FIELD PERFORMANCE OF SMOOTH BROMEGRASS (*BROMUS INERMIS* LEYSS.) STRAINS FROM DIFFERENT REGIONAL SOURCES

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INTRODUCTION

Smooth bromegrass (Bromus inermis Leyss.) is a long-lived, perennial sod forming grass with strong creeping rhizomes. It is also known as awnless bromegrass, Hungarian bromegrass, Russian bromegrass, and bromegrass. A native of Europe, Siberia, and China, it was first introduced into the United States in 1884 and since that time has become the foremost hay and pasture grass over a wide area of the United States and Canada. It is best adapted to regions of moderate rainfall and low to moderate temperatures; however, it withstands periods of extended drought. It requires a soil of moderate to high fertility and soon becomes "sod-bound" when the supply of available nitrogen has been exhausted. Because of this characteristic, it is usually planted with alfalfa or ladino clover which helps to furnish it with a needed nitrogen supply. Smooth bromegrass becomes a cool season grass when its region is extended southward. It becomes dormant under the climatic conditions of Oklahoma during the hot, dry months of July, August, and September.

Hoover, Hein, Daxton, and Erlanson (7)[1] point out that two distinct types of smooth bromegrass, differing in growth behavior, are generally recognized. These two types are referred to as the "southern type" and the "northern type." The "southern type" originated in central Europe and is best adapted to the Corn Belt states and the Central Great Plains. The "northern type" originated in Siberia and is grown widely in the Northern Great Plains and Western Canada.

The region of smooth bromegrass production is moving steadily southward and considerable attention has been directed to the apparent superiority of smooth bromegrass strains from southern seed sources.

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[1] Figures in parenthesis refer to "Literature Cited," p. 36.

In 1935 a field was seeded to smooth bromegrass on the Oklahoma Agricultural Experiment Station Agronomy Farm at Stillwater, Oklahoma. It is believed that the seed used in establishing this field was Kansas commercial seed. From this planting several strains have been developed which have attracted attention of plant breeders in Oklahoma and neighboring states.

This study was undertaken to compare the field performance of four of these Oklahoma strains with other southern strains from different regional seed sources and to study the adaptability of both "southern" and "northern" types to climatic conditions prevailing in Oklahoma.

REVIEW OF LITERATURE

Experiments have been conducted in several states to test the adaptability and productivity of "southern" and "northern" types of smooth bromegrass. Other states are in the process of testing bromegrass strains but have not published their findings.

Newell and Keim (9) studied several bromegrass strains from northern and southern seed sources at Lincoln, Nebraska and found strains from southern seed sources to be much more productive in forage yields than strains from northern seed sources. The strains of the southern type produced more vigorous seedlings during the short days of fall and early spring and were more tolerant of heat and drought conditions. The vegetative vigor and rapid growth of the southern strains in the early spring was an indication that these strains were earlier than those of northern origin. Additional evidence of the superior adaptation and forage productivity of the southern type in the states of Kansas, Iowa, and Missouri has been reported by Anderson (1, 2); Wilsie (12); Wilsie, Peterson and Hughes (13); and Brown (3). Fuelleman, Burlison and Kammlade (6) in reporting on preliminary tests conducted in Illinois indicate that southern types of bromegrass produced more forage than the northern types, especially in southern Illinois. Similar results were reported by Thomas and McPherron (11) in Minnesota. They state that, "Southern bromes are clearly superior in the southern part of Minnesota and appear to be as good in the northern part." Lincoln and Achenbach strains gave the highest forage yields in the state as a whole in the Minnesota experiments. In Michigan, Churchill (4) found the advantages of southern strains to be less evident, especially when grown with alfalfa. The Achenbach strain produced the highest total yield of dry hay per acre but did not produce as much protein per acre as some of the northern strains. In Western Canada, Knowles and White (8) conducted several experiments and found the forage production of southern strains to be similar to that of northern strains when planted in pure stands and with alfalfa.

In most cases the primary emphasis in bromegrass strain testing has been placed on the establishment of a good stand and the production of forage for pasture or hay. Only a few of the states have reported seed yields. It is generally found that strains of the northern type are more productive in seed yields and that the seed are heavier and less chaffy than seed of the southern type strains. Newell and Keim (9) report that the southern strains gave their highest seed yields in the second year and outyielded the northern strains; however, in the third year the northern strains outyielded the southern strains. In Minnesota, Thomas and McPherron (11) tested seed production of four strains of bromegrass at six locations with varying number of years from one to four using Fischer as the southern strain in these tests. Canada Commercial was the highest yielding strain and Fischer was the lowest with the Martin strain being intermediate. In Western Canada, Knowles and White (8) found that seed production of southern strains at three stations was inferior to that of northern commercial bromegrass. The yield of Achenbach and Lincoln was about one-half that of northern commercial bromegrass.

