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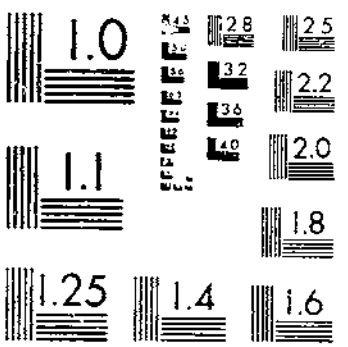
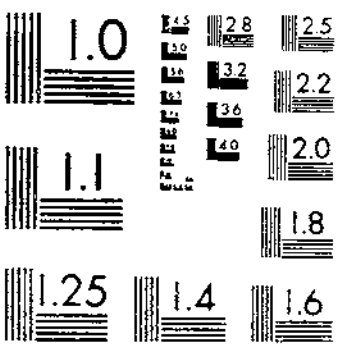


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



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

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UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

CEREAL EXPERIMENTS AT THE FORT HAYS BRANCH STATION, HAYS, KANS., 1912 TO 1923

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THE UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE KANSAS AGRICULTURAL EXPERIMENT STATION

CONTENTS

INTRODUCTION [1]

The investigations with cereals at the Fort Hays Branch Station have consisted chiefly of varietal experiments with wheat, oats, barley, emmer, sorghums, corn, and flax. Improvement of cereal

[1] The Fort Hays Branch Station, near Hays, Ellis County, Kans., is controlled by the Kansas State Agricultural College. From 1902 to 1909 the agronomic experiments were under the direct supervision of the superintendent of the station. From 1909 to 1911 a State agronomist was in charge of the small grain experiments. In 1910 a representative of the present Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, began investigations with grain sorghums, in

varieties by selection and by hybridization, and cultural experiments on seeding winter wheat, top-dressing wheat with straw, and on spacing kafir also have been conducted.

All of the experiments have been made under dry-farming conditions. Owing to varying climatic factors the yields of the different crops show large fluctuations from year to year. The results obtained are applicable to much of the central Great Plains area, particularly the western two-thirds of Kansas, and to a varying degree to southwestern Nebraska, eastern Colorado, and northwestern Oklahoma.

HISTORY OF THE REGION

Following the Civil War, settlers began to arrive in the central section of Kansas. Cattle grazing was at first the chief occupation, followed by the gradual development of crop farming. During the early seventies a colony of aristocratic people of English birth acquired large holdings in Ellis County and attempted to establish extensive estates. As they were unfamiliar with methods of dry-land farming and unable to cope with adverse economic conditions, their adventure was a failure.

German-Russian immigrants seeking greater freedom in a new land comprised the next inflow of people. These people, many of whom came in 1876, remained and in time became extensive wheat growers. From 1886 until the early nineties the rest of the country surrounding the town of Hays, and western Kansas in general, was gradually settled by farmers from the Eastern States. During this period drought, grasshoppers, and national financial conditions forced many of the pioneers at different times to desert their farms; but each successive tide retreated to a less degree than the one before, and eventually the country developed a permanent agriculture based on the raising of wheat and livestock.

Wheat continues to be the chief cash crop. Sorghums, barley, oats, alfalfa, and corn also are grown, and the farmers who to-day are most prosperous are those who have followed a diversified system of crop and livestock farming.

THE FORT HAYS BRANCH STATION

HISTORY

When the Kansas Pacific Railroad (now the Union Pacific) was being built in 1867, Fort Hays was established as a frontier post on a 7,600-acre reservation, adjoining the town of Hays on the south. With the advance of civilization and the retirement of the Indian

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cooperation with the Fort Hays Branch Station and the Kansas Agricultural Experiment Station. The project was further enlarged in 1912 to include small grains and corn.

The data presented in this bulletin have been compiled chiefly from the cooperative experiments conducted during the 12 years, 1912 to 1923, inclusive. The results obtained from 1902 to 1911, inclusive, have not been published, and therefore brief abstracts of the general conclusions reached by the early workers at the Hays station are presented in this bulletin.

At the end of 1923 the series of plot experiments at the Fort Hays Branch Station was completely reorganized. Sufficient data have not accumulated from the new series to warrant publication and therefore the data presented herein end with those of 1923. The absence of the writer for a year prevented earlier preparation of the material for publication.

The following men have been in charge of the cereal investigations since 1910: Benton E. Rothgeb from 1910 to 1911; F. A. Kiene, jr., from 1912 to April 1, 1919; and A. F. Swanson since June 1, 1919.

and the buffalo, the need for military forces in western Kansas gradually lessened, and in 1888 the soldiers were withdrawn. In 1889 the military reservation was turned over to the United States Department of the Interior for disposal. On March 28, 1900, Congress ceded the abandoned Fort Hays military reservation to the State of Kansas "for the purpose of establishing an experiment station of the Kansas State Agricultural College and a western branch of the Kansas State Normal School thereon, and for a public park." The grant was accepted by the Legislature of the State of Kansas on February 7, 1901. On February 26, 1901, the State legislature allotted the eastern 3,600 acres of the reservation to the Kansas State Agricultural College for the establishment of a branch experiment station.

Actual operation of the new station was begun March 29, 1902, with J. G. Haney as the first superintendent in charge. Most of the land was in native sod, and much of it was infested with prairie dogs. The breaking of 500 acres was completed in 1902. Such experiments as could be made on sod were started immediately, mostly on a field scale. Improvements such as fences, buildings, water systems, bridges, and working equipment naturally required a large part of the necessary work in these early years.

LOCATION

The main plant of the station is situated 1 mile south of the town of Hays in Ellis County. Hays is centrally located in an area known as the hard winter-wheat belt. It is 75 miles south of the Kansas-Nebraska line and 160 miles east of the Kansas-Colorado line. The latitude is approximately 38° 52′ north, and the longitude 99° 25′ west. The elevation is about 2,000 feet.

TOPOGRAPHY AND SOIL

The topography of the Fort Hays Branch Station farm and of the surrounding country varies from level to rolling. The general drainage is good. The station is drained by a large stream and is bounded by low bottom lands consisting of a rich silt loam of the Lincoln series. The soils of the Lincoln series are alluvial in nature, being derived from the silt loam and silty clay loam of the Summit series which occupies the bench or upland in the vicinity of Hays and from soils of the Colby series occupying the uplands 50 or 60 miles to the west of Hays.

The upland consists of first and second bench lands, lighter in texture than the bottom lands, but very fertile. The first 4 or 5 inches of these upland soils consists of a dark gray to black silt loam. The next 18 inches of the soil profile consists of a slightly lighter colored clay loam of a highly granular structure. Below this 18-inch stratum is a heavy gray clay changing to a highly calcareous gray clay. The soils of this upland, which is extensively farmed, are of the Summit series. There are local areas of soil also belonging to the Benton series in the vicinity of Hays, but these are commonly used for pasture purposes.

The soil in the Hays section is easily tilled unless very wet or dry. Under conditions of normal rainfall and proper management a mellow, ideal seed bed can be prepared readily. The soil has an

abundance of plant food, so that rainfall is the chief limiting factor in crop production. When the soil becomes extremely dry from lack of rainfall, or when it produces a heavy crop, it may check and crack. Later, when rain occurs, these fissures permit the surplus water to enter the subsoil. Under certain conditions, and sometimes because of the lack of proper management, the soils of western Kansas are subject to severe soil blowing.

NATIVE VEGETATION

The western half of Kansas lies in the Great Plains area, the section often spoken of as the "short-grass region." Native upland vegetation of the locality consists largely of two species of grass, buffalo grass (*Bulbilis dactyloides*), and blue grama (*Bouteloua gracilis*). Scattered rather thickly in this short-grass sod are bunches of wire grass (*Aristida longiseta*). In moist places in ravines and draws, taller grasses such as big bluestem (*Andropogon furcatus*) and little bluestem (*A. scoparius*) may be found.

CLIMATIC CONDITIONS[2]

PRECIPITATION

The distribution of precipitation over the State and the time of its occurrence are the chief limiting factors in crop growth, and from an agricultural standpoint usually receive more attention than all other phases of the weather. The precipitation in the Hays district is often irregular in quantity, and in seasonal distribution it is similar to that of most of the central Great Plains, especially western Kansas, eastern Colorado, and western Nebraska. The normal annual precipitation in western Kansas decreases steadily toward the west, from 27 inches at Salina to 16 inches at the Kansas-Colorado line. Rainfall is often in the form of local showers, or it may be of a general nature and cover a very large area. Torrential rains usually occur every year somewhere in the section to which these data are applicable, and may at times be the cause of considerable damage by floods and soil erosion. The distribution of precipitation throughout the year is not always favorable for the production of all of the cereals that can be grown in the section, but by careful diversification there need rarely be a complete failure of all crops for any one year.

The monthly, seasonal, and annual precipitation at Hays from 1902 to 1923, with averages for the period from 1868 to 1923, are presented in Table 1. The average annual rainfall for the 22-year period 1902 to 1923, inclusive, was 23.01 inches, and that for the months of the growing season, April to September, was 17.91 inches. The average annual rainfall for the 56-year period from 1868 to 1923, inclusive, was 22.87 inches.

The average annual precipitation for the 12-year period from 1912 to 1923, inclusive, as indicated in Figure 1, was 21.88 inches, or 0.99 of an inch less than that for the 56-year period.

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[2] Adapted from UNITED STATES DEPARTMENT OF AGRICULTURE, WEATHER BUREAU. SUMMARY OF THE CLIMATOLOGICAL DATA FOR THE UNITED STATES, BY SECTIONS. REPRINT OF SECTIONS 38 AND 39—KANSAS, 1922.

TABLE 1.—*Monthly, seasonal, and annual precipitation at the Fort Hays Branch Station, Hays, Kans., during the 22-year period 1902–1923*

[Data in inches. T. = trace]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Seasonal, Apr. 1 to Sept. 30	Annual
1902	1.00	0.55	3.80	0.20	4.28	6.44	3.84	5.64	4.93	2.56	T.	1.35	25.39	34.65
1903	.15	4.20	1.03	2.01	10.08	4.40	2.72	4.55	.55	1.85	0.88	T.	24.31	32.52
1904	.10	.06	.28	.88	4.22	2.90	2.75	2.90	.95	1.75	.06	.60	14.60	17.45
1905	.65	.54	.73	2.54	3.71	4.94	3.93	.86	1.61	1.43	2.74	T.	17.64	23.73
1906	.15	.37	.73	1.67	1.51	2.29	5.79	2.87	3.39	2.94	.86	.51	17.52	23.08
1907	.64	.22	.85	.60	.83	4.97	9.15	3.12	1.75	1.40	.11	1.76	20.42	25.40
1908	T.	.92	T.	2.18	3.06	6.02	2.90	5.86	.81	1.76	1.79	.03	20.83	25.33
1909	.39	.28	1.16	.47	1.80	16.21	3.71	1.48	2.78	1.64	3.55	1.00	20.26	28.27
1910	.58	.26	.03	.91	3.53	2.71	2.45	3.92	1.28	.36	T.	.14	14.80	16.17
1911	.12	2.12	.14	.82	2.27	.81	2.09	4.47	2.05	.30	.14	1.82	12.51	17.15
1912	.02	1.98	1.60	1.66	2.70	4.32	.88	3.52	1.85	.51	1.13	.03	14.93	20.20
1913	.36	.65	.41	2.78	5.72	3.53	.63	.11	4.80	.25	.72	3.11	17.57	23.10
1914	.04	.42	.15	2.31	2.36	3.39	2.77	2.63	.60	1.33	T.	.63	14.06	16.63
1915	.65	1.60	1.74	3.13	6.82	3.97	8.18	4.11	2.44	.93	.30	.04	28.65	34.14
1916	.53	.15	.31	2.21	1.63	5.88	.30	1.97	1.26	1.14	.02	.61	13.25	16.01
1917	.11	T.	.07	1.96	1.72	2.15	1.46	5.73	1.84	.09	1.04	.15	14.86	16.92
1918	.80	1.15	1.71	2.40	4.79	.53	3.04	1.76	1.42	2.41	1.10	2.38	14.03	23.58
1919	T.	2.18	.33	4.51	6.85	3.51	1.16	.77	3.32	1.81	1.54	.15	20.12	26.13
1920	.05	.37	.30	2.04	3.32	1.87	1.89	5.11	1.56	3.58	.73	.46	15.79	21.28
1921	.40	.10	.40	3.58	2.59	3.67	3.36	3.04	.68	.05	0	.50	16.92	18.46
1922	T.	.93	1.71	4.51	2.61	2.18	4.20	.81	.43	.32	1.23	T.	14.74	18.98
1923	T.	.10	3.04	1.63	3.97	5.90	.70	4.15	4.52	4.37	.29	.37	20.93	27.10
Average, 1902–1923	.31	.88	.85	2.05	3.64	3.94	3.09	3.15	2.04	1.49	.86	.71	17.91	23.01
Average, 1868–1923	.52	.85	.97	2.34	3.36	3.23	3.23	3.00	2.31	1.48	.77	.83	17.47	22.87

Whether precipitation has shown any progressive increase or decrease since the land was opened for settlement and the prairie sod broken has been the subject of much discussion. A study of

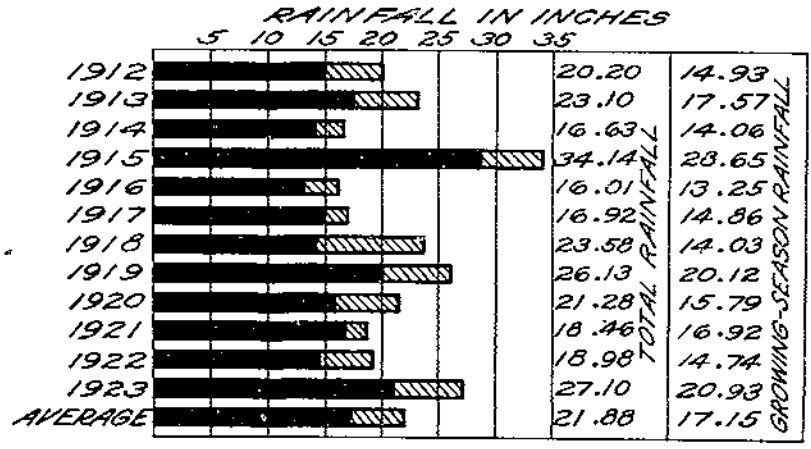

FIG. 1.—Average annual precipitation at the Fort Hays Branch Station, Hays, Kans., during the 12-year period 1912–1923. Growing season, April to September, black; remainder of year, shaded

the precipitation records for the section, a number of which were begun more than 45 years ago, fails to show any progressive change in the average annual quantity or in its distribution throughout the year. Since rainfall records have been kept at Hays the total annual

precipitation has varied from a low of 11.8 inches in 1894 to a high of 35.4 inches in 1878.

Approximately three-fourths of the precipitation falls during the six months of the growing season, April 1 to September 30. The middle third of the State receives in these months almost as much rain as occurs in the same period in Illinois, Indiana, Ohio, or New York, or in the New England States.

The annual snowfall in the Hays section varies from 10 to 24 inches. As a rule the ground is not covered with snow for a very long period. If the snow falls with a high wind, as often happens, it drifts badly. A deep snow that lies on the ground for a long period of time is very favorable for wheat.

HAIL

Hail is the most uncertain and destructive meteorological phenomenon with which farming interests in central and western Kansas have to contend. Hail is most likely to occur in May, June, and July. Wheat suffers more from hail than does any other crop in Kansas, owing to the large acreage and to the fact that the wheat matures in June and July, when hailstorms are most frequent. On the Fort Hays Branch Station during the 22-year period from 1902 to 1923, inclusive, two crops of small grains were destroyed by hail and four others were badly damaged.

RELATION OF PRECIPITATION TO CROP PRODUCTION

General observations on the relation of precipitation to crop production can be summarized as follows: (1) If a large quantity of reserve moisture from the fall and winter months previous to the crop year is available and there is a normal seasonal rainfall, the prospects for a crop are good; (2) if an abundant crop has been produced with a correspondingly heavy withdrawal of reserve moisture without replacement during the following fall and winter months, the chances are not favorable for a full crop the following year; (3) when hail has swept a territory, totally destroying crop and weed growth, the following year is often one of increased yields. This is due to an accumulation of reserve moisture, the stoppage of further withdrawal of moisture by plant growth, and the fact that farmers are more likely to follow such a disaster by early tillage, which tends to conserve moisture.

EVAPORATION

The seasonal evaporation from a free water surface at Hays is closely related to the seasonal precipitation and is generally highest when the rainfall is lowest. The daily evaporation has been recorded for the months of the growing season since 1907. The method used is that of the biophysical laboratory of the Bureau of Plant Industry. The total evaporation in inches by months from April 1 to September 30 for the years 1907 to 1923, inclusive, is shown in Table 2.

Daily evaporation records are really an index of the combined influence of the other climatic factors and are of much greater interest in understanding the nature of a season than is commonly

realized. In a general way, daily records in which the evaporation is above 0.3 inch in April, May, and September, and above 0.35 inch in June, July, and August, suggest droughty conditions. Daily evaporation greater than 0.4 inch is usually associated with temperatures or winds which are definitely injurious. Daily evaporation greater than 0.5 inch indicates severe drought and greater than 0.6 inch conditions that are practically ruinous to crop growth. The highest daily evaporation recorded at Hays was 0.745 inch on May 18, 1911, closely rivaled by an evaporation of 0.714 inch on July 15, 1913, and of 0.722 inch on August 8, 1913. Both 1911 and 1913 were seasons of almost complete crop failure.

TABLE 2.—*Monthly evaporation from a free water surface at the Fort Hays Branch Station, Hays, Kans., from April to September of each year, 1907–1923*

[Data from the Office of Dry-Land Agriculture]

Year	Evaporation (inches)							Precipitation Apr. to Sept. (inches)	Ratio of evaporation to precipitation
	Apr.	May	June	July	Aug.	Sept.	Seasonal, Apr. 1 to Sept. 30		
1907	6.520	7.199	7.261	8.612	7.846	7.210	44.648	20.42	2.19:1
1908	6.450	7.181	7.977	7.967	8.191	6.625	44.381	20.83	2.13:1
1909	6.370	9.203	7.211	7.735	10.215	6.737	47.471	20.25	2.34:1
1910	8.339	4.855	7.797	9.258	7.601	5.969	43.819	14.80	2.96:1
1911	6.504	8.887	13.981	11.885	10.274	8.233	59.824	12.51	4.78:1
1912	6.077	8.284	6.417	9.987	9.178	7.022	46.965	14.03	3.15:1
1913	6.666	7.640	8.521	13.815	14.451	7.250	58.283	17.57	3.32:1
1914	5.758	5.094	9.282	9.256	9.817	7.889	47.096	14.06	3.35:1
1915	4.486	5.529	5.328	7.059	5.381	5.494	33.277	28.65	1.16:1
1916	4.228	7.037	7.731	12.201	11.125	7.909	50.231	13.25	3.79:1
1917	6.351	6.527	11.089	11.871	8.140	6.488	50.469	14.86	3.40:1
1918	4.325	7.491	8.936	9.662	11.244	6.511	47.569	14.03	3.39:1
1919	4.065	4.528	5.405	10.272	9.344	7.382	40.996	20.12	2.04:1
1920	4.783	4.682	8.117	9.646	6.291	6.257	39.776	15.79	2.52:1
1921	6.174	7.252	6.043	8.671	8.188	8.229	44.557	16.92	2.63:1
1922	4.388	5.912	7.931	8.258	10.531	10.300	47.320	14.74	3.21:1
1923	5.997	5.578	6.583	9.823	8.584	6.238	42.803	20.93	2.05:1
Average	5.734	6.640	7.977	9.728	9.199	7.161	46.440	17.33	2.68:1

TEMPERATURE

At the Fort Hays Branch Station temperatures are recorded daily by the observer of the Weather Bureau of the United States Department of Agriculture. Subzero temperatures occur from one to several times each winter, but excessively cold periods usually are relatively short. The lowest temperature recorded at Hays was −24° F. on February 7, 1895. The coldest month in Kansas is January, with an average temperature for the State of 30° F., although the lowest temperatures of winter often occur in February. After the middle of February there is normally an irregular but general increase in mean temperature until the latter part of July or early August. July has the highest average temperature, although the heat is generally more oppressive in August. During July and the first part of August temperatures from 100° to 105° F. are almost sure to occur for short periods in the Hays district. If accompanied by winds of some velocity, such temperatures are likely to prove injurious to crops, particularly corn. The highest tem-

peratures recorded at Hays were 114° F., June 25, 1911, and 110°, July 5, 1901, and again July 14, 1913.

