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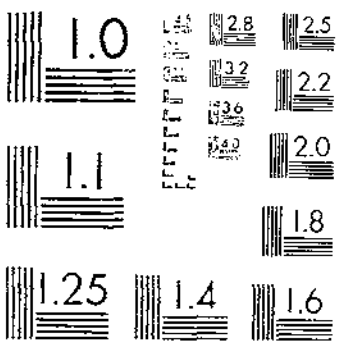
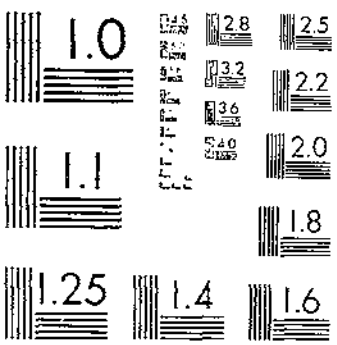


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



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EXPERIMENTS WITH FORAGE CROPS AT THE FORT HAYS BRANCH STATION, HAYS, KANS. 1913 TO 1928

By

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

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EXPERIMENTS WITH FORAGE CROPS AT THE FORT HAYS BRANCH STATION, HAYS KANS., 1913 TO 1928 [1]

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CONTENTS

INTRODUCTION

The Fort Hays Branch Station of the Kansas Agricultural Experiment Station [2] (fig. 1) is located about one half mile south of Hays, the county seat of Ellis County, Kans., in the center of the hard winter-wheat belt of west-central Kansas. It is about 100 miles west of the ninety-eighth meridian, which is ordinarily considered

[1] These experiments were conducted under a cooperative agreement between the Bureau of Plant Industry U.S. Department of Agriculture, and the Kansas Agricultural Experiment Station

[2] A brief historical sketch of the station and the section in which it is located appears in the following publication: SWANSON, A. F., CEREAL EXPERIMENTS AT THE FORT HAYS BRANCH STATION, HAYS, KANS., 1912 TO 1923. U.S. Dept. Agr. Tech. Bull. 11, 56 pp., illus. 1927.

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the eastern boundary of the Great Plains, and at an altitude of 2,000 feet.

The results of experiments conducted at this station in the production of cultivated forage crops for the period 1913–28 are reported in this bulletin.[3] Occasional reference is made to earlier unpublished results, especially with alfalfa, for the period 1902–12.

The experiments, except certain ones with alfalfa, were conducted on upland soil under dry-farming conditions representative of an extensive area in the central Great Plains. Sorghums have had the leading place in these experiments and the results are of most value to the northern part of the sorghum belt, namely, western Kansas and adjacent territory in eastern Colorado and southwestern Nebraska.

Sorghums are now the principal cultivated forage crops of this section. The increase in the acreage of sorghums was very rapid

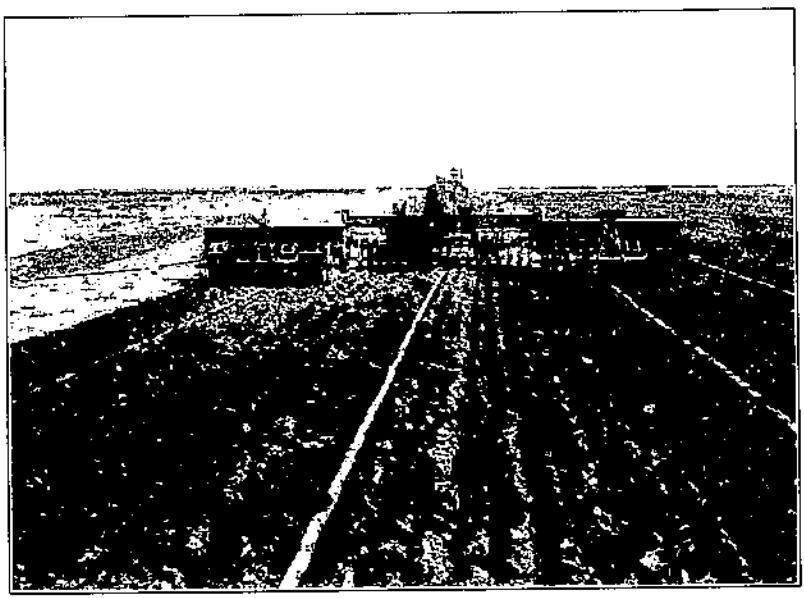

FIGURE 1.—View on the Fort Hays Branch Station at Hays, Kans., in the heart of the Kansas wheat belt. Wheat farming requires expensive machinery which results in a large overhead and often makes it less profitable than a combination of forage crops and livestock.