Chemical analyses of bromegrass have indicated that it has a high protein and mineral content. In Illinois, Fuelleman and Burlison (5) ran tests on the chemical composition of forage samples from bromegrass pastures over a three year period. The average protein content was 13.42% with a range of 7.16% to 20.89%. The calcium content averaged 0.391% with a range of 0.236% to 0.476%. The phosphorus content averaged 0.235% with a range of 0.170% to 0.355%.

Disease has not been a serious problem in bromegrass production in the

United States; however, during periods of high rainfall there are two diseases which sometimes cause leaf deterioration. These diseases are commonly known as brown-spot caused by Pyrenophora bromi Died., and leaf-blotch caused by Selenophoma bromigena (Sacc.) Sprague and A. G. Johnson. Knowles and White (8) reported a somewhat serious infection of leaf-blotch in 1945 and rated both northern and southern strains according to the amount of leaf damage caused by the disease. According to their rating all strains of the southern type tested were significantly higher in resistance to leaf-blotch than a northern commercial strain used for comparison. No significant difference in resistance to leaf-blotch could be found between strains within either type.

A study of morphological and physiological differences between strains of the "northern type" and "southern type" by Newell and Keim (9) indicated that the two types were derived from different parental material. The physical appearance of southern strains was distinctly different from that of the northern strains. Panicle development of the southern strains preceded that of the northern strains by several days; however, the maturity dates of the two types did not vary appreciably. Knowles and White (8) found that the most striking difference between the two types as observed in Western Canada was in the nature of the leaf. Leaves of the southern type were wider, coarser, and were borne at a lower level on the culms than those of the northern type. Panicles of the southern type were generally more contracted and the seed appeared to be more chaffy than the northern type; however, they did not find any differences in the bushel test weight or weight per thousand seed between the two types. Observations of rhizome development did not reflect any significant difference between Achenbach and a northern commercial variety. The southern strains were found to be a few days later in flowering at Canadian latitudes which is in contrast to the results observed in experiments conducted in Nebraska.

MATERIALS AND METHODS

This study was conducted from October 1948 to July 1950 on the Oklahoma Agricultural Experiment Station Agronomy Farm at Stillwater, Oklahoma. Seed of the various strains of bromegrass was submitted for testing by the Experiment Stations of the states included in the study. Commercial seed was obtained from a seed firm in Enid, Oklahoma. One lot of seed was designated as commercial seed from Ohio; and the other, commercial seed from Kansas. The identification of bromegrass strains is given in Table 1.

All of the strains were planted October 7, 1948 on a comparatively uniform soil that is transitional between typical Kirkland silt loam and typical Renfro very fine sandy loam. A crop of Austrian Winter peas had been turned under during the previous spring. Immediately before planting the bromegrass the entire area was fertilized with 20% Superphosphate drilled at the rate of 150 pounds per acre. The design used for the experiment was randomized blocks with four replications (Table 2). The strains were randomized within each of the replications. Plantings were made in 5-row plots, 36 feet long with the rows 12 inches apart. The seed was planted with a Columbia drill which had the seed box replaced with a funnel. One man pushed the planter while another dropped the seed through the funnel as uniformly as possible. The seeding rate was heavy enough to insure a good stand with the provision that all strains would be thinned to a 6-inch spacing during the spring of 1949. A border of five rows was planted around the entire experimental area.

The fall of 1948 was unusually dry (Table 3) and the available moisture was soon exhausted by the prevailing hot, dry winds. To prevent a possible delay in getting the experiment started, the plots were irrigated by sprinklers to insure germination of the seed. Three sprinklings were made about one week apart before weather conditions were such that no further watering was necessary.

Table 1. Seed source and identification of smooth bromegrass strains.

Plot No.	Seed Source	Identification of Strain
1	Oklahoma	Oklahoma 79
2	Missouri	Elsberry
3	Colorado	Sandburg
4	Ohio	Commercial Seed
5	Minnesota	Martin
6	Iowa	Fischer
7	North Dakota	North Dakota 404
8	Oklahoma	Oklahoma No. 1
9	Oklahoma	Oklahoma 1936
10	Nebraska	Nebraska 36
11	Nebraska	Lincoln
12	Oklahoma	Oklahoma Synthetic
13	Kansas	Achenbach
14	Nebraska	Nebraska 44
15	Kansas	Commercial Seed

Table 2. Planting plan — randomized blocks with four replications.