The dates of the last killing frost in the spring and the first in autumn for each year from 1908 to 1923, inclusive, are shown in Table 3. The average date of the last killing frost in spring varies from April 9 in the extreme southeastern part of the State to the first week in May in the northwestern part, and killing frosts have been known to occur over nearly all of the western and northwest-central counties as late as May 27. Killing frosts have occurred in September in nearly all sections of the State, but the time of their usual appearance ranges from the first week in October in the northwestern counties to October 23 in the southeastern counties.

TABLE 3.—*Dates of the last killing frost in spring and the first in autumn at the Fort Hays Branch Station, Hays, Kans., for each year, 1908–1923*

Year	Killing frost, 32° F.		Frost-free period (days)	Year	Killing frost, 32° F.		Frost-free period (days)
	Last in spring	First in fall			Last in spring	First in fall	
1908	May 8	Oct. 23	168	1917	May 8	Oct. 8	153
1909	May 1	Oct. 12	164	1918	May 1	Sept. 20	142
1910	Apr. 26	Oct. 21	178	1919	Apr. 17	Oct. 10	176
1911	May 2	Oct. 9	160	1920	Apr. 27	Sept. 29	155
1912	May 16	Sept. 26	133	1921	May 3	Oct. 8	158
1913	Apr. 12	Oct. 17	188	1922	Apr. 18	Oct. 9	174
1914	May 13	Oct. 25	165	1923	May 16	Oct. 21	158
1915	Apr. 3	Oct. 5	185				
1916	May 3	Sept. 29	149	Average	Apr. 30	Oct. 10	163

The growing season in Kansas is sufficiently long on the average for the development and maturing of all of the principal crops, with the possible exception of grain sorghums in the northwestern counties. Freezing temperatures are rarely so low as to be a limiting factor in winter-wheat production, unless the low temperatures are accompanied by a low moisture supply or a high wind velocity.

WIND

Records of wind velocity have been kept at the Hays station since 1908. The velocity of the wind during the months of the growing season has averaged from 10.7 miles an hour in April to 6.5 miles in August. Records have not been kept of the wind velocity from October 1 to March 31.

The winds over the eastern third of Kansas are not noticeably higher than those that prevail in other States between Kansas and the Atlantic Ocean, but the western third of Kansas is one of the windiest inland localities in the country.

The prevailing winds of Kansas are from the south from April to October, inclusive, except in the western portion, where they are from the southeast during April, May, and June, and in some western sections during July and August. In the winter months north or northwest winds prevail, though south winds are frequent. In nearly all parts of Kansas April is the windiest month and August has the least wind movement. There is a marked variation during the day in wind velocity, which increases toward the warmest part

of the day and decreases at night. High northerly winds often precede and accompany cold waves, but blizzards are not of common occurrence.

The hot winds cause the most damage. These winds usually occur during late June, July, and August after a prolonged period of high temperatures. When of high velocity they cause great injury to growing crops, such as corn and sorghums, particularly if these crops are in the early fruiting period Hot drying winds very commonly occur during the last 10 days of June. Such winds have a very marked influence on the ripening of the small grains. If the small grains have reached the hard-dough stage in vigorous growth, the ripening winds of late June are regarded as a favorable factor for the full development of the crop.

Severe soil blowing often may occur in February, March, and April if precipitation is low during these months or if the soil has been subjected to alternate periods of freezing and thawing. Under such conditions the soil quickly becomes friable and ashy and is readily moved by winds of high velocity. Plowed fields which are left bare over winter and are finely cultivated, or which are sown late to wheat, also are subject to soil blowing. In the western half of the State, soil blowing sometimes causes much damage to fields of wheat, exposing the roots or burying the plants under drifted soil.

CROPS OF THE SECTION

The Hays station represents in a general way the western two-thirds of the State, or that portion of Kansas lying west of the meridian of 97.5° west longitude. This section embraces that part of the State west from the 1,500-foot contour. The maximum elevation of this section is nearly 3,700 feet, and the average rainfall ranges from 30 inches along the 1,500-foot contour to 16 inches in some of the extreme western counties.

Winter wheat is the most important grain crop. Of the 9,500,000 acres of wheat grown in Kansas in 1922, 7,000,000 acres were grown in the western two-thirds of the State, or west of a line extending from Washington County on the north to Cowley County on the south.

In this section were grown also nearly all of the 1,000,000 acres of barley produced in the State, as well as one-half of the total oat acreage of 1,500,000 acres, and one-fourth of the total State corn acreage. Corn is not well adapted to the uplands of this section except in the northern and northwestern tier of counties.

The Kansas grain-sorghum crop of 1922 was grown on 1,200,000 acres. Kafir, grown more or less uniformly throughout the State, was the leading variety. Of the 942,000 acres of kafir, 604,000 acres were in the western two-thirds of the State. Milo, largely grown in the southwestern counties, ranked second of the grain sorghums.

In 1922 a little over 70,000 acres of rye were grown, the largest acreage being in the south-central part of the State. The crop was used largely for pasture.

Spring wheat is almost a negligible crop, only about 15,000 acres being grown in the northwestern counties in 1922. The hard winter wheats are far superior to the spring wheats for Kansas, but occasion-

ally the latter crop is used to replace the former if winterkilling has been severe.

Broomcorn, confined to the southwestern counties, is another minor crop with an acreage of less than 20,000. In earlier years a considerable acreage of broomcorn was grown in central Kansas.

EXPERIMENTAL METHODS

PREPARATION OF THE SEED BED

The records are not clear as to the rotations followed in the experiments prior to 1912 at the Hays station. In 1913 a new rotation was arranged as follows: (1) Green manure (rye); (2) experimental grain sorghums; (3) fallow; (4) experimental winter grain; (5) commercial crop of wheat; (6) spring grains and corn. This rotation was continued until 1919.

With the increase of the sorghum nursery a new rotation was laid out in 1920 and has since been followed. This rotation is: (1) Fallow; (2) experimental wheat and nursery work; (3) experimental wheat, barley, and oats; (4) commercial wheat uniformly cropped; (5) experimental sorghums and corn. The second year after fallow the cropped land is plowed or listed, after which the ground is worked down previous to seeding, either in the fall or in the spring, depending on whether winter wheat or spring grain is seeded.

The yields of winter wheat grown on summer-fallow land are more nearly certain and somewhat higher than those resulting from any other method of seed-bed preparation. In the experiments the yields of wheat the second year after fallow were almost as high as the wheat yields following fallow. The yields of wheat the third year after fallow also have been satisfactory. The varietal experiments with oats and barley usually have been seeded on land the second year after fallow, and the sorghums have followed the commercial wheat crop, occupying fourth place after fallow in the rotation. The five-year rotation outlined above has given every indication of being a very satisfactory system for the practical farmer who desires to grow wheat as a cash crop, supplementing it with oats, barley, and sorghums as feed crops. A thorough fallow once every five years leaves the soil in excellent physical condition, the effects of which are apparent for several years. Sorghums follow three years of wheat to good advantage. Any deleterious after effects of sorghums appear to be eliminated by a good fallow.

PLOT EXPERIMENTS

From 1913 to 1919 the varietal experiments were carried on in field plots 8 rods long and of varying widths. Since 1920 all of the various small-grain plots have been 8 rods long by 6½ feet wide. The small grains were sown with an eight-hole 8-inch drill. On plots 6½ feet wide such a drill gives a sown area 56 inches from outside row to outside row and alleys 22 inches wide between the outside rows of adjoining plots. Such a plot is actually slightly less than one-fiftieth of an acre in area. The plants draw considerable moisture and plant food from the alleys, however, and it is considered fair to compute acre yields as from an area one-fiftieth of an acre in size.

Plots of one-fiftieth of an acre were used for the rate-and-date-of-seeding experiments with winter wheat. The furrow drill experiment and the experiment in top-dressing wheat with straw were made on plots one twenty-fifth of an acre in size. The sorghum and corn varieties were grown in plots fractionally larger than one twenty-fifth of an acre. These plots were 8 rods long and consisted of four rows 40 inches apart. Two additional border rows were used but were removed previous to harvest. A view of the plots of the cereal experiments in 1920 is shown in Figure 2.

NURSERY EXPERIMENTS

Prior to 1912 a large number of new selections and importations of hard winter wheat were tested at the Hays station. Many of these selections were afterwards grown in plots for from 1 to 12 years. Between 1912 and 1919 approximately 2,000 selections,

FIG. 2.—General view of the cereal plots at the Fort Hays Branch Station, Hays, Kans., in 1920

largely from the Kharkof and Turkey varieties, were grown in the nursery for from 1 to 5 years. Owing to the necessity for more detailed nursery work with sorghums, only a limited number of wheat selections have been grown in the nursery at Hays since 1919, as it was more practicable to conduct wheat experiments of this type at the central station at Manhattan. Nursery experiments with barley and oats were not begun at Hays until 1923.

Since 1920 the nursery has largely centered on the sorghums. From 300 to 400 sorghum selections have been grown each year in nursery rows, as well as large numbers of individual plants for detailed studies.

The chief objects of the pure-line selection studies have been to obtain high-yielding strains having drought and disease resistance. In the case of sorghums more desirable types for both forage and grain production have been sought.

In the earlier years of the small-grain nursery rows of varying length were employed, depending on the quantity of seed available.

Standard nursery rows have been used since 1920. For wheat the rows were 16 feet long; for barley, 20 feet; and for oats, 15 feet. The rows were 12 inches apart. The head selections of sorghums were grown in rows 4 rods long and 40 inches apart. A good sorghum head usually produces sufficient seed to plant two or more rows 4 rods long.

INTERPRETATION OF RESULTS

The actual acre yields of each variety or crop are given in the tables for each year in which it was grown. Where the plots were replicated, the recorded yields are the averages for all plots of a variety.

Because of the great variability of the yields of crops and of seasonal conditions from year to year, the average yield of a variety grown for a short period may not be comparable with the average yield of a variety grown for a long period. The yield of each variety for each crop, therefore, has been compared with a standard for the same years, the standard being a variety grown during all the years of the experiments. The average plus or minus difference of any variety from the standard is recorded in terms of bushels as well as a percentage of the standard. The probability that these differences are not due to chance is expressed as odds obtained by "Student's" method [3] for determining the probable error of the mean, as follows:

$$\text{Mean} \div \text{standard deviation} = z$$

The odds are then computed from the probability tables for different values of z and n (the number of samples). In determining the average difference from the mean the computation was carried to only one decimal place. For the value of z the results were computed to three decimal places.

A difference in yield of plus 2 bushels an acre between a given variety of oats and a standard, such as Burt×Sixty-Day, indicates that in these experiments the odds are 10 to 1 that the result is not due to chance, and that such a variety is a higher yielder than Burt×Sixty-Day by the amount of the difference. Odds of 10 to 1 are not of any particular significance. With odds of 22 to 1 or more, greater reliance may be placed on differences being significant and not due to chance.

Odds were computed by Student's method for all of the varietal experiments of the major crops and for the rate and date of seeding experiments with winter wheat.

EXPERIMENTS WITH WINTER WHEAT

Hard winter wheat is the most important small-grain and cash crop in the central Great Plains area, consequently the experiments with wheat at the Hays station have been more extensive than with any other crop. The experiments with winter wheat consisted chiefly of varietal tests, rate and date of seeding tests, tests of straw as a top-dressing on wheat, and a comparison of the furrow drill with the common drill. Considerable attention was given also to the improvement of varieties by selection. Both hard red and soft red winter wheats were grown. The results show rather definitely

[3] ANONYMOUS. THE PROBABLE ERROR OF A MEAN. By STUDENT. Biometrika 6: 1–25. 1908.

that the hard red winter wheats of the Crimean group are best adapted to the central Great Plains area, of which the Hays section is representative.

VARIETAL EXPERIMENTS WITH WINTER WHEAT

The varietal experiments with winter wheat were begun in the fall of 1902 and have since been continuous, although only meager records are available for the period 1907 to 1909. It is reported that from 1903 to 1906, 380 varieties and types of winter wheat were grown with the hope of establishing new and hardier strains better adapted to the semiarid portion of the Great Plains area.

The following quotation taken from an early record at the Hays station gives interesting conclusions regarding the Kharkof and Crimean varieties:

> The station in the three years passed (1904–1906) has been experimenting with 380 different varieties and types of winter wheat with the hope of establishing new ones. These varieties were received from the United States Department of Agriculture. * * * Considerable work has been done in making selections for the purpose of originating new varieties that will produce better yields. Twenty-four of the new varieties were grown in field trials on 1-acre plots in comparison with the common Turkey wheat secured in the vicinity of the station. All the plots were given precisely the same treatment, and the average of the yields for the three years shows that five of the new sorts of recent importation gave better yields than did the common Turkey variety. These are No. 4 Kharkof, No. 7 Crimean, Theiss, Weissenberg, and No. 42 Kharkof. The increased yields of the several importations over the common Turkey, which made an average yield of 17.7 bushels per acre, was from one-half to 2 bushels per acre for the three years under ordinary field conditions. The No. 4 Kharkof seems hardy and well adapted to western conditions, and in general the hard red wheats, whether they be from Turkey or Russia, do well. Of the Russian varieties * * * the Kharkof is among the best. The Hungarian varieties are quite promising and the Crimean wheats show up well, especially in the dry seasons.

In 1906 the Kansas Agricultural Experiment Station at Manhattan made a number of selections from the Crimean group, from which originated the variety known as Kanred,[4] now extensively grown throughout the State.

In the period from 1912 to 1923 a new group of winter wheat varieties was selected and grown in the varietal test. The varieties were grown in single plots from 1912 to 1916. Each year since then, unless otherwise noted, four systematically replicated plots of each variety were grown, except in 1918, when five plots of each variety were grown. Summer-fallowed land was used for the experiments from 1912 to 1918, but each year since then two plots have been grown on cropped land and two on summer fallow.

The average annual yield of winter wheat for farms in Ellis County for the 16-year period, 1908 to 1923, inclusive, was approximately 10 bushels to the acre. Yields varied widely for individual years, but they may be grouped roughly into four general classes including (1) failure, (2) poor, (3) fair, and (4) good. A yield of 2 bushels or lower is classed as failure, 3 to 6 bushels as poor, 7 to 9 bushels as fair, and 10 bushels or above as good. During the 16-year period production was as follows:

1908, good; 1909, fair; 1910, good; 1911, failure; 1912, good; 1913, poor; 1914, good; 1915, good; 1916, good; 1917, failure; 1918, fair; 1919, fair; 1920, good; 1921, poor; 1922, poor; 1923, failure.

[4] For more complete information on Kanred, see SALMON, S. C., ESTABLISHING KANRED WHEAT IN KANSAS. Kans. Agr. Expt. Sta. Circ. 74, 16 p., illus. 1919.

TABLE 4.—*Average annual yields of 59 varieties and strains of winter wheat grown at the Fort Hays Branch Station, Hays, Kans., during the 10 years 1912–1914 and 1916–1922, and the average difference in yield from that of Kharkof (C. I. No. 2193) for comparable years* [1]

Class and variety	C. I. No.	Acre yield (bushels)										Comparison of average acre yield, in bushels, with that of Kharkof (C. I. No. 2193)					
		1912	1913	1914	1916	1917	1918	1919	1920	1921	1922	Number of years compared	Variety named	Kharkof (C. I. No. 2193), same years	Difference from Kharkof	Percentage of Kharkof	Odds in favor of the difference being significant
Hard red winter:																	
Altara	5797							5.2	28.9	23.5	13.1	4	17.7	19.1	−1.4	92.7	3.7:1
Alton	1438	8.8	[2] 15.3	15.2	26.7	[2] 16.7						4	16.5	22.5	−6.0	73.3	83.0:1
Beloglina (H–750)	1543			20.5	29.3	[2] 10.9						2	24.9	28.0	−3.1	88.9	13.1:1
Blackhull	6251							9.5	33.1	33.0	14.5	4	22.5	19.1	+3.4	117.8	37.2:1
Crimean (P–761)	1425			21.3	31.9	18.9	10.3					4	20.6	22.0	−1.4	93.6	237.1:1
Do	1436	24.3	13.6	20.9	32.6	18.9	10.6	8.3	27.9	27.7	11.0	10	19.6	19.8	−.2	99.0	1.5:1
Do	1437	22.5	5.6									2	14.1	17.0	−2.9	82.9	1.5:1
"Defiance"	6214							3.9	29.3	27.8	9.5	4	17.6	19.1	−1.5	92.1	4.1:1
Iowa No. 1946	6676									22.9	9.3	2	16.0	19.6	−3.6	81.6	9.4:1
Kanred	5146			25.6	36.4	20.9	10.8	12.6	[2] 34.9	29.1	16.0	8	23.3	20.5	+2.8	113.7	160.3:1
Karmont	6700									27.1	9.4	2	18.3	19.6	−1.3	93.4	5.3:1
Kharkof (6P2)	1442	16.2	23.2	23.0	34.4	20.2	13.7	6.8	26.0	28.0	12.3	10	20.4	19.8	+.6	103.0	3.4:1
Do	2193	16.8	17.2	22.9	33.1	20.7	11.1	9.0	28.0	27.7	11.5	10	19.8				
Kharkof (Hays No. 2)	6686				37.0	20.4	11.8	9.2	27.8	29.5	11.4	7	21.0	20.2	+.8	104.0	10.7:1
Kharkof (N–35)				22.5	34.0	20.8	10.7	9.0	22.3			6	19.9	20.8	−.9	95.7	4.0:1
Kharkof (N–63)						20.9	11.4					2	16.2	15.9	+.3	101.9	12.5:1
Kharkof (N–65)						15.5	11.6					2	13.6	15.9	−2.3	85.5	2.6:1
Kharkof (N–77)				25.3	34.7	20.3	11.1	6.8	25.9			6	20.7	20.8	−.1	99.5	1.1:1
Kharkof (N–78)					31.7	19.8	11.3	10.0	27.6			5	20.1	20.4	−.3	98.5	2.8:1
Kharkof (N–322)						18.6	13.2	8.7				3	13.5	13.6	−.1	99.3	1.1:1
Malakof	2908	16.4	18.4	22.7	30.9	18.7	13.8	6.6	27.3	25.8	11.4	10	19.2	19.8	−.6	97.0	6.2:1
Minturki	6155								22.7	21.2	7.1	3	17.0	22.4	−5.4	75.9	160.3:1
Montana No. 36	5549							9.8	21.9			2	15.9	18.5	−2.6	85.9	2.5:1
Nebraska No. 6	6249								26.4	28.1	13.2	3	22.6	22.4	+.2	100.9	1.3:1
Nebraska No. 60	6250								26.6	23.5	10.0	3	20.0	22.4	−2.4	89.3	15.6:1
Pesterboden	1564	17.5	18.6	21.1	31.2	19.6	10.7					6	19.8	20.3	−.5	97.5	5.4:1
P–1066	5879							10.8	29.8	29.9	10.6	4	20.3	19.1	+1.2	106.3	9.4:1
P–1068	5880							12.5	27.2	29.4	13.1	4	20.6	19.1	+1.5	107.9	9.6:1
Red Winter	6213								22.7	22.3		2	22.5	27.9	−5.4	80.6	343.8:1
Romanella (P–1036)				16.2	28.7							2	22.5	28.0	−5.5	80.4	14.5:1