from 1885 to 1912, and there has been some increase since that time, but with wide fluctuations. Increases in sorghum acreage usually follow periods of poor returns from wheat and corn, and decreases in sorghum are associated with cycles of unusual profits from either or both of the cereals named. Over 2,000,000 acres of sorghums have been grown annually in Kansas during the past 10 years. About one third of this acreage is planted to sorgos, almost wholly for forage purposes. The remainder consists mainly of kafir, milo, and feterita, in the order named. These are commonly known as grain sorghums, but kafir is grown usually for both forage and grain.

Sudan grass ranks next in importance. In the 20 years since it was first grown commercially in Kansas, its acreage has increased to

[3] The data contained in this bulletin have been given, in part, in previous publications, as follows: With reference to sorghums, U.S. Dept. Agr. Bulls. 383 and 1260; Sudan grass, U.S. Dept. Agr. Bull. 981; and for all work up to 1919, inclusive, in Kans. Agr. Expt. Sta. Bull. No. 225. Reference has been made to certain subjects in Farmers' Bulls. 794, 1126, and 1158 of the U.S. Department of Agriculture.

more than 100,000, about equally divided between the eastern and western halves of the State.

Millet was the leading cultivated hay crop of the early settlers, reaching its maximum of more than 500,000 acres in Kansas in 1885. With the introduction of improved sorghums and Sudan grass, millet has continuously declined in importance, and now totals less than 100,000 acres.

Alfalfa increased rapidly in acreage from 1890 to 1910 on the narrow strips of bottom land along small streams in western Kansas. It reached a peak of 283,574 acres in the western 46 counties in 1910 but has since decreased steadily to less than half this acreage. The decline is largely accounted for by the increasing difficulty in obtaining and maintaining stands of the crop.

Sweetclover and certain annual legumes have attracted some interest in recent years but are as yet relatively unimportant under dryland conditions. A few thousand acres of sweetclover are grown largely on low, sandy river-bottom land, as along the Arkansas River.

Prairie hay was an important source of feed with the early settlers. At the present time it is produced mainly on irregular and scattered areas in the draws where the soil moisture is increased by the run-off from surrounding areas, and the land is perhaps too rough to plow. Big and little bluestem are the most prominent grasses in such places.

The earliest cattlemen depended entirely on native pastures, of which buffalo grass and the grama grasses are the principal constituents. They suffered great losses, however, in severe winters when snow covered the ranges and when the water supplies in the creeks were frozen. As land came into cultivation, stockmen began raising supplementary feeds, thus avoiding many losses. Only in very recent years, however, has the reliance on native pastures alone disappeared, as disaster overtook one after another of the few old-time ranchers who refused to adapt themselves to modern methods.

On land that appeared adapted to the production of cultivated crops, large areas of the native grasses have been plowed under. The diversion of grazing lands to cultivated crops is greatest in periods of favorable rainfall and high prices. Some cultivated land usually reverts to grass in periods of depression or low rainfall, but the tendency has been to bring more and more of the level land into cultivation. In some localities it would seem that too large an acreage of grassland had been plowed up for wheat, but where farming is diversified it usually has been possible to devote a considerable acreage to wheat and yet grow enough forage crops to support an increased number of livestock. During the period of rising land values and tax rates when the decreased expense of producing wheat due to the introduction of new machines, such as the combine, and favorable prices made wheat production profitable some of the best farmers deemed it unwise to devote level land to pastures since it required 5 to 10 acres of grassland in addition to supplementary winter feeds to support one animal.

Now that the idea of cultivated forage crops for winter feeding has been generally accepted, the problem seems to be the choice of crops and varieties, their improvement, and the development of the most effective methods of culture and utilization.

Sorghums have best met the need for high-yielding forage crops that can be grown cheaply on any land suited to cultivation. By the use

of silos, it has been found possible to double the acre-feeding value of sorghums and hold feed in reserve for a period of years. This latter is of special importance, for, at best, the dry-land sections are subject to partial or complete crop failure in many seasons.