Replication 2	Replication 1
7. North Dakota 404	12. Oklahoma Synthetic
15. Commercial (Kansas)	1. Oklahoma 79
4. Commercial (Ohio)	3. Sandburg
14. Nebraska 44	13. Achenbach
2. Elsberry	5. Martin
12. Oklahoma Synthetic	9. Oklahoma 1936
9. Oklahoma 1936	10. Nebraska 36
1. Oklahoma 79	6. Fischer
8. Oklahoma No. 1	14. Nebraska 44
13. Achenbach	11. Lincoln
11. Lincoln	2. Elsberry
3. Sandburg	8. Oklahoma No. 1
5. Martin	7. North Dakota 404
6. Fischer	4. Commercial (Ohio)
10. Nebraska 36	15. Commercial (Kansas)
Replication 4	**Replication 3**
14. Nebraska 44	1. Oklahoma 79
3. Sandburg	4. Commercial (Ohio)
2. Elsberry	3. Sandburg
1. Oklahoma 79	7. North Dakota 404
12. Oklahoma Synthetic	6. Fischer
4. Commercial (Ohio)	12. Oklahoma Synthetic
13. Achenbach	5. Martin
9. Oklahoma 1936	8. Oklahoma No. 1
5. Martin	11. Lincoln
8. Oklahoma No. 1	13. Achenbach
11. Lincoln	14. Nebraska 44
6. Fischer	10. Nebraska 36
7. North Dakota 404	15. Commercial (Kansas)
15. Commercial (Kansas)	2. Elsberry
10. Nebraska 36	9. Oklahoma 1936

Figure 1.--Plot arrangement of smooth bromegrass strains in the field. Clipped for forage yields (Right). Clipped for seed yields (Center). Photographed June 29, 1950.

Observations were made at intervals throughout the fall and winter months as to the seedling vigor of the different strains. They were rated on a comparative basis and the ratings are recorded in Table 14.

On March 15, 1949 all plots were thinned to 6-inch spacings within the rows with an ordinary hoe.

Forage yields were taken for the first time on May 6, 1949. Sixteen feet of the center three rows were clipped with a push type lawn mower. The clippings were placed in paper bags, weighed, and placed in an oven for drying. Subsequent clippings were made on May 23, June 10, and June 17, 1949. Each of the strains failed to recover after the June 17 clipping and remained in a dormant state until fall.

Seed yields were taken from sixteen feet of the three center rows of each plot. Each plot was harvested as it reached maturity. The dates of maturity ranged from July 1 for the earliest strains to July 14 for the later ones. The plots were cut and threshed by hand. The seed was cleaned with sieves and weights were taken. Yields of seed in pounds per acre were computed from these weights. Test weights of the seed were not taken in 1949 due to low yields of several of the strains.

An unidentified bacterial disease started in several plots during the cool, wet days of late May, 1949, and soon spread to all plots. Observations of the damage sustained by each strain were made on June 17 and the extent of damage was given a numerical rating (Table 14).

Two clippings were made in the fall of 1949: One on October 1 and the other on November 19. The grass did not make enough growth to clip again until the spring of 1950.

On February 24, 1950, ammonimum nitrate (32% nitrogen) was applied to all plots at the rate of 110 pounds per acre. All strains were putting out new shoots at this time. The spring of 1950 was dry (Table 5), and none of the strains made sufficient growth to clip until May 16. Another clipping was made on June 10. Clippings were made by a power mower which was set about $2\frac{1}{2}$ inches above the crowns to prevent injury to the plants.

A composite, oven-dry sample of all strains was taken after each clipping for chemical analysis. The chemical analyses were made under the direction of Mr. W. Elmo Baumann[2] in the State Soil Conservation Soil Testing Laboratory.

Due to the unfavorable climatic conditions all strains made rapid panicle development and all strains were matured and ready for harvest by June 30, 1950. The plots were cut and threshed by hand. The seed was cleaned by sieves and a seed blower. The test weight was taken on the seed of each strain and is recorded in Table 10.

Analysis of variance has been calculated for the data obtained in this experiment. Statistical procedures, as outlined by Snedecor (10), were followed. Due to unequal moisture conditions prevailing in the clipped portion of Replication 3, the forage yields of this replication were not used in computing average forage yields or in the analysis of variance found in Tables 6, 7, 8, and 9.

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[2] Soils Laboratory Technician (U.S.D.A.)