Roum anian (No. 237)			12.7				13.8				12.8	3	13.1	13.3	−.2	98.5	.5:1
"Stat ion Red"	6467									27.5	13.4	2	20.5	19.6	+.9	104.6	2.7:1
Tauranian (Ripka)	6202					20.4	12.3	9.8	27.2	25.3		5	19.0	19.3	−.3	98.4	2.0:1
Theiss	1561	17.5	14.0									2	15.8	17.0	−1.2	92.9	2.2:1
Turkey	1538									25.8	27.2	10.5	3	21.2	22.4	−1.2	94.6	13.2:1
Do	1571	19.8	18.4	21.2	33.9	19.2	10.1	8.2					7	18.7	18.7	0	100.0	1.0:1
Turkey (Improved)	5592			19.2	27.1	12.5		2.5	26.5	26.9	12.0		7	18.1	21.8	−3.7	83.0	75.9:1
Turkey (Kansas No. 1664)	6472								26.7	25.0	11.9		3	21.2	22.4	−1.2	94.6	5.4:1
Turkey (H-204) (Renners)			16.8	20.8	29.4	[1]10.6	11.9	7.1					5	17.2	18.6	−1.4	92.5	15.1:1
Turkey (Wender)						21.6	12.2	8.4					3	14.1	13.6	+.5	103.7	3.4:1
Turkey (Ingard)						[2]21.1	15.4	9.2	26.7				4	18.1	17.2	+.9	105.2	2.9:1
Turkey (Pioneer)	6613					[2]25.7	13.0	7.9	29.5	26.8	9.9		6	18.0	18.0	0	100.0	1.0:1
Turkey (New)							11.4	7.2					2	9.3	10.1	−.8	92.1	2.4:1
Turkey (C. I. 611)			22.6	22.6	31.9	17.6	10.0						5	20.9	21.0	−.1	99.5	1.1:1
Turkey (H-3)			15.0	23.4	32.7	20.2	12.1	8.3					6	18.6	19.0	−.4	97.9	3.9:1
Turkey (N-1)						18.1	11.4	8.9					3	12.8	13.6	−.8	94.1	3.3:1
Turkey (N-12)						16.8	10.4						2	13.6	15.9	−2.3	85.5	4.2:1
Turkey (N-21)					33.3	16.8	10.9	9.3					4	17.6	18.5	−.9	95.1	5.6:1
Turkey (N-44)					35.2	20.4	12.1	8.9	27.2				5	20.8	20.4	+.4	102.0	3.1:1
Turkey (N-47)				[2]21.7	[2]31.1	17.8	11.6	8.2					5	18.1	19.3	−1.2	93.8	2.2:1
Turkey (N-50)						16.1	10.6						2	13.4	15.9	−2.5	84.3	3.7:1
Turkey (N-85)				21.0	31.8	17.2	10.1						4	20.0	21.9	−1.9	91.3	46.4:1
Turkey (N-321)						19.5	11.4	7.0					3	12.6	13.6	−1.0	92.6	6.2:1
Soft red winter:																		
Bullum No. 17	3330	5.0	1.0										2	3.0	17.0	−14.0	17.6	19.1:1
Fulcaster	6471									23.2	9.9		2	16.6	19.6	−3.0	84.7	6.2:1
Harvest Queen	6199								21.8	20.3	12.4		3	18.2	22.4	−4.2	81.3	7.1:1
Mediterranean	1395-2	18.0	8.3										2	13.2	17.0	−3.8	77.6	2.4:1
Minhardi	5149									19.6	5.3		2	12.5	19.6	−7.1	63.8	22.8:1
Nebraska No. 28	5147					11.3	6.7	8.9	24.1	21.1	16.5		6	14.8	18.0	−3.2	82.2	9.9:1

[1] Crop of 1915 lost from hail and excessive lodging.
[2] Average of only 2 plots.
[3] Not comparable; smaller plots.
[4] Reseeded Oct. 13.

The yields of wheat on the experimental plots at the Fort Hays Branch Station from 1912 to 1914, inclusive, were normal. The 1915 crop was partly destroyed by hail on June 15, following a period of excessive growth and subsequent lodging owing to an unusually heavy rainfall. The crop was not harvested. The crop yields for 1916 and 1917 were favorable owing to the use of fallow land, but the yields for 1918 were below normal. An abundance of rainfall in the spring of 1919, causing excessive growth, was followed by hail on May 2 and by drought during the fruiting period in June, the yield of wheat being thus materially reduced. The yields of wheat in 1920 and 1921 were above normal, the distribution of the rainfall being timely and effective.

The 1922 crop is of interest because it was subject to extremely unfavorable factors and yet produced a good yield. The results answer the question whether winter wheat germinated in midwinter can produce a crop. The bulk of the seed sown in the fall of 1921 for the 1922 crop did not germinate until late in February, nor did it emerge until March. This was because of an unusually dry and unfavorable fall. About 40 per cent of the wheat seeded on fallow ground germinated, but only a 10 per cent stand survived the dry fall and winter. On the fall-plowed land 10 per cent of the wheat emerged, but not more than 1 per cent of the total possible stand survived. The one-half inch of moisture in the form of snow on December 3 and the 0.93 inch of moisture on February 22 probably were the important factors which enabled the seed that had not germinated early in the fall to pass successfully through the winter-dormancy period. This late-sprouted wheat emerged between March 16 and 20, weak and stunted, after growing several inches laterally under a crust. Well-distributed precipitation from that time, however, combined with cool, ideal growing weather up to maturity, permitted a surprising development, with yields of from 14 to 18 bushels.

The 1923 wheat crop was destroyed by hail. The best yields would not have exceeded 5 bushels per acre, however, as the fall and winter of 1922–23 had been extremely dry, the drought continuing into May.

During the 12-year period from 1912 to 1923, inclusive, two experimental crops of wheat were lost by hail or excessive rain, three made poor yields, and seven were fair or above. The yields of all winter-wheat varieties grown and harvested in the 10 years out of the possible 12 years from 1912 to 1923 are presented in Table 4.

Blackhull wheat (C. I. No. 6251) was first grown at the Hays station in 1919 and has been surpassed by Kanred (C. I. No. 5146) in yield by only 0.7 bushel. Blackhull was developed by Earl G. Clark, a farmer living near Sedgwick, Kans., and is said to have originated from three black heads which were found in 1912 in a field of Turkey wheat. The seed used in sowing this field was from a stock of Russian wheat brought into this country at an earlier date. Blackhull has not been so winter hardy as Kanred wheat at Hays, but this has not seriously affected the yield when the crop was seeded at the normal rate of 4 pecks to the acre, since the surviving plants tillered sufficiently to compensate for whatever loss of stand occurred.

The soft winter wheats have not been equal to the hard winter group in yield. Nebraska No. 28 (C. I. No. 5147) is of interest as a drought-escaping wheat, being from 5 to 10 days earlier than the hard winter wheat varieties, but is not recommended for commercial use.

Yields of eight representative winter wheats grown at Hays are shown graphically in Figure 3.

Of the varieties grown for three or more years, Blackhull (C. I. No. 6251), Kanred (C. I. No. 5146), P–1066 (C. I. No. 5879), P–1068 (C. I. No. 5880), and Kharkof, Hays No. 2 (C. I. No. 6686), have distinctly exceeded the yield of the standard Kharkof (C. I. No. 2193). Kanred has been an outstanding wheat at the Hays station since it was first grown in 1914. It is followed closely by Blackhull, which has been grown for a shorter period. The Kharkof selections have slightly outyielded the Turkey strains. Kharkof, Hays No. 2 (C. I. No. 6686), was selected at the Hays station in 1909 and has since been grown continuously either in the nursery or in plots, having outyielded all other strains of Kharkof. The selection has since been distributed to other stations and has produced favorable results. P–1066 and P–1068 are Kansas selections from the Crimean group and, while similar to Kanred, have not equaled it in yield.

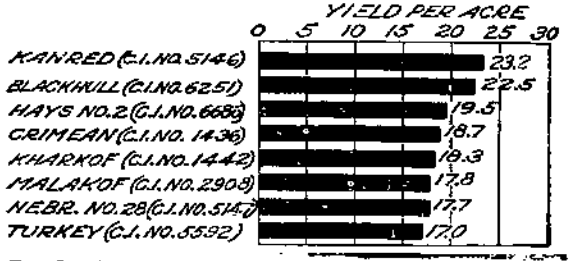

FIG. 3.—Average acre yields of eight representative varieties of winter wheat grown at the Fort Hays Branch Station, Hays, Kans., during the four-year period 1919–1922

RATE-AND-DATE-OF-SEEDING EXPERIMENTS WITH WINTER WHEAT

Experiments to determine the best rate-and-date-of-seeding hard red winter wheat were conducted from 1914 to 1923, inclusive. From 1914 to 1919, beginning in the early part of September, the wheat was sown at 15-day intervals on from five to six dates, at rates varying from 1 to 9 pecks per acre. From 1920 to 1923 weekly seedings were made from September 8 to October 27 at rates of 1, 2, 3, and 4 pecks per acre.

From 1914 to 1916 the plots were sown in duplicate on cropped land. From 1917 to 1923, two plots were sown on each date and at each rate, one on fallow and one on fall-prepared wheat land the second year after fallow. In Table 5 are presented the average annual yields from the different rates and dates of seeding from 1914 to 1922, inclusive, regardless of seed-bed preparation. Yields for the 4-peck rate for seed sown September 17 to September 22 were taken as the standard, all other rates and dates of seeding being compared with it.

TABLE 5.—*Average annual yields of winter wheat sown on nine dates and at six rates at the Fort Hays Branch Station, Hays, Kans., during one or more of the nine years 1914–1922, together with the average difference of each from the yields obtained from wheat sown September 17 to 22 at the 4-peck rate in comparable years*

Date and rate of seeding	Acre yield (bushels)											Comparison of yield, in bushels, of wheat with that from 4-peck seeding Sept. 17 to 22					
	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average 3 years, 1920–1922	Average 9 years, 1914–1922	Years compared	Date and rate named	Control plot, same years	Difference from control plot	Percentage of control plot	Odds in favor of the difference being significant
Sept. 4–8:																	
1 peck	25.3	14.3	19.6	-------	16.7	11.5	34.2	6.5	8.0	16.2	-------	8	17.0	22.8	−5.8	74.6	10.5:1
2 pecks	25.6	12.9	22.4	15.8	21.3	9.9	29.4	21.9	12.3	21.2	19.1	9	19.1	22.3	−3.2	85.7	16.2:1
3 pecks	25.9	10.8	22.8	12.5	21.8	9.6	33.8	29.5	15.7	26.3	20.3	9	20.3	22.3	−2.0	91.0	15.1:1
4 pecks	27.7	10.2	23.2	13.1	20.8	9.3	35.4	32.7	16.3	28.1	21.0	9	21.0	22.3	−1.3	94.2	6.4:1
5 pecks	27.4	-------	-------	-------	20.4	8.7	-------	-------	-------	-------	-------	3	18.8	17.9	+.9	105.0	4.2:1
Sept. 15:																	
1 peck	-------	-------	-------	-------	-------	-------	33.4	14.8	8.4	18.9	-------	3	18.9	30.8	−11.9	61.4	11.1:1
2 pecks	-------	-------	-------	-------	-------	-------	32.3	27.1	11.7	23.7	-------	3	23.7	30.8	−7.1	76.9	13.5:1
3 pecks	-------	-------	-------	-------	-------	-------	32.3	27.5	15.9	25.2	-------	3	25.2	30.8	−5.6	81.8	21.0:1
4 pecks	-------	-------	-------	-------	-------	-------	34.6	30.3	19.6	28.2	-------	3	28.2	30.8	−2.6	91.6	8.6:1
Sept. 17–22:																	
1 peck	26.2	15.0	-------	-------	19.7	10.7	30.9	10.1	17.5	19.5	-------	7	18.6	22.4	−3.8	83.0	5.1:1
2 pecks	25.0	11.6	24.7	17.6	20.4	8.7	33.2	22.1	19.6	25.0	20.3	9	20.3	22.3	−2.0	91.0	9.7:1
3 pecks	25.0	11.1	23.8	14.3	21.6	8.2	35.0	29.4	24.0	29.5	21.4	9	21.4	22.3	−.9	96.0	7.1:1
4 pecks	25.0	10.8	25.3	18.1	19.7	9.1	34.4	33.9	24.0	30.8	22.3	9	22.3	-------	-------	100.0	-------
5 pecks	25.0	9.4	-------	-------	22.2	9.9	-------	-------	-------	-------	-------	4	16.6	16.2	+.4	102.5	2.3:1
Sept. 29:																	
1 peck	-------	-------	-------	-------	-------	-------	30.0	16.5	17.9	21.5	-------	3	21.5	30.8	−9.3	69.8	12.3:1
2 pecks	-------	-------	-------	-------	-------	-------	32.1	29.9	21.3	27.8	-------	3	27.8	30.8	−3.0	90.3	69.9:1
3 pecks	-------	-------	-------	-------	-------	-------	32.7	27.2	24.2	28.0	-------	3	28.0	30.8	−2.8	90.9	5.3:1
4 pecks	-------	-------	-------	-------	-------	-------	27.3	30.8	25.0	27.7	-------	3	27.7	30.8	−3.1	89.9	5.3:1
Oct. 1–6:																	
1 peck	23.2	-------	-------	-------	-------	-------	27.1	0	22.7	16.6	-------	4	18.3	28.3	−11.0	62.5	7.1:1
2 pecks	22.0	14.5	-------	15.3	17.3	10.6	30.2	23.0	20.4	24.5	-------	8	19.2	21.9	−2.7	87.7	15.8:1
3 pecks	24.1	13.6	28.3	17.5	18.0	11.0	30.2	23.2	18.0	23.8	20.4	9	20.4	22.3	−1.9	91.5	6.6:1
4 pecks	25.0	13.1	26.5	16.5	17.9	9.2	30.2	28.4	22.5	27.0	21.0	9	21.0	22.3	−1.3	94.2	11.6:1
5 pecks	25.9	12.3	-------	-------	19.4	8.3	-------	-------	-------	-------	-------	4	16.5	16.2	+.3	101.9	2.5:1
6 pecks	-------	11.0	-------	-------	20.7	8.7	-------	-------	-------	-------	-------	3	13.5	13.2	+.3	102.3	2.5:1

Oct. 13–15:																	
1 peck	13.9						22.1	0	15.2	12.4		4	12.8	29.3	−16.5	43.7	29.2:1
2 pecks	22.3	10.7				11.4	22.1	0	17.3	13.1		6	14.0	22.9	−8.9	61.1	11.3:1
3 pecks	22.9	10.7				10.3	29.0	0	19.3	15.1		6	14.9	22.9	−8.0	65.1	9.1:1
4 pecks	25.0	10.5				10.9	24.7	0	21.7	15.5		6	15.5	22.9	−7.4	67.7	7.2:1
5 pecks	24.1					9.5						2	16.8	17.1	−.3	98.2	1.6:1
6 pecks						9.3						1	9.3	9.1	+.2	102.2	
Oct. 18–20:																	
1 peck							13.1	0	15.6	9.6		3	9.6	30.8	−21.2	31.2	18.5:1
2 pecks				13.3	12.8		18.9	0	16.1	11.7		5	12.2	26.0	−13.8	46.9	31.7:1
3 pecks			29.5	14.6	12.9		20.8	0	19.6	13.5		6	16.2	25.9	−9.7	62.5	14.1:1
4 pecks			30.2	15.1	13.7		16.6	0	22.7	13.1		6	16.4	25.9	−9.5	63.3	11.5:1
5 pecks			30.2		12.7							2	21.5	22.5	−1.0	95.6	1.3:1
6 pecks					13.0							1	13.0	19.7	−6.7	66.0	
Oct. 24–28:																	
1 peck	5.7						8.5	0	17.7	8.7		4	8.0	29.3	−21.3	27.3	55.5:1
2 pecks	10.4	8.6					9.1	0	20.2	9.8		5	9.7	25.6	−15.9	37.9	32.7:1
3 pecks	14.6	7.2					12.0	0	23.6	11.9		5	11.5	25.6	−14.1	44.9	22.4:1
4 pecks	19.3	8.6					12.9	0	25.0	12.6		5	13.2	25.6	−12.4	51.6	14.0:1
5 pecks	20.5											1	20.5	25.0	−4.5	82.0	
Nov. 1–12:																	
3 pecks		3.0	19.8		10.8	11.4	7.9					5	10.6	19.9	−9.3	53.3	15.4:1
4 pecks		3.1	17.9	12.9	11.9	11.0	13.7					6	11.8	19.6	−7.8	60.2	41.2:1
5 pecks	7.2			13.9	10.8	10.5	12.7					5	11.0	21.3	−10.3	51.6	26.0:1
6 pecks	8.0			12.8	10.3	12.4	13.5					5	11.4	21.3	−9.9	53.5	23.0:1

The data obtained from 1920 to 1922, inclusive, are presented in Table 6. The highest yields for this period were obtained from seedings made September 22 and September 29. There was a slight decrease for October 6, followed by a very marked decline for later seedings. The same trend was noted for the entire period 1914 to 1922, inclusive.

The optimum period for seeding wheat therefore is believed to be from September 20 to October 1. If moisture conditions are favorable, seeding at this time permits ample but not excessive fall growth, and the crop largely escapes the fall infestation of Hessian flies. The plants also usually develop a good root system with sufficient top growth to withstand winterkilling and soil blowing.

TABLE 6.—*Annual and average yields from rate-and-date-of-seeding experiments with winter wheat sown on fallow and on cropped land, and average yields from the two preparations, at the Fort Hays Branch Station, Hays, Kans., during the three-year period 1920–1922*

Date and rate of seeding	Acre yield (bushels)									
	Fallow land				Cropped land				3-year average of fallow and cropped land	
	1920	1921	1922	3-year average	1920	1921	1922	3-year average	Actual	Net [1]
Sept. 8:										
1 peck	30.4	0.8	7.1	12.8	37.9	12.1	8.8	19.6	16.2	15.9
2 pecks	30.8	21.7	10.0	20.8	27.9	22.1	14.6	21.5	21.2	20.7
3 pecks	31.7	33.1	14.6	26.5	35.8	27.8	16.7	26.1	26.3	25.5
4 pecks	34.6	37.7	15.0	29.1	36.2	27.7	17.5	27.1	28.1	27.1
Sept. 15:										
1 peck	32.5	11.2	7.5	17.1	34.2	18.3	9.2	20.6	18.9	18.6
2 pecks	32.1	29.6	10.8	24.2	32.5	24.6	12.5	23.2	23.7	23.2
3 pecks	29.6	31.2	14.2	25.0	35.0	23.7	17.5	25.4	25.2	24.4
4 pecks	37.1	33.3	16.7	29.0	32.1	27.3	22.5	27.3	28.2	27.2
Sept. 22:										
1 peck	34.2	7.5	14.2	18.6	27.5	12.7	20.8	20.3	19.5	19.2
2 pecks	34.0	20.2	17.9	24.2	31.7	23.9	21.2	25.6	24.9	24.4
3 pecks	36.7	30.0	21.7	29.5	33.3	28.7	25.2	29.4	29.5	28.7
4 pecks	32.9	36.2	23.3	30.8	35.8	31.5	24.6	30.6	30.7	29.7
Sept. 29:										
1 peck	29.2	14.2	17.9	20.4	30.8	18.7	17.9	22.5	21.5	21.2
2 pecks	33.3	32.1	19.6	28.3	30.8	27.7	22.9	27.1	27.7	27.2
3 pecks	33.3	30.0	25.4	29.6	32.1	25.4	22.9	26.8	28.2	27.4
4 pecks	30.8	35.8	27.9	31.5	23.7	25.8	22.1	23.9	27.7	26.7
Oct. 6:										
1 peck	24.2	0	19.2	14.5	30.0	0	26.2	18.7	16.6	16.3
2 pecks	30.0	28.1	17.1	25.1	30.4	17.9	23.7	24.0	24.6	24.1
3 pecks	27.1	21.7	11.7	20.2	33.3	24.6	24.2	27.4	23.8	23.0
4 pecks	26.2	31.5	19.6	25.8	34.2	25.2	25.4	28.3	27.1	26.1
Oct. 13:										
1 peck	15.6	0	11.2	8.9	28.7	0	19.2	16.0	12.5	12.2
2 pecks	15.8	0	12.9	9.6	28.3	0	21.7	16.7	13.2	12.7
3 pecks	21.2	0	15.0	12.1	30.8	0	23.3	18.0	15.1	14.3
4 pecks	18.7	0	18.3	12.3	30.8	0	25.0	18.6	15.5	14.5
Oct. 20:										
1 peck	6.2	0	12.5	6.2	20.0	0	18.7	12.9	9.6	9.3
2 pecks	12.5	0	12.9	8.5	25.4	0	19.2	14.9	11.7	11.2
3 pecks	16.2	0	17.1	11.1	25.4	0	22.1	15.8	13.5	12.7
4 pecks	9.6	0	20.8	10.1	23.7	0	24.6	16.1	13.1	12.1
Oct. 27:										
1 peck	2.9	0	16.7	6.5	14.2	0	18.7	11.0	8.8	8.5
2 pecks	5.0	0	17.5	7.5	13.3	0	22.9	12.1	9.8	9.3
3 pecks	5.8	0	20.0	8.6	18.3	0	27.1	15.1	11.9	11.1
4 pecks	7.9	0	22.1	10.0	17.9	0	27.9	15.3	12.7	11.7

[1] Net yields obtained by subtracting the quantity of grain seeded per acre from the actual yields obtained.