Sudan grass has helped to meet the need of a catch crop for hay production and of a grass that will provide abundant pasturage during the late summer when the native grasses are unproductive.

Sorghums, Sudan grass, and the millets (the forage crops best adapted to upland conditions) are all high in carbohydrates and relatively low in protein. There remains a need for legume crops that can be grown to supply this protein, and with the decline in alfalfa production in recent years the need has become greater. So far, it has appeared more practical for most stockmen to buy protein concentrates, such as cottonseed cake, rather than attempt to grow any of the legumes extensively under upland conditions.

SOILS

The upland soil, or wheat land, on which nearly all of the experimental work was done, belongs to the black earth soil belt of the United States and is similar to the black earth of Russia, Rumania, Argentina, and Canada. The surface 8 to 18 inches is medium heavy, relatively dark, and very fertile. The subsoil is a heavier, more compact, and lighter-colored silty clay loam or clay of excellent moisture-holding capacity. The black earth soils occupy a belt extending north and south across Kansas, bounded on the east by a line running approximately through Smith Center, Osborne, Ellsworth, Lyons, Kingman, and Anthony and on the west by a line running approximately through Meade, Dighton, Hoxie, and Oberlin.

The black earth soils, comprising 55 percent of the total land area of the 46 counties of western Kansas, differ very little in texture and crop adaptation from the Colby silt loam adjoining them on the west and making up 35.8 percent of this area. The difference in these soils is mainly in productiveness due to the thickness of the dark surface layer, the percentage of nitrogen and humus, and the higher rainfall in the black earth belt. Both series come within the farmers' classification of hard land in contrast with the sandy land more commonly found adjacent to the Arkansas River and southward in Kansas.

The bottom lands on which some of the alfalfa experiments were located lie along Big Creek and are similar to soils of the Cass series, one of the important alluvial soils of the Great Plains. It is a dark, rich, alluvial soil with a water table at an average depth of 20 feet, to which the roots of successfully established alfalfa penetrate.

All of the soils in this section are subject in varying degrees to drifting from hard winds, usually in the late winter and early spring. This factor is sometimes serious at the Hays station when fields are left smooth and bare through the winter, as when row crops are removed or when fall-seeded wheat lacks moisture to grow and cover the ground. Soil drifting is controlled by roughly cultivating or listing the land at right angles to the prevailing winds.

CLIMATIC CONDITIONS

PRECIPITATION

The average annual precipitation at the Fort Hays station is 22.8 inches, as computed from a continuous 61-year record of the United States Weather Bureau from 1868 to 1928, inclusive. The highest annual rainfall was 35.4 inches in 1878 and the lowest 11.8 inches in 1894. Within the period of the forage-crop experiments at the Hays station, from 1913 to 1928, the average precipitation was 22.09 inches; the highest, 34.14 inches in 1915; the lowest, 14.51 inches in 1924. Comparison of the data for the 61-year period with those for the last 16 years at the Hays station and a study of long-time records at other dry-land points as well show the fallacy of the popular theory that rainfall follows the plow. Attempts have often been made to prove that wet and dry seasons prevail in approximately definite cycles, hoping from this study to be able to formulate a plan for reliable forecasts of rainfall conditions one or more years ahead.[4]

More than three fourths of the annual rainfall is received during the 6 months, April 1 to September 30, the season of most active crop growth. The exact distribution for any 1 year, however, is highly uncertain and has ranged from more than 10 inches in 1 month down to as little as 0.16 of an inch in 4 months. The heavier summer rains are often torrential, and much of such precipitation is lost from run-off; on the other hand, many showers in summer are so light that they scarcely penetrate the soil and evaporate so quickly that they seem to be of little, if any, benefit. Monthly and annual precipitation records at Hays, Kans., for 1913-28, inclusive, are given in table 1.

