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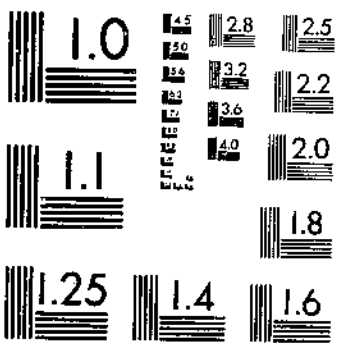
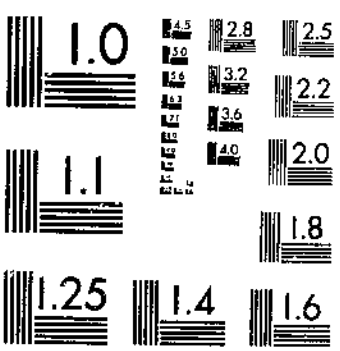


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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Effects of Some CULTURAL PRACTICES ON GRASS PRODUCTION at Mandan, North Dakota

By Jesse L. McWilliams,[1] *plant materials technician, Soil Conservation Service*

SUMMARY

The use of grass, both in soil conservation and general agricultural operations, has increased considerably during the last two decades. To determine cultural practices needed to insure the most rapid and consistent establishment of grasses under Northern Great Plains conditions, the Soil Conservation Service Nursery set up in 1942 a series of studies at Mandan, N. Dak. The practices studied were widths of row spacings for the production of grass seed; dates, depths and rates of seeding, and seedings of grass and grass-legume mixtures.

This project was carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the North Dakota Agricultural Experiment Station.

Results of tests with different row spacings indicate that, in general, 30-inch rows are the best for grass-seed production. Russian wildrye is an exception, for it requires row spacings of 36 inches or more for satisfactory seed yields. While the grass stands are from 1 to 3 years old, however, satisfactory yields are obtained from 18-inch rows. Over that age, the 18-inch rows produce poorly while the 30- and 42-inch rows continue to produce satisfactorily.

Both the depth and date of seeding have marked effects on the establishment of stands of grasses. Cool-season grasses produce satisfactory stands from seeding depths of ½ to 1 inch, but generally they produce better stands from seedings at a depth of ½ inch. Some species, however, produce better stands from 1-inch-deep seedings when they are seeded in the spring. Poor stands result from all seedings at depths greater than 1 inch. Warm-season grasses produce satisfactory stands from seedings at depths of ¼ to ½ inch, but seeding depths greater than ½ inch generally resulted in poorer stands.

With the exception of western wheatgrass, cool-season grasses produce better stands from early fall seedings (September 5 to September 20) than from late fall or spring seedings. The best stands of western

[1] The author gratefully acknowledges the cooperation and assistance of G. A. Rogler, research agronomist, Field Crops Research Branch, and R. W. Carpenter, formerly research agronomist, Soil and Water Conservation Research Branch, Agricultural Research Service, Northern Great Plains Field Station, Mandan, N. Dak.

wheatgrass are obtained from midfall seedings (October 10). Late spring seedings generally result in poor stands of all cool-season grasses, but satisfactory stands can usually be obtained from seedings between April 5 and 20. The best stands of warm-season grasses are obtained from seedings between April 20 and May 10. Results from later seedings generally are poor.

Seeding rates affect both the stand establishment and forage yields of grasses, although some species produce satisfactory stands and yields from lower seeding rates than do others. A seeding rate of 4 pounds per acre produced satisfactory stands of switchgrass and sideoats grama. This rate, however, was not sufficient to produce satisfactory stands of crested wheatgrass, Russian wildrye, or green needlegrass. The stand of western wheatgrass produced by a 3-pound-per-acre seeding was not satisfactory until it was 3 years old. Seeding rates of 5 pounds per acre produced satisfactory stands of Canada wildrye, smooth bromegrass, blue grama, and big bluestem. Eight pounds of seed per acre were needed to produce satisfactory stands of crested wheatgrass, Russian wildrye, and green needlegrass. In most cases, forage yields from the light seeding rates are lower in new stands but they increase and become equal to or greater than yields from the heavier seeding rates when the stands become older. In no case in the tests, with the possible exception of green needlegrass, did seeding rates greater than 10 pounds per acre result in better stands or increased yields.

Yields of grass mixtures are dependent on the species composition of the mixture. The individual species in these tests yielded the same when grown in a grass mixture as when grown alone. Legumes in grass mixtures have a twofold effect on the forage yield. First, the production by the legume itself increases the forage yield. Secondly, there is an increase in the yields of the grasses as a result of the legume being included in the mixture. The addition of biennial sweetclover to a mixture of cool-season grasses increased the yield of the grasses up to 2 years after the clover had disappeared from the mixture.

Aggressive sod-forming grasses, such as intermediate wheatgrass and smooth bromegrass, tend to crowd out other species in mixtures. Mixtures maintain their original composition better when each species is seeded separately in alternate rows than when they are mixed in the rows, but the yields are comparable when the composition is the same.

SOILS AND TOPOGRAPHY

The tract of land where these studies were carried out is located on the bench above the Missouri River about 2 miles northeast of Mandan, N. Dak. (fig. 1).[2] Its elevation is 1,700 feet above mean sea level. The predominant soil type is Morton silt loam, which is a deep, medium-textured, permeable, upland soil. Topography of the area is nearly level, with an overall slope to the east and north of about 2 percent. This is Class II land under the land-capability classification. Prior to the first grass plantings in 1942, it had been under continuous cultivation for 30 years or more.

[2] W. W. Austin and R. W. Carpenter planned and initiated the studies in 1942, C. L. Reafs took over the work in 1943, and L. G. Wolfe in 1946. The project was assigned to the author in 1947.

FIGURE 1. General view of area near Mandan, N. Dak., on which the nursery trials were conducted. Missouri River bluffs in the distance. In the foreground, crested wheatgrass to the left, and bromegrass on the right had been drilled in wheat stubble in the fall of 1943 and photographed 2 years later.

CLIMATIC INFORMATION[1]

The climate of this area is classed as semiarid. Precipitation is variable from year to year in both amount and distribution. Average annual precipitation is 15.59 inches, but precipitation ranged during the course of these studies from 21.15 inches in 1943 to 13.71 inches in 1948. The precipitation is characterized by heavy rains in late spring and early summer and light rainfall and snow in fall and winter. Normally, almost 50 percent of the annual precipitation falls in the 3 months of May, June, and July, and about 75 percent of the annual total is received during the growing season, April 1 to September 30. June is generally the month of heaviest precipitation.

The area is subject to severe drying winds during all seasons of the year. Prevailing wind direction is west or northwest. Hot, dry, southerly winds during the summer frequently damage crops severely.

Season evaporation, April 1 to September 30, from a free-water surface ranged during the course of the studies from 25.01 inches in 1942 to 32.82 inches in 1946.

The average date of the last killing frost in the spring is May 11 and of the first killing frost in the fall is September 26, with an average frost-free period of 138 days.

[1] Information contained in this section was taken from the records of the Northern Great Plains Field Station and from the U. S. Department of Agriculture Yearbook for 1941, Climate and Man.

