SOME FACTORS AFFECTING SMOOTH BROMEGRASS, *BROMUS INERMIS* LEYSS., SEED PRODUCTION IN THE KLAMATH BASIN

by

DONALD STEPHEN BLACK

A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1957

APPROVED:

Redacted for Privacy

Associate Professor of Farm Crops

In Charge of Major

Redacted for Privacy

Head of Department of Farm Crops

Redacted for Privacy

Chairman of School Graduate Committee

Redacted for Privacy

Dean of Graduate School

Date thesis is presented January 8, 1957

Typed by Clara Homyer

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to Dr. J. Ritchie Cowan for his suggestions and guidance in the conduct of this study; to Dr. W. H. Foote for his assistance in the preparation of the manuscript; to Dr. D. D. Hill for his critical reading of the manuscript, and to the personnel of the Klamath Experimental Area for their interest and assistance in this study.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
LITERATURE REVIEW	3
MATERIALS AND METHODS	10
Experiment A (Individual Plants)	12
Varieties	12
Establishment	13
Heading and Flowering Pattern Observations	14
Temperature Records	16
Harvesting	18
Statistical Analysis	18
Experiment B (Varietal Production Trials) .	19
Establishment	19
Harvesting and Cleaning	19
Statistical Analysis	20
EXPERIMENTAL RESULTS	20
Temperature	20
Heading Dates	23
Flowering	24
Flowering Patterns	26
Anther Observations	26
Maturity	28
Number of Panicles Produced	28

	Page
Seed Production Trials	29
Aftermath Forage Production	35
DISCUSSION	39
SUMMARY AND CONCLUSIONS	47
BIBLIOGRAPHY	51
APPENDIX	53

LIST OF TABLES

Table		Page
1	National smooth bromegrass seed production in acreage, average yields per acre, and highest state yield per acre for period 1945-1952. . .	4
2	The production, imports, supply, disappearance and carry-over of smooth bromegrass seed in the United States in the period from 1945-1953. Listed in thousands of pounds.	5
3	Last spring minimums of 24, 28, and 32 degrees F. and number of days between last spring and first fall temperatures of 24, 28, and 32 degrees F. at the Klamath Falls Airport . . .	10
4	Varieties of smooth bromegrass used in Experiment A	13
5	The number of days of below freezing temperatures and the lowest temperatures reached during the flowering period in 1954-1956 on the Field and Airport thermometers	23
6	Average heading date and the period from initial heading to completion for each variety for the individually spaced plants in Experiment A	24
7	Per cent of the spaced plants flowering by varieties and replications on the first day of flowering in 1956	25
8	The average per cent of shriveled anthers for each variety during 1956 flowering period. Average is from visual estimates based on ten plants	27
9	The average per cent of good seed, and the grams of clean seed from the threshed material from the individual plants according to their estimated per cent of shriveled anthers	28
10	Total panicles produced by ten plants of each variety in 1955 and 1956	29

Table		Page
11	The relationship of total seed yield of each variety expressed in per cent of Canada Commercial seed yield	30
12	Yearly averages, and analysis of variance calculations for 1953-1955 for the Lower Lake tract seed trial. Yields are in grams per plot	31
13	Yields in grams of plots harvested in the Lower Lake seed trial in 1956	32
14	Yearly averages, and analysis of variance calculations for 1955 and 1956 for the Station seed trial. Yields in grams per plot	33
15	Results of germination tests on samples from Lower Lake and Station seed trials in 1954 and 1956	34
16	Summary of average yields of aftermath and analysis of variance calculations from smooth bromegrass seed trial - Lower Lake tract - 1953-1955 - yields in pounds dry matter per plot	36
17	Summary of average yields of aftermath and analysis of variance calculations from the Station smooth bromegrass seed trial in 1955 and 1956. Yield in pounds dry matter per plot	37
18	Crude protein of smooth bromegrass aftermath from 6 samples from both Station and Lower Lake tract - 1955	38
19	Minimum temperatures for four locations for periods from May 17 to August 12 for 1954, 1955 and 1956	53
20	Heading dates of the individual plants on the Station in 1955	57

Table		Page
21	The observed amount of shriveled anthers for each plant in two replications on five dates during the flowering period in 1956	58
22	Seed yields in grams of the individual plants in 1955 and 1956	60
23	Yields by plots and replications of 15 varieties in the Lower Lake tract seed trial for years 1953-1955. Yields are in grams of clean seed per plot	62
24	Yields by plots and replications of 13 varieties in the Station seed trial for years 1955 and 1956. Yields are in grams of clean seed per plot	64

LIST OF FIGURES

Figure		Page
1	100 seedlings each of five varieties for experiment A, in greenhouse prior to transplanting in May 1954	15
2	Clumps of five varieties of smooth bromegrass transplanted on the Station for preliminary information in 1954. Picture taken May 1954	15
3	Maximum-minimum thermometers used for field temperatures on the Station in 1954-1956	17
4	Type of weather box used for thermographs and some thermometers during study . .	17
5	Variations in degrees F. of temperatures on the Station thermograph, the Airport thermometers, and the Lower Lake thermograph, from the Station field temperatures during the 16 day period before and during flowering in 1956. Freezing temperatures are denoted for each day	21

SOME FACTORS AFFECTING SMOOTH BROMEGRASS, <u>BROMUS INERMIS</u> LEYSS., SEED PRODUCTION IN THE KLAMATH BASIN

INTRODUCTION

Agricultural production in the Klamath Basin is limited to a small number of crops because of a relatively short growing season and severe late spring and early fall frosts. The area is located in the southern portion of central Oregon on the east side of the Cascade Mountains. Most of the Basin is 4000 feet or more elevation and the annual precipitation is from 10-12 inches. The average number of frost free days is 131, and occasionally these periods may be less than 100. The main agricultural lands have been leveled and are irrigated. The present major crops grown are potatoes, small grains, alsike clover seed, hay and pasture. The common rotation for these crops is potatoes two years, small grains one year, and alsike clover two years or hay three to five years.

Over production and low prices of some of the main crops have caused farmers to become interested in other crops which might be grown successfully in the area. A crop which would fit well in the rotation and which could also be handled by present equipment without major changes, might be readily adopted.

Grass seed production would fit both of these factors on many farms and might be profitably grown if certain species or strains which are in demand were proven to be adapted to this area for seed production purposes.

Smooth bromegrass has become one of the important grasses in both pasture and hay mixtures in the United States, and many new varieties and strains are now available. Plant breeders and agronomists are interested in finding areas which can produce large amounts of good quality seed. The major areas of smooth bromegrass seed production in the United States have followed the common practices of cutting smooth bromegrass for hay rather than for seed in years of short hay supplies. Such practices, along with low yields, have created an interest for new areas to produce seed of these new strains.

Heretofore, grass seed production has been limited to only a few farms in the Basin, and smooth bromegrass has not been grown for seed in this area. The only previous experimental work on grass seed production has been a smooth bromegrass variety trial planted in 1952.

This study was initiated to investigate some of the factors which might influence the feasibility of producing smooth bromegrass seed in the Klamath Basin. One of the main factors to be studied was the relationship of temperature to the plant, particularly during the flowering period, and to determine any injurious effects on certain plants or varieties. Another phase of the problem was to study varietal differences at various locations to find if the different soil and climatic differences might be a major factor in seed production in this area.

LITERATURE REVIEW

A number of studies (2, pp.923-932; 3, pp.248-251 and 8, pp.1-34) have been conducted to determine the effect of daylength, and temperature on panicle production, heading and flowering of smooth bromegrass, particularly under greenhouse conditions. There is, however, a lack of references on the effect of low temperatures and other environmental factors on smooth bromegrass and other grasses during these same plant growth periods.

The research that is being done may have an effect on the future production of bromegrass seed. Both acreage of smooth bromegrass and yield per acre have been subject to much variation in the past few years. The total acreage and the average yield per acre for the United States are given in Table 1.

Table 1. National smooth bromegrass seed production in acreage, average yields per acre, and highest state yield per acre for period 1945-1952 (10, p.20).

Year	Acreage in thousands of acres	Average per acre-National	Highest State average per acre	State with highest average
1945	64.0	170	250	North Dakota
1946	33.1	136	175	Michigan
1947	72.6	177	190	Nebraska
1948	27.5	143	170	Nebraska
1949	81.8	137	215	Washington
1950	133.5	196	500	Oregon
1951	86.8	168	750	Oregon
1952	53.8	133	400	Idaho

The variation in imports in addition to the variation in domestic production has caused a fluctuation in the total seed supply. Even with this fluctuation in the supply the demand has been great enough to reduce the carry-over to generally less than 25 per cent of the total yearly supply, as shown in Table 2.

Table 2. The production, imports, supply, disappearance and carry-over of smooth bromegrass seed in the United States in the period from 1945-1953 (10, p.20). Listed in thousands of pounds.

