control followed by spring cultivation and direct seeding. The average numbers of plants per foot of row established with spring planting on summer-fallow, spring-cultivated, and direct-seeding plots are significantly different from one another at the 5 percent level (Table 2).

Summer-fallowed strips used for late-summer plantings were as effective as those used for spring plantings when crested wheatgrass planted with 3 drills common to both dates of seeding was considered. Fallowed strips planted in the spring with the depth-band, single-disc, and hoe-type drills produced an average of 0.78 plants per foot of row. Fallowed strips planted in late summer with the same machinery produced an average of 0.71 plants per foot of row (Table 3).

Even in summer-fallowed strips the edge effect of the competition was apparent for two to three feet into the fallowed area where stands were thin and seedling establishment poor. This is an indication of the extent to which competition operated against seedlings when the lister and sweep-type drills were used in direct seeding.

In addition to better competition control, the fallowed seedbeds made more moisture available for seedling establishment. Seedlings often emerged in all plots after a rain and then died as the soil moisture was depleted and no additional rain fell. Seedlings in the fallowed plots were able to survive longer between rains.

Drills.—The depth-band drill was the only machine to give an accurate depth of planting under all conditions. The uniform depth of planting by the depth-band drill produced uniform seedling emergence. Seedling emergence with the other drills was usually patchy.

Spring plantings with all four species resulted in 0.32 plants per foot of row for the depth-band drill as compared to 0.21 for the single-disc drill and only 0.14 for the hoe-type (Table 4). The depth-band drill was significantly better than the disc drill, and the disc drill was significantly better than the hoe drill.

Late-summer planting results

Table 4. Average number of seeded grass plants established per foot of row in 1956, 1957, and 1958 with spring planting using three drills.

Species	Drill: Depth band	Drill: Single disc	Drill: Hoe type	Mean
	(Number[1])			
Crested wheatgrass	0.67	0.51	0.29	0.49[a]
Russian wildrye	0.41	0.13	0.10	0.21[b]
Blue grama	0.09	0.16	0.07	0.11[b]
Side-oats grama	0.10	0.06	0.08	0.08[b]
Mean	0.32[a]	0.21[b]	0.14[c]	0.22

[1]Values are averages of three methods of seedbed preparation. Counts were made two years after planting. Border means with different superscripts are different at the 5% level.

on summer-fallowed ground also showed the depth-band drill to be most effective. The single-disc drill and the hoe-type drill produced about equal stands, while the lister-type planter was least effective (Table 3). In late-summer plantings the depth-band drill was significantly better than the single-disc and hoe-type drills, and they were significantly better than the lister-type planter. With the lister-type planter it was possible to place the seed at the desired depth, but subsequent erosion of the furrow walls usually covered the seed too deeply. The sweep-type drill, used only in direct seeding, did not give successful stands.

Date of Seeding.—Date of seeding influenced the amount of competing vegetation in the plowed strips. When either a spring-cultivated or summer-fallowed seedbed was prepared for spring planting, many Russian thistle (*Salsola kali* var. *tenuifolia* Tausch.), sunflower (*Helianthus* spp.), lambsquarter (*Chenopodium album* L.), plains bahia (*Bahia oppositifolia* (Nutt.) DC.), and sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray) seedlings appeared at about the same time as the seeded species. When a fallowed seedbed was prepared for late-summer planting, the cool-season species planted were the only ones to appear on the plots until the following spring.

For Russian wildrye, late-summer planting was significantly better than spring planting (Table 3). The spring plantings of Russian wildrye resulted in a greater loss of seedlings than the late-summer plantings. With spring planting, while soil moisture was still available, many Russian wildrye seedlings died where they were located in unshaded areas. Surviving seedlings were found where they were shaded by weeds. This was observed in July of each year when seedlings had two or three leaves and were between two and three inches tall. On July 15, 1957 at 1:00 P.M. soil temperatures at the 1-inch depth averaged 106° F. in the unshaded areas where seedlings were dead, and 98° F. in the shaded areas where seedlings were alive. A paired comparison t-test of temperature differences between shaded and unshaded spots showed the difference to be highly significant. This type of seedling loss of Russian wildrye was not observed in the late-summer plantings. Many of the spring-planted seedlings that survived in the shade of the weeds, died later in the summer as the soil moisture was depleted by the weeds.