TABLE 1.—*Climatic data from USDA Northern Great Plains Field Station, Mandan, N. Dak., 1943–48*

MEAN TEMPERATURES

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Apr.–Aug.	Annual
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Average 1915–48	9	13	27	43	55	64	72	69	58	45	28	15	61	42
1943	−1	16	18	47	51	62	72	69	57	49	29	22	60	41
1944	23	11	17	42	59	60	69	67	57	50	25	16	59	41
1945	14	16	33	40	50	58	70	69	55	47	23	8	57	40
1946	12	13	38	51	51	65	73	67	58	41	27	16	61	43
1947	18	11	25	41	51	61	72	71	56	52	24	16	59	42
1948	12	8	18	44	56	63	70	71	65	46	31	12	61	41

PRECIPITATION

	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Average 1915–48	0. 37	0. 43	0. 76	1. 52	2. 03	3. 29	2. 41	1. 45	1. 39	0. 90	0. 62	0. 42	10. 70	15. 59
1943	1. 17	. 55	1. 67	. 87	1. 95	7. 67	1. 56	3. 20	. 16	1. 56	. 60	. 19	15. 25	21. 15
1944	. 26	. 49	. 27	1. 22	3. 13	5. 54	. 67	3. 19	1. 17	. 07	3. 44	. 01	13. 75	19. 46
1945	. 60	. 25	1. 01	1. 02	1. 54	1. 78	1. 94	3. 48	1. 85	. 04	. 53	. 61	9. 76	14. 65
1946	. 04	. 63	1. 36	1. 28	1. 81	3. 14	1. 25	1. 28	2. 36	2. 56	. 24	. 82	8. 76	16. 77
1947	. 52	. 15	. 32	1. 90	. 73	7. 72	3. 21	1. 17	1. 77	2. 15	1. 08	. 39	14. 73	21. 11
1948	. 47	. 95	. 41	3. 21	. 80	2. 32	2. 28	1. 08	. 61	1. 34	. 53	. 31	9. 69	13. 71

GROWING-SEASON DATA

Year	Last killing frost, spring	First killing frost, fall	Frost-free period	Evaporation [1] Apr.–Sept.
			Days	Inches
1943	May 12	September 9	120	28. 59
1944	May 4	October 7	156	26. 77
1945	May 13	September 24	134	27. 47
1946	May 11	September 27	139	32. 82
1947	May 19	September 21	125	28. 90
1948	April 19	October 8	172	31. 81

[1] From free-water surface.

Summers are short and warm; winters are long and cold. Minimum winter temperatures of −30° F. are normal, and as low as −46° F. has been recorded. Maximum temperatures of 100° F. or more may be expected during midsummer.

A tabulation of climatic data for the period 1943 through 1948 is given in table 1.

EFFECTS OF ROW SPACINGS ON SEED YIELDS OF GRASSES

Methods of Study

Crested wheatgrass (*Agropyron desertorum*), smooth bromegrass (*Bromus inermis*), Canada wildrye (*Elymus canadensis*), Russian wildrye (*E. junceus*), green needlegrass (*Stipa viridula*), and switchgrass (*Panicum virgatum*) were used. Plantings were made in 3 replications of a randomized block design in plots 50 feet by 12 feet. Row spacings of 18, 30, and 42 inches were used for each species, with additional spacings of 6, 12, and 36 inches for Russian wildrye. The seedbed was well prepared. Seedings were all made at a uniform depth of ½ inch with a hand seeder with good depth control and equipped with a covering device and packer wheel. The same drill setting was used on all row spacings, which gave the same seed spacing within the row. Seeding rates were approximately 10 pounds per acre with rows 18 inches apart, 6 pounds per acre for the 30-inch row spacings, and 4 pounds per acre for the 42-inch row spacings.

The first plantings were made in April 1942, but a severe infestation of footrot disease depleted the stands so badly that they had to be reseeded in April 1943. Excellent stands of all species were obtained from the 1943 seedings. All plots were cultivated from 1 to 3 times per year to control weed growth. The cultivations were more frequent when the stands were young. The first seed harvest was in 1944. An area of 0.001 acre from the center rows in each plot was harvested by hand with a sickle. Samples were dried and hand threshed and the yields computed in pounds per acre.

Table 2.—*Yields per acre for 5 years of crested wheatgrass seed from seedings made in 1943, with row spacings of 18, 30, and 42 inches*

Year	Row spacings in inches			F value [1]	Least significant difference
	18	30	42		
	Pounds	*Pounds*	*Pounds*		
1944	75	73	33	3. 88	[2]
1945	420	470	387	2. 33	[2]
1946	125	216	375	[3] 10. 39	154
1947	108	179	173	[3] 12. 68	44
1948	30	56	59	1. 44	[2]
5-year average	152	198	205	1. 18	[2]

[1] F values in this and succeeding tables were determined by the method set forth in the book, "Statistical Methods," by George W. Snedecor, and checked for significance in Fischer's Tables.

[2] Not significant.

[3] Significant at the 5-percent level.

CRESTED WHEATGRASS

In the first 2 years of harvest, 1944 and 1945, crested wheatgrass with both 18- and 30-inch row spacings produced the highest yields of seed per acre (table 2). During the last 3 years of the tests, the yields were larger from the 30- and 42-inch rows. The 5-year-average yields also were larger from the wider-spaced rows, but the differences were not significant. The highest yield—470 pounds of seed per acre—was obtained from 30-inch rows in the second harvest year.

SMOOTH BROMEGRASS

The effects of different row spacings were more apparent in the yields of smooth bromegrass seed than in the case of crested wheatgrass. There were significant differences in yields every year (table 3). Seed yields in pounds per acre in the first harvest year were largest from the rows with a 30-inch spacing and lowest from the 42-inch rows. After the first year, yields from the 18-inch rows were lowest. The highest yield—306 pounds of seed per acre—was obtained from 42-inch rows in the second harvest year. The seed yield from the 18-inch rows was 50 percent less in the second year than in the first. In the same year, the yields from the 30-inch rows declined only 26 percent, but the yields from the 42-inch rows increased 63 percent.

CANADA WILDRYE

Rows with 30-inch spacings produced the highest per-acre yields of Canada wildrye seed in 4 out of the 5 test years (table 4). Unlike smooth bromegrass and crested wheatgrass, seed yields from the 18-inch rows of Canada wildrye held up fairly well throughout the tests. The highest yield—782 pounds of seed per acre—was obtained from 42-inch rows in the second harvest year.

RUSSIAN WILDRYE

Seed yields of Russian wildrye increased as row spacing increased up to and including 36 inches (table 5). The highest yield—280 pounds of seed per acre—was obtained from the 36-inch rows in the first year of harvest. This species was not harvested in 1944 or 1948 because the amount of seed it produced was so small. Seed yields from the closer-spaced rows—6, 12, and 18 inches—were poor.

An additional planting of Russian wildrye was made in April 1947, using row spacings of 36, 42, 48, 60, and 72 inches. Two-year results, 1949 and 1950, are available from this planting. In 1949, the seed yields increased with increased row spacings up to and including the 60-inch spacing (fig. 2). Yields are given in table 6.

There was no significant difference in these yields, the F value for significance at the 5-percent level being 3.84.

GREEN NEEDLEGRASS

Green needlegrass produced higher per-acre seed yields from both the 30- and 42-inch row spacings than from the 18-inch rows (table 7).

TABLE 3.—*Yields per acre for 4 years of smooth bromegrass seed from seedings made in 1943, with row spacings of 18, 30, and 42 inches*

Year	Row spacings in inches			F value [1]	Least significant difference
	18	30	42		
	Pounds	*Pounds*	*Pounds*		
1944	233	294	194	[2] 12. 69	55
1945	117	218	306	[2] 8. 77	89
1946	20	75	73	[2] 10. 28	38
1947	72	129	145	[2] 6. 94	61
4-year average	111	179	180	2. 52	([3])

[1] See table 2, footnote 1.
[2] Significant at the 5-percent level.
[3] Not significant.

TABLE 4.—*Yields per acre for 5 years of Canada wildrye seed from seedings made in 1943, with row spacings of 18, 30, and 42 inches*

Year	Row spacings in inches			F value [1]	Least significant difference
	18	30	42		
	Pounds	*Pounds*	*Pounds*		
1944	356	530	410	[2] 7. 14	123
1945	725	748	782	. 19	([3])
1946	209	259	246	1. 33	([3])
1947	196	375	293	4. 56	([3])
1948	59	96	52	[2] 10. 52	28
5-year average	309	402	357	[2] 5. 88	36

[1] See table 2, footnote 1.
[2] Significant at the 5-percent level.
[3] Not significant.