Year	Production	Imports	Domestic supply	Domestic disappearance	Carry-over
1945	10,895	8,198	21,343	17,458	2,537
1946	4,512	6,402	14,722	12,629	3,885
1947	12,820	4,554	19,467	17,714	2,093
1948	3,920	6,721	12,394	11,990	1,753
1949	11,240	5,856	17,500	16,193	404
1950	26,194	9,913	37,414	30,290	1,307
1951	11,990	6,581	25,695	20,034	7,124
1952	7,161	12,495	25,317	19,388	5,661
1953	13,415	9,646	28,990	20,853	5,929

Smooth bromegrass has been found by many workers (2, pp.24-25; 3, p.249 and 7, p.423) to require a period of growth under conditions of short days and cool temperatures prior to long photoperiods, before flowering. Selders (8) in Nebraska, found indications that a period of growth of about three months under short days, cool temperatures, and a high nitrogen level prior to a 16 hour day was necessary to bring about maximum production of panicles from seedling plants and clones of smooth bromegrass. When working with early, midseason and late flowering clones in Iowa, Evans and Wilsie (2, pp.24-25) found that no flowering occurred under short days, but some occurred under 15 hour days, and relatively good flowering occurred with 18 hour day lengths. Each clone responded differently to changes in day length, temperature and level of fertility.

Temperature differentials during the short days influenced the number of panicles produced in orchardgrass, meadow fescue, smooth bromegrass and Reed canarygrass in trials made by Hanson and Sprague (3, p.249) in Pennsylvania. High temperatures during the short day period reduced the number of panicles, but in orchardgrass this effect was partially compensated by lower temperatures during the long day period. Low temperatures during the long day period increased the interval from heading to flowering.

Newell (7, pp.419-420), in greenhouse studies, was able to increase the number of panicles, and consequently the seed yields, of one plant over another plant from the same clone using controlled life cycles. All paired plants of 15 clones were moved from the field to the greenhouse in November. One group was moved to a 16 hour photoperiod soon after being moved from the field and the other was held at normal day lengths (December) for one month longer before being moved to the 16 hour photoperiod. Both were maintained at cool temperatures and allowed free interpollination within each group. The group held on normal day lengths for an extra month produced an average of 52.4 grams of seed per plant, while the other group on the longer photoperiod produced only 6.3 grams of seed per plant.

Several investigations have recorded observations in plant development and flowering. These studies were made for use in plant improvement programs on the particular grasses. Jones and Newell (4, pp.6-8), working in Nebraska, observed several grasses in a study of pollination cycles and pollen dispersal in relation to grass improvement. In smooth bromegrass they found that occasional plants started anthesis by 3:00 p.m. and that this number increased slowly until 4:30 p.m. The majority of the plants began anthesis in the 15 minute period from 4:25 p.m. to 4:40 p.m. Their data also showed flowering was delayed 30 minutes to one hour on afternoon following days of heavy pollen shedding. Peaks on these days were much lighter than on other days. During their study the heaviest pollen shedding occurred on June 22nd. This came 48 hours after the previous heavy shedding of pollen. Temperatures of 80 to 85 degrees F. were found optimum for the blooming of smooth bromegrass, although active blooming occurred between 74 and 90 degrees F. Temperatures below 70 degrees F. inhibited blooming on two days. The pollination cycle occurred in late May or early June over an eight year period from 1936-1943. Pollen spreading lasted for 12 days in the breeding nursery and only eight days in the field, where plants were of a more uniform type.

Wolfe (12, p.611) found that practically no flowering occurred in orchardgrass on cool cloudy days following nights when temperatures had dropped to 40 degrees F.

Observations by Cowan (1, pp.35-40) indicate that the time of day at which flowering takes place on tall fescue, seems to be markedly influenced by temperatures and humidity. No flowering took place on days which were cloudy and rainy. On normal days flowering did not occur prior to 1:30 p.m. and the peak was reached about 4:00 p.m. and was practically complete by 6:00 p.m.

Northern strains of smooth bromegrass were superior to southern strains in seed production at three stations in western Canada, according to Knowles and White (5, pp.440, 442-443, and 445). Achenbach and Lincoln smooth bromegrass produced only about one-half as much seed as the northern commercial bromegrass. Southern strains were from two to four days later in flowering and showed more resistance to fall and spring frosts. Forage production, at nine stations, was found to be quite similar.

No references were found on the effects of below freezing temperatures on grasses for the period from heading through flowering. Some studies have been made to find the effects of low temperatures on wheat for various stages from heading through flowering.

No sterility was found by Livingston and Swinebank (6, p.154) in winter wheat heads when exposed to zero degrees C. for as long as 14 hours. Practically no injury resulted from exposure for two hours at minus two degrees C., but increased exposure time at this temperature increased the amount of injury. The percentage of heads showing sterility was much greater at the four hour exposure at minus four degrees than at the two hour exposure. They found more injury in later plant growth stages, i.e., after pollination and until the fertilized embryo were practically one-third enlarged, than from the boot through the pollination period. They found varietal differences in the susceptibility to frost, but floral sterility was influenced more by the stage of head development at the time of exposure than by varietal susceptibility.

The average date for the last spring killing frosts for Klamath Falls (principal town in the Klamath Basin) from 1899-1938 was May 18 (9, p.1081). September 16 is the average date for the first fall killing frost. The earliest and latest dates for the last killing frost for the 39 year period is April 8 and June 29, respectively.

The last spring minimums of 24, 28, and 32 degrees F. for the Klamath Falls Airport are given in Table 3.

Table 3. Last spring minimums of 24, 28, and 32 degrees F. and number of days between last spring and first fall temperatures of 24, 28, and 32 degrees F. at the Klamath Falls Airport (11).

	Last spring minimum of			No. of days between dates of last spring and first fall temperature of		
Year	24° or below	28° or below	32° or below	24° or below	28° or below	32° or below
1951	4-30	4-30	6-5	170	169	121
1952	4-15	6-12	6-15	200	132	127
1953	5-10	5-22	5-26	145	133	129
1954	5-1	6-1	6-17	177	109	93

MATERIALS AND METHODS

This study was conducted on sites which are fairly representative of major agricultural areas in the Klamath Basin. The four sites were the Klamath Experimental Station, the Lower Lake tract, the Fort Klamath area, and Langell Valley.

The Station is the main headquarters of the Klamath Experimental Area and is located about five miles south of Klamath Falls. The soil is a sandy loam which is moderately alkaline with a pH from 7.2 to 7.5. The trials were on fairly well drained land and is similar to soil in the potato, grain, and alsike clover or hay rotation area.

The Lower Lake tract is located on a muck soil which also has a pH range from 7.2 to 7.5. This tract is near Worden, Oregon, on land which was under a shallow lake prior to drainage about 40 years ago and has been cropped mainly to oats since that time.

The Fort Klamath site is northwest of Klamath Falls in an area where freezing temperatures are often recorded every month during the summer. The area is almost entirely devoted to pastures. The soil at this site is a partially decomposed peat, and has a pH of 5.5.

The fourth site was located about 30 miles southeast of Klamath Falls, in Langell Valley. This portion of Langell Valley was poorly drained until a deep drain was dug about five years ago. It is a clay soil with a pH near 7.5 and is now cropped primarily to oats and other small grains. Temperature records are not available for this area.

The trials at Fort Klamath and Langell Valley were irrigated by sprinklers to establish the stand before flood irrigating. These new seedlings dried out much more rapidly than was anticipated and there was not enough time or equipment available to keep adequate moisture on them through the critical period soon after seeding. The stands which developed were very thin and were discontinued.

Fertilizers were added to both trial sites prior to seeding. At the Station, gypsum was added at the rate of one ton per acre before rotovating the trial area. An application of 25 pounds per acre of nitrogen was made at planting time. An additional 70 pounds per acre of nitrogen and 87 pounds per acre of P_2O_5 was added in the spring of 1955. Another 80 pounds per acre of nitrogen was added in the early spring of 1956. Surface applications of fertilizers were made prior to rotovating on the Lower Lake tract. These soils have been found to be deficient in phosphate, copper, manganese and zinc, and fertilizers containing these elements were added. Both trials were flood irrigated.

Two experiments were initiated to study the effects of temperature, locations and varieties on the production of smooth bromegrass seed. Experiment A, located on the Station, was designed to study the effect of temperature on individual plants of smooth bromegrass and to relate any differences to the various temperature records available at the Station. Experiment B was planned to measure yield and varietal effects at several locations. These locations were chosen to give a variety of conditions that are representative of those found in the Klamath Basin, and make it possible to better interpret the data obtained from Experiment A.

Experiment A (Individual Plants)

Varieties

Five varieties of smooth bromegrass were selected for this study. Four were named varieties and the other, Canada Commercial, is representative of much of the smooth bromegrass which is raised for seed in Canada and which has not been selected and increased as a definite strain.

Two of the varieties are "northern" types, i.e., originating from the smooth bromegrass imported from Russia in 1896-98. Three of the varieties were of the "southern" type, i.e., originated from the smooth bromegrass imported from Hungary via France. Each variety was included in the U. S. Department of Agriculture's uniform smooth bromegrass seed production trial for 1952 and was grown in the United States at that time. The varieties, the type (northern or southern) and the state in which it was developed are given in Table 4.

Table 4. Varieties of smooth bromegrass used in Experiment A.

Variety or Strain	Type	Origin as variety
Canada Commercial	Northern	--
Martin	Northern	Minnesota
Lincoln	Southern	Nebraska
Achenbach	Southern	Kansas
Oklahoma	Southern	Oklahoma

Establishment

Seeds of these five varieties were planted in flats in the greenhouse in February 1954. In April, 100 seedlings from each variety were transplanted in plant bands (Figure 1) and left in the greenhouse. Twenty of these plants were randomly selected on May 27, 1954, and transplanted on the Station in rows with four foot centers. Five plants were included in each of four replications.