There was no significant difference between spring plantings and late-summer plantings of crested wheatgrass on summer-fallowed strips (Table 3).

Years.—The pressure of competing vegetation on the seeded species was influenced by the year in which the planting was made. Total annual and May 1 to September 30 precipitation for the three years of planting are compared with 20-year averages in Table 5. Considering all four species and all treatments spring planted in each of the three years, an average of 0.33 plants per foot of row established in 1957 was significantly better than 0.14 established in 1956 and 0.19 established in 1958.

In late-summer planting with crested wheatgrass there was no significant difference due to years. This was not the case with Russian wildrye planted in late summer. Late-summer plantings with all machines made in 1956 resulted in an average of 1.11 Russian wildrye plants per foot of seeded row. This was significantly better than the 0.55 made in 1957, which in turn was significantly better than the 0.18 plants per foot of row established in 1958.

Some spring-planted treatment combinations that produced failures in 1956 and 1958 produced successful stands in the wet year 1957. The additional moisture in 1957 eliminated the difference between spring cultivation and summer fallow observed in 1956 and 1958 when the single-disc drill was used in spring planting. In 1957, considering an average of all four species, 0.49 plants per foot of row were established with the single-disc drill in spring-cultivated ground, and 0.48 plants were established in fallowed ground with the same drill. In 1956 and 1958, 0.22 and 0.32

Table 5. Seasonal (May 1-September 30) and annual precipitation in inches.

Year(s)	Seasonal	Annual
1956	7.2	9.7
1957	12.0	16.6
1958	8.8	13.3
1939-58	8.5	11.8

plants, respectively, per foot of row were established in the fallowed ground with the single-disc drill as compared to only 0.08 and 0.16 established in the spring-cultivated ground. This difference was particularly obvious in 1962 as one observed spring-planted crested wheatgrass plots of the study. In the 1956 and 1958 plantings, seeded plants were apparent only on the summer-fallowed plots planted with the depth-band drill. In the 1957 planting, seeded plants were apparent on both summer-fallowed and spring-cultivated plots planted with depth-band, single-disc, and hoe-type drills. The additional moisture in 1957, however, was not sufficient to overcome the effects of the competition in the direct-seeding plots where there were no crested wheatgrass plants.

Interactions.—Russian wildrye plantings were best when made in late summer with the depth-band drill on summer-fallowed strips (Table 3). Late-summer planting was significantly better than spring planting, and results with the depth-band drill were significantly better than those with either the single-disc or hoe-type drills.

Crested wheatgrass was the only species to be successfully established in all three years. Considering means of both spring and late-summer planting times, the depth-band drill was significantly better than the single-disc drill, and the single-disc drill was significantly better than the hoe-type drill (Table 3). Spring planting in summer-fallowed strips with the depth-band drill, and late-summer planting in fallowed strips with both the depth-band and single-disc drills consistently resulted in successful stands of crested wheatgrass. Although stands obtained with the single-disc and hoe-type drills in spring planting averaged above or near the 0.50 plants per foot of row required for a successful stand, the results were erratic, with stands higher than 0.50 occurring only in 1957. Late-summer planting with the hoe-type drill was also erratic with results varying from 0.17 to 1.04 plants per foot of seeded row. Figure 3 taken in 1959 shows crested wheatgrass planted August 27, 1956 in a summer-fallowed strip with the depth-band drill and a 12-inch row spacing.

FIGURE 3. Crested wheatgrass planted August 27, 1956 in a summer-fallowed plot with the depth-band drill and a 12-inch row spacing. Picture taken September 1959.

Row Spacing and Yield.—Row spacing was evaluated in terms of pounds of air-dry herbage of the reseeded species produced per acre in 1961 when the stands were 3, 4, and 5 years old. Row spacing was evaluated for crested wheatgrass using data from the late summer planting on fallowed plots with the single-disc drill. The growth form of the crested wheatgrass differed with row spacing. Plants in the plots with the 7-inch row spacing were smaller and more numerous than those in the plots with wider row spacings. Mean yields per acre across all ages for 7-, 14-, and 28-inch row spacings were 1604, 1300, and 1320 pounds per acre respectively. Although yields from the 7-inch spacing seem much higher, the differences were not significant.