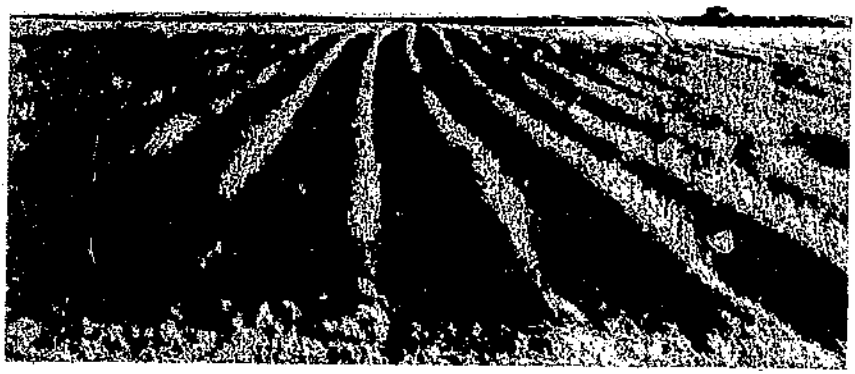

FIGURE 2.—Part of a 40-acre field of Russian wildrye seeded in rows spaced at 42 inches 5 years previously. The spacing between rows was increased to 85 inches by plowing out every other row.

TABLE 5.—*Yields per acre for 3 years of Russian wildrye seed from seedings made in 1943, with row spacings of 6, 12, 18, 24, 30, 36, and 42 inches*

Year	Row spacings in inches							F value [1]	Least significant difference
	6	12	18	24	30	36	42		
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1945	11	41	81	215	143	280	231	[2] 32. 14	29
1946	6	10	12	23	31	67	114	[3] 4. 12	39
1947	37	25	58	63	102	141	131	[2] 6. 43	51
3-year average	18	25	50	100	92	163	159	[3] 3. 56	29

[1] See table 2, footnote 1.
[2] Significant at the 1-percent level.
[3] Significant at the 5-percent level.

TABLE 6.—*Yields per acre for 2 years of Russian wildrye seed from seedings made in 1947, with row spacings of 42, 48, 60, and 72 inches*

Year	Row spacings in inches				F value [1]
	42	48	60	72	
	Pounds	*Pounds*	*Pounds*	*Pounds*	
1949	167	171	207	138	1. 10
1950	213	210	244	226	. 97

[1] See table 2, footnote 1.

TABLE 7.—*Yields per acre for 3 years of green-needlegrass seed from seedings made in 1943, with row spacings of 18, 30, and 42 inches*

Year	Row spacings in inches			F value [1]	Least significant difference
	18	30	42		
	Pounds	*Pounds*	*Pounds*		
1945	233	350	272	2. 46	([2])
1946	111	217	267	[3] 16. 44	77
1947	147	252	300	3. 21	([2])
3-year average	164	273	280	[3] 7. 73	53

[1] See table 2, footnote 1.
[2] Not significant.
[3] Significant at the 5-percent level.

The 42-inch rows produced the highest yields, except in the first year, but the difference in yields from the 30- and 42-inch rows was not large enough to be significant. The highest yield—350 pounds of seed per acre—was obtained from 30-inch rows in the first harvest year.

The 42-inch rows made their best yield in the last year of the tests, whereas both 18- and 30-inch rows made their best yields in the first year.

SWITCHGRASS

Seed yields of switchgrass from rows with 18-inch spacing was higher than the yields from either 30- or 42-inch rows the first year and about equal to them the second year (table 8). Yields from the 18-inch rows declined as the stand became older, however, and were only 4 pounds per acre in the fifth year. The highest yield—341 pounds of seed per acre—was obtained from 42-inch rows in the second year. Yields from 30- and 42-inch rows did not differ significantly until the fifth year, when the 42-inch rows yielded more than twice as much seed as the 30-inch rows.

TABLE 8.—*Yields per acre for 5 years of switchgrass seed from seedings made in 1943, with row spacings of 18, 30, and 42 inches*

Year	Row spacings in inches			F value [1]	Least significant difference
	18	30	42		
	Pounds	*Pounds*	*Pounds*		
1944	171	101	86	[2] 8.71	32
1945	311	333	341	.75	[3]
1946	90	170	176	[2] 13.26	56
1947	66	123	149	[2] 8.66	57
1948	4	61	137	[2] 10.06	26
5-year average	128	158	178	1.59	[3]

[1] See table 2, footnote 1.
[2] Significant at 5-percent level.
[3] Not significant.

EFFECTS OF DATE AND DEPTH OF SEEDING ON STAND ESTABLISHMENT OF GRASSES

METHODS AND PURPOSE

This study was for determination of dates and depths of seeding that consistently would produce the best stands of several of the more important species of grasses. Crested wheatgrass, western wheatgrass, Russian wildrye, Canada wildrye, smooth bromegrass, and green needlegrass were the cool-season grasses used. The warm-season grasses were side-oats grama (*Boutelona curtipendula*), blue grama (*B. gracilis*), big bluestem (*Andropogon geradi*), and switchgrass.

All seedings were made on a uniform seedbed—wheat stubble 8 to 10 inches tall, without seedbed preparation. Grain stubble is commonly used for a seedbed for grass in this area. Seedings were made in 3 replications of a randomized block design, with plots 6 feet by 20 feet.

Each main plot contained a single species seeded on a single date, with subplots of different seeding depths. Thus, each plot of cool-

season grass contained nine rows, of which three rows were seeded at ½-inch depth, three rows at 1-inch depth, and three rows at 1½-inch depth. Since four different depths were used for warm-season species, each main plot contained 12 rows. Seeding depths were ¼ inch, ½ inch, 1 inch, and 1½ inches for big bluestem and switchgrass, and ¼ inch, ½ inch, ¾ inch, and 1 inch for blue grama and side-oats grama.

Grass rows were seeded 6 inches apart between the stubble rows. A hand seeder, with an adjustable shoe which could be set to gage the depth accurately, was used for all seedings. The seeder was equipped with a covering device and packer wheels. Seeding rates were 8 pounds per acre for switchgrass and blue grama; 10 pounds per acre for side-oats grama, big bluestem, crested wheatgrass, Russian wildrye, and green needlegrass; and 15 pounds per acre for the other species.

The dates of seeding of the cool-season grasses were September 5, September 20, October 10, November 1, April 5, April 20, and May 10. For the warm-season grasses, the dates were April 20, May 10, June 1, and June 20. Owing to weather conditions, it was not always possible to make seedings on the selected dates, and at times some seeding dates were skipped entirely. In most cases, however, seedings were made within 5 days of the selected date.

Seedings were made each year from 1942 to 1948. Each seeding was kept through the second year in order to check final stand establishment. The field was then plowed and seeded to wheat to provide seedbeds for the next year's plantings.

Emergence counts were made a month to 6 weeks after seeding, except for late fall seedings on which counts were made about the following May 1. Final established stands were determined about a year after the emergence count. Stand determinations were not made by actual plant counts, but were estimated on the basis of total plant population for each individual seeding. They were expressed in terms of the percentages of the ground that would be covered by the mature plants. A stand of 65 percent or more was considered satisfactory if applied to field-scale operations.

Stand Establishment—Cool-Season Grasses

Table 9 gives the 6-year average emergence and average established stands, in percent, of cool-season grasses. In general, there was little difference in stands obtained from ½- and 1-inch seeding depths. Stands were reduced considerably when the seeding depths were increased to 1½ inches, however. Only green needlegrass produced what would be considered a satisfactory stand at this seeding depth.

Cool-season grasses produced better stands from fall seedings than from spring seedings. In several instances, emergence from early spring seedings was very good but final established stands were poor. Observations indicate that seedings from late spring plantings suffer more from footrot disease than do early spring or fall seedings.