Table 3

WEATHER DATA 1948
Stillwater, Oklahoma (U.S. Weather Bureau)
Elevation 880

Month	Temperature: Mean T	Dep. from normal	High	Date	Low T	Date	No. of days: Max. 90° or above	Min. 32° or below	Precipitation: Total	Dep. from normal	High	Date	Snow, sleet, hail: Total	Max. depth on ground	Date	Days of .01" or more
January	32.6	-4.3	69	8	3	28	—	—	0.45	-0.68	0.40	1	4.5	—	—	2
February	37.8	-2.2	76	17	12	9	—	—	1.83	0.56	0.80	5	10.0	—	—	10
March	45.3	-4.9	81	20	- 5	12	—	—	4.15	1.96	1.36	1	14.5	—	—	8
April	66.4	6.6	90	6	33	1	—	—	2.61	-1.20	2.20	25	0.0	—	—	5
May	68.1	0.2	92	22	41	7	4	—	2.65	-2.12	1.08	10	0.0	—	—	9
June	77.3	0.4	100	19	57	2	18	—	7.84	3.75	1.85	23	0.0	—	—	14
July	79.9	-1.5	96	28	62	31	17	0	4.83	2.15	1.15	8	0.0	—	—	13
August	78.7	-2.6	100	21	58	5	17	0	3.55	0.32	.85	8	0.0	—	—	14
September	74.3	0.8	99	7	47	27	18	0	0.61	-2.91	.60	24	0.0	—	—	2
October	61.0	-0.8	90	14	28	18	1	1	0.41	-2.57	.16	21	0.0	—	—	4
November	48.0	-1.2	82	1	22	29	0	12	2.48	0.25	1.70	28	T	—	19	4
December	41.5	2.7	81	14	14	30	0	22	0.23	-1.22	.11	2	0.0	—	—	5

Table 4

WEATHER DATA 1949
Stillwater, Oklahoma (U.S. Weather Bureau)
Elevation 880

Month	Temperature: Mean T	Dep. from normal	High	Date	Low T	Date	No. of days: Max. 90° or above	Min. 32° or below	Precipitation: Total	Dep. from normal	High	Date	Snow, sleet, hail: Total	Max. depth on ground	Date	Days of .01" or more
January	28.8	-8.1	68	3	-9	30	0	29	5.56	4.43	—	—	13.3	6	28	—
February	38.0	-2.0	71	20	8	1	0	23	0.97	-0.30	0.44	15	0.7	1	14	6
March	47.7	-2.5	78	29	23	16	0	10	1.34	-0.85	0.62	26	T	—	—	6
April	58.4	-1.4	90	24	32	2	2	2	1.27	-2.54	0.96	27	1.8	—	—	4
May	70.1	2.2	88	24	49	11	0	0	7.31	2.54	1.93	19	T	—	—	13
June	78.0	1.1	97	22	60	15	13	0	1.75	-2.34	0.49	3	0.0	—	—	12
July	82.2	0.8	102	20	65	17	22	0	2.47	-0.21	1.55	9	0.0	—	—	6
August	78.6	-2.7	99	13	52	22	22	0	1.04	-2.19	0.33	14	0.0	—	—	9
September	68.0	-5.5	95	13	38	29	4	0	4.50	0.98	1.73	4	0.0	—	—	12
October	62.0	0.2	88	7	28	31	0	1	2.60	-0.38	0.88	21	0.0	—	—	12
November	53.3	4.1	82	11	23	22	0	8	0.00	-2.23	0.00	—	0.0	—	—	0
December	40.9	2.1	69	20	16	13	0	22	1.43	-0.02	1.23	21	T	—	—	4

Table 5

WEATHER DATA 1950
Stillwater, Oklahoma (U.S. Weather Bureau)
Elevation 880

Month	Temperature								Precipitation							
	Mean T	Dep. from normal	High	Date	Low T	Date	No. of days: Max. 90° or above	No. of days: Min. 32° or below	Total	Dep. from normal	High	Date	Snow, sleet, hail: Total	Snow, sleet, hail: Max. depth on ground	Snow, sleet, hail: Date	Days of .01" or more
January	35.6	-1.3	81	25	6	4	0	24	0.84	-0.29	0.40	5	1.0	1	5	3
February	41.8	1.8	75	26	14	1	0	20	1.02	-0.25	0.50	28	0.0	—	—	3
March	45.8	-4.4	85	26	14	13	0	17	0.37	-1.82	0.19	15	0.2	T	3	4
April	59.4	-0.4	87	22	30	13	0	3	1.32	-2.49	1.13	3	T	—	—	6
May	69.0	1.1	96	3	47	12	2	0	4.89	0.12	1.28	26	0.0	—	—	11
June	—	—	99	26	48	4	16	0	2.23	-1.86	1.21	3	0.0	—	—	4

EXPERIMENTAL RESULTS AND DISCUSSION

During the fall of 1948 and early spring of 1949, rather striking differences in seedling vigor were observed between the bromegrass strains. The difference between strains of a particular group was not as apparent as the difference between northern and southern types. In spite of the excellent seed quality, the northern strains produced extremely weak seedlings and some transplanting was necessary in order to bring one of these strains to a full stand. The commercial strain from Ohio and the North Dakota 404 strain were the least vigorous in the seedling stage. Practically no thinning was required for standardizing these two strains to a six-inch stand. All southern strains required thinning and exhibited varying degrees of seedling vigor. Each strain is given a rating for seedling vigor in Table 14. The Oklahoma No. 1 strain was somewhat outstanding in seedling vigor and was rated above all the other strains in this respect. Oklahoma Synthetic was rated second.