Row spacing was evaluated for Russian wildrye using data from the late-summer planting on fallowed plots with the depth-band drill. Air-dry herbage yield of Russian wildrye from the plots with 12-inch row spacing was 464 pounds per acre, which was not significantly different from the mean yield of 624 pounds from the plots with 24-inch row spacing.

The yield of crested wheatgrass was significantly higher than that of Russian wildrye at the 5 percent level. However, the value of the two species should not be determined on yield alone. Crested wheatgrass yields included many seed heads and culms, while the Russian wildrye yields were predominantly from leaves. In preliminary grazing trials conducted at Central Plains Experimental Range, cattle have made much more use of Russian wildrye than crested wheatgrass. Cattle grazed Russian wildrye throughout the May-October season when they had free access to native range and seeded plots. Crested wheatgrass was grazed mainly during the early and late portions of the summer grazing season.

Discussion

The selection of a species with enough seedling vigor to become established under extreme conditions is important in reducing the risk of failure in seeding abandoned cropland in this area. In seeding trials conducted at Central Plains Experimental Range and reported by McGinnies et al. (1963), side-oats grama was the only one of 20 species to persist and improve in stand rating from planting time in May 1944 through 1958. Although blue grama is a native species and therefore adapted to the site, crested wheatgrass and Russian wildrye were the only species successfully established under the conditions of the study reported here. Additional work on requirements for germination and plant establishment for blue grama is required. Bement et al. (1961) reported that blue grama shallowly planted under an asphalt-emulsion mulch in late June, developed rapidly. This same rapid development of June plantings of blue grama has been noted without the mulch on recent date of seeding trials conducted at the Central Plains Experimental Range.

Clean summer fallow solved the problem presented by competing vegetation. Barnes et al. (1952), Franzke and Hume (1942), Getty (1934), Hull et al. (1958), and many others advise against the use of clean summer fallow on the plains because of the high wind erosion hazard. Most recommendations call for weed control from May until late June when sudan grass, sorghum, or millet is planted to provide a stubble for soil protection and subsequent grass seeding. This type of preparation was successfully done primarily in areas receiving 17 to 24 inches of annual precipitation. With an average annual precipitation of less than 12 inches, it was decided that a cover crop would not be used in the summer-fallow plots of this study, and that narrow strips would be used to provide protection from wind erosion.

Prepared seedbeds in this study were cultipacked only once. McGinnies (1962) conducted seedbed-firming studies with crested wheatgrass at Central Plains Experimental Range and concluded that packing more than once on the sandy soil had little effect on the number of seedlings established.

Conclusions

Recommendations for reseeding abandoned cropland under conditions similar to those in this study can be made for crested wheatgrass and Russian wildrye. The risk of failure in seeding both species can be reduced by:

1) planting in narrow summer-fallowed strips when stored moisture is available,
2) using a double-disc, depth-band drill equipped with packer wheels and set to plant approximately a 1-inch depth, and
3) planting during the last week in August or the first week in September. Chances for success in seeding crested wheatgrass are equally good if the planting is made in the spring during the last two weeks of March or the first two weeks of April.

Summary

Cultural practices required to establish crested wheatgrass, Russian wildrye, blue grama, and side-oats grama on abandoned plowed lands were investigated at the Central Plains Experimental Range near Nunn, Colorado. The four species were spring planted in 1956, 1957, and 1958 on strips of ground that had been summer fallowed, spring cultivated, or had received no preparation. The cool-season species were also planted in late summer in summer-fallowed plots and in the fall in unprepared seedbeds. Five pieces of equipment used for planting were a double-disc depth-band drill, a single-disc drill, a hoe-type drill, a lister-type planter, and a sweep-type drill. Row spacings used were 7, 12, 14, 24, 28, and 34 inches.

Blue grama and side-oats grama were not successfully established. Crested wheatgrass and Russian wildrye were successfully established by late-summer planting in summer-fallowed strips using the double-disc depth-band drill. Crested wheatgrass was also successfully established by spring planting in summer-fallowed strips using the depth-band drill. Row spacings between 7 and 28 inches had little effect on forage production.

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