Four portions of the row, or clumps of each of these five varieties, were dug from the rows in the varietal seed trial on the Lower Lake tract on April 17, 1954. These were transported to the Station and transplanted so that preliminary observations on heading and blooming might be made in 1954 before the seedling plants were established. These were also transplanted in rows with four foot spacings between clumps (Figure 2). The plants were retarded enough so that no observations were obtained.

Heading and Flowering Pattern Observations

Observations were made on the average heading and flowering dates in 1955. A plant was considered headed when at least 50 per cent of the panicles had emerged from the sheath. In 1956 daily observations were made on dates of flowering and the plant, panicle and spiklet flowering patterns. The flowering date was recorded as the first day the florets were open.

Figure 1

100 seedlings each of five varieties for experiment A, in greenhouse prior to transplanting in May 1954.

Figure 2

Clumps of five varieties of Smooth Bromegrass transplanted on the Station for preliminary information in 1954. Picture taken May 1954.

Temperature Records

Maximum and minimum temperatures were obtained in the field by placing a maximum-minimum thermometer in the individually spaced plants. The thermometers (Figure 3) were exposed, except for a tinfoil covering of the bulb, and the height above the ground was regulated to correspond with the plant height. Field temperatures were obtained nearly every day, from heading until after flowering in 1954 and 1956, and only the extremely low temperatures were obtained in 1955.

In 1954, temperatures were recorded from a maximum-minimum thermometer located in a weatherbox which was about 200 feet from the field thermometer and four and one-half feet above the ground. In 1956 temperatures were recorded on a thermograph. The thermograph was in a weatherbox (Figure 4) which was three inches above the ground and located adjacent to the field thermometer.

Official temperatures were obtained from the official Weather Bureau records for Oregon (11). These temperatures are from readings made by the Civil Aeronatics Authority personnel at the Klamath Falls Airport. The airport is located about one-half mile east of the Station, and the thermometers are in official type weather boxes located on the roof of the airport

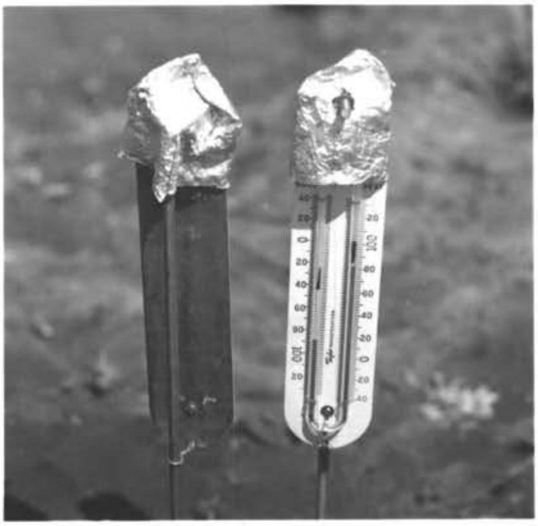


Figure 3

Maximum-minimum thermometers used for field temperatures on the Station in 1954-1956.

Figure 4

Type of weather box used for thermographs and some thermometers during study.

Administration building 15-20 feet above the ground.

Maximum and minimum temperatures from the Lower Lake tract were obtained from thermograph recordings. The thermograph was in a weather box which was three inches above the ground and located near the seed production trial.

Harvesting

Seed was harvested from the plants at maturity and threshed in a Vogel type nursery thresher. The threshing operation did not separate the seeds from the sterile florets and chaff. An "Office" model Clipper Cleaner was used to clean the seed. Panicle counts were made on ten plants of each variety in both 1955 and 1956 prior to harvest.

Statistical Analysis

The data from this experiment were summarized and analyzed statistically for the various factors studied. An analysis of variance was calculated on the seed yields.

Experiment B (Varietal Production Trials)

Establishment

The trial on the Lower Lake tract was seeded in July 1952, while the Station trial was seeded in July 1954. Fifteen varieties or strains were included in the Lower Lake trial and only thirteen in the Station trial.

A randomized block design was used with three replications. Each plot was a single row 20 feet long with border rows on the outside of each replication. The row spacings used were three feet on the Lower Lake tract, and three and one-half feet on the Station trial.

Harvesting and Cleaning

Hand sickles were used to harvest the smooth bromegrass soon after it matured. The crop was cut above the basal foliage, bagged and stored in the greenhouse for about four weeks prior to threshing. The threshing and cleaning operations were the same as described for the individual plants.

Germination tests were made on composite samples of all replications of each variety in both 1954 and 1956.

Part of the Lower Lake trial was accidently mowed about heading time in 1956, leaving only two-thirds of each replication. The remaining plots were harvested, but the data could not be analyzed.

The aftermath or basal foliage was cut soon after seed harvest and dry matter yields were obtained. Crude protein analysis was determined for five varieties in each trial in 1955.

Statistical Analysis

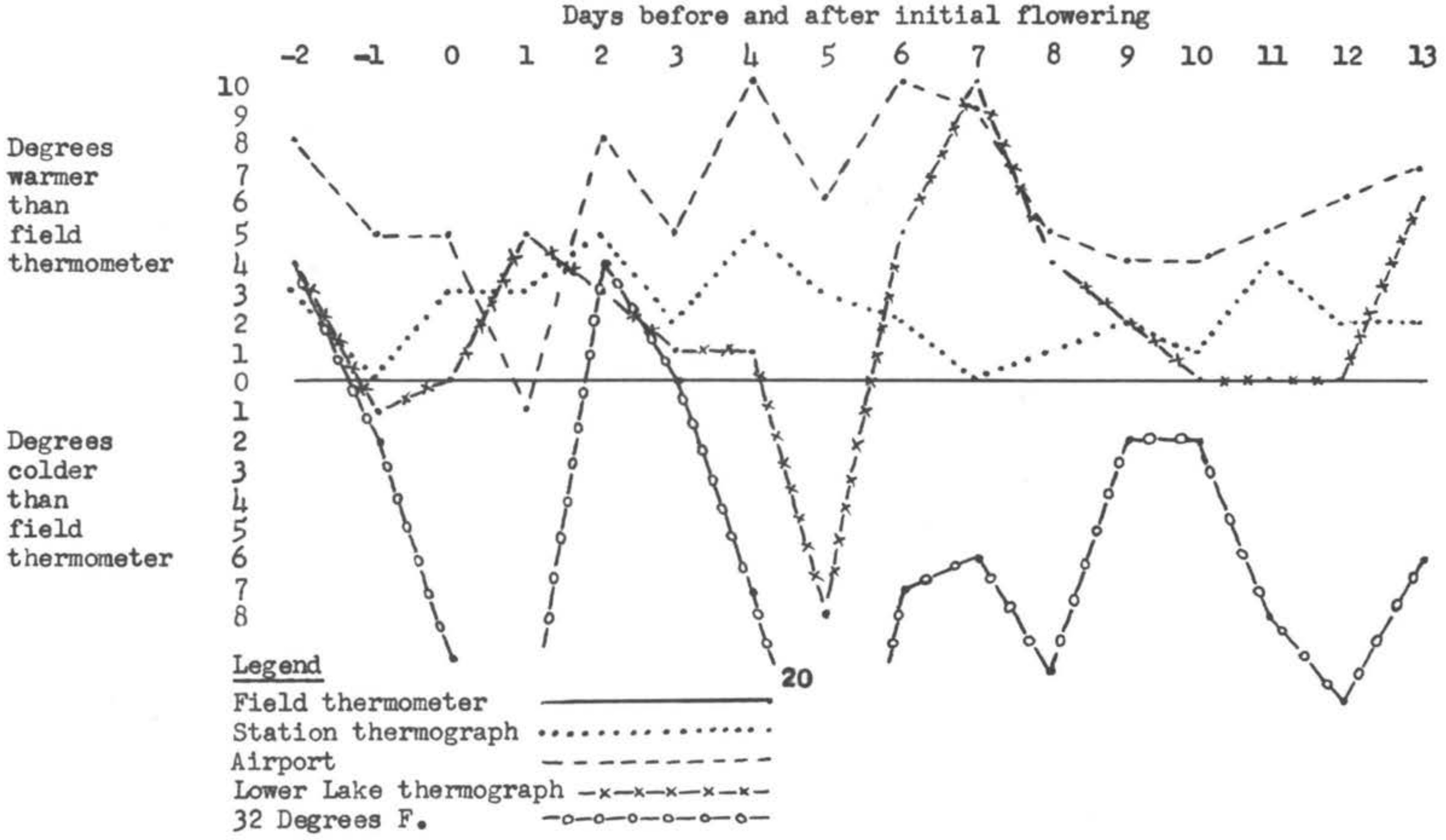
The seed yields from each trial were subjected to an analysis of variance for each year. Least significant differences were determined when significant differences were found.

EXPERIMENTAL RESULTS

Temperature

Temperature records were obtained at the various locations to determine if low temperatures had any injurious effects on smooth bromegrass, particularly during the flowering period. In analyzing these data it was evident that there were rather wide variations between locations. The temperatures from May 10 through the flowering period for 1954-1956 are given in the Appendix in Table 19. Some of these variations between locations are shown in a graph (Figure 5) covering a 16 day period before and during flowering in 1956. It shows the

Figure 5 Variations in degrees F. of temperatures on the Station thermograph, the Airport thermometers, and the Lower Lake thermograph, from the Station field temperatures during the 16 day period before and during flowering in 1956. Freezing temperatures are denoted for each day.



variation as the number of degrees warmer or colder the different locations were than the field temperatures, regardless of the actual minimum temperatures for each location. The 32 degree F. line on the graph shows whether the actual temperatures were above or below freezing. The exposed maximum-minimum thermometers in the field on the Station generally had the lowest temperatures. The thermograph, located nearby in a weather box, was usually slightly higher and the temperatures at the airport, except for one day, were several degrees higher than the field thermometers. The Lower Lake temperatures were not as consistent. The temperature variations during this 16 day period in 1956 are characteristic of those observed during the entire study. The minimum temperatures at the airport were lower than field temperatures at the Station only five times during the 70 day period in 1956, and the temperatures at both locations were several degrees above freezing on days when this occurred.