Forage yields were secured by clipping at approximately two week intervals during the growing season in order to measure the production of the strains on a basis comparable to pasturing conditions. All strains had made sufficient growth to be clipped by May 5, 1949 when the first yields were taken. Three subsequent clippings were made on May 23, June 10 and June 17 respectively. All strains became dormant after the June 17 clipping due to hot, dry weather. The forage yields of the northern strains were significantly lower on the average than were the southern strains during the early part of the 1949 season. The difference was less apparent as the season progressed and the average yield of the northern strains from the June 17 clipping was higher than the average of the southern strains for this clipping. This is in keeping with the tendency toward lateness of

Figure 2.--Variations in seedling vigor of four smooth bromegrass strains. A. Oklahoma Synthetic. B. Martin. C. Oklahoma No. 1. D. Lincoln. Photographed March 23, 1949.

the northern strains. The total forage yields for 1949 are given in Table 6 and the analysis of variance in Table 7. Due to a high variability between all strains and between plots within the replications, no significance can be ascribed to differences between strains within either type. The difference of 613 pounds between the average yields of northern and southern strains is highly significant.

During September 1949 the rainfall at Stillwater was 4.5 inches which is slightly above normal for that month. Temperatures were likewise below normal and all strains had made enough growth to be clipped by October 1. Rainfall in October was slightly below normal and was limited in the main to a series of small showers which contributed very little to the available moisture supply for plant growth. No rain fell during the month of November 1949. Another clipping was made on November 19; however, the yield was about half that of the October clipping. The average yields of green forage for the fall season are given in Table 6. Since the fall and subsequent spring seasons are considered somewhat continuous in Oklahoma for cool season grasses, it seemed advisable to treat them as one season in analyzing the forage data. For this reason analysis of variance was not computed on the fall clipping data alone. Some thinning of the northern strains due to the summer heat and drought occurred during the summer of 1949. It was more pronounced in the section of the plots from which seed yields were taken than from the section cut for testing forage production. Rainfall during the winter of 1949 and early spring of 1950 was below normal; however, the temperature in February was slightly above normal, and all bromegrass strains began to show some growth. In anticipation of a normal season with ample moisture during the months of March, April, and May, it seemed advisable to apply a nitrogen fertilizer to the bromegrass strains to restore the nitrogen supply used in

Table 6. Forage yields of bromegrass strains from different regional seed sources — (Average of three replications).

Strain No.	Source or name	Yields per acre in lbs of green forage				
		Spring 1949	Fall 1949	Spring 1950	Total Fall 1949 Spring 1950	Grand Total
		Northern strains				
3	Sandburg	3,376	1,621	2,064	3,685	7,061
4	Ohio (Commercial seed)	3,820	1,886	1,529	3,415	7,235
5	Martin	4,119	1,950	2,042	3,992	8,111
7	North Dakota 404	4,015	1,362	1,626	2,988	7,003
	Average	3,833	1,705	1,815	3,520	7,353
		Southern strains (Oklahoma)				
1	Oklahoma 79	4,151	1,907	3,260	5,167	9,318
8	Oklahoma No. 1	4,940	1,823	2,989	4,812	9,752
9	Oklahoma 1936	4,560	1,942	2,979	4,921	9,481
12	Oklahoma synthetic	4,199	1,661	3,028	4,689	8,888
	Average	4,463	1,833	3,064	4,897	9,360
		Southern strains (Other)				
10	Nebraska 36	4,458	2,050	2,785	4,835	9,293
11	Lincoln	4,592	1,696	2,335	4,031	8,623
14	Nebraska 44	3,717	1,547	1,878	3,425	7,142
13	Achenbach	4,495	1,964	3,102	5,066	9,561
15	Kansas (Commercial seed)	5,021	1,834	3,162	4,996	10,017
2	Elsberry	4,475	1,892	1,973	3,865	8,340
6	Fischer	4,298	2,241	2,547	4,788	9,086
	Average	4,446	1,869	2,726	4,600	9,046
	Grand mean	4,282	1,825	2,487	4,312	8,594

Table 7. Analysis of variance of the spring 1949 bromegrass forage yields.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Total	44	5,379,153.8	—	—
Replications	2	369,152.1	184,576.0	—
Strains	14	2,058,113.4	147,008.1	1.39
Northern strains vs. southern strains	(1)	828,531.8	828,531.8	7.86**
Oklahoma strains vs. Achenbach	(1)	640.3	640.3	0.006
Other comparisons	(12)	1,228,941.3	102,411.8	0.97
Error	28	2,951,888.3	105,424.6	—