TABLE 1.—*Monthly and annual precipitation at the Fort Hays Branch Station, Hays, Kans., for the 16-year period 1913-28, compared with the averages for the Hays station and vicinity for the 61-year period, 1868-1928*

[Data in inches. T=trace. Adapted from published records of the U.S. Weather Bureau]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1913	0.30	0.68	0.41	2.78	5.72	3.53	0.63	0.11	4.80	0.25	0.72	3.11	23.10
1914	.01	.42	.15	2.31	2.26	3.39	2.77	2.63	.60	1.33	T	.63	16.65
1915	.58	1.80	1.73	3.13	6.82	3.97	8.18	4.11	2.44	.93	.30	.01	34.14
1916	.53	.15	.31	2.21	1.63	5.88	.30	1.97	1.26	1.14	.02	.61	16.01
1917	.11	T	.07	1.66	1.72	2.15	1.46	5.73	1.81	.09	1.61	.15	16.92
1918	.80	1.15	1.71	2.49	4.79	.53	3.01	1.76	1.42	2.41	4.19	2.38	23.58
1919	T	2.18	.33	4.51	6.85	3.51	1.16	.77	3.32	1.81	1.54	.15	26.13
1920	.05	.37	.30	2.01	3.32	1.87	1.89	5.11	1.56	3.58	.73	.46	21.28
1921	.40	.10	.49	3.58	2.59	3.67	3.36	3.04	.68	.05	0	.50	18.46
1922	T	.93	1.73	4.51	2.61	2.18	4.20	.81	.43	.32	1.28	T	18.98
1923	T	.10	1.04	1.63	3.07	5.96	.70	1.15	1.52	4.37	.29	.37	27.10
1924	.31	.26	1.81	1.05	3.39	.77	2.32	1.95	1.03	.46	.25	1.11	14.51
1925	.05	.24	.38	1.27	1.01	4.43	6.73	3.33	.96	.75	1.12	.02	23.02
1926	.36	1.13	1.75	.81	2.16	2.55	1.91	.83	2.83	.60	1.12	.37	16.45
1927	.01	.98	1.85	3.69	1.81	8.03	1.82	6.63	2.80	T	.03	.10	27.21
1928	.03	1.57	1.42	1.27	3.13	9.13	6.86	1.78	.81	2.61	1.88	.02	29.94
Average, 1913-28	.23	.75	.97	2.69	3.36	3.83	2.96	2.79	1.96	1.26	.75	.63	22.09
Average, 1868-1928	.19	.85	1.01	2.32	3.27	3.37	3.29	2.90	2.25	1.42	.76	.77	22.80

[4] An interesting attempt of this kind was the following publication: EMMONS, C. H., THE EMMONS RAIN CHART AND CROP GUIDE. 32 p. Hill City, Kans. [1927]. Mr. Emmons, then living at Hill City, Kans., classified the precipitation in 6-year cycles, 3 dry and then 3 wet years. He based this on a study of the average rainfall from 1881 to 1928 in North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Minnesota, Iowa, Missouri, and Arkansas. He also studied the long-time records at 10 selected stations in the western third of Kansas, and later included all records for the 105 stations in that part of the State. One of these alleged cycles has recently been completed (1923-28). The reader may judge from the table of precipitation data presented for the Hays station with what reliability, if any, the cycle theory can be applied to the rainfall at this station during the period 1913-28.

A very important factor in crop production is the reserve of available moisture in the subsoil. When rainfall is plentiful in the late summer or fall of one year, some very good crops are often produced the following season with relatively light precipitation during the growing period. Likewise, if the season begins with very little reserve moisture in the subsoil, crops are likely to suffer considerably at any time that the current rainfall is deficient, even for a short period. To judge the moisture available for crop production in any year at Hays, consideration should be given to the preceding year's record, as to what conditions prevailed after the preceding crop ceased to use moisture. The years 1914 and 1924 furnished notable examples of good crops produced with a light seasonal rainfall, but following a wet fall.

Some calendar years with approximately normal rainfall, or more, have been poor for crop production because of the unequal distribution of the rains. In 1913 the annual rainfall was about normal, yet one of the worst crop failures on record occurred because of poor distribution.

Hail cut crops to the ground on June 29, 1923, but sorghums, Sudan grass, and millets recovered fairly well. Lighter hail has occurred at other times in May, June, and July, but it has not been a factor of much importance in the results with forage crops. A very destructive hailstorm occurred on June 13, 1909. Forage crops usually recover from hail damage much better than the cereals, and, if necessary, early varieties can be reseeded up to July 1 with the prospect of a fair crop.