As shown in Figure 4, the yields from cropped land were almost equal to those obtained from fallow for dates of seeding as late as September 29. Throughout October the yields were somewhat higher for the cropped land, apparently because the stubble afforded protection from soil blowing and winterkilling. It was noted during the course of the experiment that plots seeded late on fallow were more easily and readily damaged by soil blowing than those seeded on stubble land. The results suggest the need for relatively earlier seeding on bare ground, in order that the plants may establish their own protection. This does not agree with the theory of many farmers, which is to sow later on the more thoroughly prepared ground. In Figure 5 are presented the combined average yields for all rates for each of the eight different dates of seeding.

The optimum rate for seeding winter wheat has not yet been determined. Unfortunately, very few tests of rates of seeding higher than 4 pecks were made. The type of seed bed and the quantity of moisture available at planting time are determining factors so far as rate of seeding is concerned. With timely seeding on a well-prepared seed bed, in which there is present both reserve and surface moisture, satisfactory results have been obtained with only 2 pecks of seed. However, so many disturbing factors, such as limited moisture supply, soil blowing, insect injury, and late spring freezes, are likely to occur that it is good crop insurance to use plenty of seed. The higher rates used in these experiments yielded at least as well as the lower rates in good years, and in unfavorable years there has been a distinct gain from the heavier rates. For that reason a rate of not less than 4 pecks is recommended.

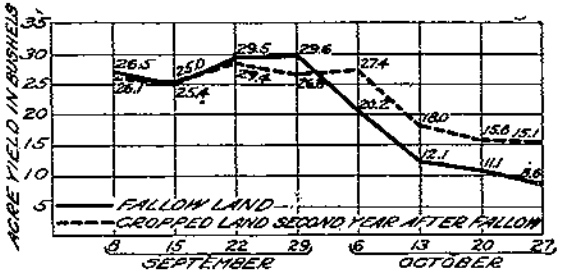

FIG. 4.—Average acre yields of winter wheat sown on eight different dates at a 3-peck rate on fallow and on cropped land at the Fort Hays Branch Station, Hays, Kans., during the three-year period 1920–1922

Fall infestation of Hessian flies was determined for the 1921 crop. In the September 8 seeding, 4.4 per cent of the plants were found to be infested; 3.3 per cent were found infested in the September 15 seeding; 3.9 per cent in the September 22 seeding; 1.6 per cent in the September 29 seeding; and 1 per cent in the October 6 seeding. No fall infestation was found on the plots seeded after October 6. The count was made in plots located on cropped land.

RELATION OF RAINFALL AND TEMPERATURE TO DATE AND RATE OF SEEDING WINTER WHEAT

Annual rainfall, mean temperatures in early fall, and the yields of wheat obtained from the experiments with various rates and dates of seeding for each of the years 1920, 1921, and 1922 are shown graphically in Figures 6, 7, and 8. A close relationship is indicated between the climatic factors and the yield. Precipitation

varied considerably in both quantity and distribution for the different years. Timely distribution of fall moisture was the most important precipitation factor. For example, the fall of 1919 was very favorable for starting wheat because of rains just at seeding time. In the fall of 1920, with greater total rainfall, dry surface soil from early September until October 20 proved a great handicap. Plots of wheat seeded later than October 6 did not get well established and were destroyed by soil blowing and the severe freeze of March 27. In the fall of 1921 there was almost no effective rainfall after the middle of August. Seedings for all dates were therefore made in dry surface soil. The only immediate germination was about 25 per cent for the September 8 and September 15 seedings, and only 1 per cent of the resulting plants survived the winter. Limited precipitation occurring December 3 permitted germination but no aboveground growth. Most of the wheat plants from all dates of seeding failed to emerge until March 16 to 21. Fair yields, nevertheless, were obtained because of ample spring moisture and favorable temperatures.

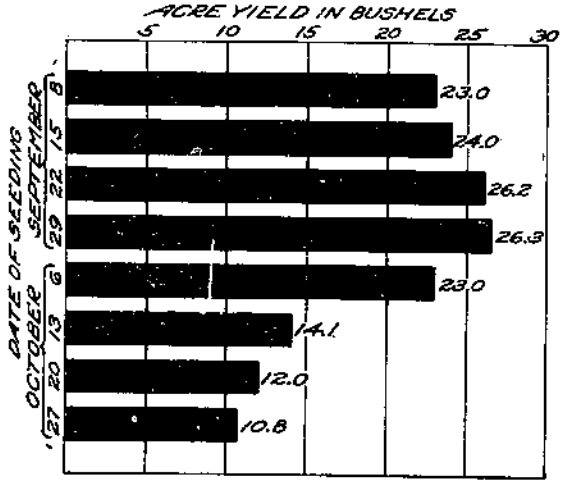

FIG. 5.—Average acre yields of winter wheat sown on eight different dates at 1-peck to 4-peck rates on fallow and on cropped land at the Fort Hays Branch Station, Hays, Kans., during the three-year period 1920–1922

Mean-temperature curves by seven-day periods for the fall seeding season are included in the graphs to show the relation of declining fall temperatures to the yields of wheat sown on different dates. In 1920 and 1921 the decline in yield was quite marked for wheat sown after October 6 and September 29, respectively. Mean temperatures below 65° F. closely following the seeding period caused a slower early growth, and if temperatures were below 60° F. fall growth was retarded to a degree that resulted in reduced yields. Dry soil conditions which delayed germination in the fall of 1921 largely nullified the temperature effect so far as that season was concerned. Differences in spring condition of wheat sown on different dates in the fall of 1919 are shown in Figures 9 and 10.

FURROW DRILL COMPARED WITH COMMON DRILL FOR SEEDING WINTER WHEAT[8]

Experiments to determine the effect of seeding small grain in furrows were begun at the Fort Hays Branch Station in the fall of 1913.

[8] The earliest experiments in Kansas on seeding wheat in furrows appear to be those of the Kansas Agricultural Experiment Station by E. W. Shelton in 1888. These were discontinued in 1899 and resumed again at Manhattan in 1913 by S. C. Salmon. For more complete information on the use of the furrow drill in Kansas, see SALMON, S. C. SEEDING SMALL GRAIN IN FURROWS. Kans. Agr. Expt. Sta. Tech. Bul. 13, 55 p., illus. 1924.

In these first experiments winter oats, emmer, and spelt were drilled in open furrows 4 and 6 inches deep, made by a small nursery plow. Measured quantities of grain were drilled into the furrows with a garden drill. Winter survival was in every case higher in the furrows than in surface-drilled check plots.

The experiments were repeated for the season 1915, but owing to a hailstorm and other unfavorable climatic conditions no data were obtained.

For the 1916 crop wheat was sown in furrows made with a light-draft harrow on which small lister points were attached to shanks spaced 16 inches apart. The grain was sown in these furrows with

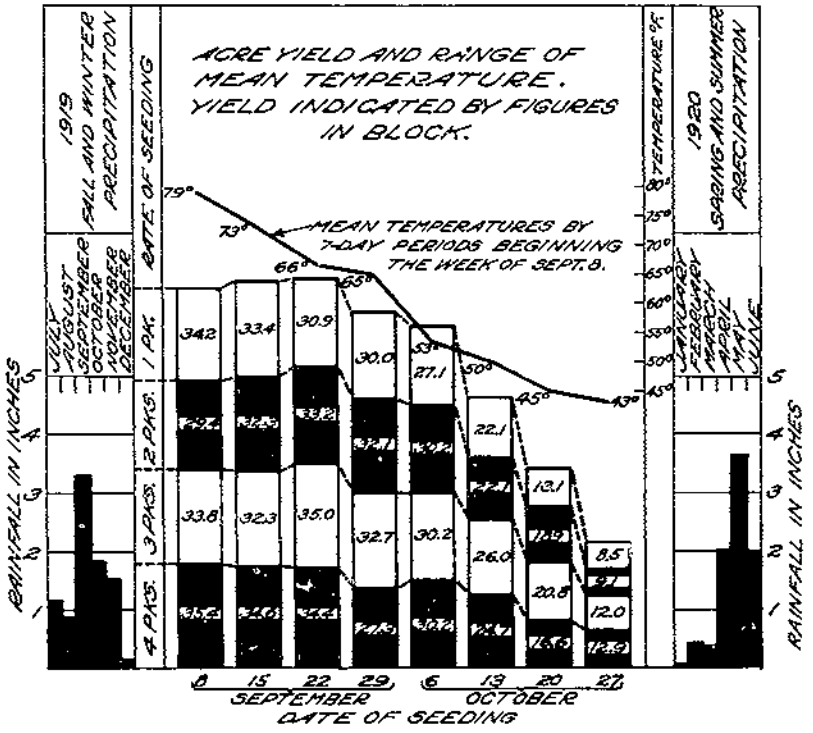

FIG. 6.—Relation of rainfall and temperature to date and rate of seeding winter wheat at the Fort Hays Branch Station, Hays, Kans., in 1920

an 8-inch drill, the alternate holes of which were stopped and the corresponding disks lifted and tied. Surface-drilled check plots also were put in with the drill adjusted as above described and the rows spaced the same distance apart.

The 1917 experiments were sown with a 7-inch drill, from which alternate disks were removed and the corresponding feed holes stopped up. Furrow-opening attachments were designed for the remaining feed spouts, each of which carried two disks, one mounted in front and set to throw dirt to the left, opening a furrow about 3 inches deep, and one running behind the other, throwing dirt to the right, and opening the furrow 2 inches deeper. The seed was

sown in these furrows which, when the operation was complete, were about 4 inches deep from the top of the ridges to the loose dirt in the bottom of the furrow. A view of a furrow drill is shown in Figure 11. Check plots were sown with an ordinary disk drill. The same drills were used in sowing the 1918 and 1919 crops.

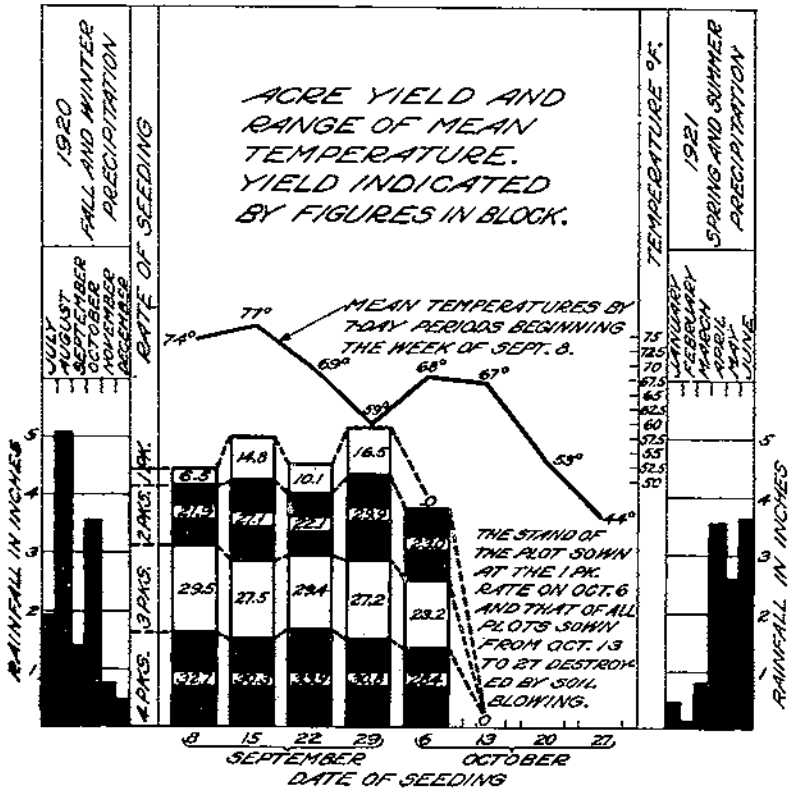

FIG. 7.—Relation of rainfall and temperature to date and rate of seeding winter wheat at the Fort Hays Branch Station, Hays, Kans., in 1921

The yields obtained from using the furrow drill and the common disk drill for the years from 1916 to 1919, inclusive, are given in Table 7.

TABLE 7.—*Yields of winter wheat sown with a furrow drill and with a common drill at the Fort Hays Branch Station, Hays, Kans., during the three-year period 1916–1919*

Kind of drill	Acre yield (bushels)				
	1916	1917	1918	1919	Average
Furrow drill [1]	25.4	14.2	13.2	10.2	15.8
Common drill	31.6	13.0	11.0	10.7	16.6

[1] In 1916 the furrows were made with a harrow and spaced 16 inches apart; in 1917, 1918, and 1919 the furrows were made with a disk drill and spaced 14 inches apart.

The data of Table 7 were not considered conclusive, because of differences in plot width and other defects in plot technic. For the 1920 crop the furrow drill was redesigned to make the furrows 12 inches instead of 14 inches apart. Wheat was sown on replicated one-twentieth-acre plots with this drill and with the common 8-inch disk drill for each crop from 1920 to 1923, inclusive. The wheat was sown with each drill at rates varying from 1 to 5 pecks, in north and south and in east and west directions, and on both fallow and wheat-stubble land. The yields are presented in Table 8. Hail destroyed the crop of 1923.

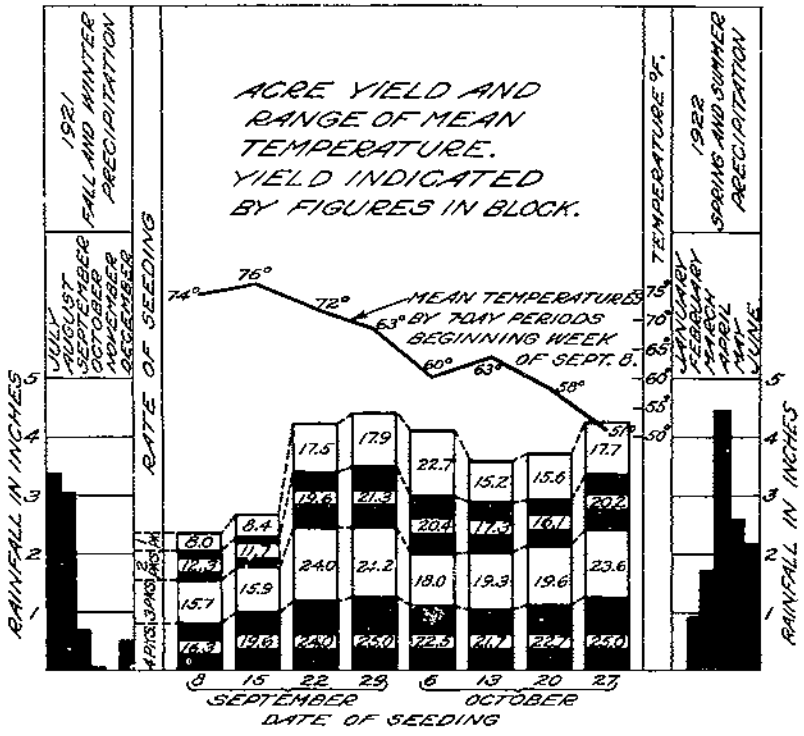

FIG. 8.—Relation of rainfall and temperature to date and rate of seeding winter wheat at the Fort Hays Branch Station, Hays, Kans., in 1922

In 1920 there were no significant differences in yields between the two methods. In 1921, plots sown with the common drill gave slightly better yields. Severe soil blowing occurred during the spring of 1921, but no serious damage resulted to plots seeded with either drill. A late freeze with a minimum of 10° F. occurring on March 27, after the plants had begun active growth, caused a heavy mortality in the plots seeded at 4 and 5 pecks with the furrow drill. Before the freeze the plants in these plots appeared to be overcrowded in the rows. Such a condition tends to hasten development, and as a result these plants possibly were in a less hardy stage than others.

The fall of 1921 was extremely dry. Stands of wheat were therefore irregular on all plots, regardless of the drill used in seeding.

In 1922 only parts of some of these plots could be used to determine yields. The wheat sown on fallow became weedy in the spring, and those plots sown with the furrow drill were the most infested. The yields from the plots sown with the common drill were much superior to those from plots sown with the furrow drill.

TABLE 8.—*Yields of winter wheat sown with a furrow drill (12 inches apart) and with a common 8-inch disk drill at the Fort Hays Branch Station, Hays, Kans., in the three-year period 1920–1922*

Preparation of ground and kind of drill used in seeding	Acre yield (bushels) with different rates and directions of seeding									
	1 peck		2 pecks		3 pecks		4 pecks		5 pecks	
	East and west	North and south	East and west	North and south	East and west	North and south	East and west	North and south	East and west	North and south
Furrow drill:										
1920 fallow land	39.1	38.1	37.5	30.8	38.6	39.5	34.5	35.1	32.8	34.2
1921 fallow land	28.5	32.5	29.5	33.6	29.3	32.6	31.6	29.2	30.4	25.9
1922 fallow land	19.3	(1)	21.0	5.9	14.0	11.7	16.8	15.7	14.7	23.0
Three-year average	29.0	[2]35.3	29.3	26.4	27.3	27.9	27.6	26.7	26.0	27.7
1920 cropped land	35.3	38.9	36.4	34.8	38.6	32.4	33.7	34.4	34.5	29.5
1921 cropped land	24.5	31.0	27.6	30.3	26.2	25.6	23.6	21.6	21.3	21.9
1922 cropped land	11.5	10.0	18.5	10.7	15.0	20.2	19.3	20.6	22.0	22.5
Three-year average	23.8	26.6	27.5	25.3	26.6	26.1	25.5	25.5	25.9	24.6
Common drill:										
1920 fallow land	38.8	40.8	39.8	41.5	29.0	32.6	34.3	38.1	33.2	33.6
1921 fallow land	26.8	36.1	34.0	35.1	33.6	35.9	33.2	31.2	31.8	38.3
1922 fallow land	26.6	(1)	17.6	8.3	15.0	12.7	23.6	19.0	21.6	16.0
Three-year average	30.7	[2]38.5	30.5	28.3	25.9	27.1	30.4	29.4	28.9	28.6
1920 cropped land	30.3	29.6	32.7	32.0	25.5	26.2	32.5	32.9	29.4	37.4
1921 cropped land	22.6	29.5	26.7	29.5	34.9	33.9	22.9	21.3	26.0	30.3
1922 cropped land	13.5	11.7	19.0	15.8	20.3	25.9	21.3	26.5	23.6	28.6
Three-year average	24.1	23.6	26.1	25.8	26.9	28.7	25.6	26.9	29.7	32.1
Three-year average for furrow drill (fallow and cropped land)	26.4	.....	28.4	25.9	27.0	27.0	26.6	23.1	26.0	26.2
Three-year average for common drill (fallow and cropped land)	27.4	.....	28.3	27.1	26.4	27.9	28.0	28.2	29.3	30.4

[1] Plots destroyed by soil blowing. [2] Two-year average.

The three-year average yields for all comparisons of the furrow and common drills are shown in Figure 12.

In all of the experiments from 1916 to 1922, inclusive, the use of the furrow drill resulted in a slight decrease in yield. The furrows are effective in preventing soil blowing until the ridges are leveled down. On the other hand, the wider spacing necessary to form the furrows

prevents full occupancy of the ground by the wheat and permits more weed competition. The use of the furrow drill has shown no outstanding advantage over that of the common drill in the prevention of soil blowing or in yield, either on experimental plots or in the station's general fields.