Below freezing temperatures occurred in the field during the flowering period in all three years. A summary of the number of times these occurred during this period and the minimum temperature reached are shown in Table 5.

Table 5. The number of days of below freezing temperatures and the lowest temperatures reached during the flowering period in 1954-1956 on the Field and Airport thermometers.

Year	Number of days below freezing		Lowest temperature in degrees F.	
	Field	Airport	Field	Airport
1954	1	0	28	34
1955	2	1	26	32
1956	2	0	28	36

Sunrise occurred around 5:00 a.m. during the days the plants were flowering. The low temperatures, as recorded on the thermograph, occurred for about 20-30 minutes before sunrise, and were followed by a rapid rise in temperature. High temperatures occurred between 2:00 and 4:00 p.m. with a rapid decrease beginning after 4:00 p.m.

Maximum temperatures were several degrees higher in the field than in the weather box on sunny days.

Heading Dates

The earliest date of heading of smooth bromegrass in the Lower Lake seed trial was May 16, 1954. In 1955 heading began at the Station on June 1. The heading dates of the individual plants are shown in Table 20 of the Appendix. Individual plant heading dates were not obtained in 1956, although the heading began approximately May 20. Heading at both the Lower Lake and the Station began near the same time during 1955 and 1956.

The variety Lincoln showed a slight tendency (Table 6) to head earlier and to complete heading sooner than the other varieties.

Table 6. Average heading date and the period from initial heading to completion for each variety for the individually spaced plants in Experiment A.

Variety	Heading Date	Dates from initial heading to completion
Martin	6-4	6-1 to 6-8
Canada Commercial	6-4	6-1 to 6-8
Achenbach	6-4	6-1 to 6-8
Lincoln	6-3	6-1 to 6-6
Oklahoma	6-4	6-1 to 6-7

Flowering

The earliest flowering dates varied by only five days during the three year period, beginning on June 24 in 1954, June 22, 1956 and June 27, 1955. Flowering as well as heading occurred at nearly the same time on both the Lower Lake and the Station plantings.

Flowering occurred in 69 per cent of the spaced plants on the first day of flowering in 1956. The per cent of total plants flowering on this day are given in Table 7.

Table 7. Per cent of the spaced plants flowering by varieties and replications on the first day of flowering in 1956.

Variety	Replication 1	2	3	4	Av.
Martin	80	80	60	100	80
Canada Commercial	60	60	40	60	55
Achenbach	80	100	40	60	70
Lincoln	100	80	60	40	70
Oklahoma	60	80	60	80	70
Average	76	80	48	72	69

The flowering period lasted only ten days in the Lower Lake seed trial in 1954, finishing July 3. In 1955 and 1956 it continued over a two week period at both locations.

Flowering did not occur on days which were cloudy and cool. On June 23 and 24, 1956, the weather was several degrees cooler than on June 22 and no flowering occurred. On June 25 the temperature rose to 78 degrees F. on the thermograph (96 degrees F. on field thermometer) and fairly heavy flowering occurred, although no observations were made on individual plants. The heaviest pollen shedding occurred on June 26. The following day, June 27, flowering did not begin until nearly 6:00 p.m., which was the latest time of day it had started during the three year period of the study. Fewer florets were observed blooming than during the previous day. Flowering began at

5:30 p.m. on June 28 and was also light. On both June 27 and 28 a wind came up in the evening about 6:00 p.m., but the plants continued blooming until after 7:30 p.m.

Flowering Patterns

The plants differed some in their flowering pattern, although there was a definite tendency for the heaviest flowering to occur on the south one-half of the plant during the first two or three days of flowering. After that it was quite uniform until the final days when the heaviest flowering occurred on the north to northwest portion of the plant.

Flowering began at the top of each panicle, and after the first day or two, florets were blooming on each spiklet of the panicle. The lowest florets on each spiklet began blooming first and then progressed to the top florets by the end of the flowering period.

Anther Observations

The anther produced on the individually spaced plants in 1956 ranged in color from a bright yellow to dark brown. The dark colored anthers were somewhat shriveled. The amount of shriveling varied, and visual observations were made on whether 0, 25, 50, 75 or 100 per cent of the anthers were shriveled. The estimated amount of shriveled anthers for each plant is given in the Appendix in Table 21 and a summary of each variety is given in Table 8. No differences were evident between varieties. No tests were made to determine the viability of the pollen.

Table 8. The average per cent of shriveled anthers for each variety during 1956 flowering period. Average is from visual estimates based on ten plants.

Variety	Days after initial flowering 5	6	11	12	14	Av.
Martin	50	25	25	50	50	40
Canada Commercial	50	50	50	50	50	50
Achenbach	50	25	25	50	50	40
Lincoln	50	25	25	50	75	45
Oklahoma	50	25	25	50	50	40

When the individual plants were threshed the threshed material was largely composed of sterile florets and the seed. Weights were taken before and after cleaning to determine if the shriveled anthers had any noticeable effect on the per cent of sterile florets obtained from each plant. The grams of clean seed and the average per cent of good seed in the threshed material from the plants according to their estimated per cent of shriveled anthers are shown in Table 9. It is apparent from these results that the rating of the shriveled anthers had no noticeable effect on the per cent of good seed or the amount of clean seed in the threshings.

Table 9. The average per cent of good seed, and the grams of clean seed from the threshed material from the individual plants according to their estimated per cent of shriveled anthers.

Estimated per cent of shriveled anthers	No. of plants	Grams of clean seed per plant		Per cent of good seed in threshings	
		Av.	Range	Av.	Range
0	2	42	2-81	32	4-59
25	18	37	0-96	53	0-84
50	19	42	0-98	54	0-76
75	10	34	2-6	61	2-86
100	1	47	47	62	62

Maturity

No detailed notes were made on maturity since the plants ripened at nearly the same time. The ripening date between years varied by only four days in the Lower Lake seed trial from 1953-1956. It was August 11 in 1953 and 1954, August 14, in 1955, and August 12, in 1956.

Number of Panicles Produced

Fewer panicles were produced by most plants in 1956 than in 1955. The total panicles produced by ten plants of each variety are given in Table 10. The fifty plants counted produced only 45 per cent as many panicles in 1956 as in 1955. These ranged from a total of 74 per cent for Canada Commercial to 26 per cent for Achenbach.

Table 10. Total panicles produced by ten plants of each variety in 1955 and 1956.

Variety	Total number of panicles 1955	1956	Per cent of 1955
Canada Commercial	2869	2122	74
Martin	2769	1639	59
Lincoln	3019	880	29
Oklahoma	2666	933	35
Achenbach	2843	741	26

Although the total number of panicles in 1956 were reduced in each variety, the seed yields obtained ranged from 90-141 per cent of the 1955 seed yields.

Seed Production Trials

The northern strains, Canada Commercial and Martin, were the highest seed producers in total seed yields for the individual plants of each variety. The seed yield for the individual plants, which are given in Table 22 of the Appendix, varied considerably between plants in 1955 and 1956, although the total seed yields of the 20 plants for each variety were nearly the same as in 1955. The relationships of the total seed yields of each variety expressed in per cent of Canada Commercial seed yields are given in Table 11.

Table 11. The relationship of total seed yield of each variety expressed in per cent of Canada Commercial seed yield.

Year	Canada Commercial	Martin	Lincoln	Oklahoma	Achenbach
1955	100	56	54	46	35
1956	100	86	53	47	48

The yields of five spaced plants were analyzed by the analysis of variance and significant differences at the five per cent level were found between varieties in both 1955 and 1956.

Significant differences between varieties in the Lower Lake seed trials were also found in 1955. Canada Commercial was significantly higher yielding than all other varieties except Manchar and Sandburg. The yearly averages and the analysis of variance calculations for 1953-1955 are given in Table 12. Yields by plots for this period are given in Table 23 of the Appendix. Oklahoma, the lowest yielding variety for the three year period, yielded only 62 per cent as much as Canada Commercial.

Table 12. Yearly averages, and analysis of variance calculations for 1953-1955 for the Lower Lake tract seed trial. Yields are in grams per plot.

Variety	1953	1954	1955	Total	Average	Per cent of Canada Commercial
1. Canada Commercial	633	670	462	1765	588	--
2. Manchar	762	498	422	1682	561	95
3. Martin	766	466	330	1562	521	89
4. Southland	723	536	218	1477	492	84
5. #404	481	572	345	1398	466	79
6. Lyon	625	508	263	1396	465	79
7. Sandburg	524	487	380	1391	464	79
8. B. in. 12	541	485	349	1375	458	78
9. Fischer	615	460	257	1332	444	76
10. Homesteader	514	492	319	1325	442	75
11. Achenbach	646	461	218	1325	442	75
12. Lincoln	506	459	279	1244	415	71
13. Lancaster	516	410	226	1152	384	65
14. Elsberry	500	398	226	1124	375	64
15. Oklahoma	442	440	210	1092	364	62
L.S.D. (5%)	NS	NS	77			

Variation Due to	Degrees of Freedom	Mean Squares 1953	1954	1955
Total	44			
Replications	2	51,354.500	66,005.000++	64,363.500++
Varieties	14	34,696.714	13,302.714	19,189.429
Error	28	31,954.787	7,387.607	2,178.107

++ Significant at 1% level

In 1956 only 28 plots were harvested from the Lower Lake trial. Although incomplete, the yields show an accelerated downward trend which began in 1955. The yields on the plots harvested in 1956 were less than 50 per cent as high as the 1955 yields. These 1956 yields are given in Table 13. No counts were made of panicles in this trial, but it was noted during harvest that there was a marked decrease in the number of panicles in 1956.