EVAPORATION

The amount of water evaporated daily from a tank at ground level has been recorded from April 1 to September 30 throughout the years 1907–28. Monthly and annual totals are presented in table 2. Evaporation records are of particular value as an index to the combined effects of precipitation, temperatures, and wind. The data here presented afford in condensed form excellent comparisons of the crop-producing possibilities of different seasons. High evaporation indicates hot, dry, or windy weather, usually droughty. Low evaporation indicates cold, wet, or quiet conditions, usually a favorable condition when less than 10 percent below normal, but injurious to the germination, early growth, and maturity of sorghums when much below normal over a protracted period. Monthly totals exceeding 10 inches indicate drought, increasing in severity as the total evaporation rises. Where the 6-months total evaporation exceeds 50 inches it has been associated with ruinous drought extending over a considerable period.

TABLE 2.—*Monthly and seasonal evaporation from a free-water surface at the Fort Hays Branch Station, Hays, Kans., from April to September of each year, 1918–28*

[Data from the Division of Dry Land Agriculture]

Year	Evaporation (inches)						
	April	May	June	July	August	September	Seasonal, Apr. 1 to Sept. 30
1918	6.606	7.610	8.521	13.815	11.451	7.250	58.283
1914	5.75	5.091	9.282	9.256	9.817	7.889	47.089
1915	4.186	5.529	5.928	7.059	5.381	5.191	33.277
1916	4.228	7.037	7.731	12.301	11.125	7.909	50.231
1917	6.351	6.527	11.089	11.871	8.140	6.488	50.469
1918	4.325	7.191	8.036	9.062	11.244	6.541	47.569
1919	4.085	4.528	5.105	10.272	9.311	7.382	40.996
1920	4.783	4.682	8.117	9.616	6.201	6.257	39.776
1921	6.171	7.252	6.043	8.671	8.188	8.220	44.557
1922	4.388	5.912	7.931	8.278	10.531	10.309	47.329
1923	5.907	5.378	6.583	9.823	8.584	6.238	42.803
1924	5.183	6.782	7.738	10.835	10.325	7.459	48.622
1925	6.002	6.781	11.633	9.487	7.925	6.978	48.809
1926	5.501	7.457	9.382	11.408	11.159	7.227	52.034
1927	4.550	7.509	7.660	9.261	6.270	6.963	42.522
1928	6.107	6.451	4.965	8.092	8.159	8.321	42.305
Average	5.320	6.401	7.896	9.933	9.183	7.306	46.042

FROST DATA

The dates of the last killing frost in the spring and the first one in the fall have been recorded by the United States Weather Bureau at Hays from 1892 to the present time. These dates are of particular importance for the fall season in this northern section of the sorghum territory, where midseason to late varieties may be killed prematurely in a season like 1918, for example, when frost came on September 20. The average date of the last frost in spring is April 30 and the first in the fall is October 12, giving an average frost-free period of 166 days.

Large departures from normal in about one fourth of the seasons add a marked element of risk, especially to sorghum production. The latest killing frost in the spring recorded at Hays occurred on May 27, 1907. It ruined the first crop of alfalfa, and corn had to be replanted. Other extremes of late frost were recorded on May 19, 1894; May 26, 1901; and from May 12 to 16 in 1895, 1904, 1914, 1923, and 1924. Frost was reported in September eight times in 37 years, the earliest being on September 17 in 1901 and 1903; others on September 20, 1918; September 26, 1912; and on September 29 in 1895, 1916, 1920, and 1924. Usually frosts as late as the last week of September only slightly affect results with sorghums, for the weather is ordinarily so cold from this time on as to permit but little development. Frost delayed 10 days or more beyond normal is rarely preceded as in 1927 and 1928 by sufficiently warm October weather to let sorghums ripen to any extent during that month.