Crested wheatgrass seeded on September 20 at a depth of ½ inch produced the best average stands—84 percent (fig. 3). Stands from September 20 seedings at a depth of 1 inch and from September 5 seedings at both ½- and 1-inch depths were almost as good. The later fall and the April 5 seedings at a depth of ½ inch produced satisfac-

TABLE 9.—*Average emergence stands and average established stands about a year later for cool-season grasses from various dates and depths of seeding, 1942–48*

Species	Seeding dates	Depths of seeding—					
		½ inch		1 inch		1½ inch	
		Emergence	Established stand	Emergence	Established stand	Emergence	Established stand
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Crested wheatgrass	September 5	88	81	84	81	55	50
	September 20	80	[1] 84	83	82	59	42
	October 10	74	78	70	71	52	54
	November 1	63	75	67	68	45	38
	April 5	75	75	86	72	75	42
	April 20	84	31	93	31	83	28
	May 10	43	0	36	0	23	0
Western wheatgrass	September 5	71	81	72	76	54	57
	September 20	76	76	76	79	55	51
	October 10	82	[1] 92	89	91	68	65
	November 1	46	55	45	56	38	48
	April 5	59	47	69	55	48	38
	April 20	71	28	75	31	56	12
	May 10	0	0	0	0	0	0
Smooth bromegrass	September 5	79	[1] 96	81	94	50	56
	September 20	69	79	70	79	51	59
	October 10	40	49	53	52	27	28
	November 1	20	38	31	55	20	40
	April 5	46	42	55	57	44	36
	April 20	58	50	74	58	62	24
	May 10	34	14	34	9	32	4
Canada wildrye	September 5	46	64	48	[1] 69	39	50
	September 20	31	42	29	42	18	20
	October 10	21	34	23	42	17	18
	November 1	16	19	21	22	15	23
	April 5	48	24	60	34	57	22
	April 20	60	20	69	33	61	13
	May 10	66	20	77	23	71	22
Russian wildrye	September 5	62	70	59	64	31	20
	September 20	77	[1] 75	66	64	50	37
	October 10	63	69	45	56	47	31
	November 1	67	52	71	56	40	37
	April 5	59	52	70	54	54	19
	April 20	83	14	79	15	70	4
	May 10	54	5	50	12	36	5
Green needlegrass	September 5	64	80	72	[1] 90	59	63
	September 20	61	77	66	78	46	57
	October 10	55	87	57	[1] 90	54	67
	November 1	51	60	55	82	52	70
	April 5	56	23	63	46	56	30
	April 20	66	51	71	65	65	46
	May 10	30	41	40	39	31	22

[1] Best established stand for species.

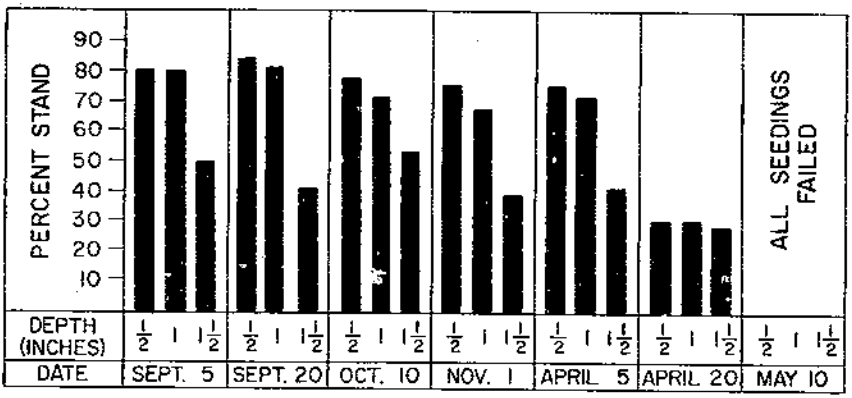

FIGURE 3.—Established stands of crested wheatgrass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

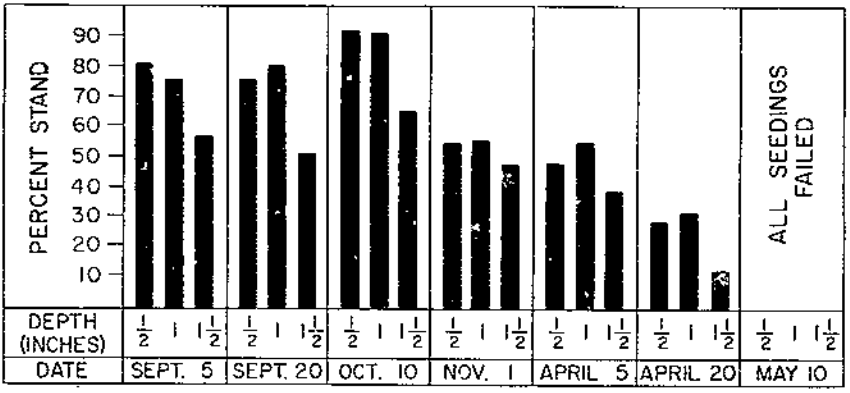

FIGURE 4.—Established stands of western wheatgrass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

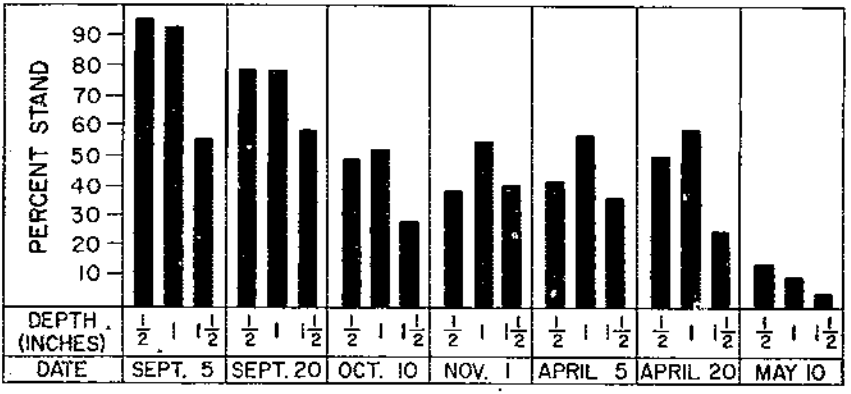

FIGURE 5.—Established stands of smooth bromegrass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

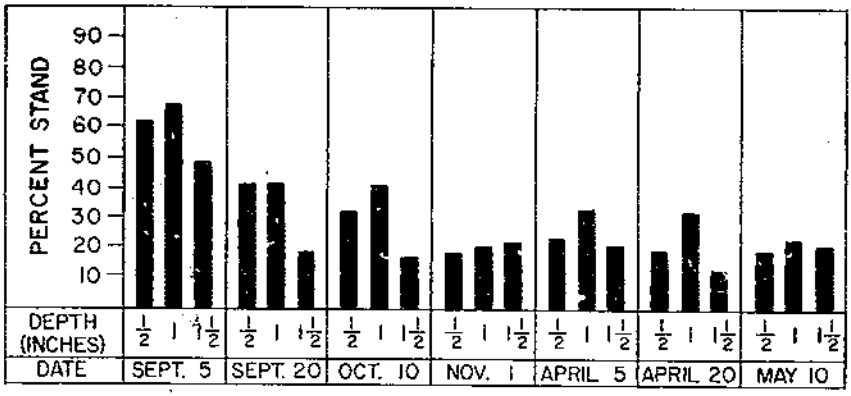

FIGURE 6.—Established stands of Canada wildrye grass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

tory stands, but later spring seedings did not. Seedings at depth of 1½ inches produced no satisfactory stands.

Best results with western wheatgrass were obtained from the October 10 seedings at both the ½- and 1-inch seeding depths (fig. 4). Even seedings made at a depth of 1½ inches on this date produced a 65-percent average stand. The earlier fall seedings at both ½- and 1-inch depths produced stands of 72 percent or more. The November 1 and all spring seedings failed to produce satisfactory stands.

The best average stands of smooth bromegrass were obtained from September 5 seedings at depths of ½ and 1 inch—96 and 94 percent, respectively (fig. 5). The only other satisfactory stands—79 percent—resulted from September seedings at both the ½- and 1-inch depths. Seedings at a depth of 1½ inches produced no satisfactory stands.

Relatively poor stands were obtained from Canada wildrye (fig. 6). The best average—69 percent—was obtained from September 5 seedings at a depth of 1 inch. Seedings at the ½-inch depth on this date produced average stands of 64 percent. No other seedings produced satisfactory stands.