Table 13. Yields in grams of plots harvested in the Lower Lake seed trial in 1956.

	Replication		
	I	II	III
1. Manchar	162	127	160
2. Canada Commercial	--	--	104
3. Lancaster	112	56	--
4. B. in. 12	69	86	88
5. Martin	110	--	45
6. Lincoln	91	34	96
7. Sandburg	57	--	88
8. Lyon	--	--	53
9. Southland	--	34	70
10. Oklahoma	51	--	--
11. Fischer	--	32	64
12. Homesteader	--	--	44
13. #404	--	42	--
14. Achenbach	44	22	--
15. Elsberry	28	33	--

The seed production trial on the Station had highly significant differences between varieties in both 1955 and 1956. A summary of these results and the analysis of variance calculations are shown in Table 14. Canada Commercial and Manchar were the highest yielding varieties, being significantly higher yielding at the five per cent level than nine other varieties in 1955. Canada Commercial was significantly higher yielding than only two varieties in 1956. Manchar was significantly higher than six other varieties. The yields by plots for both 1955 and 1956 are given in Table 24 of the Appendix.

Table 14. Yearly averages, and analysis of variance calculations for 1955 and 1956 for the Station seed trial. Yields in grams per plot.

Variety	1955	1956	Total	Average	Per cent of Canada Commercial
1. Canada Commercial	612	477	1089	544	--
2. Manchar	550	530	1080	540	99
3. B. in. 12	435	446	881	440	81
4. Martin	491	361	852	426	78
5. Mandan	399	429	828	414	76
6. Homesteader	265	408	673	336	62
7. Lincoln	397	240	637	318	58
8. Lyon	241	351	592	296	54
9. Fischer	309	227	536	268	49
10. Southland	303	181	484	242	44
11. Lancaster	209	238	447	223	41
12. Elsberry	160	236	396	198	36
13. Achenbach	191	202	393	196	36
L.S.D.	129	254			

Variation Due to	Degrees of Freedom	Mean Squares 1955	Mean Squares 1956
Total	38		
Replications	2	2,402.000	3,016.000
Varieties	12	61,092.583**	41,677.250**
Error	24	5,893.125	8,033.375

** Significant at 1% level

There were some differences in the varieties relative standing between the Lower Lake tract and the Station, but the higher yielding varieties at one location tended to also be the higher yielding varieties at the other location.

Germination tests were made on composite samples of each variety from the Lower Lake tract in 1954, and on 12 varieties in 1956. Similar tests were made on all varieties from the Station in 1956. Results of the tests are given in Table 15. These results show that most varieties in both trials have rather high germination. Lancaster, in 1954, was the only variety tested with below 85 per cent germination.

Table 15. Results of germination tests on samples from Lower Lake and Station seed trials in 1954 and 1956.

	Lower Lake Tract		Station
	1954	1956	1956
1. Manchar	98	97	92
2. Canada Commercial	98	94	94
3. Homesteader	96	94	95
4. Sandburg	96	--	--
5. B. in. 12	96	95	93
6. #404	95	--	--
7. Southland	95	93	97
8. Oklahoma	95	--	--
9. Lincoln	94	95	97
10. Elsberry	93	93	93
11. Achenbach	93	93	91
12. Martin	92	90	94
13. Fischer	89	93	95
14. Lyon	89	91	96
15. Lancaster	81	94	95
16. Mandan			96

Aftermath Forage Production

The aftermath, or basal foliage, in the seed trials, left standing when the seed was harvested, was cut and dry weights obtained after all seed harvests at both locations. A summary of these yields by years and analysis of variance calculations are given in Table 16 for the Lower Lake tract, and Table 17 for the Station. Significant differences at the five per cent level were found at the Lower Lake tract in 1953 and 1955. No significant differences were found in either 1955 or 1956 at the Station.

Table 16. Summary of average yields of aftermath and analysis of variance calculations from Smooth Bromegrass seed trial - Lower Lake tract - 1953-1955 - yields in pounds dry matter per plot.

	1953	1954	1955	Total	Average	Average Tons/A
1. Elsberry	9.30	7.92	6.21	23.43	7.81	3.15
2. Southland	7.98	7.92	7.27	23.06	7.69	3.10
3. Achenbach	8.41	6.33	7.44	22.18	7.39	2.98
4. Lyon	9.36	5.79	6.74	21.89	7.26	2.93
5. Fischer	8.90	5.41	7.15	21.46	7.15	2.88
6. Oklahoma	7.98	7.25	6.21	21.44	7.15	2.88
7. Martin	8.06	7.52	5.08	20.66	6.89	2.78
8. Homesteader	7.76	6.74	4.87	19.37	6.46	2.61
9. Manchar	7.75	6.60	4.70	19.05	6.35	2.56
10. Sandburg	7.27	6.07	5.27	18.61	6.20	2.50
11. B. in. 12	7.30	6.09	4.93	18.32	6.11	2.46
12. Canada Commercial	7.23	6.21	4.60	18.04	6.01	2.42
13. Lincoln	5.95	6.42	5.54	17.91	5.97	2.41
14. #404	5.87	6.91	4.88	17.66	5.89	2.38
15. Lancaster	5.13	7.02	5.39	17.54	5.85	2.36

Variation due to	Degrees of Freedom	Mean Square 1953	1954	1955
Total	44			
Replication	2	83.39630++	3.42285+	16.75625++
Varieties	14	4.37712+	1.09991	1.65782+
Error	28	1.67349	.64854	.62552

\+ Significant at 5% level

++ Significant at 1% level

Table 17. Summary of average yields of aftermath and analysis of variance calculations from the Station Smooth Bromegrass seed trial in 1955 and 1956. Yield in pounds dry matter per plot.

	1955	1956	Total	Average	Average Tons/A
1. Lyon	6.23	8.03	14.26	7.13	2.46
2. Southland	6.23	7.77	14.00	7.00	2.42
3. Lincoln	6.15	7.72	13.87	6.94	2.40
4. Elsberry	5.47	7.66	13.13	6.56	2.27
5. Martin	5.57	7.33	12.90	6.45	2.23
6. Achenbach	5.26	7.64	12.90	6.45	2.23
7. Fischer	6.04	6.76	12.80	6.40	2.21
8. B. in. 12	5.14	7.46	12.60	6.30	2.18
9. Homesteader	4.92	7.40	12.32	6.16	2.13
10. Canada Commercial	5.23	6.91	12.14	6.07	2.10
11. Lancaster	5.26	6.41	11.67	5.84	2.02
12. Manchar	4.29	6.57	10.86	5.43	1.88
13. Mandan	4.08	6.74	10.82	5.41	1.87

Variation due to	Degrees of Freedom	Mean Squares 1955	1956
Total	30		
Replication	2	.50440	.1730
Varieties	12	1.42635	.815158
Error	24	1.47565	.832254

The varieties that were high seed producers were not generally the highest forage producers. The high forage (aftermath) producers in the seed trials were generally the same varieties that were high forage producers in the Smooth Bromegrass variety forage trial, although not in all cases. Crude protein analysis determinations made in 1955 on six samples from each trial indicate a crude protein percentage from 4.94-5.91 on the Lower Lake tract. The Station aftermath had an analysis from 6.12 to 10.71 per cent crude protein. The results of these tests by varieties for both the Lower Lake and the Station are in Table 18.

Table 18. Crude protein of Smooth Bromegrass aftermath from 6 samples from both Station and Lower Lake tract - 1955.

	Muck	Station
1. Fischer	5.66	
2. Elsberry	5.52	
3. Southland	4.94	
4. Manchar	5.91	
5. Lincoln	5.22	
6. Oklahoma	5.47	
7. Canada Commercial		7.50
8. Mandan		8.33
9. Homesteader		6.12
10. B. in. 12		6.93
11. Martin		10.71
12. Achenbach		6.57
Average	5.49	7.69

DISCUSSION

The effects of climate and soil differences are important factors in determining the adaptability of new crops to the Klamath Basin. Severe late spring frosts and short growing seasons have limited the number of crops that can be grown profitably. Successful grass seed production has previously been limited to only a few farms in the area largely because of danger of losses from late frosts. Geary Bros. farm, the largest producers of grass seed in the Basin, are located northwest of Klamath Falls and have successfully grown bluegrass and bentgrass seed for several years. The farm is located in a small valley which was reclaimed from Klamath Lake, and location has enough of a moderating effect on the temperatures to escape some, but not all, of the frost injury that occurs in most of the Basin.

Small grain production has an advantage over perennial grasses in that the time of heading and flowering can be regulated somewhat by planting dates rather than being controlled largely by the climate. These conditions make it necessary to find grasses that are adapted to the climate, since little control can be influenced over dates of heading and flowering periods. Smooth Bromegrass grown as a seed crop may be more adapted to the climate of the Klamath Basin than other grasses such as tall fescue and orchardgrass which head and flower earlier than Smooth Bromegrass.