MAXIMUM AND MINIMUM TEMPERATURES

Temperatures throughout the season are of much interest in interpreting the results with warm-weather crops such as sorghums, Sudan grass, and millets; also in comparing sorghums with corn. The chief interest in the data recorded at the Hays station from April 1 to September 30 by the Division of Dry Land Agriculture centers around the maximum and the mean temperatures within the frost-free period. Often a warm period around the second to the last week in May, suitable for seeding sorghum, is followed by from 1 to 3 weeks of cold wet weather. This happened in 1915, 1916, 1917, 1919, 1923, 1924, 1926, 1927, and 1928, or in 9 of the 16 seasons, during the forage-crop experiments. While the latter part of May is the normal planting season for sorghums in this locality, the danger of sufficiently cold wet weather to interfere with their stands and early growth exists until after June 15.

The maximum temperature on record at Hays was 114° F. on June 25, 1911, and the next highest was 111° on July 14, 1913. By

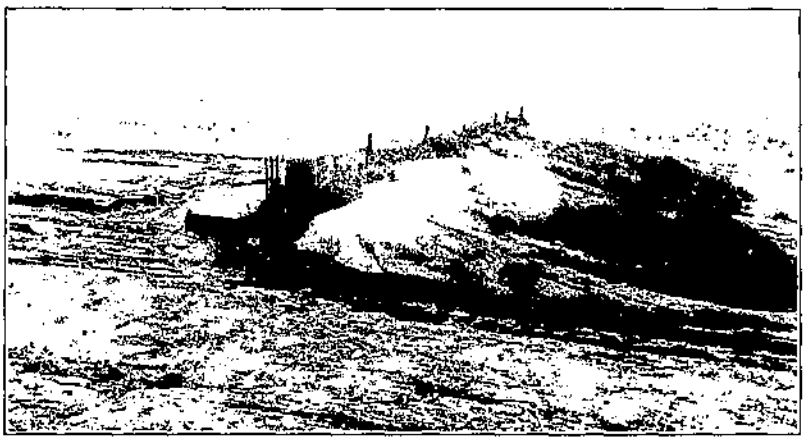

FIGURE 2.—The disastrous effect of wind erosion on soils left unprotected is illustrated by the condition of this field near Hill City, Kans.

contrast, the maximum temperature for June was only 87° in 1915 and 1928. The relative severity of high temperatures for the different seasons is effectively indicated by the number of days registering 100° or above during July and August. During the hottest season, 1913, there were 36 such days, 13 of which occurred in one consecutive 14-day period, from August 3 to 16. During 1915 there were none, in 1927 only one, and in 1928 only three; in neither of the latter seasons was 100° recorded later than July 10. The year 1913 was one of severe drought while the last three named (1915, 1927, and 1928) were exceptionally favorable seasons. Corn thrived greatly in these cool wet seasons, but it suffered in other seasons approximately in proportion to the number of days registering 100° or more in July and August.

WIND VELOCITY

Data on wind velocity at the Hays station have been recorded by the Division of Dry Land Agriculture in terms of average miles per hour for each 24-hour period from April 1 to September 30 for 1908

to 1928, inclusive. The measurements are taken 3 feet above the ground, in order to be near the average level of growing crops. The highest daily record was 27.2 miles on April 14, 1912, and the next highest was 27.1 on May 8, 1927. The latter date was notable for the great damage done in northwestern Kansas from soil drifting (fig. 2) and for injury to all growing crops, especially winter wheat (fig. 3), through so-called "electric winds." While the highest winds of the growing season are usually recorded in April and May, they are much less important to the growing of forage crops than the extremes occurring after July 1.

High winds in July and August, associated as they usually are with hot dry weather, may cause partial or total ruin to a corn crop in a

FIGURE 3.—Alfalfa in rows covered by soil blown from an adjoining wheat field

day or two at the pollinating stage. Sorghums are noted for enduring such conditions much better, and if injured they usually make more or less recovery as soon as the drought is relieved. High winds in September may cause the sorghums to lodge and may also dry and blow off the lower leaves prior to the ripening of the grain. These latter conditions have prevailed in seasons like 1925, 1927, and 1928, when an extra-tall, succulent growth of sorghums was suddenly checked by the near exhaustion of its supply of soil moisture. High winds often cure and destroy within a few days the foliage of sorghums previously killed by frost, and they may also cause the stalks to lodge more readily than before frost. Winds may merely break the heads over and cause a great loss of grain. This situation proves a serious limitation to the practice of letting sorghums stand for harvesting with a combine.