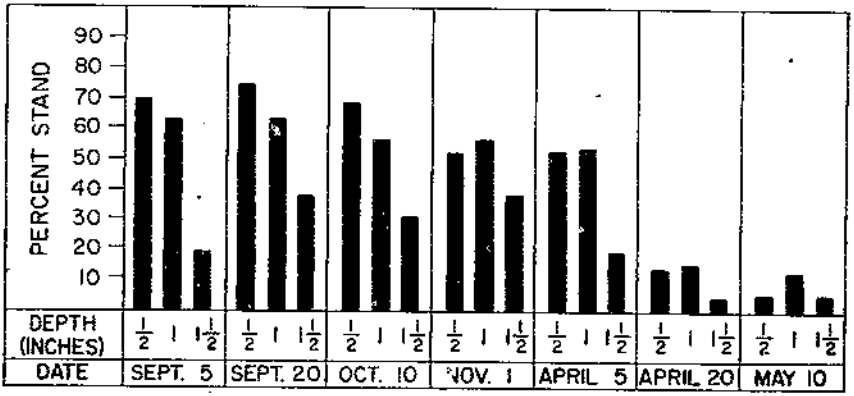

FIGURE 7.—Established stands of Russian wildrye grass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

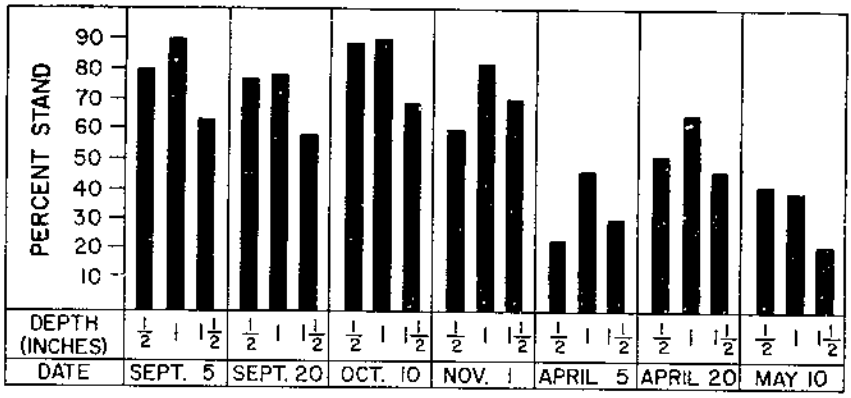

FIGURE 8.—Established stands of green needlegrass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

The best average stand of Russian wildrye—75 percent—was obtained from September 20 seedings at the ½-inch depth (fig. 7). September 5 and October 10 seedings at a depth of ½ inch also produced satisfactory stands—70 and 69 percent, respectively. Stands from all other seedings were less than 65 percent.

Green needlegrass showed the greatest adaptability of any of the cool-season grasses, producing satisfactory stands from 9 different combinations of seeding dates and depths (fig. 8). The best average stands—90 percent—were obtained from both the September 5 and October 10 seedings at a depth of 1 inch. All fall seedings at the 1-inch depth produced average stands of over 75 percent. The highest average stand from spring plantings was 65 percent, obtained from April 20 seedings at 1-inch depths. Stands from the other spring plantings were poor.

STAND ESTABLISHMENT WARM-SEASON GRASSES

Table 10 gives the 6-year average emergence and the average established stands, in percent, of the warm-season grasses. The April 20 and May 10 plantings generally produced better stands than later plantings, and seedings at ¼- and ½-inch depths produced better stands than deeper seedings.

Blue grama made average stands of 98 and 97 percent from May 10 seedings at depths of ¼ and ½ inch, respectively (fig. 9). These were the best. April 20 seedings at depths of ¼ and ½ inch produced stands of 95 percent and 82 percent, respectively. Results from June seedings were much poorer. The best—a 66-percent stand—came from the June 1 seedings at the ¼-inch depth. No satisfactory stands were obtained from the June 20 plantings. All seedings deeper than ½ inch resulted in decreased stands.

All side-oats grama seedings ¼ to ½ inch deep produced satisfactory stands (fig. 10). The best average stands were from April 20 seedings—98 percent from the ½-inch seeding depth and 97 percent from the ¼-inch depth. The May 10 seedings were almost as good, the ¼- and ½-inch seeding depths producing 90 and 93 percent stands,

TABLE 10.—*Average emergence and average established stands about a year later for warm-season grasses from various dates and depths of seeding, 1943–48*

Species	Seeding dates	Depths of seeding—							
		¼-inch		½-inch		¾-inch		1-inch	
		Emergence	Established stand	Emergence	Established stand	Emergence	Established stand	Emergence	Established stand
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Blue grama	April 20	60	95	61	82	44	65	33	34
	May 10	63	[1] 98	70	97	46	82	20	37
	June 1	36	66	45	62	18	29	2	8
	June 20	17	20	25	21	14	16	2	4
Side-oats grama	April 20	62	97	61	[1] 98	55	84	39	40
	May 10	60	90	70	93	55	76	48	67
	June 1	59	77	68	72	24	27	4	15
	June 20	42	84	44	88	23	61	11	28
Switchgrass	April 20	63	78	75	89	65	79	45	55
	May 10	79	86	85	[1] 92	89	[1] 92	65	83
	June 1	62	69	86	77	55	60	27	28
	June 20	13	8	22	18	21	11	1	3
Big bluestem	April 20	54	91	65	95	58	84	38	48
	May 10	64	95	70	[1] 97	91	96	46	82
	June 1	61	91	69	95	55	90	38	74
	June 20	12	46	31	56	38	54	12	30

[1] Best established stand for species.

respectively. The June seedings produced stands 10 to 20 percent less than earlier seedings. All seedings deeper than ½ inch resulted in decreased stands.

Switchgrass produced satisfactory stands from all May 10 seedings, but the best average stands—92 percent—were obtained from seedings

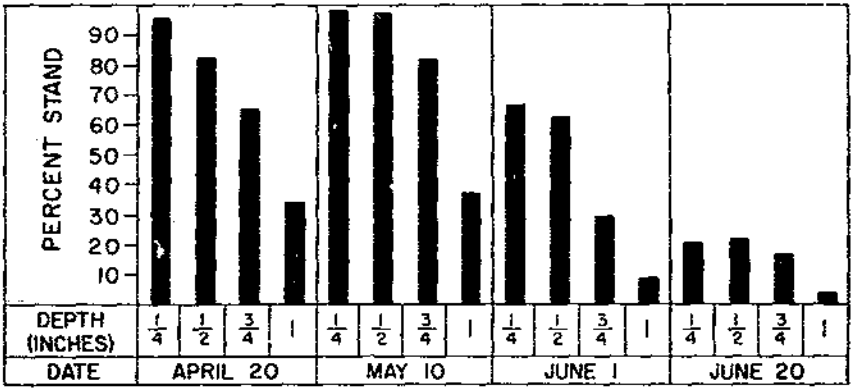

FIGURE 9.—Established stands of blue grama grass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

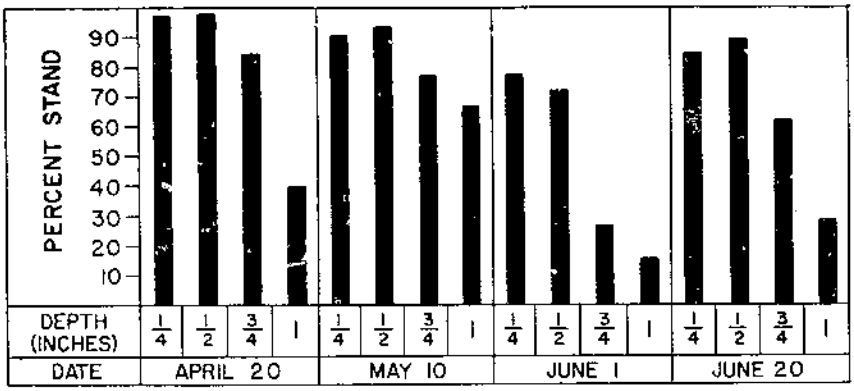

FIGURE 10.—Established stands of side-oats grama grass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