Cool temperatures throughout the early growing season and until flowering of Smooth Bromegrass have been found to be common for this area. According to Selders (8), Evans and Wilsie (2, p.931) and Hanson and Sprague (3, p.249), low temperatures during the short daylengths are necessary for maximum panicle production and good flowering. Although conditions similar to these do exist, it was not determined in this study whether maximum panicle production was obtained.

Heading began from mid-May to early June, a period when occasional frosts may occur, and although fairly low temperatures did occur from heading until flowering no detrimental effects were found. Livingston and Swinebank (6, p.154) found less injury to low temperatures in the boot through flowering stages than in stages from pollination until the fertilized embryo was one-third enlarged. If similar conditions exist in Smooth Bromegrass, these earlier frosts may not be nearly as critical as less severe temperatures that may occur during flowering.

Flowering occurred in late June, a period in which field frosts occurred during all three years of this study. The lowest temperatures occurred two days after flowering began in 1955. The temperature, which reached a low of 26 degrees F., was lower than normal for late June. In 1954 and 1956 the lowest field temperatures were 28 degrees F. for both years, which is not uncommon for this period. No evidence was found in seed yields to indicate severe damage by the low temperatures during this period.

The short duration of these temperatures may reduce injury that might occur at these temperatures if maintained for longer times. In 1956 when the 28 degree F. temperature was recorded, the thermograph showed a drop from 33 to 28 degrees F. from 3:00 to 4:45 a.m., when the minimum was reached just prior to sunrise. Within one-half hour the temperature had risen to 33 degrees F. again and continued a rapid rise. Livingston and Swinebank (6, p.154) found no injury in winter wheat when exposed to similar temperatures for a period of only two hours. They did, however, find minor injury at temperatures slightly below 26 degrees F. when exposed for two hours. While the discoloration and shriveling of the anthers may have been due to frost injury, seed yields were apparently not affected, at least in plants where the shriveled anthers were abundant. Techniques used in this study probably would not detect minor injury.

If Smooth Bromegrass is no more susceptible to frost damage than the winter wheat varieties used by Livingston and Swinebank, it could be assumed that temperatures found in this study were not severe enough for more than minor injury. To determine adequately the minimum temperature necessary for frost damage to occur during the blooming period or other periods it would be necessary to have facilities for exposing the plants to various definite temperatures at certain stages of flowering.

The wide range of plant characteristics within each variety may also have masked any differences which may have been caused by climate or other factors. This possibility may have been greatly reduced here since all plants headed, flowered and matured near the same time, even though Knowles and White (5, p.242-243) found that the southern strains were from two to four days later in flowering at three stations in Western Canada, than were the northern strains.

The temperatures obtained at the various locations would indicate that official temperatures which are available in the Klamath area are not adequate to determine the actual temperatures which occur in the field. When official temperatures are recorded in the same vicinity in this area they reflect the general trend, but a field thermometer should be used to determine actual temperatures. This would be especially true if it is known at what temperature damage may occur to a particular crop. Temperature records will be more important in outlying plots because as indicated by the temperatures at the Lower Lake tract, they may fluctuate considerably from the official temperatures or from the temperatures on the Station.

The time of day in which the plant flowered corresponded closely with that reported by Jones and Newell (5, p.6-8). The flowering began during or soon after the warmest part of the day and continued until nearly evening. No flowering occurred on cool or cloudy days. Similar observations were made in orchardgrass studies by Wolfe (12, p.611) and in observations in tall fescue by Cowan (1, p.35-40). Periods of cloudy weather during late June or early July are not likely to continue for more than one or two days.

Since flowering occurs only during the warmer periods of the day, the possibility of damage because of the time of day in which it flowered, would be limited primarily to any adverse effects of heat or humidity. Such factors were not considered important during this study and no attempts were made to determine their effect on the plant.

Flowering occurred fairly uniformly over the two week period with the exception of the peak day soon after flowering began. Since the low temperatures were reached when the florets were closed, any injury might be expected to be more likely to occur to more than to just those florets flowering on the day of the low temperatures.

Seed production of the individual plants varied to a wide degree, but the total seed yields of the twenty plants of each variety corresponded rather closely with the seed yields from the varietal seed trial. This may indicate that the randomly selected plants, as a group, fairly well represented each variety.

Varietal differences in seed yields were found in only one of three years on the Lower Lake tract although large differences occurred between the averages of the different varieties. The error within varieties or replications was large enough in both 1953 and 1954 to mask any varietal differences. The cause of this is not known, but it may have been caused to some degree by poor stands after seeding, although all spaces were filled in the fall of the year the trial was seeded and stands appeared fairly uniform the following spring.

A decrease in total yields in most varieties occurred in 1954 and a greater decrease in 1955. The yields obtained in 1956 were extremely low. These decreasing seed yields may have been due to soil deficiencies even though minor elements and phosphorous were applied in 1952 prior to seeding. No additional fertilizers were applied until early spring of 1956 which may have been too late to affect yields if soil deficiencies were the cause of the decreased yields. Trials on barley have shown that deficiencies do exist, but sufficient data are not available for forage crops to determine the rates and frequency of applications necessary to maintain high levels of fertility in these soils.

Highly significant differences between varieties were found on the Station in both 1955 and 1956. Even with the difference between locations the varieties which were high yielding at the Station tended to be higher yielding at the Lower Lake tract. The highest yielding varieties at both locations were the northern type Smooth Bromegrass, i.e., Canada Commercial and Martin. Similar results were found by Knowles and White (5, p.442-443) in Western Canada, when comparing northern commercial strains of bromegrass with southern strains of bromegrass. The northern strains of Smooth Bromegrass were also the higher seed producers in the individually spaced plants. Manchar, a selection at Pullman, Washington, from seed introduced from Manchuria, was also a very good seed producer. Although there is a definite tendency for the northern varieties to be the heaviest seed producers, there is only a small difference in seed yield between the northern varieties and the higher seed yielding southern varieties. This, along with the wide range in seed yields between varieties, will make it important to test varieties before recommending them for seed production in the area. It can then be determined whether higher or lower yields might be expected than from those varieties that may already be grown in the Basin.

If Smooth Bromegrass seed production should begin in the Klamath Basin it will be necessary to test the varieties in the locations in which they are grown, if possible, since all varieties did not produce equally as well in both locations when compared with all other varieties, even though there was a tendency toward it.

Germination tests in 1954 and 1956 showed all varieties, except Lancaster in 1954, above present minimum requirements for certified Smooth Bromegrass seed in Oregon. All varieties tested in both seed trials in 1956 had 90 per cent or above germination.

The hay crop, after the seed is harvested, will be an economic factor favorable to Smooth Bromegrass seed production in the Klamath Basin where cattle are important. The hay made from this is low in protein, but still satisfactory for many feeding operations.

SUMMARY AND CONCLUSIONS

Agricultural production in the Klamath Basin is limited to a small number of crops because of severe spring frosts and short growing seasons. Over production and low prices of some of the main crops have caused an interest in new crops for the Basin. Crops which could be grown by using present equipment and which are in demand might be readily adopted. Grass seed production could be produced on most farms without major changes in farm operations.

Smooth Bromegrass is one of the important grasses in both pasture and hay mixtures in the United States and will probably maintain or increase in importance. This study was initiated to investigate the effect of temperatures and locations on Smooth Bromegrass seed production in the Klamath Basin.

Twenty seedling plants were randomly selected from each of five varieties and grown in spaced plantings in the field on the Klamath Experimental Station. Temperatures were recorded from a maximum-minimum thermometer in the field at the Station and from thermographs in weather boxes at both the Station and the Lower Lake tract. These official temperatures were recorded at the airport which is one-half mile east of the Station. The temperatures were obtained during the heading and flowering periods from 1954 to 1956 in an attempt to determine the effects of low temperatures occurring during those periods.

Varietal seed trials grown at two locations to determine if the responses on the different soils and the response to temperatures affected Smooth Bromegrass seed production. Both northern and southern varieties of Smooth Bromegrass were used in both experiments. The aftermath, or the remaining basal foliage after the seed is harvested, was cut for hay in the varietal seed trials. The total dry weight was determined for each plot.

Heading, flowering and maturity occurred at nearly the same time for all varieties. No differences were noted in the flowering patterns of any plants or varieties.

Temperatures below freezing occurred up to and into the flowering period in each year of the study. No detrimental effects of the low temperatures could be determined even though the temperatures reached a minimum of 26 degrees F. during the flowering period in 1955. Shriveled anthers were observed in most plants in 1956, but seed yields were apparently not affected, even on plants with a high percentage of shriveled anthers.

Minimum temperatures at the airport were usually several degrees warmer than field temperatures, particularly on mornings when below freezing temperatures occurred. Temperatures from the Lower Lake tract were not as consistent as the other temperatures obtained in this study.

Northern varieties tended to produce more seed than southern varieties at both locations. Significant differences were found at the Lower Lake tract in only one of three years, although rather wide differences occurred between averages of the varieties. Highly significant differences in seed yields were found between varieties in both 1955 and 1956 on the Station. Canada Commercial and Manchar were the two highest yielding varieties at both locations. There was a slight tendency for varieties to have the same relative position at both locations, however this did not occur in all cases.