Days with average wind velocities of 20 miles or more per hour are considered very severe for growing crops, both as to mechanical injury

and the transpiration of moisture. Days having 15 miles or greater average velocity are considered severe, but not necessarily ruinous. Months with an average of 10 percent or more above normal are usually associated with other droughty factors noticeably injurious. Normal wind velocities for April to September, respectively, are 10.3, 8.8, 7.6, 6.7, 6.5, and 7.6 miles per hour.

A summary of the most important of the climatic data discussed is given in table 3.

TABLE 3.—*Summary of various climatic records for the Fort Hays Branch Station, Hays, Kans., 1913–28*

[Data for precipitation and frost dates adapted from reports of the U.S. Weather Bureau; other factors adapted from records of the Division of Dry Land Agriculture]

Year	Precipitation for the 6 months ending—		Evaporation		Dates of killing frost		Days with maximum temperature of 100° F. or above in July and August	Days in which the wind velocity averaged 10 miles or more per hour from—	
	Mar. 31	Sept. 30	Total, Apr. 1 to Sept. 30	Number of days with ¼ inch or more during July and August	Last in spring	First in fall		Apr. 1 to June 30	July 1 to Sept. 30
	Inches	*Inches*	*Inches*				*Number*	*Number*	*Number*
1913	3.12	17.37	58.28	22	Apr. 12	Oct. 17	26	43	30
1914	1.60	11.06	47.10	1	May 13	Oct. 25	18	31	13
1915	6.18	28.17	33.28	0	Apr. 3	Oct. 5	0	22	8
1916	2.26	13.25	50.24	10	May 4	Sept. 20	22	23	26
1917	1.95	11.86	50.47	9	May 8	Oct. 8	15	43	13
1918	5.51	14.08	47.57	7	May 1	Sept. 20	21	31	11
1919	8.10	20.12	41.09	8	Apr. 17	Oct. 10	14	19	13
1920	1.22	15.70	39.78	0	Apr. 27	Sept. 29	7	25	9
1921	5.76	16.92	44.56	0	May 3	Oct. 8	6	25	12
1922	3.19	14.74	47.32	3	Apr. 18	Oct. 9	11	21	24
1923	2.71	20.93	42.80	2	May 16	Oct. 21	6	30	15
1924	7.41	10.31	48.62	7	May 15	Sept. 29	10	24	20
1925	2.49	20.46	48.81	2	May 1	Oct. 9	11	28	10
1926	5.13	14.12	52.03	9	Apr. 28	Oct. 24	17	26	30
1927	4.96	24.21	42.52	2	Apr. 22	Nov. 2	1	28	9
1928	3.15	23.01	42.31	2	Apr. 16	Oct. 22	3	24	18
Average	4.45	17.50	46.04	5	Apr. 28	Oct. 11	12	28	16

In table 3 the precipitation data are arranged to show: (1) The quantity received during 6 months previous to the growing season, which gives a fair basis for comparing different seasons as to relative amounts of available soil moisture; (2) the amounts for the 6 growing-season months. Where the October-to-March precipitation was well below normal, as for 1913, 1916, 1917, 1922, 1923, 1925, and 1928, crops depended almost entirely on rain received while growing. In the first 3 years named this was inadequate; in the latter 3 it was abundant for good crops. This indicates about a 50 percent prospect of good forage-crop yields if the growing season opens without a reserve of moisture. Where precipitation shown in the first column is about normal, as in 1914, 1920, 1926, and 1927, wide variations occurred in the succeeding crops, yields being generally in proportion to rainfall received while growing. Results also varied for the seasons that opened with the greatest reserves of moisture, but it is noteworthy that in one of these seasons (1924) it was possible to produce fairly good crops of nearly all kinds with only 10.31 inches of rainfall during the growing period.

The data for evaporation, maximum temperatures, and wind velocity indicate clearly the relative merits of the seasons; the lower the figures shown, the better the crop returns.

INSECT PESTS

The leading insect pests affecting the experimental work with forage crops have been grasshoppers and chinch bugs.

Widespread outbreaks of grasshoppers have occurred throughout this section at varying intervals ever since its earliest agricultural history. The most severe in recent years was that of 1913 when from late June to early September they did much damage to Sudan grass, alfalfa, annual legumes, and corn; medium injury to sweetclover, millet, and milo; but relatively little to the other sorghums. They have since appeared every summer in varying numbers, often sufficient to do considerable damage. However, since 1913 they have been checked through the spreading of poisoned bran mash, so that they have not greatly damaged the forage-crop experimental work at the Hays station.