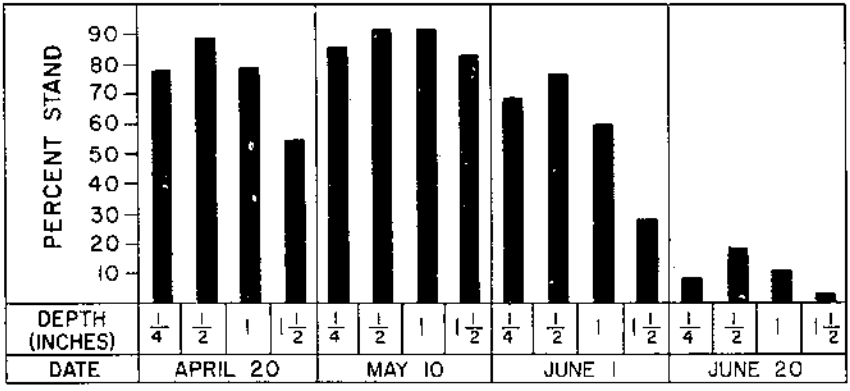

FIGURE 11.—Established stands of switchgrass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

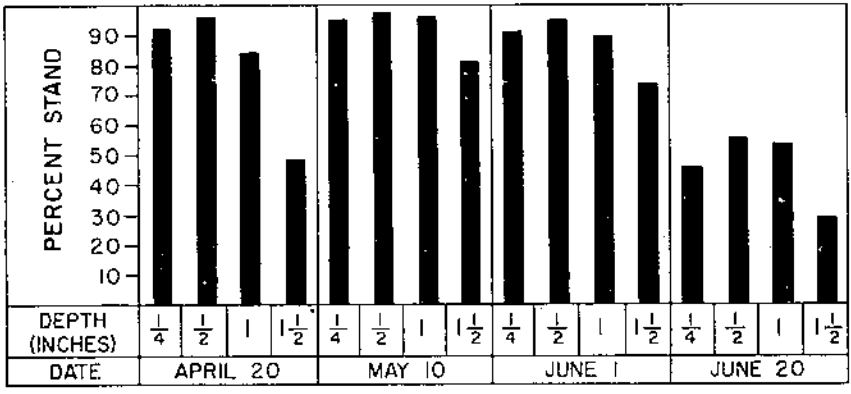

FIGURE 12.—Established stands of big bluestem grass from various dates and depths of seeding. Percent stands are averages of 6 years' results, 1943–48, Mandan, N. Dak.

at the ½- and ¾-inch depths (fig. 11). April 20 seedings from ¼ to 1 inch deep produced satisfactory stands. June 1 seedings produced stands of 69 and 77 percent from ¼- and ½-inch depths, respectively. Poor stands were obtained from all June 20 seedings.

Big bluestem produced excellent stands from April 20, May 10, and June 1 seedings at depths ranging from ¼ to 1 inch (fig. 12). The best—an average stand of 97 percent—came from May 10 seedings at ½-inch depth. Satisfactory stands were obtained from the May 10 and June 1 seedings at 1½-inch depth, but they were inferior to shallower seedings. No June 20 seedings produced satisfactory stands.

EFFECTS OF SEEDING RATES ON STAND ESTABLISHMENT AND FORAGE YIELDS OF GRASSES

Methods and Purpose

The rates of seeding necessary to produce grass stands that are satisfactory from the standpoints of ground cover and forage yield were studied, using 10 grass species. Seeding rates were 4, 8, and 12 pounds per acre for crested wheatgrass, green needlegrass, switchgrass, side-oats grama, and Russian wildrye; 5, 10, and 15 pounds per acre for blue grama, Canada wildrye, big bluestem, and smooth bromegrass; and 3, 9, and 15 pounds per acre for western wheatgrass. All seeding rates were on a basis of 85-percent-pure live seed. Seeding was done with a 6-foot single-disk grain drill on a well-prepared spring-plowed seedbed in 3 replications of a randomized block design, in plots 6 feet by 40 feet. Four seedings were made—in 1942, 1943, 1946, and 1947—all of them between April 5 and 25. It is recognized that spring is not the best time to seed cool-season grasses. Seeding of both the warm- and cool-season grasses at the same time was decided on for this test, however.

Data were obtained each year on the percent stands and forage yields. Stands were determined about May 25 each year. Second-year readings were considered to show established stands, since any

Table 11.—*Density of stands of grasses established from several seeding rates (averages of second-year readings for 4 plantings of each species and rate, 1942–47)*

Species	Stand at a seeding rate per acre of—							
	3 pounds	4 pounds	5 pounds	8 pounds	9 pounds	10 pounds	12 pounds	15 pounds
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Crested wheatgrass		40		75			82	
Russian wildrye		41		66			74	
Green needlegrass		52		82			90	
Switchgrass		90		96			98	
Side-oats grama		88		86			92	
Canada wildrye			80			86		93
Smooth bromegrass			99			99		100
Blue grama			93			93		90
Big bluestem			96			96		95
Western wheatgrass	60				81			85

future increase would likely be due to spreading from old plants rather than from the original seedings. Forage yields were obtained by harvesting a 3-foot strip from the center of each plot when the grasses were in the early flowering stage of growth. A small power mower was used. Samples were air-dried and weighed, and yields calculated in pounds per acre.

Forage Yields and Stand Establishments

From the standpoint of ground cover, the 4-pound-per-acre seeding rate did not produce satisfactory stands of crested wheatgrass, Russian wildrye, and green needlegrass (table 11). Otherwise, satisfactory stands of all species were obtained from each rate of seeding. The 3-pound-per-acre seeding rate of western wheatgrass, however, did not produce satisfactory stands until the third season. At that age, these stands had filled in and were equal to those from the heavier seeding rates. Switchgrass, side-oats grama, smooth bromegrass, blue grama, and big bluestem produced excellent stands from the medium seeding rates (8 to 10 pounds per acre).

Forage yields apparently were not directly dependent on the rates of seeding. Table 12 gives the average air-dry forage yields by species and seeding rates from the 1942 plantings. Yields from the other plantings were comparable. Because of their generally low production, Russian-wildrye and western wheatgrass plots were not harvested

Table 12.—*Average air-dry forage yields of grasses from different seeding rates planted*

Species	Seeding rate	Yields per acre					
		1943	1944	1945	1946	1947	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Crested wheatgrass	4	(1)	(1)	160	303	764	409
	8	(1)	(1)	210	308	1, 243	587
	12	(1)	(1)	308	353	846	516
Green needlegrass	4	223	619	613	349	1, 365	634
	8	516	893	563	289	1, 171	680
	12	507	1, 169	828	323	1, 239	813
Side-oats grama	4	623	1, 452	796	632	1, 153	932
	8	603	1, 299	732	550	899	817
	12	665	1, 166	615	462	901	762
Switchgrass	4	1, 638	1, 902	1, 728	935	1, 602	1, 451
	8	1, 309	1, 672	1, 602	864	1, 412	1, 372
	12	1, 335	1, 804	1, 588	884	1, 465	1, 415
Canada wildrye	5	1, 956	2, 575	1, 610	614	834	1, 518
	10	2, 207	2, 551	1, 522	449	879	1, 542
	15	2, 139	2, 661	1, 609	481	948	1, 568
Smooth bromegrass	5	736	1, 051	717	197	820	704
	10	706	744	616	131	877	614
	15	835	914	736	194	821	700
Blue grama	5	(1)	491	304	277	416	372
	10	(1)	624	331	267	471	423
	15	(1)	674	368	314	400	439
Big bluestem	5	1, 439	2, 071	1, 838	1, 160	1, 924	1, 686
	10	1, 648	1, 950	1, 787	1, 223	1, 687	1, 659
	15	1, 535	2, 266	1, 859	1, 268	2, 164	1, 818

[1] Not harvested.