Germination tests in 1954 and 1956 showed all varieties, except Lancaster in 1954, to be above present minimum requirements for Smooth Bromegrass certification in Oregon.

Significant differences were also found between varieties in yield of aftermath, on the Lower Lake seed trial in 1953 and 1955. The per cent of crude protein was slightly higher in the varieties which were analyzed from the Station than were the varieties from the Lower Lake trial. Crude protein in the aftermath ranged from

4.94 to 10.71 per cent.

A number of conclusions can be drawn from these trials:

1. Dates of heading, flowering and maturity of Smooth Bromegrass were nearly the same for all varieties at both locations and are not a factor in determining adaptability between varieties.
2. Temperatures as low as 26 degrees F. in the field during the flowering period did not materially reduce the production of the seed crop.
3. Temperatures should be obtained at the plot site if accurate temperature records are necessary.
4. Northern varieties of Smooth Bromegrass were higher seed producers than southern varieties in these trials, but all varieties should be tested to determine whether they are high or low seed producers because of the range between the highest and lowest varieties.
5. Varieties should be tested in the location where grown if possible, because all varieties did not retain the same relative position at both locations.
6. Hay yields from aftermath do not vary much between varieties, particularly on the Station and although it is fairly low in protein, it is still satisfactory for many feeding operations.

BIBLIOGRAPHY

1. Cowan, J. Ritchie. Some plant breeding studies with tall fescue, Festuca arundinacea Schreb. Ph.D. thesis. Minneapolis, University of Minnesota, 1952. 90 numb. leaves.

2. Evans, M. and C. P. Wilsie. Flowering of bromegrass, Bromus inermis, in the greenhouse as influenced by length of day, temperature, and level of fertility. Journal of American society of agronomy 38:923-932. 1946.

3. Hanson, A. A. and V. G. Sprague. Heading of perennial grasses under greenhouse conditions. Agronomy journal 45:248-251. 1951.

4. Jones, M. D. and L. C. Newell. Pollination cycles and pollen dispersal in relation to grass improvement. Lincoln, University of Nebraska, 1946. 42p. (Nebraska. Agricultural experiment station. Research bulletin no. 148).

5. Knowles, R. P. and W. J. White. The performance of southern strains of bromegrass in western Canada. Scientific agriculture 29:437-450. 1949.

6. Livingston, J. E. and J. C. Swinebank. Some factors influencing the injury to winter wheat heads by low temperatures. Agronomy journal 42:153-157. 1950.

7. Newell, L. C. Controlled life cycles of bromegrass, Bromus inermis Leyss., used in improvements. Agronomy journal 43:417-424. 1951.

8. Selders, A. A. Effect of several environmental factors on panicle production of bromegrass. Master's thesis. Lincoln, University of Nebraska, 1947. 34 numb. leaves.

9. U.S. Dept. of agriculture. Climate and man. Washington, U.S. Government printing office, 1941. 1248p. (U.S. Dept. of agriculture. Yearbook of agriculture 1941).

10. U.S. Dept. of agriculture. Field seeds, crop years 1939-1955. Washington, U.S. Government printing office, 1955. 30p.

11. U.S. Dept. of commerce. Climatological data, Oregon vol. 57-62, Asheville, U.S. Weather bureau, N.W.R.C. 1951-1956

12. Wolfe, T. K. Observations on the blooming of orchardgrass flowers. Journal of American society of agronomy 17:605-618. 1925.

APPENDIX

Table 19. Minimum temperatures for four locations for periods from May 17 to August 12 for 1954, 1955 and 1956.

Locations

Field - Open thermometer in the field at the Station.
Station - Weather box at the Station. A thermometer was used in 1954 and 1955 and a thermograph in 1956.
Airport - Official temperatures recorded at the airport.
LLT - Temperatures from Lower Lake tract. Recorded on a thermograph.

Date	1954				1955				1956			
	Field	Station	Airport	LLT	Field	Station	Airport	LLT	Field	Station	Airport	LLT
May 17		50	49		40	40	40		34	32	42	37
18	41	45	48		32	34	36		36	43	46	44
19	40	43	48		38		44		38	43	46	44
20	42	45	42		44	46	48		38	46	45	46
21	35	44	38		34	38	43		39	47	48	40
22	26	30	32		27	27	30		41	52	53	43
23	32	36	40		26	30	32		36	45	49	48
24	42	43	36	43	38	40	41		30	40	43	40
25	30	34	35	32	27	31	33		38	34	41	39
26	36	38	33	39		36	36			40	36	41
27	17	24	28	24	24	26	29		28	30	31	32
28	31	35	35	30			35		35	38	41	41
29	28	30	34	40			43		34	50	52	50
30			46	28		44	31		46	48	48	45
31		46	36	46		29	30		36	39	41	34

Table 19 - Continued

Date	1954 Field	1954 Station	1954 Airport	1954 LLT	1955 Field	1955 Station	1955 Airport	1955 LLT	1956 Field	1956 Station	1956 Airport	1956 LLT
June 1	21	26	28	29	24	27	28		38	41	41	36
2	34	36	37	32	30	33	36		36	38	42	37
3	44		41	42	38	44	44		42	47	39	42
4	30	31	33	34	38	40	42		36	37	35	34
5	30	31	32	30	40	42	45		28	29	32	29
6	24	27	30	33	35	39	44		28	30	35	29
7	26	29	31	29	42	46	51		30	34	39	37
8	40	40	39	41	58	60	63		34	37	42	34
9	26	28	35	37	62		64		39	40	46	40
10	37	38	39	39	62	60	65		41	45	42	45
11	32	34	36	34	58		61		29	33	36	32
12	44	39	42	44	36		50		30	38	44	36
13	40	40	40	39			43		38	40	43	37
14	38		41	44			46		48	49	44	46
15	50	39	41	49			44		34	37	38	35
16	29	30	32	34	25		33		38	42	42	42
17	26	28	30	32			43	38	30	35	38	39
18	29	32	34	30			40	35	38	40	45	38
19	38	39	41	40			43	36	46	47	43	37
20	40		46	44			48	38	28	31	36	32
21			42	38			43	36	34	34	39	33
22	35	37	47	42			45	41	42	45	47	42
23	42	45	48	45			43	38	45	48	44	50
24	43	45	49	46	25		33	29	28	33	36	31
25	44	46	50	45			47	41	32	34	37	33
26	46	47	51	45			45	40	39	44	49	40
27		52	42	46			42	32	52	55	58	44
28	28	30	34	32			37	30	39	42	49	40
29	41	43	45	36	26		32	35	39	41	49	44
30			46	52	38		42		38	38	47	48

Table 19 - Continued

Date	1954 Field	1954 Station	1954 Airport	1954 LLT	1955 Field	1955 Station	1955 Airport	1955 LLT	1956 Field	1956 Station	1956 Airport	1956 LLT
July 1	38	39	39	40	32		35	30	42	43	47	46
2	38	38	40	32			39	33	34	36	38	36
3	38	40	44	38	35		40	36	34	35	38	34
4	40	42	46	36	33		42	38	40	44	45	40
5	36	38	41	35			39	35	43	45	49	43
6	49	49	52	45			39	37	38	40	45	44
7			50	37	27		34	29	49	53	57	44
8			44	41	40		46	46	54	59	61	39
9			49	45	48		50	44	49	51	56	44
10			50	42			44	44	48	48	53	46
11			47	40			45	37	42	44	48	44
12			53	48	38		55	39	46	49	52	50
13			57	48	48		56	46		46	49	38
14			57	48	46		53	42	44	45	49	47
15			52	45			52	47	36	40	45	60
16			51	43			46	45	48	50	57	44
17			50	42			38	42	54	57	63	53
18			50	41			41	37	48	53	59	51
19			50	42			45	39	53	56	66	60
20			42	37			51	46	50	50	54	49
21			40	36			52	41	44	46	51	45
22			47	46			53	40	48	50	55	45
23			54	46			53		54	58	64	
24			50	40			50		52	53	58	
25			51	42	33		42		54	57	62	
26			49	42			43		54	57	61	54
27			48	40			42		50	50	55	48
28			45	37			47			49	51	47
29			49	43	34		44			43	48	41
30			53	38			48			47	52	42
31			53	42			52			45	49	41

Table 19 - Continued

Date	1954 Field	1954 Station	1954 Airport	1954 LLT	1955 Field	1955 Station	1955 Airport	1955 LLT	1956 Field	1956 Station	1956 Airport	1956 LLT
Aug. 1			50	40			49		41	46		45
2			52	44			48		32	34		36
3			41	38			52		30	32		30
4			48	50			57			38		34
5			39	40			55			47		45
6			41	33			61		37	38		36
7			47	38			60			48		42
8			47	38			51			53		46
9			48	40			53			46		50
10			46	39			53			42		36
11			45				51			45		40
12			45	38			48			40		36

Table 20. Heading dates of the individual plants on the Station in 1955.