DIRECTION OF SEEDING WINTER WHEAT

In the experiments with the furrow drill as compared with the common drill 20 plots were sown in an east and west direction and

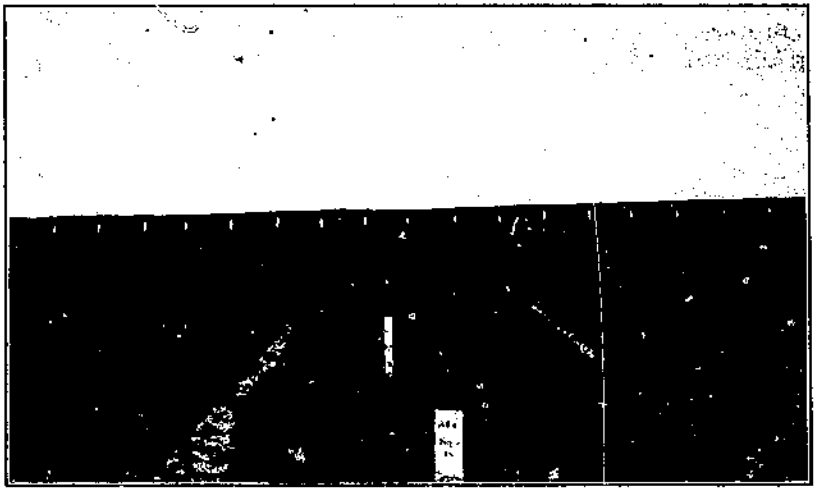

FIG. 9.—Experiment in date and rate of seeding winter wheat on summer fallow at the Fort Hays Branch Station, Hays, Kans. Seeded September 22, 1919, at the rate of 3 pecks per acre. Photographed April 26, 1920. Note vigorous growth. Yield 36.7 bushels per acre

20 plots in a north and south direction each year. Yield data from the plots sown in the two directions are given in Table 9.

TABLE 9.—*Yields of winter wheat sown in east and west and in north and south directions with both furrow and common drills, together with gain or loss in yield from either practice, at the Fort Hays Branch Station, Hays, Kans.*

Method of seeding	Rate and direction of seeding and acre yield (bushels)										Average gain
	1 peck		2 pecks		3 pecks		4 pecks		5 pecks		
	East and west	North and south	East and west	North and south	East and west	North and south	East and west	North and south	East and west	North and south	
Furrow	26.4	30.3	28.4	25.9	27.0	27.0	26.6	26.1	26.0	26.2	0.2 bushel, north and south.
Gain		3.9	2.5				.5			.2	
Common	27.4	29.5	28.3	27.0	26.4	27.9	28.0	28.2	29.3	30.4	0.7 bushel, north and south.
Gain		2.1	1.3			1.5		.2		1.1	

The average differences favoring north and south seeding are too small with both types of drill to be significant. Most farmers prefer to seed in an east and west direction on account of supposedly smaller risk from soil blowing.

TOP-DRESSING WINTER WHEAT WITH STRAW IN THE FALL

The experiment of top-dressing winter wheat with straw was planned in order to determine its effect on winter survival and yield. The experiment was conducted with Kanred wheat sown the last week in September on fallow land at the rate of 3 pecks per acre. Plots were sown with both the furrow and the common drill. The plots were one-twentieth of an acre in size. The straw was spread during November before freezing had taken place. To prevent the

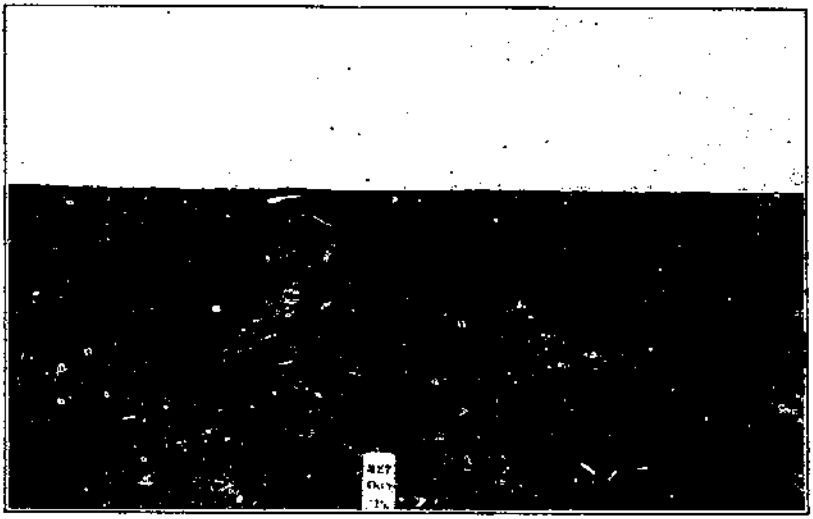

FIG. 10.—Experiment in date and rate of seeding winter wheat on summer fallow at the Fort Hays Branch Station, Hays, Kans. Seeded October 20, 1919, at the rate of 3 pecks per acre. Photographed April 26, 1920. Note lack of vegetative growth and injury from soil blowing. Yield 16.2 bushels per acre

straw from blowing away, a packer with narrow V-rimmed wheels 6 inches apart or a weighted disk set at a slight angle was run over the plots to press the straw into the ground.

The yields obtained in 1920 and 1921 are presented in Table 10. Reliable yields were not obtained in 1922, because of poor stands resulting from extremely dry weather the previous fall. Hail destroyed the 1923 crop. As reliable conclusions can not be drawn from only two years' data, the experiment is being continued.

There was no advantage from top-dressing the 1920 crop. The winter being mild and the rainfall effectively distributed, there was no need for protection. The season of 1921 was more extreme. Severe soil blowing occurred in February and March, with a low freezing temperature of 10° F. on March 27, and the unprotected plots of wheat suffered more severely than those to which straw had been applied.

TABLE 10.—*Yields of winter wheat sown with furrow and common drills and top dressed with straw at different rates at the Fort Hays Branch Station, Hays, Kans., 1920 and 1921*

Kind of drill used and year test was made	Rate of straw application and acre yield (bushels)					
	Control plot (no straw)	One-fourth ton	One-half ton	1 ton	2 tons	3 tons
Furrow drill:						
1920	38.6	35.7	34.2	31.7	27.0	24.6
1921	29.3	33.6	37.6	41.1	39.5	30.1
Two-year average	34.0	35.2	35.9	36.4	33.3	27.4
Common drill:						
1920	38.1	35.6	36.7	35.3	35.3	32.2
1921	29.0	38.6	36.7	42.2	43.4	39.4
Two-year average	33.6	37.1	36.7	38.8	39.4	35.8

It was noted that when the application of straw was heavier than 2 tons to the acre some of the plants were smothered, resulting in a reduced stand. Other factors may have influenced the results, but

FIG. 11.—Furrow drill used at the Fort Hays Branch Station, Hays, Kans. Alternate disks of a single-disk drill were removed and the mountings of the remaining disks remodeled so that two disks ran in pairs, one in front set to throw the dirt to the left and one in the rear set to throw the dirt in the opposite direction. The result was a furrow in which the grain was sown

the yields from plots with an application of 3 tons of straw to the acre were always lower than yields from plots with the 2-ton application.

These experiments, as previously indicated, can not be accepted as conclusive, yet there is some practical support for the practice of top-dressing wheat in certain cases. In southern Nebraska, along the northern limits of winter wheat production, some farmers make a light application of straw to their fields of wheat. They assert that

there is a resulting increase in yield sufficient to warrant the expense. In certain sections of Oklahoma, where the soil is sandy and subject to blowing, farmers report that a light application of straw, evenly spread, is an aid in preventing soil movements. When used to prevent soil blowing the application of straw must be evenly distributed. A small bunch of straw easily may become the nucleus of a soil drift.

EXPERIMENTS WITH OTHER SMALL GRAINS

The experiments with other small grains included varietal experiments with spring wheat, oats, and barley. Since 1911 there has been a very marked decline in the acreage of spring wheat grown in Kansas, and the acreage of oats has remained practically stationary. In the last 10 years there has been a substantial increase in the acreage of barley, which was especially marked in years when there was an extensive abandonment of winter wheat.

The climatic conditions of western Kansas are not always favorable for the production of spring grains unless there is a good reserve of fall and winter soil moisture. As has been indicated elsewhere, the normal precipitation for the six months preceding April 1 is only one-fourth of the annual precipitation. As a result, the ground often lacks sufficient moisture to insure prompt germination and rapid early development of spring crops. Throughout March and April high winds often prevail and are sometimes injurious to spring grains, especially when the young plants have not become well established. The continual whipping of the tender foliage by the wind and the "sandpapering" effect of the drifting soil usually result in some injury to the crop.

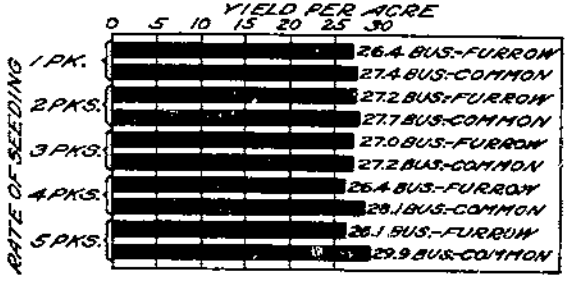

FIG. 12.—Average acre yields of winter wheat sown at five rates with furrow and common drills at the Fort Hays Branch Station, Hays, Kans., during the three-year period 1920–1922

Favorable yields of oats and barley have been obtained when adapted varieties were sown at an early date. No similarly adapted variety of spring wheat has been available. In general, varieties of spring grains adapted for growing in western Kansas are early maturing and produce a minimum percentage of straw to grain. Varieties which can not mature by June 20 when sown on the normal date (March 15) are often injured by high temperatures during the latter part of the season.

VARIETAL EXPERIMENTS WITH SPRING WHEAT

Ten varieties of common spring wheat and six varieties of durum wheat were grown for three or more years in the 11-year period 1912 to 1922, inclusive. The annual and average yields for all of the varieties are presented in Table 11. The yields of Kharkof and Kanred (hard winter wheats) are not directly comparable with those of the spring varieties, but are given for general comparison.

TABLE 11.—*Comparative yields of varieties of spring and winter wheat grown at the Fort Hays Branch Station, Hays, Kans., during the 11-year period 1912–1922*

Group and variety	C. I. No.	Acre yield (bushels)											Comparison of average acre yield, in bushels, with that of Marouani (C. I. No. 2235)					
		1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average 5 years, 1918–1922	Number of years compared	Variety named	Marouani, same years	Difference from Marouani	Percentage of Marouani	Odds in favor of the difference being significant
Common:																			
Prelude	4323	----	----	----	----	----	----	6.8	5.1	6.9	14.9	19.4	10.6	5	10.6	13.7	−3.1	77.4	5.2:1
Pioneer	4324	----	----	----	----	----	----	4.2	----	2.1	11.4	17.5	----	4	8.8	13.1	−4.3	67.2	7.5:1
Marquis	3641	----	----	----	----	----	----	3.2	4.7	5.4	12.8	16.7	8.6	5	8.6	13.7	−5.1	62.8	20.9:1
Preston	3081	----	----	----	----	----	----	4.6	5.1	2.1	6.1	16.5	6.9	5	6.9	13.7	−6.8	50.4	50.3:1
Kota	5878	----	----	----	----	----	----	----	----	----	7.3	15.6	----	2	11.5	15.0	−3.5	76.7	5.6:1
Hard Federation	4733	----	----	----	----	----	----	----	----	----	----	18.6	----	1	18.6	17.3	+1.3	107.5	----
Emerald (white spring)	4397	2.3	6.0	3.6	2.3	3.0	0	----	----	4.5	----	----	----	7	3.1	6.3	−3.2	49.2	12.5:1
Fretes	1596	2.8	4.2	3.6	----	----	----	----	----	----	----	----	----	3	3.5	7.7	−4.2	45.5	6.0:1
Galgalos	2398	2.1	5.4	1.5	----	----	----	----	----	----	----	----	----	3	3.0	7.7	−4.7	39.0	5.6:1
Converse (Red Russian)	4141	2.7	1.4	2.0	----	----	----	----	----	----	----	----	----	3	2.0	7.7	−5.7	26.0	16.6:1
Durum:																			
Acme	5284	----	----	----	----	----	----	4.8	10.2	8.2	15.9	22.9	12.4	5	12.4	13.7	−1.3	90.5	2.2:1
Kubanka	1440	----	2.8	5.4	0	3.4	0	4.4	9.1	9.8	15.6	20.2	11.8	10	7.1	8.6	−1.5	82.6	10.7:1
Marouani	2235	12.2	3.8	7.0	1.0	5.2	0	7.7	16.3	14.6	12.6	17.3	13.7	11	8.9	----	----	100.0	----
Peliss	1584	----	----	----	----	----	----	2.9	8.6	----	----	----	----	2	5.8	12.0	−6.2	48.3	12.6:1
Kubanka	2246	7.4	3.4	4.5	----	----	----	----	----	----	----	----	----	3	5.1	7.7	−2.6	66.2	10.1:1
Saragolla	2228	8.0	3.6	5.7	----	----	----	----	----	----	----	----	----	3	5.8	7.7	−1.9	75.3	6.9:1
Hard winter for comparison:																			
Kharkof	2193	16.8	17.2	22.9	----	33.1	20.7	11.1	9.0	28.0	27.7	11.5	17.5	10	19.8	9.7	+10.1	204.1	101.0:1
Kanred	5146	----	----	25.6	----	36.4	20.9	10.8	12.6	34.9	29.1	16.0	20.7	8	23.3	10.1	+13.2	230.7	100.0:1

Good yields of spring wheat were obtained only in 1921 and 1922, the yields for the remaining years ranging mostly from fair to failure. The average yield of the best common spring wheat for the five-year period from 1918 to 1922 was approximately 50 per cent of that of Kanred. Acme (C. I. No. 5284), a durum wheat, during the same period gave an average yield 60 per cent of that of Kanred. A comparison of the leading varieties of spring wheat is shown in Figure 13.

Prelude (C. I. No. 4323) was the leading variety of common spring wheat. It matured from 7 to 10 days earlier than most of the other varieties, thus escaping the injurious effects of drought in a larger degree. Marquis (C. I. No. 3641) is too late in maturity to escape drought in a dry year and too susceptible to rust in a season of abundant moisture.

Six varieties of durum wheat were grown in two or more years during the 11-year period 1912 to 1922. Marouani (C. I. No. 2235), Kubanka (C. I. No. 1440), and Acme (C. I. No. 5284) were about equal in yield. It was reported that at Hays, previous to 1906, there was not much difference between Kubanka, Velvet Don, Black Don, or Yellow Gharnovka, but that "Kubanka yielded just a little better than any of the others."

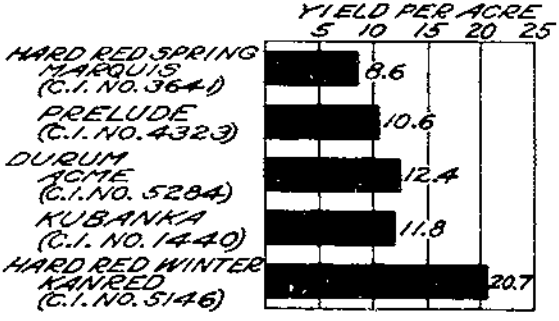

FIG. 13.—Average acre yields of four varieties of spring wheat compared with Kanred, a hard red winter wheat, at the Fort Hays Branch Station, Hays, Kans., during the five-year period 1918–1922

Spring wheats are poorly adapted to most of Kansas, except in the extreme northwestern corner of the State, where the altitude is higher with correspondingly lower mean temperatures than in the central and southern parts of the State. Factors which are necessary for spring wheat production in the section are early seeding, early maturity, moderately cool weather during the latter part of the growing period, and rust resistance. Early seeding and an abundance of spring moisture are essential to give the crop a good start. An early variety such as Prelude is often able to escape the drought and has an advantage over a late-maturing variety such as Marquis. The grain-developing period for most spring wheats is just late enough to fall during the latter part of June, when high temperature and dry weather are the rule rather than the exception; consequently the crop often is severely affected by drought. If the latter part of June is rainy and damp a severe epidemic of stem rust often occurs, so that from all angles spring wheat is at a decided disadvantage.

VARIETAL EXPERIMENTS WITH SPRING OATS

Early experiments with oats at the Hays station included both spring and winter types. Winter oats failed to survive the winter

and no yields were obtained. Spring types grown with more or less favor previous to 1912 were Swedish Select, Red Rustproof (Red Texas), Black Tartar, and Kherson and its derivatives. The five-year average acre yields of Kherson and Red Rustproof (Red Texas) grown in 1903, 1904, 1905, 1908, and 1910 were, respectively, 30.8 and 27.2 bushels.

The yields for the 16 varieties of spring oats grown during the 11-year period, 1912 to 1922, inclusive, are given in Table 12. Hail destroyed the 1923 crop. The early-maturing varieties and selections have given the best yields. Varieties which are late have been injured either by dry weather late in June or by crown rust if wet weather prevailed.

Good yields of oats were obtained in 1912 and from 1919 to 1922. There were poor yields or failures from 1913 to 1918, which may be attributed partly to a series of unfavorable seasons and partly to the fact that the varieties usually were seeded in April. In 1920 and thereafter the date of seeding was advanced to March 15, and higher yields were obtained. Date-of-seeding experiments have since been started, and the limited results so far obtained indicate March 15 as the optimum time for seeding oats.

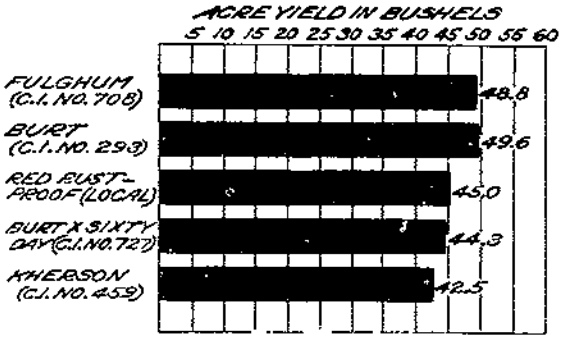

FIG. 14.—Average acre yields of five varieties of oats grown at the Fort Hays Branch Station, Hays, Kans., during the three-year period 1920–1922

The best yields of oats have been obtained from varieties of the red-oat group represented by Fulghum and certain selections of Burt. The Fulghum group includes Fulghum (C. I. No. 708) and Kanota (C. I. No. 839), a mass selection developed at the Kansas Agricultural Experiment Station and now widely distributed throughout the State. Fulghum and Kanota, though similar in appearance, are distinctive in several characters from other varieties generally grown in the section. In early growth they are less spreading than Red Rustproof, though more spreading than the Kherson strains. In seasons of limited rainfall Fulghum and Kanota have the ability to limit their vegetative growth and to make grain where other varieties continue to produce straw and leaves at the expense of grain. The kernels are of a reddish color, plump, and of a high test weight.

The best representatives of the Kherson type of oats have been Richland (C. I. No. 787), Albion (C. I. No. 729), and Burt×Sixty-Day (C. I. No. 727), the latter because of its earliness. The test weights of the Kherson strains have never been so high as those of the Fulghum strains. The yields of five representative oat varieties are shown graphically in Figure 14.