TABLE 13.—*Air-dry forage yields per acre for 3 and 5 years of crested wheatgrass and green needlegrass from seedings made in 1942–47, at seeding rates of 4, 6, 8, and 12 pounds per acre*

Species and year	Yields per acre at seeding rates per acre of—				F value [1]	Least significant difference
	4 pounds	6 pounds	8 pounds	12 pounds		
	Pounds	*Pounds*	*Pounds*	*Pounds*		
Crested wheatgrass:						
1945	160	210	.....	350	[2] 16.93	94
1946	303	308	.....	353	.65	([3])
1947	764	1,243	.....	846	3.75	([3])
3-year average	409	587	.....	516	2.09	([3])
Green needlegrass:						
1943	223	.....	516	507	[4] 23.00	198
1944	619	.....	893	1,169	[2] 10.90	320
1945	613	.....	563	828	[2] 11.93	160
1946	340	.....	289	323	.17	([3])
1947	1,365	.....	1,171	1,239	.38	([3])
5-year average	634	.....	680	813	1.83	([3])

[1] See table 1, footnote 1.
[2] Significant at the 5-percent level.
[3] Not significant.
[4] Significant at the 1-percent level.

for forage yields except in 1947 and are not included in the table. Forage production was generally less from the lower than from the heavier seeding rates during the first year or two. The yield from the low seeding rates increased in later years, however, until it was about as much as, and in some cases greater than, yields from the more heavily seeded plots. Plots of several grasses seeded at low rates outyielded the more heavily seeded plots in every year except the first. Yields of crested wheatgrass and green needlegrass, however, were definitely better from seeding rates of 8 or 12 pounds per acre than from the 4-pound rate. Generally, the seeding rates of 8 or 10 pounds per acre produced satisfactory results with all species, both in stand establishment and forage yield. In no instance, with the possible exception of green needlegrass, did the heavier seeding rates—12 or 15 pounds per acre—increase stands or forage yields sufficiently to warrant their use.

Table 13 gives the yields of crested wheatgrass and green needlegrass from the different rates of seeding. Yields of the other species varied little with the different seeding rates.

TESTS OF MIXTURES OF GRASSES AND LEGUMES

METHODS AND PURPOSE

These tests were for determination of the forage yields of grasses in mixtures, the effect of legumes on yields of mixtures, and the persistence of various grasses when seeded in mixtures.

Several of the more important grasses of this area were seeded in mixtures with each other, and with alfalfa or sweetclover. Plantings

were made in 3 replications of a randomized block design, in plots 6 feet by 20 feet. Seeding was done with a hand drill in 6-inch rows, and seed composition of the mixtures was determined on a weight basis. Data were collected on stands, composition, and forage yields.

The first seeding of the grass mixtures was made in the spring of 1942. Warm-season grasses produced good stands from this seeding, but the cool-season grasses failed because of footrot disease. Cool-season grass mixtures were reseeded in 1944 with good results. Forage yields were determined by harvesting a 3-foot strip from the center of each plot with a small power mower. Harvested samples were air-dried and weighed, and yields computed in tons per acre.

Results—Cool-Season Grass Mixtures

Tables 14 and 15 give the air-dry forage yields and composition of the cool-season grass mixtures. It is apparent that the seeding of these grasses in mixtures had little or no effect on the yields.

Table 14.—*Forage yields per acre of cool-season grass mixtures and check plots of individual species seeded*

Species or mixture	1945	1946	1947	3-year average
	Tons	*Tons*	*Tons*	*Tons*
Intermediate wheatgrass (check)	0. 74	0. 39	1. 09	0. 74
Canada wildrye (check)	. 87	. 41	. 72	. 67
Crested wheatgrass and intermediate wheatgrass	. 57	. 43	. 85	. 62
Russian wildrye and intermediate wheatgrass	. 53	. 33	. 73	. 53
Crested wheatgrass, green needlegrass, Canada wildrye	. 26	. 33	. 76	. 45
Crested wheatgrass and green needlegrass	. 33	. 27	. 73	. 44
Russian wildrye, bromegrass, and Canada wildrye	. 49	. 23	. 56	. 43
Green needlegrass (check)	. 17	. 29	. 80	. 42
Crested and western wheatgrass and green needlegrass	. 24	. 33	. 69	. 42
Crested wheatgrass (standard) (check)	. 28	. 27	. 67	. 41
Smooth bromegrass (check)	. 43	. 28	. 52	. 41
Crested wheatgrass (fairway) (check)	. 34	. 31	. 56	. 40
Crested wheatgrass and Russian wildrye	. 18	. 22	. 57	. 32
Russian wildrye, western wheatgrass, and green needlegrass	. 17	. 18	. 51	. 29
Russian wildrye (check)	. 16	. 18	. 47	. 27
Least significant difference at 1-percent level	. 12	. 10	. 14	. 17
Least significant difference at 5-percent level	. 09	. 07	. 10	. 12

In 1945, for example, the check plots of crested wheatgrass (standard), green needlegrass, and Canada wildrye yielded 0.28, 0.17, and 0.87 ton per acre, respectively. In the same year, the mixture of these 3 species yielded 0.26 ton per acre. The composition of this mixture in 1945 was 45 percent crested wheatgrass, 47 percent green needlegrass, and 8 percent Canada wildrye. Calculating an expected yield from the mixture by using these percentages and the check-plot yields gives this result:

Crested wheatgrass—45 percent of 0.28 ton per acre =	0.1260
Green needlegrass—47 percent of 0.17 ton per acre =	.0799
Canada wildrye—8 percent of 0.87 ton per acre=	.0696
Total tons per acre	0.2755

The calculated yield of 0.2755 ton per acre is comparable to the actual yield of 0.26 ton per acre. The calculated and actual yields of this mixture in 1946 were 0.308 and 0.33 ton per acre, respectively, and in 1947, 0.7635 and 0.76 ton per acre. This would indicate that the yields of these individual species within a mixture are the same as they are in pure stands, and that yields of mixtures are directly related to their species composition.

TABLE 15.—*Composition of mixture and check plots of cool-season grasses seeded in 1944 and for 3 years thereafter*

Species or mixture	Seeded	1945	1946	1947
	Percent	*Percent*	*Percent*	*Percent*
Intermediate wheatgrass	100	100	100	100
Canada wildrye	100	100	100	100
Crested wheatgrass	50	35	27	20
Intermediate wheatgrass	50	65	73	80
Stiffhair wheatgrass	100	100	100	100
Russian wildrye	50	30	7	5
Intermediate wheatgrass	50	70	93	95
Crested wheatgrass	33	45	30	25
Green needlegrass	33	47	50	70
Canada wildrye	33	8	20	5
Crested wheatgrass	50	57	62	60
Green needlegrass	50	43	38	40
Russian wildrye	33	10	0	0
Smooth bromegrass	33	90	100	100
Canada wildrye	33	0	0	0
Green needlegrass	100	100	100	100
Crested wheatgrass	33	67	50	64
Western wheatgrass	33	8	10	6
Green needlegrass	33	27	40	30
Crested wheatgrass (standard)	100	100	100	100
Smooth bromegrass	100	100	100	100
Crested wheatgrass (fairway)	100	100	100	100
Crested wheatgrass	50	50	63	73
Russian wildrye	50	50	37	27
Russian wildrye	33	47	40	30
Western wheatgrass	33	15	0	0
Green needlegrass	33	38	60	70
Russian wildrye	100	100	100	100

FIGURE 13.—Three-year-old field of intermediate wheatgrass at the Mandan, N. Dak., Soil Conservation Service nursery. The grass was seeded with a 40-inch row spacing and cultivated to control weeds. A good seed crop is in prospect.

Intermediate wheatgrass (*Agropyron intermedium*) was the highest yielding cool-season grass in the check plots, and mixtures containing it were the highest yielding mixtures of cool-season grasses (fig. 13). Russian wildrye was the lowest yielding grass in check plots, and mixtures containing an appreciable percent of this grass were the lowest in yield.

Smooth bromegrass and intermediate wheatgrass tended to dominate mixtures in which they occurred, with bromegrass the more aggressive in this respect. Neither Canada wildrye nor western wheatgrass was very persistent in the mixtures used in these tests.

The best cool-season grass mixtures, from the standpoint of compatibility, were crested wheatgrass with green needlegrass, crested wheatgrass with Russian wildrye, and green needlegrass with Russian wildrye.

RESULTS—COOL SEASON GRASSES AND LEGUMES

Crested wheatgrass, Russian wildrye, and green needlegrass were the grasses and Ladak alfalfa and Madrid sweetclover the legumes. Tables 16 and 17 give the forage yields and composition of these mixtures. The addition of a legume, either sweetclover or alfalfa, increased the yield of mixtures in all cases. The mixture with a seeded composition of 90 percent crested wheatgrass and 10 percent alfalfa produced the highest forage yields. The lowest yields were obtained from a mixture of Russian wildrye and crested wheatgrass without a legume.