** Significant at the 1% level.

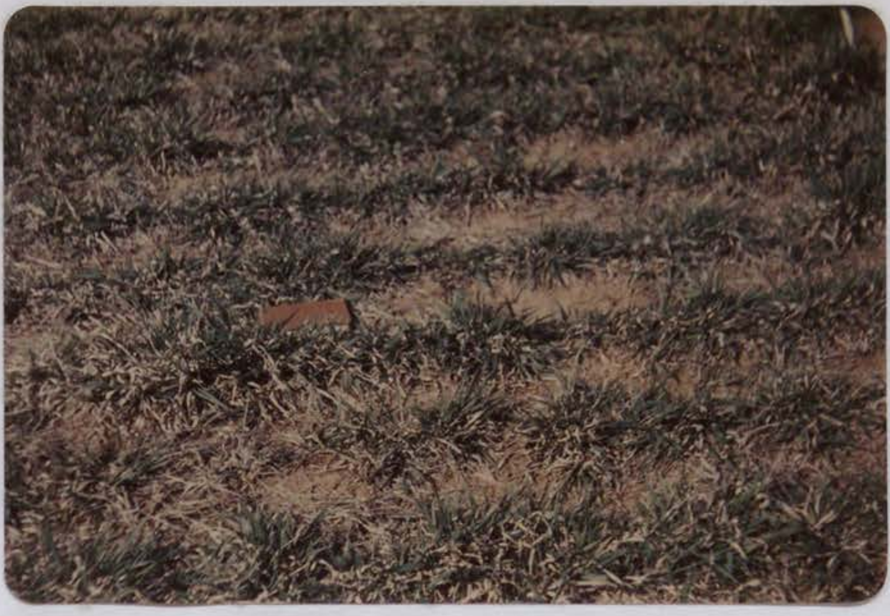

Figure 3.--A typical southern smooth bromegrass strain showing density of stand second year. Photographed March 24, 1950.

Figure 4.--A typical northern smooth brome strain showing density of stand second year. Photographed March 24, 1950.

making the 1949 growth. On February 24, an application of ammonimum nitrate (32% nitrogen) was made on all plots at the rate of 110 pounds per acre. In contrast to expectation, the spring months were unusually dry and cold and growth of the bromegrass strains was almost negligible until early May. Rainfall in May was approximately normal and all strains were ready for clipping on May 16. The tendency toward lateness was not so apparent in the northern strains during this season. All strains were making considerable panicle development at the time of the first clipping. After recovering from clipping all strains attempted to make a seed crop and much of the yield of the second and final clipping was due to culm and panicle formation. It could not be determined whether the application of ammonimum nitrate had invluenced the yield of forage. It may have been a contributing factor in retarding the growth of forage during the period of low available moisture. The final clipping was made on June 10. Soil moisture was too low to support further growth and all strains became dormant. Average forage yields for the 1950 spring season are recorded in Table 6. Analysis of variance was computed on the combined fall and spring data and may be found in Table 8. The F value for strains was significant at the 1% level of probability. The difference between the averages of the two types was highly significant at the 1% level with the southern strains giving the higher yield. There was no significant difference between the average of the Oklahoma strains and the Achenbach strain. Analysis of variance for the total forage yields for 1949 and 1950 is given in Table 9. Based on this experiment significant differences exist between the forage yields of the strains tested. The greatest difference was found to be between strains classed as "northern type" and those classed as "southern type."

Seed yields in 1949 showed a trend similar to those of forage yields

Table 8. Analysis of variance of the fall 1949 and spring 1950 bromegrass forage yields.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Total	44	16,290,910.0	—	—
Replications	2	7,416,587.8	3,708,293.9	—
Strains	14	5,368,554.6	383,468.2	3.06**
Northern strains vs. southern strains	(1)	2,566,224.0	2,566,224.0	20.50**
Oklahoma strains vs. Achenbach	(1)	17,136.6	17,136.6	0.16
Other comparisons	(12)	2,785,194.0	232,099.5	1.85
Error	28	3,505,767.6	125,205.9	—

** Significant at the 1% level.

Table 9. Analysis of variance of the combined 1949 and 1950 bromegrass forage yields.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Total	44	26,665,518.5	—	—
Replications	2	8,864,684.6	4,432,342.3	—
Strains	14	11,685,811.1	834,700.8	3.82**
Northern strains vs. southern strains	(1)	6,311,053.5	6,311,053.5	28.9**
Oklahoma strains vs. Achenbach	(1)	24,401.7	24,401.7	0.11
Other comparisons	(12)	5,350,355.9	445,862.9	2.04
Error	28	6,115,022.8	218,393.7	—

** Significant at the 1% level.

but the yields were very low (Table 10). Under farm conditions it is doubtful that a seed harvest during the first season would be advisable from an economic standpoint. Analysis of variance of the 1949 seed yields (Table 11) indicates that highly significant differences exist between strains within groups as well as between the southern and northern types. There was considerable variability among the southern strains in the rate of panicle development and the dates of pollination. The southern strains, as a group, were earlier than the northern strains. The northern strains developed panicles rapidly during the hot days of June and early July and had reached maturity by mid-July. Oklahoma No. 1 strain had reached maturity by July 1, which was approximately one week earlier than any other strain in the test. Maturity dates for 1949 are given in Table 10.