TABLE 12.—*Yields of 16 oat varieties at the Fort Hays Branch Experiment Station, Hays, Kans., during the 11-year period 1912–1922, together with average differences from the yields of Burt × Sixty-Day (C. I. No. 727) in comparable years*

Group and variety	C. I. No.	Acre yield (bushels)											Comparison of average acre yield, in bushels, with that of Burt × Sixty-Day					
		1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average three years, 1920–1922	Number of years compared	Variety named	Burt × Sixty-Day, same years	Difference from Burt × Sixty-Day	Percentage of Burt × Sixty-Day	Odds in favor of the difference being significant
Red oats:																			
Fulghum	708								75.6	39.8	47.6	59.0	48.8	4	55.5	47.2	+8.3	117.6	6.9:1
Burt (Kans. 5020)	293									44.2	47.6	57.1	49.6	3	49.6	44.3	+5.3	112.0	4.0:1
Kanota	839										41.8	55.4		2	48.6	45.1	+3.5	107.8	1.5:1
Burt (Kans. 5219)	2023									35.9	46.7	59.8	47.5	3	47.5	44.3	+3.2	107.2	1.8:1
Red Rustproof (Local)		16.6	2.8	8.4		14.7	0	3.9		37.6	43.2	54.3	45.0	8	20.6	23.1	−2.5	89.2	4.1:1
Kherson and derivatives:																			
Richland	787									36.4	49.0	51.9	45.8	3	45.8	44.3	+1.5	103.4	1.6:1
Burt × Sixty-Day	727		5.8	18.4	22.6	12.4	0	15.1	56.0	42.6	48.4	41.8	44.3	10	26.3			100.0	
Sixty-Day	165								53.1	36.4	44.9	49.2	43.5	4	45.9	47.2	−1.3	97.2	1.9:1
Albion	729		5.8	17.2	12.1	8.0	0	3.3		39.5	47.1	50.8	45.8	9	20.4	23.0	−2.6	88.7	7.1:1
Kherson	459							3.9	45.3	36.7	48.0	42.9	42.5	5	35.4	40.8	−5.4	86.8	18.9:1
Kherson (Hays No. 116)		39.8	5.9	14.0										2	10.0	12.1	−2.1	82.6	2.9:1
Nebraska No. 21	1924										28.5	46.1		2	37.3	45.1	−7.8	82.7	2.1:1
Iowar	847									28.6	42.4	35.6	35.5	3	35.5	44.3	−8.8	80.1	23.8:1
Sixty-Day	626		6.4	14.0	11.7	5.8	0	3.2						6	6.9	12.4	−5.5	55.6	38.1:1
Miscellaneous:																			
Aurora	831									44.2	44.9	54.7	47.9	3	47.9	44.3	+3.6	108.1	2.8:1
Kansas Black		14.2	5.6	15.2										2	10.4	12.1	−1.7	86.0	3.3:1

Previous to the introduction of Fulghum into western and central Kansas, selections of Kherson, Sixty-Day, and Red Rustproof (Red Texas) oats were largely grown. The introduction of Fulghum, which is superior to the other varieties named, has been a distinct gain to the oat industry of the western two-thirds of the State. Approximately 750,000 acres of oats are grown in this section annually. A view of a field of Fulghum oats is shown in Figure 15.

Whether the acreage of oats in western Kansas should be increased is an open question. Commercially, other crops offer greater cash returns. A small acreage of oats could well be grown on every farm as feed for horses. In case drought should prevent the production of grain the crop can be cut for hay.

The most important factors in successful oat production are early seeding and the selection of an adapted variety. If the season is unfavorable no variety or date of seeding can insure good yields. Oats is a good crop to follow sorghum or corn. The yields of oats are usually less in pounds per acre than the yields of barley.

FIG. 15.—Field of Fulghum oats at the Fort Hays Branch Station, Hays, Kans., in 1919

VARIETAL EXPERIMENTS WITH SPRING BARLEY

Thirty varieties of barley received from the United States Department of Agriculture were grown at the Hays station in 1902 and 1903. A number of these selections were introductions from Europe, Australia, and Africa. Of this group Beldi Dwarf (C. I. No. 190) and Telli (C. I. No. 192) from Algeria seemed well adapted to western Kansas. White Smyrna and Black Arabian also were promising.

In 1910, yields of 50, 49.9, 34.9, and 17.1 bushels per acre were reported for Common Six-Row, Stavropol, U. S. No. 195,[6] and Mansury, respectively. The Common Six-Row, a local barley, was later designated as Ellis (C. I. No. 2107). This variety is similar to

[6] U. S. No. 195 probably was White Smyrna (C. I. No. 195).

Stavropol (C. I. No. 2103), which came from Southern Russia. Ellis, or the Common Six-Row barley, seems to have been brought from southern Russia by Russian immigrants who settled in the vicinity of Hays and in other sections of the State. There was a large acreage of this barley in northwestern Kansas before it was more widely distributed. The spring barley grown in Kansas is predominantly the Stavropol type, which also appears to be widely distributed over the uplands of eastern Colorado where irrigation is not practiced. A field of Ellis barley is shown in Figure 16.

In 1911 seven varieties were grown in the varietal test, but drought and chinch bugs destroyed the plants before they reached the heading

FIG. 16.—Field of Ellis barley (C. I. No. 2107), grown on land previously cropped to sorghums, at the Fort Hays Branch Station, Hays, Kans., in 1920. The barley produced 50 bushels per acre

stage. The yields for 19 varieties of spring barley grown for two or more years from 1912 to 1922 are presented in Table 13. Hail destroyed the 1923 crop. Only four varieties were grown during the entire period. Seventeen varieties were grown during the three-year period from 1920 to 1922, but only nine were grown in all three years. The yields of the varieties grown continuously during the 11-year period 1912 to 1922, inclusive, are shown graphically in Figure 17.

TABLE 13.—*Yields of 19 varieties of spring barley grown at the Fort Hays Branch Station, Hays, Kans., during the 11-year period 1912–1922, together with average differences from the yields of Stavropol (C. I. No. 2103) in comparable years*

Group and variety	C. I. No.	Acre yield (bushels)												Comparison of average acre yield, in bushels, with that of Stavropol (C. I. No. 2103)					
		1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average 3 years, 1920–1922	Average 11 years, 1912–1922	Number of years compared	Variety named	Stavropol, same year	Difference from Stavropol	Percentage of Stavropol	Odds in favor of difference being significant
Six-rowed, hulled:																				
Consul	690	24.2	4.6	20.0	26.5	8.5	0	16.6	.....	26.1	46.8	40.6	37.8	.....	10	21.4	21.0	+0.4	101.9	1.6:1
Stavropol	2103	23.4	4.0	19.6	27.1	11.4	0	20.8	43.1	29.7	37.5	36.7	34.6	23.0	11	23.0	.....	.....	100.0	.....
Beldi	190	22.7	7.8	14.0	23.0	8.5	0	23.8	41.3	20.3	33.8	41.8	34.0	22.1	11	22.1	23.0	−.9	96.1	4.0:1
Gatami	575	20.2	6.3	14.1	22.2	12.0	0	20.2	35.2	12.0	32.3	35.2	26.4	19.0	11	19.0	23.0	−4.0	82.6	50.8:1
Odessa	182	.....	.....	.....	.....	.....	.....	.....	.....	21.2	28.5	34.9	28.2	.....	3	28.2	34.6	−6.4	81.5	17.0:1
Manchuria	244	10.0	2.1	9.9	.....	.....	.....	.....	.....	17.0	25.6	28.1	23.6	.....	6	15.5	25.2	−9.7	61.5	768.2:1
Flynn	1311	.....	.....	.....	.....	.....	.....	.....	.....	.....	49.0	42.8	.....	.....	2	45.9	37.1	+8.8	123.7	9.5:1
Club Mariout	261	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.2	42.6	.....	.....	2	43.9	37.1	+6.8	118.3	22.8:1
California Mariout	1455	.....	.....	.....	.....	.....	.....	.....	.....	.....	40.0	43.3	.....	.....	2	41.7	37.1	+4.6	112.4	6.4:1
Mariout (Hays)	.....	19.4	2.4	21.8	29.0	9.7	0	20.0	45.8	28.7	.....	.....	.....	.....	9	19.7	19.9	−.2	99.0	1.4:1
Ellis	2107	26.4	4.0	18.8	29.0	12.2	0	17.7	.....	32.6	.....	.....	.....	.....	8	17.6	17.0	+.6	103.5	3.5:1
Oderbrucker	2184	7.3	2.7	9.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	6.5	15.7	−9.2	41.4	10.9:1
Two-rowed, hulled:																				
White Smyrna	195	17.9	7.2	14.6	33.4	6.1	0	21.1	35.4	30.8	36.2	45.6	37.5	22.6	11	22.6	23.0	−.4	98.3	1.6:1
Hannchen	531	14.0	2.9	7.1	.....	.....	.....	1.5	.....	.....	32.4	34.9	.....	.....	6	15.5	23.7	−8.2	65.4	50.1:1
Svanhals	187	13.3	1.5	6.1	.....	.....	.....	.....	.....	.....	20.7	32.5	.....	.....	5	16.6	24.2	−7.6	68.6	106.5:1
Blackhull	878	.....	.....	.....	.....	.....	.....	.....	.....	.....	43.7	44.0	.....	.....	2	43.9	37.1	+6.8	118.3	34.6:1
Hull-less:																				
Himalaya	620	.....	.....	.....	.....	.....	.....	.....	.....	22.2	23.0	35.4	26.9	.....	3	26.9	34.6	−7.7	77.7	10.2:1
Hooded:																				
Meloy	1176	.....	.....	.....	.....	.....	.....	.....	.....	27.6	27.3	36.0	30.3	.....	3	30.3	34.6	−4.3	87.6	6.1:1
Hooded (spring)	716	5.0	1.3	18.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	8.2	15.7	−7.5	52.2	5.5:1

The six-rowed barleys that have given the best yields at Hays are Club Mariout (C. I. No. 261), Coast (C. I. No. 690), Stavropol (C. I. No. 2103), and Flynn (C. I. No. 1311). The first three possess long barbed awns, to which many object. Flynn, a smooth-awned variety developed by the Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, is very promising at Hays. California Mariout (C. I. No. 1455) was grown only two years. The variety ranked high in yield but was too short to be successfully harvested with either a header or a binder. Late-maturing varieties, such as Manchuria (C. I. No. 244) and Odessa (C. I. No. 182), are not adapted to western Kansas, the climate being too dry.

White Smyrna (C. I. No. 195) and Blackhull (C. I. No. 878) were the best two-rowed barleys, ranking with the best six-rowed varieties. Hannchen (C. I. No. 531) and Svanhals (C. I. No. 187), two-rowed types, mature too late to escape the effects of drought.

High yields of spring barley were obtained in 1912, 1915, 1918, 1919, 1920, 1921, and 1922. A failure occurred in 1917, and only fair yields were obtained in 1913, 1914, and 1916. The experiments were made on cropped land, which was either plowed or blank-listed in the fall, the seed bed being worked down in the spring. Good yields have not been obtained as a rule when the fall, winter, and early spring have been dry or if the seeding has been late. Barley is often used to replace abandoned wheat and in this capacity may serve a very useful purpose. It should be kept in mind, however, that conditions unfavorable for winter wheat are not likely to be optimum for a high yield of barley.

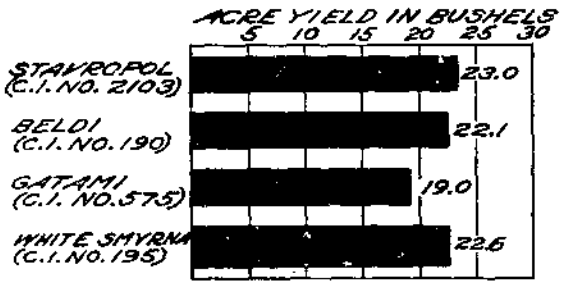

FIG. 17.—Average acre yields of four varieties of spring barley grown at the Fort Hays Branch Station, Hays, Kans., during the 11-year period 1912–1922

Barley is an exceptionally good crop to follow sorghum or corn, if the seed bed is disked prior to seeding the barley. Winter wheat can then follow the barley, any deleterious effects of the sorghums on succeeding wheat yields being largely eliminated.

VARIETAL EXPERIMENTS WITH WINTER BARLEY

Varietal experiments with winter barley were conducted on a small scale from 1912 to 1917. The experiments received limited attention because the crop is not sufficiently winter hardy to be practical for the Hays section. In the south-central section of the State, winter barley is grown for fall pasturage, with the expectation that more or less of the crop will winterkill.

The yields of five varieties of winter barley grown in some or all of the years from 1913 to 1916 are presented in Table 14. Tennessee Winter (C. I. No. 257), the hardiest of the group, was the only

variety grown continuously from 1912 to 1917. This variety completely winterkilled in 1912 and again in 1917, so that its average yield for the six-year period is not so high as that indicated in Table 14 for the four-year period. Tennessee Winter made an average yield of 11.1 bushels for the six years it was grown, as compared with 15.1 bushels for Ellis (C. I. No. 2107), a local spring barley. For the four years in which Tennessee Winter survived the winter, the average acre yields of Tennessee Winter and Ellis were 16.6 and 16 bushels, respectively. If winter barley survives the winter with a 59 to 60 per cent stand, it usually yields fairly well in comparison with the spring types.

TABLE 14.—*Yields of five varieties of winter barley and one variety of spring barley (included for comparison) grown at the Fort Hays Branch Station, Hays, Kans., during the four-year period, 1913–1916, together with average differences from the yields of Tennessee Winter (C. I. No. 257) in comparable years*

Variety	C. I. No.	1913	1914	1915	1916	Comparison, average yield in bushels, with that of Tennessee Winter (C. I. No. 257)					
						Number of years compared	Variety named	Tennessee Winter, same years	Difference from Tennessee Winter	Percentage of Tennessee Winter	Odds in favor of difference being significant
Austrian	2185	12.1	17.6	6.8	15.0	4	12.9	16.6	−3.7	77.7	9.5:1
Tennessee Winter	257	21.4	22.9	7.5	14.7	4	16.6			100.0	
Omar	808	------	18.7	10.8	12.9	3	14.1	15.0	−.9	94.0	1.8:1
Wisconsin Winter	519	------	26.7	7.4	13.7	3	15.9	15.0	+.9	106.0	2.3:1
Scottish Pearl	277	------	10.9	0	------	2	5.0	15.2	−10.2	32.9	11.0:1
Ellis (spring)	2107	4.0	18.8	29.0	12.2	4	16.0	16.6	−.6	96.4	1.2:1

The fall growth of winter barley at Hays has been much more abundant than that of winter wheat. This characteristic gives the crop some value for pasture purposes, but its grain value for north-central and western Kansas is doubtful. Also, the extensive introduction of winter barley into the winter-wheat belt would be undesirable on account of the probability of resulting mixtures of volunteer barley and winter wheat.

EXPERIMENTS WITH GRAIN SORGHUMS

Sorghum is one of the most productive crops grown in most of the western half of the State, whether considered from a grain or a forage viewpoint. Sorghum is least likely to fail, and its value is being more and more appreciated.

Through many years of careful selection, the sorghums have been brought to a high degree of uniformity, adaptability, purity, and yield. It is doubtful if present-acre yields of sorghums grown under normal favorable conditions can be greatly increased. There is a great field for future improvement of sorghums, however, through the creation of varieties more resistant to disease, insect injury, lodging, and weathering, and better adapted to machine methods of harvesting. The elimination of the bitter substance from the seed of forage sorghums also is possible and desirable.

Preliminary to any improvement program, however, should come the determination of the relative value of the different varieties

and the proper cultural practices for growing the crop. As such information is obtained, detailed work with plant selections and strains may be undertaken. This has been the procedure in these experiments.

VARIETAL EXPERIMENTS WITH GRAIN SORGHUMS[7]

Experiments with grain sorghums at the Fort Hays Branch Station were begun in 1908 but resulted in almost total failure because of drought. The 1909 crop was destroyed by hail. In 1910 a more extensive experiment was planned, including a wider range of varieties and new introductions. Chinch bugs entirely destroyed the plots of milo, and drought prevented a large number of varieties from maturing. The few yields recorded were as follows: Feterita (C. I. No. 182), 12.7 bushels; Red kafir (C. I. No. 34), 14.4 bushels; Dawn (Dwarf) kafir (C. I. No. 340), 29.3 bushels; and Standard (Blackhull) kafir (C. I. No. 204), 22.9 bushels. The chief accom-

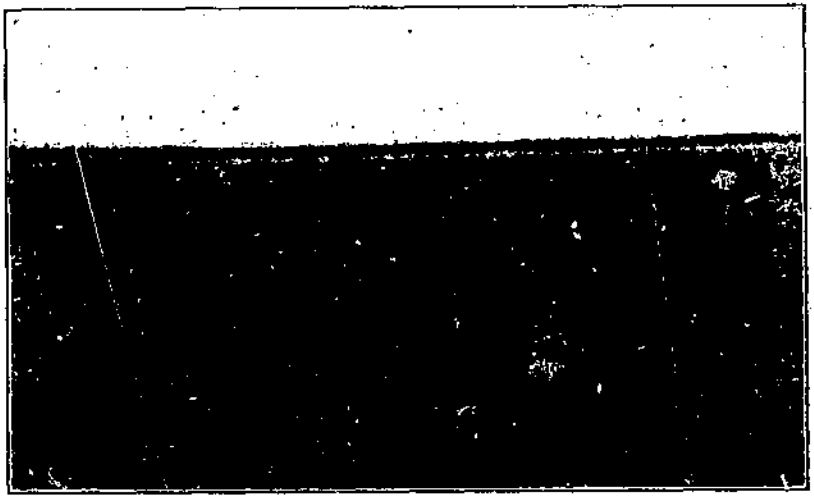

FIG. 18.—Milo destroyed by chinch bugs at the Fort Hays Branch Station, Hays, Kans., in 1911

plishment in 1910 was the isolation in head-row tests of Pink kafir (C. I. No. 432), the original seed having been obtained from William Rockefeller, of Russell County, Kans. It is believed that the variety was first imported into this country in 1905 by the United States Department of Agriculture. Pink kafir has since been widely distributed in Kansas.

In 1911 the sorghum plots were destroyed by drought, chinch bugs, and grasshoppers. A view of the milo plantings in 1911 is shown in Figure 18. These discouraging results naturally meant very slow early progress not only in the Hays district but more or less throughout the western part of the State.

Beginning with 1912, yields have been more certain. From 1912 to 1923, 38 varieties of grain sorghums were grown in the varietal experiments for a period of two or more years. The grain and

[7] For further information on varietal tests at Hays, see the following bulletin: VINALL, H. N., GETTY, R. E., and CRON, A. B. SORGHUM EXPERIMENTS ON THE GREAT PLAINS. U. S. Dept. Agr. Bul. 1260: 13–23, 76–78, 1924.

forage yields of these varieties are presented in Tables 15 and 16, respectively. Corn was added to the experiment in 1919 in order to make possible a direct comparison between this crop and sorghum. The average yields of different varieties of grain sorghums are shown graphically in Figure 19.

Dwarf Yellow milo (C. I. No. 332) is used as the standard of comparison. This crop is extensively grown in the Southwest, and at Hays it ranked among the highest in yield. Neither Standard Yellow, Standard White, nor Dwarf White milo equaled the yield of Dwarf Yellow milo (C. I. No. 332), although Early White milo (C. I. No. 480) compared favorably with it. This latter variety is well adapted to the district northwest of Hays because of its extreme earliness, but as yet its distribution is limited. Despite their high yields, the milos have certain serious disadvantages. The heads of milo recurve when grown under favorable conditions and therefore are difficult to harvest. Plots of milo were destroyed by chinch bugs at Hays in 1910, 1911, 1913, and 1917.

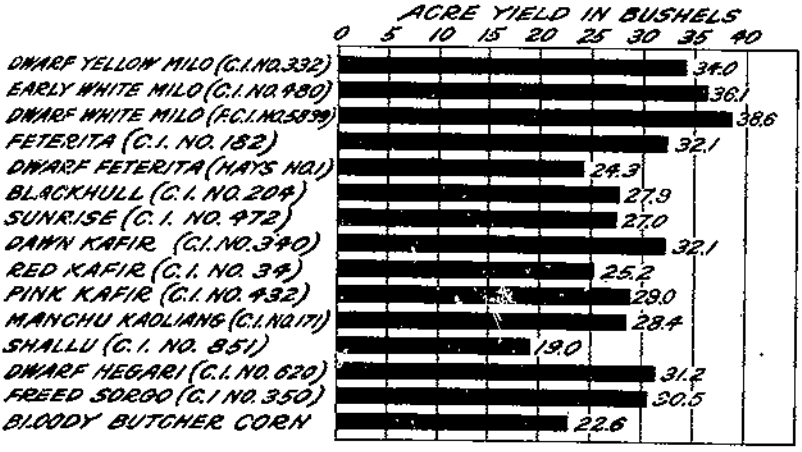

FIG. 19.—Average acre yield of 14 varieties of grain sorghum compared with Bloody Butcher corn, grown at the Fort Hays Branch Station, Hays, Kans., during the five-year period 1919–1923

Feterita (C. I. No. 182) is a valuable crop in seasons of limited moisture and next to kafir is the grain sorghum most universally grown in Kansas. The variety is particularly valuable in the district west and north of Hays, because of its earliness, but is useful farther east also for late planting. Feterita improvement was actively undertaken at the Hays station in 1919, when a large number of head rows were grown. One outstanding head row was advanced to plots in 1920. Its earliness and attractiveness and its yield, somewhat higher than that of common feterita (C. I. No. 182), led to its increase and its distribution to farmers in 1923. This selection (C. I. No. 182–1) appears to germinate under more severe conditions (such as cold and wet seed bed) than other strains of feterita. The chief limitation to growing feterita has been the difficulty that farmers have experienced in getting good stands. The use of copper-carbonate dust to treat the seed has helped to correct this condition, but the value of a strain of feterita of better seed quality can not be overestimated. A field of feterita is shown in Figure 20.