TABLE 16.—*Forage yields per acre of cool-season grass mixtures with and without legumes, seeded in 1944*

Species or mixture	1945	1946	1947	3-year average
	Tons	*Tons*	*Tons*	*Tons*
Crested wheatgrass and alfalfa	0. 55	0. 78	1. 94	1. 09
Alfalfa (check)	. 87	. 54	1. 78	1. 06
Crested wheatgrass, Russian wildrye, alfalfa	. 43	. 51	1. 44	. 79
Crested wheatgrass, green needlegrass, and sweetclover	. 78	. 64	1. 05	. 82
Russian wildrye and alfalfa	. 29	. 60	1. 32	. 74
Crested wheatgrass, Russian wildrye, and sweetclover	. 79	. 41	. 96	. 72
Crested wheatgrass and green needlegrass	. 33	. 27	. 73	. 44
Green needlegrass (check)	. 17	. 29	. 80	. 42
Crested wheatgrass (check)	. 30	. 27	. 67	. 41
Crested wheatgrass and Russian wildrye	. 18	. 22	. 57	. 32
Russian wildrye (check)	. 17	. 18	. 51	. 29
Least significant difference at 1-percent level	. 11	. 22	. 43	. 16
Least significant difference at 5-percent level	. 08	. 16	. 32	. 12

TABLE 17.—*Composition of cool-season grass mixtures with and without legumes at seeding in 1944 and for 3 years thereafter*

Species or mixture	Seeded	1945	1946	1947
	Percent	*Percent*	*Percent*	*Percent*
Crested wheatgrass	90	65	30	50
Alfalfa	10	35	70	50
Alfalfa	100	100	100	100
Crested wheatgrass	45	50	35	47
Russian wildrye	45	23	15	5
Alfalfa	10	27	50	48
Crested wheatgrass	45	23	72	78
Green needlegrass	45	18	28	22
Sweetclover	10	59	0	0
Russian wildrye	90	76	33	70
Alfalfa	10	24	67	30
Crested wheatgrass	45	20	71	78
Russian wildrye	45	15	29	22
Sweetclover	10	65	0	0
Crested wheatgrass	50	57	62	60
Green needlegrass	50	43	38	40
Green needlegrass	100	100	100	100
Crested wheatgrass	100	100	100	100
Crested wheatgrass	50	50	63	73
Russian wildrye	50	50	37	27
Russian wildrye	100	100	100	100

TABLE 18.—*Forage yields per acre of warm-season grass mixtures and check plots seeded in 1942*

Species and composition	1943	1944	1945	1946	1947	5-year average
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Big bluestem, 75 percent; alfalfa, 25 percent	1. 53	2. 46	1. 20	0. 67	2. 21	1. 61
Switchgrass, 75 percent; alfalfa, 25 percent	1. 40	2. 35	1. 51	1. 00	2. 40	1. 53
Side-oats grama and alfalfa, alternate rows	1. 25	1. 83	1. 64	. 91	2. 03	1. 53
Switchgrass and alfalfa, alternate rows	1. 06	1. 90	1. 21	. 71	2. 06	1. 39
Big bluestem, check	. 69	1. 40	1. 01	. 58	1. 40	1. 02
Switchgrass, 75 percent; big bluestem, 25 percent	. 80	1. 26	1. 06	. 64	1. 29	1. 01
Switchgrass and big bluestem, alternate rows	. 62	1. 18	. 87	. 52	1. 72	. 98
Switchgrass, 25 percent; big bluestem, 75 percent	. 69	1. 19	. 99	. 65	1. 14	. 93
Switchgrass, check	. 65	1. 03	. 94	. 52	. 84	. 80
Big bluestem, 50 percent; side-oats grama, 50 percent	. 34	1. 13	. 73	. 47	. 97	. 75
Switchgrass, 50 percent; side-oats grama, 50 percent	. 43	1. 03	. 78	. 50	. 77	. 70
Side-oats grama, check	. 25	. 70	. 53	. 36	. 62	. 49
Least significant difference at 1-percent level	. 23	. 31	. 30	. 15	. 32	. 21
Least significant difference at 5-percent level	. 17	. 23	. 22	. 11	. 23	. 16

Two mixtures of grasses and Madrid sweetclover were seeded: crested wheatgrass, Russian wildrye, and sweetclover; and crested wheatgrass, green needlegrass, and sweetclover. Also seeded were the same grasses in mixtures without sweetclover—crested wheatgrass with Russian wildrye, and crested wheatgrass with green needlegrass. These mixtures were planted in 1944 and first harvested in 1945. None of the sweetclover volunteered, so there were no sweetclover plants in any of the plots after 1945. In 1946 and 1947, the composition of the mixtures on the plots that originally contained sweetclover was practically the same as the composition on the plots seeded to grasses only.

In 1945, when sweetclover made up 59 percent of the composition of the mixture of crested wheatgrass, green needlegrass, and sweetclover, the yield was 0.78 ton per acre; from the mixture of the 2 grasses without clover, the yield was 0.33 ton per acre. In 1946, the yields from the mixtures originally with and without clover were 0.64 and 0.27 ton per acre, respectively, and in 1947 they were 1.05 and 0.73 tons per acre. Since there was no sweetclover in the mixture during the last 2 years, it is apparent that the fixation of nitrogen by the sweetclover during the first 2 years served to increase the yield of the grasses in the later years.

This same effect was noticeable on the plots seeded to mixtures of crested wheatgrass and Russian wildrye, both with and without sweetclover. Although Russian wildrye was consistently low in forage

yields throughout these tests, it should not be underrated because of its showing here. It is primarily a pasture grass that produces most of its leaves at the base of the plants. Accurate information on its forage-producing capacity was not obtained with the harvesting methods used in this study.

Results—Warm-Season Grasses With and Without Legumes

Tables 18 and 19 give the forage yields and composition of these mixtures. As in the case of the cool-season grasses, mixtures had little or no effect on the yield of the individual species within the mixtures. Yields from mixtures of warm-season grasses with alfalfa were generally higher than from mixtures of grasses alone. The highest average yield—1.61 tons per acre—was obtained from a mixture of 75 percent big bluestem and 25 percent alfalfa. The highest average yield from a mixture not containing a legume was 1.01 tons per acre. This was produced by a mixture of 75 percent switchgrass and 25 percent big bluestem. Of the 3 grasses used in the study, big

Table 19.—*Composition of warm-season grass mixtures at seeding in 1942 and for 5 years thereafter*

Species or mixture	Seeded	1943	1944	1945	1946	1947
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Big bluestem	75	47	70	37	32	27
Alfalfa	25	53	30	63	78	73
Switchgrass	75	16	60	50	45	40
Alfalfa	25	84	40	50	55	60
Side-oats grama	(1)	53	50	50	50	50
Alfalfa	(1)	47	50	50	50	50
Switchgrass	(1)	55	50	50	50	50
Alfalfa	(1)	45	50	50	50	50
Big bluestem	100	100	100	100	100	100
Switchgrass	75	78	78	64	68	70
Big bluestem	25	22	22	36	32	30
Switchgrass	(1)	51	50	50	50	50
Big bluestem	(1)	49	50	50	50	50
Switchgrass	25	50	12	18	18	20
Big bluestem	75	50	88	82	82	80
Switchgrass	100	100	100	100	100	100
Big bluestem	50	47	37	43	40	39
Side-oats grama	50	53	63	57	60	61
Switchgrass	50	63	52	39	45	50
Side-oats grama	50	37	48	61	55	50
Side-oats grama	100	100	100	100	100	100

[1] Alternate rows.

bluestem produced the highest average yield in check plots—1.02 tons per acre. The average yield from check plots of switchgrass and side-oats grama were 0.80 and 0.49 ton per acre, respectively.

Several of the mixtures were made with each species seeded in alternate rows. This had little or no effect on the forage yields, but these seedings maintained their original composition better than when the grasses were mixed in each row.

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