Due to the unusually dry spring of 1950, the strains did not follow a similar pattern in seed development to that of 1949. Growth was delayed for all strains until early May. As soon as moisture was available for plant growth, all strains started panicle development and had reached maturity by June 30. Seed yields in 1950 (Table 10) were quite variable and significant differences were found within groups as well as between the northern and southern types. The average of the Oklahoma strains was not significantly different from the Achenbach strain.

A composite sample was taken of all strains for chemical analysis after each clipping. The results of these analyses are recorded in table 13. The protein content decreased slightly as the season progressed but remained high during the entire season with an average of 24.7% protein. The low reading of 17.7% protein from the June 10, 1950 clipping is to be expected in view of the amount of culm formation at this cutting. The calcium and phosphorus content averaged 0.368% and 0.2285% respectively, which is similar

Table 10. 1949 and 1950 seed production of bromegrass strains from different regional seed sources.

Strain No.	Source or name	Maturity date 1949	Yield in lbs. per acre 1949	Yield in lbs. per acre 1950	Bushel test weight of seed 1950
		Northern strains			
3	Sandburg	July 14	44	292	8.6
4	Ohio (Commercial seed)	" 14	27	253	8.0
5	Martin	" 14	44	258	8.3
7	North Dakota 404	" 14	27	230	8.8
	Average		35.5	258.3	8.4
		Southern strains (Oklahoma)			
1	Oklahoma 79	July 6	100	262	7.5
8	Oklahoma No. 1	" 1	115	257	7.2
9	Oklahoma 1936	" 7	66	347	7.4
12	Oklahoma Synthetic	" 6	98	364	7.2
	Average		94.8	307.5	7.3
		Southern strains (Other)			
10	Nebraska 36	July 7	98	365	7.7
11	Lincoln	" 10	99	289	7.2
14	Nebraska 44	" 10	90	414	8.0
13	Achenbach	" 7	69	319	8.3
15	Kansas (Commercial seed)	" 7	133	422	7.6
2	Elsberry	" 10	66	278	7.4
6	Fischer	" 13	74	285	8.2
	Average		91.6	327.5	7.6
	Grand mean		76.6	309.0	7.8

Table 11. Analysis of variance of the 1949 bromegrass seed yields.

Source of variation	Degrees of freedom	Sum of squares		Mean square		F
Total	59	18,092.8		—		—
Replications	3	879.3		293.1		—
Strains	14	14,130.5		1,009.3		13.75**
Northern strains vs. southern strains	(1)		9,225.1		9,225.1	125.68**
Oklahoma strains vs. Achenbach	(1)		546.0		546.0	7.44**
Other comparisons	(12)		4,359.4		363.3	4.94**
Error	42	3,083.0		73.4		—

** Significant at the 1% level.

Table 12. Analysis of variance of the 1950 bromegrass seed yields.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Total	59	177,068.73	—	—
Replications	3	86,095.66	28,698.5	—
Strains	14	50,788.23	3,627.7	3.79**
Northern strains vs. southern strains	(1)	14,053.10	14,053.1	14.69**
Oklahoma strains vs. Achenbach	(1)	82.0	82.0	0.09
Other comparisons	(12)	36,653.13	3,054.4	3.19**
Error	42	40,184.84	956.8	—

** Significant at the 1% level.

Table 13. Chemical composition of a composite sample from fifteen bromegrass strains for each harvest period.

Sampling Date	Protein %	Calcium %	Phosphorus %	Magnesium %
May 6, 1949	29.1	0.49	0.2575	0.234
May 23, 1949	31.6	0.43	0.2887	0.254
June 10, 1949	27.1	0.37	0.2620	0.330
June 17, 1949	24.1	0.30	0.2635	0.129
October 1, 1949	22.9	0.34	0.1550	0.042
November 19, 1949	21.0	0.47	0.1740	0.074
May 16, 1950	24.1	0.26	0.2100	0.133
June 10, 1950	17.7	0.28	0.2175	0.079
Average	24.7	0.368	0.2285	0.159

to the results obtained by Fuelleman and Burlison (5) in Illinois. The magnesium content averaged 0.159% in these tests.

An infection causing leaf and stem deterioration occurred on all strains during the wet weather of May 1949. According to pathologists of the Oklahoma Experiment Station, the disease was caused by a bacteria; however, the specific organism was not named. Microscopic examination of the plant tissue showed bacteria present in the exudate, in the vascular system, and intracellularly. The damage seemed to be more severe on the strains nearing maturity. As soon as the weather became dry and hot, the extent of damage caused by the disease was greatly reduced. A numerical rating of the severity of damage caused by the disease is given in Table 14. It is believed that the differences in damage are due primarily to differences in the stages of growth rather than to a greater suceptability of one strain over another. There were no serious outbreaks of any fungus disease during the period of this experiment.