	Replication I	II	III	IV	Total Av.
1. Martin	6-4	6-4	6-1	6-6	6-4
	6-4	6-1	6-2	6-2	
	6-4	6-8	6-7	6-6	
	6-5	6-8	6-4	6-5	
	6-4	6-5	6-1	6-1	
2. Canada Commercial	6-6	6-8	6-7	6-2	6-4
	6-2	6-3	6-7	6-1	
	6-1	6-4	6-4	6-6	
	6-1	6-5	6-3	6-3	
	6-3	6-3	6-2	6-3	
3. Achenbach	6-3	6-2	6-8	6-6	6-4
	6-2	6-1	6-8	6-3	
	6-4	6-1	6-5	6-3	
	6-1	6-5	6-4	6-6	
	6-4	6-1	6-4	6-2	
4. Lincoln	6-3	6-1	6-1	6-4	6-3
	6-3	6-2	6-6	6-3	
	6-4	6-2	6-3	6-3	
	6-3	6-1	6-3	6-4	
	6-4	6-2	6-2	6-2	
5. Oklahoma	6-3	6-5	6-5	6-1	6-4
	6-7	6-1	6-4	6-2	
	---	6-2	6-3	6-1	
	6-4	6-6	6-7	6-2	
	6-6	6-5	6-3	6-4	
Replication Av.	6-4	6-3	6-4	6-3	

Table 21. The observed amount of shriveled anthers for each plant in two replications on five dates during the flowering period in 1956.

Amount of shriveling

1 - No shriveling
2 - 25% estimated shriveling
3 - 50% estimated shriveling
4 - 75% estimated shriveling
5 - 100% shriveled

	Plant No.	Dates of Observation 6/27	6/28	7/3	7/4	7/6	Av.
1. Martin	6	2	1	2	--	3	2
	7	2	1	3	2	2	2
	8	2	1	1	2	1	1
	9	2	1	1	2	2	2
	10	3	3	1	5	5	3
	26	5	3	5	5	5	5
	27	2	1	3	4	3	3
	28	2	1	3	2	2	2
	29	2	2	3	4	4	3
	30	5	4	3	4	5	4
2. Canada Commercial	21	2	1	4	4	4	3
	22	2	1	2	--	2	2
	23	2	1	2	1	3	2
	24	3	1	3	--	3	2
	25	4	2	4	5	5	4
	31	--	--	3	3	3	3
	32	3	1	3	--	--	2
	33	2	--	1	2	3	2
	34	5	3	5	5	--	4
	35	4	1	3	3	3	3

Table 21 - Continued

	Plant No.	Dates of Observation 6/27	6/28	7/3	7/4	7/6	Av.
3. Achenbach	1	2	--	1	2	3	2
	2	2	2	1	3	4	2
	3	3	--	2	4	4	3
	4	3	2	4	--	--	3
	5	2	--	1	3	4	2
	36	2	1	3	4	3	3
	37	2	2	1	2	2	2
	38	5	2	2	4	4	3
	39	5	1	2	3	3	3
	40	5	2	2	3	--	3
4. Lincoln	11	4	--	3	5	5	4
	12	4	3	2	5	4	4
	13	5	4	4	--	5	4
	14	2	2	2	4	4	3
	15	2	1	2	4	4	3
	46	2	1	2	3	3	2
	47	3	3	3	3	4	3
	48	4	1	3	4	4	3
	49	2	1	2	3	3	2
	50	3	1	2	3	3	2
5. Oklahoma	16	2	1	2	4	4	3
	17	3	--	2	2	2	2
	18	5	--	2	4	5	4
	19	2	--	2	3	4	3
	20	2	1	1	1	2	1
	41	5	3	2	4	4	4
	42	5	3	3	3	4	4
	43	4	1	3	4	3	3
	44	2	1	3	3	3	2
	45	5	3	2	4	4	4

Table 22. Seed yields in grams of the individual plants in 1955 and 1956.

MARTIN			CANADA COMMERCIAL			ACHENBACH		
Plant No.	1955	1956	Plant No.	1955	1956	Plant No.	1955	1956
6	75	95	21	8	81	1	3	6
7	2	0	22	100	65	2	7	9
8	53	81	23	3	54	3	7	40
9	3	92	24	148	96	4	22	63
10	76	22	25	110	30	5	42	14
Total	209	290		369	326		81	132
% of Var. Total	28	28		28	27		17	23
26	140	47	31	23	87	155	12	
27	19	8	32	50	92	37	36	6
28	1	0	33	141	28	38	18	87
29	7	39	34	117	36	39	1	8
30	88	57	35	21	7	40	2	7
Total	255	151		352	250		212	120
% of Var. Total	35	14		26	20		45	21
71	1	12	61	60	138	66	1	13
72	106	97	62	27	60	67	18	22
73	1	1	63	44	76	68	121	18
74	1	89	64	118	40	69	1	2
75	49	66	65	165	58	70	1	3
Total	158	265		414	372		142	58
% of Var. Total	21	25		31	31		30	10
96	3	13	81	23	76	91	8	42
97	108	73	82	9	128	92	2	33
98	0	170	83	34	9	93	15	77
99	3	4	84	28	40	94	1	68
100	6	80	85	103	9	95	10	45
Total	120	340		197	262		36	265
% of Var. Total	16	33		15	22		8	46
TOTAL	742	1046		1332	1210		471	575

Table 22 - Continued

LINCOLN Plant No.	1955	1956	OKLAHOMA Plant No.	1955	1956
11	3	18	16	--	70
12	122	38	17	30	40
13	76	61	18	71	53
14	3	98	19	1	82
15	0	7	20	1	2
Total	204	222		103	257
% of Var. Total	28	34		17	45
46	22	12	41	65	20
47	2	19	42	173	25
48	7	0	43	18	6
49	24	23	44	43	31
50	6	2	45	5	2
Total	61	56		304	84
% of Var. Total	9	9		50	14
56	4	20	51	34	43
57	84	28	52	61	10
58	1	38	53	4	10
59	93	89	54	3	81
60	4	17	55	32	11
Total	186	192		134	155
% of Var. Total	26	30		22	27
86	3	66	76	3	7
87	53	19	77	55	9
88	9	22	78	2	2
89	182	26	79	2	55
90	16	38	80	4	9
Total	263	171		66	82
% of Var. Total	37	27		11	14
TOTAL	714	641		607	568

Table 23. Yields by plots and replications of 15 varieties in the Lower Lake tract seed trial for years 1953-1955. Yields are in grams of clean seed per plot.

	Replication I	II	III	Total	Average
1953					
1. Martin	676	869	754	2299	766
2. Manchar	829	827	630	2286	762
3. Southland	823	612	833	2268	723
4. Achenbach	718	682	537	1937	646
5. Canada Commercial	362	950	588	1900	633
6. Lyon	494	690	692	1876	625
7. Fischer	657	611	576	1844	615
8. B. in. 12	453	613	558	1624	541
9. Sandburg	776	607	190	1573	524
10. Lancaster	844	358	345	1547	516
11. Homesteader	364	741	437	1542	514
12. Lincoln	534	504	480	1518	506
13. Elsberry	133	730	636	1499	500
14. #404	445	426	572	1443	481
15. Oklahoma	366	607	354	1327	442
1954					
1. Canada Commercial	745	654	610	2009	670
2. #404	710	409	596	1715	572
3. Southland	611	457	539	1607	536
4. Lyon	579	483	461	1523	508
5. Manchar	526	392	575	1493	498
6. Homesteader	434	478	565	1477	492
7. Sandburg	420	408	634	1462	487
8. B. in. 12	526	409	521	1456	485
9. Martin	602	283	512	1397	466
10. Achenbach	605	362	415	1382	461
11. Fischer	537	428	415	1380	460
12. Lincoln	536	400	441	1377	459
13. Oklahoma	515	341	465	1321	440
14. Lancaster	562	328	340	1230	410
15. Elsberry	432	518	244	1194	398

Table 23 - Continued

1955	Replication I	II	III	Total	Average
1. Canada Commercial	482	424	480	1386	462
2. Manchar	479	337	451	1267	422
3. Sandburg	336	255	550	1141	380
4. B. in. 12	378	283	387	1048	349
5. #404	335	237	464	1036	345
6. Martin	315	276	398	989	330
7. Homesteader	260	283	414	957	319
8. Lincoln	293	186	358	837	279
9. Lyon	310	238	241	789	263
10. Fischer	202	190	379	771	257
11. Elsberry	198	193	287	678	226
12. Lancaster	235	137	305	677	226
13. Achenbach	203	177	275	655	218
14. Southland	214	159	282	655	218
15. Oklahoma	212	175	242	629	210

Table 24. Yields by plots and replications of 13 varieties in the Station seed trial for years 1955 and 1956. Yields are in grams of clean seed per plot.

	Replication				
1955	I	II	III	Total	Average
1. Canada Commercial	642	518	675	1835	612
2. Manchar	428	587	635	1650	550
3. Martin	479	503	490	1472	491
4. B. in. 12	524	285	496	1305	435
5. Mandan	485	371	341	1197	399
6. Lincoln	395	450	347	1192	397
7. Fischer	361	230	336	927	309
8. Southland	268	243	398	909	303
9. Homesteader	172	369	254	795	265
10. Lyon	229	219	274	722	241
11. Lancaster	202	233	193	628	209
12. Achenbach	123	233	218	574	191
13. Elsberry	196	180	103	479	160
1956					
1. Manchar	446	467	678	1591	530
2. Canada Commercial	442	496	493	1431	477
3. B. in. 12	412	448	477	1337	446
4. Mandan	476	385	426	1287	429
5. Homesteader	461	535	229	1225	408
6. Martin	408	380	294	1082	361
7. Lyon	347	304	403	1054	351
8. Lincoln	167	247	305	719	240
9. Lancaster	298	272	145	715	238
10. Elsberry	243	297	169	709	236
11. Fischer	125	252	305	682	227
12. Achenbach	149	358	99	606	202
13. Southland	197	109	238	544	181