TABLE 15.—*Yields of 38 varieties of grain sorghum and one variety of corn (included for comparison) grown at the Fort Hays Branch Station, Hays, Kans., during the 12-year period 1912–1923, together with average differences from the yields of Dwarf Yellow milo (C. I. No. 332) in comparable years*

Group and variety	C. I. No.	Acre yield (bushels) [1]													Comparison of average acre yields, in bushels, with that of Dwarf Yellow milo (C. I. No. 332)					
		1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	Average 5 years, 1919–1923	Average 12 years, 1912–1923	Number of years compared	Variety named	Dwarf Yellow milo (C. I. No. 332), same years	Difference from Dwarf Yellow milo	Percentage of Dwarf Yellow milo	Odds in favor of difference being significant
Milo:																					
Standard Yellow	234	13.6	0	4.3	46.7	0	2.9	10.1	54.4	31.8	43.5	31.8	7.9	29.9	18.9	12	18.9	23.4	−4.5	80.8	58.2:1
Dwarf Yellow	184								41.3	38.1	46.0	34.7	6.9	33.4		5	33.4	34.0	−.6	98.2	1.5:1
Dwarf Yellow (control)	332	14.6	0	25.6	52.5	0	5.3	13.4	36.4	44.5	42.6	36.8	9.6	34.0	23.4	12	23.4			100.0	
Dwarf Yellow	236	17.3	0	22.0	51.2	0	2.4	10.9	31.8							8	17.0	18.5	−1.5	91.9	17.2:1
Early White	480						0	6.4	37.0	46.8	51.3	35.4	10.1	36.1		7	26.7	26.9	−.2	99.3	1.2:1
Standard White	352	24.9	0	4.5	47.1	0	3.6	9.0	29.0	41.0	46.3	23.8	11.4	30.3	20.1	12	20.1	23.4	−3.3	85.9	10.2:1
Dwarf White (F. C. I. 5899)					41.7	0	0	6.9	38.2	57.4	56.5	28.4	12.3	38.6		9	26.8	26.8		100.0	1.0:1
Feterita:																					
Feterita	182	32.1	0	37.8	37.4	0	5.6	10.3	32.1	42.9	43.8	29.9	11.6	32.1	23.6	12	23.6	23.4	+.2	100.9	1.1:1
Spur	623								34.9	29.8	37.2	20.0	14.3	27.2		5	27.2	34.0	−6.8	80.0	10.7:1
Feterita	182–1									52.5	44.0	28.9	12.8			4	34.6	33.4	+1.2	103.6	1.7:1
Do	182–2									47.6	45.1	29.9	12.5			4	33.8	33.4	+.4	101.2	1.3:1
Dwarf (Hays No. 1)									20.4	35.5	31.1	21.6	12.7	24.3		5	24.3	34.0	−9.7	71.5	40.7:1
Kafir:																					
Blackhull	204	20.5	0	21.6	7.8	0	0	1.1	21.0	44.2	31.3	16.1	26.8	27.9	15.9	12	15.9	23.4	−7.5	67.9	15.8:1
Do	71								19.1	51.0	44.4	16.0	20.3	30.2		5	30.2	34.0	−3.8	88.8	2.4:1
Sunrise	472	24.6	0	32.7	47.6	0	1.1	6.9	24.1	40.7	36.7	12.9	20.6	27.0	20.7	12	20.7	23.4	−2.7	88.5	4.8:1
Dawn (Dwarf)	340	34.2	0	21.7	40.0	0	0	7.6	34.1	54.8	31.5	19.6	20.7	32.1	22.0	12	22.0	23.4	−1.4	94.0	2.1:1
Blackhull (F. C. I. 9075)									19.7	55.4	33.9	15.7	19.3	28.8		5	28.8	34.0	−5.2	84.7	3.2:1
White	342	23.9	0	26.0	27.1	0	0	4.1	16.8	41.9	34.5	23.8	20.5	27.5	18.2	12	18.2	23.4	−5.2	77.8	15.6:1
Do	314	20.7	0	23.4	24.8	0	.5	3.0	19.0	45.0	30.4	25.4	14.3	26.8	17.2	12	17.2	23.4	−6.2	73.5	36.0:1
Red	34	.6	0	22.0	32.1	0	.4	3.4	29.9	30.0	41.1	9.8	15.0	25.2	15.4	12	15.4	23.4	−8.0	65.8	152.8:1
Red (F. C. I. 02820)									27.6	31.8	41.1	22.8	15.2	27.7		5	27.7	34.0	−6.3	81.5	11.2:1
Pink	432	26.6	0	14.9	35.0	0	0	4.7	24.1	42.6	46.0	19.8	12.5	29.0	18.9	12	18.9	23.4	−4.5	80.8	17.8:1
Progressive	633						5.2	7.7	32.9	43.9	40.0	13.2	20.5	30.1		7	23.3	26.9	−3.6	86.6	4.1:1
Kaoliang:																					
Manchu Brown	171	23.8	0	28.4	39.5	0	5.2	9.8	35.9	40.5	27.0	30.6	8.2	28.4	20.7	12	20.7	23.4	−2.7	88.5	9.5:1
Shantung (Dwarf)	203	31.9	0	19.9	43.6	0	0	4.7	14.4	40.1	26.2	29.8	4.0	22.9	17.9	12	17.9	23.4	−5.5	76.5	28.1:1
Barchet	310	26.0	0	22.0	54.8	0						18.0	12.8			7	19.1	19.9	−.8	96.0	1.4:1

Miscellaneous:																				
Shallu	85								35.9	17.9	22.8	8.7	9.6	19.0		5	19.0	34.0	−15.0	55.9	26.5:1
White durra	81	14.8	0	36.3						26.5	21.4	18.4	13.6			7	18.7	24.8	−6.1	75.4	6.8:1
Dwarf hegari	620				19.1	0	2.0	0	27.8	47.3	46.2	25.2	9.4	31.2		9	19.7	26.8	−7.1	73.5	18.0:1
Freed sorgo	350	15.9		23.9		0	4.6	9.9	21.8	45.0	41.9	30.9	12.7	30.5		10	20.7	22.9	−2.2	90.4	9.1:1
Early Buff durra							4.6	5.5	37.9	46.9	30.4	22.4	8.2	29.2		7	22.3	26.9	−4.6	82.9	15.7:1
Darso	615								32.2	37.6	31.3	20.8	16.4	27.7		5	27.7	34.0	−6.3	81.5	10.3:1
Shrock	616			7.7	20.4	0	.5	6.9	34.6	36.5	39.8	10.5	10.7	26.4		10	16.8	26.7	−9.9	62.9	82.3:1
Min's Grainmaker										52.0	49.5	20.7	8.5			4	32.7	33.4	−.7	97.9	1.2:1
Tricker sorgo		11.2	0	8.3			0	6.9			35.3	18.8	12.3			8	11.6	18.5	−6.9	62.7	57.1:1
Husserita										62.7	47.6	23.7	17.0			4	37.8	33.4	+4.4	113.2	2.6:1
Red Amber sorgo									29.6	33.8	32.0	19.4	9.8	24.9		5	24.9	34.0	−9.1	73.2	56.8:1
Sudan corn										48.3	45.6	14.1	28.8			4	34.2	33.4	+.8	102.4	1.2:1
Colby Bloody Butcher corn									17.4	35.6	38.8	21.3	0	22.6		5	22.6	34.0	−11.4	66.5	150.5:1

[1] Bushel rated at 56 pounds

TABLE 16.—*Total forage yields of 38 varieties of grain sorghum and one variety of corn (included for comparison) grown at the Fort Hays Branch Station, Hays, Kans., during the 12-year period 1912–1923, inclusive, together with average differences from the yields of Dwarf Yellow milo (C. I. No. 332) in comparable years*

Group and variety	C. I. No.	Acre yield (pounds)													Comparison of average acre yields, in pounds, with that of Dwarf Yellow milo (C. I. No. 332)				
		1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	Average 5 years, 1919–1923	Average 11 years, 1912–1916, 1918–1923	Number of years compared	Variety named	Dwarf yellow milo (C. I. No. 332), same years	Difference from Dwarf Yellow milo	Percentage of Dwarf Yellow milo
Milo:																				
Standard Yellow	234	3,500	0	7,192	11,350	0	------	1,180	8,010	9,888	7,713	9,600	4,375	8,037	5,828	11	5,828	4,926	+902	118.3
Dwarf Yellow	184								6,810	6,700	7,762	8,125	3,700	6,619		5	6,619	6,532	+87	101.3
Do	332	3,300	0	5,908	10,660	0	1,430	1,660	6,260	7,088	7,488	8,413	3,413	6,532	4,926	11	4,926			
Do	236	3,400	0	5,875	10,320	0	------	1,710	6,110							7	3,918	3,970	−52	98.7
Early White	480								5,510	8,200	9,050	8,587	4,525	7,174		5	7,174	6,532	+642	109.8
Standard White	352	5,750	0	5,758	11,880	------	------	1,760	7,410	7,075	8,638	9,325	4,013	7,412	5,655	11	5,655	4,926	+729	114.8
Dwarf White (F. C. I. 5899)	627	------	------	------	8,080	0	------	1,070	5,950	7,375	8,000	8,238	3,513	6,615	------	8	5,428	5,623	−195	96.5
Feterita:																				
Feterita	182	5,050	0	6,017	5,640	------	1,242	2,150	4,510	7,413	6,425	7,500	3,500	5,870	4,382	11	4,382	4,926	−544	89.0
Spur	623								4,670	8,338	6,388	5,775	2,525	5,539		5	5,539	6,532	−993	84.8
Feterita	182-1									6,950	5,737	6,863	3,213			4	5,691	6,601	−910	86.2
Do	182-2									7,663	6,538	6,900	3,250			4	6,088	6,601	−513	92.2
Dwarf (Hays No. 1)									2,390	6,288	4,338	5,800	2,350	4,233		5	4,233	6,532	−2,299	64.8
Kafir:																				
Blackhull	204	5,430	0	5,858	1,770	0	------	1,800	5,030	8,863	6,625	5,150	5,963	6,326	4,226	11	4,226	4,926	−700	85.8
Do	71								3,500	9,713	7,463	4,825	5,350	6,170		5	6,170	6,532	−362	94.5
Sunrise	472	8,180	------	8,750	8,570	0	------	2,740	5,590	8,850	7,700	5,250	5,250	6,528		10	6,088	5,419	+669	112.3
Dawn (Dwarf)	340	9,560	0	7,600	5,840	0	------	1,830	6,100	9,188	5,563	5,338	5,488	6,335	5,137	11	5,137	4,926	+211	104.3
Blackhull (Dwarf) F. C. I.	9075								3,370	10,438	6,125	4,025	4,738	5,739		5	5,739	6,532	−793	87.9
White	342	4,200	0	6,608	2,800	0	------	2,240	3,080	6,050	5,313	5,050	5,200	4,939	3,686	11	3,686	4,926	−240	74.8
Do	314	5,060	0	8,267	3,410	0	------	2,470	3,940	9,600	6,113	5,413	3,175	5,648	4,313	11	4,313	4,926	−613	87.6
Red	34	870	0	5,433	6,330	0	------	2,440	5,840	8,525	7,288	5,000	5,513	6,433	4,294	11	4,294	4,926	−632	87.2
Red (F. C. I. 02820)									5,270	7,775	6,125	5,300	3,000	5,494		5	5,494	6,532	−1,038	84.1
Pink	432	6,609	0	6,942	4,010	0	------	3,030	3,880	7,213	7,763	5,338	2,713	5,381	4,318	11	4,318	4,926	−608	87.7
Progressive	633	------	------	------	------	------	------	1,310	5,000	8,488	6,638	3,600	4,613	5,668	------	6	4,942	5,720	−778	86.4
Kaoliang:																				
Manchu Brown	171	4,260	0	3,658	4,660	0	------	1,600	4,720	7,263	4,719	5,588	2,088	4,876	3,505	11	3,505	4,926	−1,421	71.2
Shantung (Dwarf)	293	4,020	0	3,158	2,830	0	------	1,200	2,310	5,013	3,998	4,500	1,925	3,669	2,687	11	2,687	4,926	−2,239	54.5
Barchet	310	4,050	0	3,450	7,090	0	------	------	------	------	------	4,025	2,875	------	------	7	3,070	4,528	−1,458	67.8
Shallu	85	------	------	------	------	------	------	------	6,330	7,188	5,440	4,113	4,338	5,482	------	5	5,482	6,532	−1,050	83.9
White durra	81	1,980	0	3,363	------	------	------	------	------	4,675	3,300	2,800	2,150	------	------	7	2,610	5,087	−2,477	51.3

Miscellaneous:																			
Dwarf hegari	620				2,370	0		6,200	10,425	7,113	5,675	3,363	6,573		7	5,034	6,189	−1,155	81.3
Freed sorgo	350	2,710	0	3,483			1,020	5,390	9,488	6,600	5,400	4,175	6,211		9	4,318	4,837	−519	89.3
Early Buff durra							1,220	4,710	7,450	4,270	3,325	2,325	4,416		6	3,883	5,720	−1,837	67.9
Darso	615							4,970	8,038	4,550	5,125	3,950	5,327		5	5,327	6,532	−1,205	81.6
Shrock	610			6,100	5,540	0	1,520	6,010	9,088	7,013	5,450	5,288	6,570		9	5,112	5,654	−542	90.4
Tricker sorgo		4,057	0	3,237			1,710			6,125	4,338	3,175			7	3,235	4,312	−1,077	75.0
Min's Grainmaker									7,225	7,138	3,413	3,025			4	5,200	6,601	−1,401	78.8
Husserita									8,125	6,750	4,003	3,850			4	5,697	6,601	−904	86.3
Red Amber sorgo								8,960	10,638	7,563	7,425	4,350	7,787		5	7,787	6,532	+1,255	119.2
"Sudan corn"									9,402	7,788	6,313	4,038			4	6,900	6,601	+299	104.5
Colby Bloody Butcher corn								5,510	4,575	5,263	3,638	575	3,912		5	3,912	6,532	−2,620	59.9

[1] Not used in averages.

Pink kafir is a general-purpose sorghum valued for its excellent forage. The grain yield of this variety is not so dependable in seasons of drought as those of feterita and milo. On the other hand, it has the ability to produce high yields of grain in favorable seasons.

Dawn [8] (Dwarf) kafir (C. I. 340) and Sunrise [8] (Early Blackhull) kafir (C. I. No. 472) originated from selections made in 1906 at the Amarillo (Tex.) Cereal Field Station. Dawn kafir (C. I. No. 480) slightly outyielded Pink kafir (C. I. No. 432) at Hays, but among farmers the latter variety is more popular as a general-purpose fodder and grain crop. A strain of Dawn kafir originating from a head-row selection made in 1921 is now being distributed from the Hays station. This selection is well adapted to the western third of the State, except in the extreme northwestern counties.

Sunrise kafir (C. I. No. 472) is closely related to Dawn kafir. It is about 2 feet taller, with a more slender stalk, and is inclined to

FIG. 20.—Field of feterita (C. I. No. 182–1) grown at the Fort Hays Branch Station, Hays, Kans., in 1924. The method used in collecting heads for pure seed is shown also

lodge more easily. The variety is better adapted to the south-central part of the State than to the Hays district.

Red kafir (C. I. No. 34) is too late in maturing to compete with other kafirs at Hays. Red kafir (F. C. I. 02820) has excelled red kafir (C. I. No. 34) in grain yield because of its earliness. Red kafir as a forage crop is easily and readily handled in the field.

All of the kaoliangs mature extremely early and consequently produce low total crop yields. The stalks of the kaoliangs are dry and pithy, with few leaves, so that their forage value is slight. The average grain yields, on the other hand, compare favorably with those of other sorghum varieties.

Dwarf hegari (C. I. No. 620) responds vigorously to irrigation or to exceptionally favorable growing environment. Under adverse

[8] For origin, see the following bulletin: BALL, C. R., and ROTHGEB, B. E. GRAIN-SORGHUM EXPERIMENTS IN THE PANHANDLE OF TEXAS. U. S. Dept. Agr. Bul. 698: 58–63. 1918.

conditions it heads poorly and has been so variable in growth habits that it has little to commend it for the upland districts, when compared with the more stabilized varieties.

Freed sorgo (C. I. No. 350), sometimes called "white cane," is low in forage yield, but it is a very valuable grain crop for the extreme western and northwestern tier of Kansas counties because of its early maturity. It also is a desirable catch crop. A dwarf plant was found in a plot of standard Freed in 1921 which by continued selection has become a fixed type. It has outyielded the parent stock in preliminary experiments and can be harvested with machinery similar to that used for wheat.

Husserita and Sudan corn, hybrid varieties originating in southwestern Kansas, ranked high in yield in the short period they were grown, but they are too susceptible to lodging to be of practical value.

Colby Bloody Butcher corn was compared with the different sorghum varieties for grain yield from 1919 to 1923, inclusive. The yield of this corn was 66.5 per cent of that of Dwarf Yellow milo (C. I. No. 332) in the five-year period.

SPACING EXPERIMENTS WITH DAWN KAFIR

Spacing experiments were made with Dawn (Dwarf) kafir (C. I. No. 340) in the five-year period from 1919 to 1923, inclusive. The object of the experiments was to determine the best distance between rows, between plants in a row, and the effect of the different spacings on yield.

Each variation was grown on duplicate plots except in 1919. The rows were either 40 or 80 inches apart. In the 40-inch rows the plants were spaced at 6, 12, and 18 inches. In the rows 80 inches apart the plants were spaced 3, 6, and 9 inches.

In 1923 a hailstorm on June 29 completely beat down all vegetative growth, which at that time had reached a height of about 18 inches. So many of the plants were killed that the number of stalks at maturity was less in most cases than the original number of plants in the rows. The greatest injury occurred in the most closely spaced plants.

The annual and average yields for the five-year period are presented in Table 17. The climatic factors during the years 1919, 1920, and 1921 were favorable for the production of all sorghums. In these years the plots with the thicker stands and with the plants more fully distributed over the ground produced the best yields. In 1922 the late summer was dry, and the yields of kafir from the plots with widely spaced rows slightly surpassed the yields obtained from the plots where the rows were closer together. The summer of 1923 was one of extremes, a hail occurring in June, a drought in July, and heavy rains in August.

In all cases the total crop yields of the plots with 40-inch spaced rows were consistently higher than those of plots with 80-inch spaced rows. This is shown in Table 18, where the yields obtained from the 40-inch and 80-inch row plots having the same number of plants per acre have been compared.

TABLE 17.—*Annual and average yields of Dawn (Dwarf) kafir (C. I. No. 340) grown in a spacing experiment at the Fort Hays Branch Station, Hays, Kans., during the five-year period 1919–1923*

Year	Spacing (inches)		Stalks per plant	Acre yield		Test weight of grain (pounds per bushel)
	Between rows	Between plants in rows		Total crop (pounds)	Grain (bushels)[1]	
1919	40	6	1.31	7,900	33.6	55
	40	12	2.35	6,840	35.5	54
	40	18	2.21	5,500	28.7	57
	80	3	1.20	6,900	35.0	55
	80	6	1.35	4,980	25.7	57
	80	9	1.84	4,960	26.1	57
1920	40	6	1.50	10,300	58.2	61
	40	12	3.05	9,813	58.0	62
	40	18	3.82	8,563	47.1	61
	80	3	1.48	7,850	42.6	62
	80	6	1.83	6,438	39.9	61
	80	9	2.62	4,850	45.2	61
1921	40	6	1.00	8,175	45.7	60
	40	12	1.12	5,600	30.8	60
	40	18	1.41	4,950	30.6	60
	80	3	1.11	6,600	34.9	60
	80	6	1.06	3,550	21.4	60
	80	9	1.08	4,550	29.9	60
1922	40	6	1.00	4,300	15.4	57
	40	12	1.59	4,600	19.3	57
	40	18	2.81	3,963	15.4	57
	80	3	1.04	3,938	18.0	57
	80	6	1.22	3,650	20.3	57
	80	9	1.78	3,400	16.1	57
1923[2]	40	6	.86	7,275	17.4	56
	40	12	.95	6,213	25.9	57
	40	18	1.03	5,313	21.7	58
	80	3	.71	5,213	23.7	58
	80	6	.88	4,538	21.9	59
	80	9	1.03	4,300	21.8	58
Five-year average	40	6	1.13	7,590	34.1	58
	40	12	1.81	6,613	33.9	58
	40	18	2.26	5,658	28.7	59
	80	3	1.11	6,100	30.8	58
	80	6	1.27	4,631	25.8	59
	80	9	1.67	4,412	27.8	59

[1] Bushel rated at 56 pounds.