The morphological and physiological differences exhibited between the northern and southern strains gives rise to a similar assumption to that of Newell and Keim (9); namely, that the two types are derived from different parental material. Figure 5 shows the contrast between a typical southern strain and a typical northern strain grown in this experiment. The plants of southern type were more upright in growth during the seedling stages and reached a height at maturity approximately double that of the northern strains. The leaves of the southern strains were broader and coarser than those of the northern strains. The panicles of the southern strains were more contracted and extended beyond the uppermost leaves. This characteristic would be an advantage in combine harvesting. The seed of the southern type appeared to be more chaffy; however, the seed harvested from this experiment from all strains was of low quality and did not exhibit the extreme differences of quality found in the seed furnished for planting this experiment. Bushel

Table 14. Other observed characteristics of smooth bromegrass strains from different regional seed sources.

Strain No.	Source of name	Seedling vigor, March 14, 1949*	Drought and heat tolerance July 10, 1949*	Extent of damage by bacterial disease**	Average plant height in inches
		Northern Strains			
3	Sandburg	7.8	8.0	4.2	17
4	Ohio (Commercial seed)	8.8	8.4	4.2	16
5	Martin	7.5	8.0	4.3	17
7	North Dakota 404	8.8	8.2	4.3	15
	Average	8.2	8.3	4.25	16.2
		Southern Strains			
1	Oklahoma 79	3.5	3.5	3.2	29
8	Oklahoma No. 1	2.2	3.6	3.1	27
9	Oklahoma 1936	3.5	3.6	3.1	29
12	Oklahoma Synthetic	2.8	3.7	3.1	29
10	Nebraska 36	3.2	4.2	3.2	27
11	Lincoln	3.2	4.2	3.2	26
14	Nebraska 44	4.3	4.5	3.8	27
13	Achenbach	3.4	3.5	3.1	29
15	Kansas (Commercial seed)	4.5	3.2	3.1	31
2	Elsberry	4.0	3.8	3.6	26
6	Fischer	3.5	4.2	3.8	25
	Average	3.5	3.8	3.3	26.8

*Average of ratings of four plots: 1-2, Excellent; 3-4, Good; 5, Medium; 6-7, Fair; 8-9, Poor.
**Strains rated from 1 (Severe Damage) to 5 (No Damage).

Figure 5.--Individual plants of smooth bromegrass taken from the strain test. Southern strain (Left). Northern strain (Right). Photographed June 29, 1950.

test weights for the 1950 seed harvest are given in Table 10. Glume color was darker in the case of the northern strains. Stands of the northern bromes were reduced to approximately one-half the original stand during the two years of this study (Figures 3 and 4). Annual weeds and grasses became a problem in all plots seeded to the northern strains (Figure 5). The southern strains maintained a good stand and crowded out most of the weedy grasses except during brief periods of excessive rainfall.

Panicle development of the southern strains preceded that of the northern strains by as much as three weeks in some cases. The advent of hot dry weather in late June and early July seemed to force the northern strains into rapid panicle development and the maturity dates are not as different as might be expected. The apparent unpreparedness of the northern strains for a sudden change from moderate temperature and moisture conditions to hot dry weather which frequently prevails in Oklahoma during late spring and early summer is obviously responsible for the summer killing which occurred in the summer of 1949. Table 14 gives a rating of heat and drought tolerance of the strains tested in this experiment.

Figure 6.--Ohio commercial smooth bromegrass (Center) showing effect of summer killing and competition of annual grasses as compared to Oklahoma Synthetic strain (Left) and Achenbach strain (Right). Photographed June 29, 1950.

SUMMARY

This experiment was conducted from October 1948 to July 1950 on the Oklahoma Agricultural Experiment Station Agronomy Farm at Stillwater, Oklahoma in order to compare the forage and seed yields of fifteen strains of smooth bromegrass from different regional seed sources. On the basis of origin and performance, the fifteen strains were divided into two general groups referred to as northern and southern types. Four Oklahoma strains are included in the test and are treated as a subgroup of the southern type in order to compare their average yields against those of the Achenbach strain.

The strains of the southern type produced vigorous seedlings, were more tolerant of heat and drought and were more productive under the conditions of this test than the strains of northern origin.

There were no significant differences between the yields of the Achenbach and Oklahoma strains on the average except for the 1949 seed yields. In 1949 the Oklahoma strains were significantly higher in seed yields than the Achenbach strain.

The difference of 613 pounds of green forage between the average yield of the southern and northern strains in 1949 was highly significant at the 1% level of probability. Highly significant differences also existed between the average forage yields of the northern and southern strains in 1950.

Highly significant differences existed between the average yields of seed of the southern and northern types in 1949 and 1950 as well as between strains within each group.

These tests should be continued for at least one more year before definite recommendations are made relative to the Oklahoma strains. The northern strains do not appear to be adapted to the region served by these

tests and should not be recommended for the area of the state now growing bromegrass.

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