[2] Experiment injured by hail June 29.

The greatest suckering occurred in the thinner planting. Since these plots were lower in yield, the suckering was not extensive enough to correct for differences in stand. These lower yields also indicate that with the thinner planting there were not enough plants to use the potential soil productivity.

The yields shown in Tables 17 and 18 indicate an advantage in the 40-inch over the 80-inch row spacing for both forage and grain, particularly in years of normal, effectively distributed rainfall. In seasons of drought the wider row spacing seems to have a slight advantage in grain yield, but for all years the total crop yield is lower. There was a very consistent increase in yield of both forage and grain in proportion as the number of plants per acre was increased. The best stand appears to result when the spacing is equivalent to a plant every 6 to 12 inches apart in rows 40 inches apart. A view of Dawn kafir grown in 40-inch and 80-inch rows and with equal numbers of plants per acre is shown in Figures 21 and 22.

TABLE 18.—*Yields of Dawn (Dwarf) kafir (C. I. 340), with a given number of plants per acre, grown in rows 40 and 80 inches apart, at the Fort Hays Branch Station, Hays, Kans., during the five-year period 1919–1923*

Approximate number of plants to the acre	Spacing (inches)		Acre yield		Test weight of grain (pounds per bushel)
	Between rows	Between plants in rows	Total crop (pounds)	Grain (bushels)	
26,400	40	6	7,590	34.1	58
	80	3	6,100	30.8	59
13,200	40	12	6,113	33.9	58
	80	6	4,631	25.8	59
8,800	40	18	5,658	28.7	59
	80	9	4,412	27.8	59

EXPERIMENTS WITH CORN

Corn is a very uncertain crop in most of the central and western sections of Kansas. It can be grown with fair results in the northern tier of counties, particularly in a few northwestern counties, and on

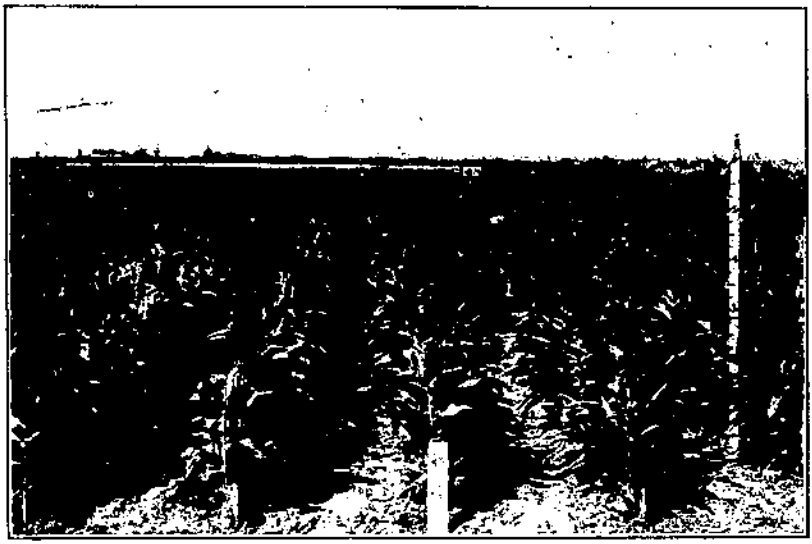

FIG. 21.—Dawn kafir grown in rows 40 inches apart with plants spaced 6 inches in the row in a spacing experiment at the Fort Hays Branch Station, Hays, Kans., in 1920

bottom land almost anywhere. Many farmers who grow corn in preference to sorghum do so largely because wheat follows the former crop to better advantage. The sorghums continue to draw on reserve moisture until they are killed by frost in the fall. This leaves the ground too dry for the successful germination and early growth of wheat. There is a belief among farmers that the tillage necessary to grow a good crop of corn also will provide a good seed bed for wheat.

TABLE 19.—*Yields of 17 varieties of corn grown at the Fort Hays Branch Station, Hays, Kans., during the 12-year period 1912–1923, together with average differences from the yield of Freed White dent in comparable years*

Variety	Acre yield (bushels)														Comparison of average acre yields, in bushels, with that of Freed White dent					
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	Average three years, 1921–1923	Average nine years, 1915–1923	Number of years compared	Variety named	Freed White dent, same years	Difference, same years	Percentage of Freed	Odds in favor of differences being significant
Freed White dent	23.1	0	28.2	51.6	2.2	0	0	2.7	28.7	36.7	18.8	0	18.5	15.6	12	16.0			100.0	
Sherrod White dent	22.5	0		37.1	0.5	0	0	9.8	20.3	31.8	23.8	0	18.5	14.7	11	14.1	14.9	−0.8	94.6	1.9:1
Pride of Saline			16.8	35.2	3.6	—	0	0	43.3	25.0	6.9	0	10.6		9	14.5	18.8	−4.3	77.1	7.8:1
Bloody Butcher			19.7	35.9	9.4	0	0	12.8	7.3	38.8	22.3	0	20.4	14.1	10	14.6	16.9	−2.3	86.4	3.1:1
Reid Yellow dent				39.2	1.5	0	0	0	38.0	24.4	9.7	0	11.4	12.5	9	12.5	15.6	−3.1	80.1	7.9:1
Iowa Silvermine			18.3	57.1	5.8	0	0	0	27.0	12.7	2.0	0	4.9	11.6	10	12.3	16.9	−4.6	72.8	11.6:1
Kansas Sunflower	14.1			35.5	4.2	0	0	0	37.7	11.4	.8	0	4.1	10.0	10	10.4	16.4	−6.0	63.4	17.0:1
Cassel White dent					5.2	0		0		27.6	22.6	0	16.7		6	9.2	10.1	−0.9	91.1	1.9:1
Calico	25.2	0	19.2	49.4	2.2	0	0				8.7	0			9	11.6	13.8	−2.2	84.1	10.0:1
Boone County White			14.2	37.8	4.8	0	0	0	36.7						7	13.4	16.2	−2.8	82.7	4.0:1
Minnesota No. 13	11.4	0		15.2	9.4	0		6.9	9.3						7	7.5	15.5	−8.0	48.4	7.9:1
Albright	15.3		12.5	50.6	6.2	0	0								6	14.1	17.5	−3.4	80.6	5.8:1
Silver King	10.1				5.2	0		0	9.3						5	4.9	11.3	−6.4	43.4	8.8:1
Corn Planter			18.7				0	0	30.0						4	12.2	14.9	−2.7	81.9	4.0:1
Joy White dent		0		40.9							12.4	0			4	13.3	17.6	−4.3	75.6	8.9:1
Swadley White dent										20.0	23.7	0	19.5		3	19.5	18.5	+1.0	105.4	1.3:1
Funk Ninety-Day										32.3	18.4	0	16.9		3	16.9	18.5	−1.6	91.4	4.4:1

Experiments with corn were begun at the Fort Hays station in 1902 on newly broken sod. Fair yields were obtained. In 1903, Minnesota No. 13, Colorado No. 1, and a local yellow corn were among the best. The acre yields varied from 20.5 to 37.4 bushels. In 1904 additional new varieties were included, and the range of yields was from 24 to 47.5 bushels. The latter was the yield for Pride of Saline, grown at the station for the first time. This variety was grown again in 1905 and produced 63.1 bushels per acre. Since then it has become the leading white dent corn for the bottom lands of western Kansas. It is not so well adapted to the uplands.

From 1912 to 1923, 17 varieties of corn were grown in the varietal experiments. The yields are presented in Table 19.

The white dent varieties of corn as a rule slightly outyield the yellow dent varieties at Hays, even though vegetative growth and

FIG. 22.—Dawn kafir grown in rows 80 inches apart with plants spaced 3 inches in the row in a spacing experiment at the Fort Hays Branch Station, Hays, Kans., in 1920

habits may be much the same. Late-maturing heavy-foliaged varieties are not well adapted to western Kansas. Iowa Silvermine is a good example. Reid Yellow dent has been one of the best medium-late maturing varieties. This variety has slightly outyielded Pride of Saline.

Freed, Sherrod, and Cassel White dent varieties have been among the best in yield. Bloody Butcher has been a consistent yielder and, as in 1919, usually has made its best record in adverse seasons. The limiting factors in the production of corn in the Hays district are high temperature at the time of pollination and lack of rainfall at critical periods. The four varieties mentioned above are medium early in maturity and intermediate in growth habit. They are early enough to become pollinated before the high temperatures which occur usually between July 15 and August 10 and catch the later

varieties. A view of a plot of Sherrod White dent corn is shown in Figure 23.

EXPERIMENTS WITH MINOR CROPS

The minor crops included in experiments at the Fort Hays station are winter rye, emmer, spelt, and flax. Rye is the only crop in this group which may be utilized more extensively with some profit. The others are too uncertain to be of economic value.

WINTER RYE

The largest acreage of rye in Kansas is grown in the south-central section. In 1922 a little more than 70,000 acres were grown in the State. Rye is used chiefly for pasture. It is objectionable where winter wheat is grown, because it volunteers readily and contaminates the latter crop sufficiently to bring about a reduction in price. Volunteer rye matures so far ahead of winter wheat that enough

FIG. 23.—Sherrod White dent corn grown at the Fort Hays Branch Station, Hays, Kans., in 1919. This variety and type are well adapted to the uplands of western Kansas

seed is shattered to carry it through from year to year, unless some row crop is included in the rotation to bring it under control. In Table 20 are presented the yields for winter rye. Rye has yielded somewhat less than winter wheat.

TABLE 20.—*Yields of winter rye varieties grown at the Fort Hays Branch Station, Hays, Kans., during the six-year period 1913–1918*

Variety	C. I. No.	Acre yield (bushels)							
		1913	1914	1915	1916	1917	1918	Average 1913–1916	Average 1913–1918
Ivanov	151	19.3	22.8	10.3	23.8	12.5	11.2	19.1	16.7
Russian	152	19.1	25.9	12.0	21.5	------	------	19.6	------
Kansas	114	13.5	26.0	9.3	20.9	------	------	17.4	------
Kharkof winter wheat	2193	[1] 17.2	22.9	10.8	33.1	------	------	[1] 21.0	------

[1] Yield used as a relative comparison; not exactly comparable.

FLAX

Limited experiments were made with flax in 1912 and 1914. The few yields obtained are presented in Table 21.

TABLE 21.—*Yields of flax varieties grown at the Fort Hays Branch Station, Hays, Kans., in the two years 1912 and 1914*

[Hail destroyed the 1913 crop]

Variety	C. I. No.	Acre yield (bushels)		
		1912	1914	Average
Minnesota No. 25	12	5.1	0	2.6
Common		3.4	0	1.7
Russian N. D. No. 608	1	5.4	0	2.7
Russian N. D. No. 152		1.9	0	1.0

In 1912 the flax was seeded on April 16, which probably was too late for best results. Hail destroyed the 1913 crop. In 1914 an extensive experiment was laid out in which four replicated plots and different rates of seeding were included. The entire experiment was a failure because of the inability of the flax to survive the drought. If the spring is favorable, flax may make a vigorous growth and flower profusely in early June, but high temperatures during the latter part of June and early July are very detrimental to the crop.

WINTER SPELT

Red winter spelt was grown from 1913 to 1918. The average yield for the five years was 10.8 bushels per acre. The crop was more or less winterkilled each year, so that a full stand was never attained. Winter spelt may therefore be considered as of little promise.

WINTER EMMER

Black winter emmer (C. I. No. 2337) was grown for a five-year period from 1914 to 1918 with an average yield of 9.3 bushels per acre. The crop was a complete failure in 1917. Winter emmer, like winter spelt, was not sufficiently hardy to be a profitable crop.

SPRING EMMER

A small quantity of seed of Khapli emmer (C. I. No. 4013) was received in 1920 and was grown in rod rows until 1921. In 1922 an increase plot produced at the rate of 32.8 bushels per acre. The most serious objection to Khapli emmer is that it does not grow tall enough to be harvested readily.

CROP YIELDS AND TYPE OF FARMING

Comparison of the acre yields in pounds of grain of representative cereals that have been grown at the Fort Hays station during the four-year period from 1919 to 1922 are shown in Figure 24. The variety of each crop chosen was among those best adapted to the district. The yields, as shown graphically, possibly may be a little

higher than might be obtained from some other four-year period, but it is believed that the relative value of one crop as compared with another is fairly represented.

The data presented in Figure 24 were obtained from a five-year rotation which has been in effect in growing the cereal experiments since 1919. The yields of winter wheat, except in 1919, when all plots of winter wheat were on fallow, are the averages obtained from plots on both fallow and cropped land the second year after fallow. During the four-year period wheat grown on land the second season

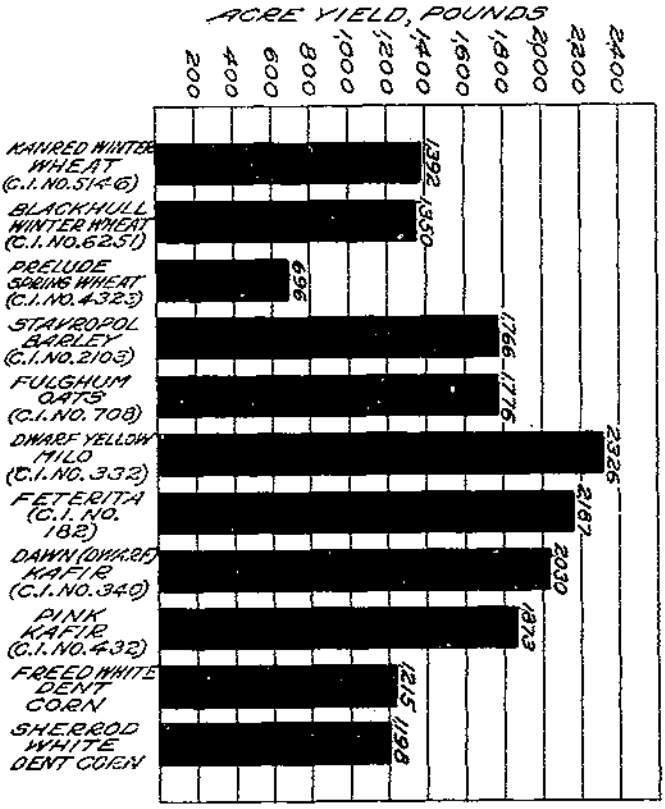

FIG. 24.—Average acre yields of grain of the leading cereal varieties grown at the Fort Hays Branch Station, Hays, Kans., during the four-year period 1919–1922

after fallow yielded only a little less than wheat grown immediately after fallow. The fallow may have a residual effect that extends into the second year.

The yields of spring wheat, barley, and oats are directly comparable. These cereals were seeded on cropped land the second year after fallow. After experimental spring grains, the land was uniformly cropped one season to winter wheat in preparation for the experimental sorghums and corn.

The yields for sorghum and corn are comparable, since these crops were always grown on wheat-stubble land the fourth year after fal-

low. These crops in turn were followed by fallow, which apparently eliminated all deleterious effects of sorghum.

The five-year rotation as outlined above has much to commend it, and in the years since it has been practiced there has been an improvement in the texture of the soil. Weeds are brought under control more easily and crops respond well to the system.

With the exception of spring wheat, all of the crops for which yields are shown in Figure 24 can be grown in the Hays district with more or less success. With a diversified cropping system, timely operations, and a fairly definite rotation plan, total crop failures need very rarely occur. The importance of this fact has not yet been realized by a large number of farmers who are inclined to follow the one-crop system, planting wheat continuously.

Winter wheat has ranked well in acre production. Spring wheat has not been a success. Barley and oats have ranked high in acre yield. Although they may not be the most profitable cash crops to grow, they should be considered as a source of feed and as crops to follow sorghum in order to bring the land back to wheat, where fallow is not to be included in the rotation system.

Sorghum has produced the greatest acre return of any crop grown. When winter wheat does not survive, no crop is so well adapted to take its place as sorghum. The fact that it need not be planted until after growing-season rains have made conditions favorable gives the crop an advantage over either barley or oats, both of which must be sown as early as possible. The only possible exception is in the northwestern section of the State. Sorghum has made a very favorable showing experimentally and statistically, but the crop has not been adopted whole-heartedly by the farmers of the central plains region. From the farmers' point of view the chief factors limiting further increase in the sorghum acreage have been: (1) The difficulty of getting a suitable stand; (2) the necessity of exercising great care in the early cultivation of the tender, slow-growing plants; (3) the somewhat greater cost and inconvenience of harvesting and threshing the crop as compared to corn; and (4) the common objection that wheat does not follow sorghum profitably.

SUMMARY

Experiments with cereals have been conducted on dry-farmed land at the Fort Hays Branch Station, Hays, Kans., since 1902. The experiments reported in this bulletin cover the period 1912 to 1923, inclusive.

The station is situated in the central two-thirds of western Kansas, in the heart of the hard winter wheat belt, 75 miles south of the Kansas-Nebraska line, and 160 miles east of the Kansas-Colorado line.

The section to which this bulletin is applicable is devoted primarily to grain production. The most important grains are winter wheat, sorghum, barley, oats, and corn. Winter rye is grown to a limited extent. Forage sorghums, Sudan grass, alfalfa, sweet clover, and millet are more or less extensively grown.

The soil on which the experiments were made is a dark gray to black silt loam, underlain with a slightly lighter colored clay loam of a highly granular structure.

The average annual precipitation for the 22-year period from 1902 to 1923, inclusive, was 23.01 inches; for the six months of the growing season, April 1 to September 30, inclusive, the average was 17.91 inches. The average rainfall for the 56-year period 1868 to 1923, inclusive, was 22.87 inches. The annual precipitation has varied from a low of 11.8 inches in 1894 to a high of 35.4 inches in 1878.

With the exception of spring wheat, all of the major crops reported in this bulletin can be grown more or less successfully in the Hays district. With a diversified cropping system, timely operations, and a fairly definite rotation plan, total crop failures need occur only rarely. The importance of this fact has not yet been realized by a large number of farmers. Single-crop farming is uncertain and, if practiced, involves unnecessary risks.

Hard winter wheats of the Crimean group have produced higher yields than the soft winter wheats and much higher yields than the durum or hard red spring wheats. Kanred was the highest yielding variety, but it is so closely followed by Blackhull that both have a place in western Kansas agriculture. Blackhull is popular in the district to the south and east of Hays and is well adapted to the lowlands because of its ability to withstand lodging. It is not so winter hardy as Kanred. Blackhull can not be recommended for the northwestern section of the State. Kharkof strains of winter wheat have slightly outyielded Turkey.

The best yields of winter wheat have been obtained when the crop was sown between September 20 and October 1. Earlier seeding is conducive to rank growth when moisture is present early in the fall, and also to Hessian fly infestation. Wheat should not be sown at a rate less than 4 pecks to the acre. Under favorable conditions lighter rates may be sufficient, but since there is no reduction in yield from rates as high as 6 pecks per acre, rates of seeding sufficiently heavy to overcome losses in stand likely to occur from unforeseen causes are good crop insurance.

The seeding of winter wheat in shallow furrows 12 inches apart gave no greater yield than that obtained from using the ordinary drill.

A light application of straw to winter wheat as a top-dressing on fall-plowed or fallow ground at the rate of from 1 to 2 tons to the acre is believed to be beneficial.

Early varieties of oats, such as Fulghum, Kanota, Burt×Sixty-Day, and Burt, have produced the highest yields. For best results, oats should be sown not later than March 25.

Early varieties of barley, such as Club Mariout, Stavropol, Flynn, and Coast, have produced the best yields. White Smyrna and Blackhull varieties, representing the two-rowed types, are promising. Both barley and oats follow sorghum and corn to good advantage.

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