Chinch bugs do considerable damage in the eastern two thirds of Kansas, but are of little, if any, importance farther west. At the Hays station they do some damage to milo, Sudan grass, corn, barley, and millet, and occasionally to sorghums other than milo, particularly feterita. Legumes are not affected, and juicy-stalked sorghums of the sorgo and kafir types, while often thickly infested, show comparatively little injury. Lodging of tall sorgos is, however, sometimes increased by the bugs. Chinch bugs are ruinous to milo, and in 1910, 1911, and 1913 they were injurious to several other crops at the station; they were definitely injurious to milo and feterita experiments in 1917, 1926, and 1927. In most other years they have been present in limited numbers.

RODENTS AND BIRDS

Rabbits are always sufficiently numerous in western Kansas to cause some damage. At the Hays station they have usually destroyed any soybeans not fenced, and in 1924 they destroyed some tepary beans. Rabbits rarely attack tepary beans, however, and have let cowpeas alone. They eat almost any small isolated plot of tender vegetation, especially during the winter, including wheat, alfalfa, sweetclover, and perennial grasses.

Pocket gophers are a common pest in the alfalfa fields. Ground squirrels often steal newly planted corn and sorghum, especially when the field adjoins prairie land. Neither of these animals has, however, seriously affected the experimental work here reported.

Sparrows and blackbirds have usually attacked the heads of a few of the earliest maturing grain sorghums, such as Freed and Early White milo. The sparrows persist, irrespective of means used to scare them, but blackbirds have been readily discouraged by shooting among them on several consecutive days. Bird injury has been negligible after the majority of sorghums headed.

DISEASES

Head smut of sorghums (*Sorosporium reilianum* (Kühn) McAlp.) was a factor of importance in the experiments with Red Amber sorgo in 1924 and has affected it to some extent in several other

seasons since 1919. Leoti Red sorgo also suffered from this to a lesser but conspicuous extent in 1924, and showed a few heads of this smut in other seasons. This disease lives over in the soil and does not yield to seed treatment, but it has been almost eradicated by the use of hand-selected seed and by seeding the sorghums on wheat-stubble land each year. Other sorgos and kafirs are also subject to this smut, but in so minor a degree that its control presents no problem.

Covered kernel smut (*Sphacelotheca sorghi* (Link) Clint.), very commonly infecting up to 50 percent of the heads of sorgos and kafirs in farmers' fields of the section, has not been a factor in the sorghum experiments at the Hays station. It scarcely ever occurs when clean hand-selected seed is used from year to year, as in this work, but, if

FIGURE 4.—Double disking wheat stubble in the fall in preparation for seeding sorghums the following spring. Early preparation of the soil greatly improves the chances for a good sorghum crop.

present, it can be easily controlled by copper carbonate and other seed treatments.

Two leaf diseases of sorghum and Sudan grass are usually present; namely, bacterial stripe, caused by *Bacterium andropogoni* E. F. Smith, commonly known as red spot, and the bacterial streak disease, caused by *B. holcicola* Elliott. Neither of these diseases has interfered seriously with the results.

The older alfalfa stands have shown in recent years such a rapidly increasing amount of disease of the crowns and roots that the acreage is being steadily reduced.

Mammoth Russian sunflowers, planted in 7 years of the experiments, died regularly at or before the beginning of bloom. A leaf rust was conspicuous on these plants.

Leaves of all the cowpeas seeded in a variety test May 29, 1928, rusted and dropped off, and the plants died during the exceptionally wet cold weather that lasted through June.

EXPERIMENTAL METHODS

Most of the experiments were conducted on $\frac{1}{10}$-acre plots or on duplicated or triplicated $\frac{1}{20}$-acre plots. The $\frac{1}{10}$-acre plots were used mainly for alfalfa and were usually duplicated; in one experiment on width of rows there were four replications. Sorghums, Sudan grass, millets, and sweetclover were commonly grown on $\frac{1}{20}$-acre plots. With crops of minor importance grown primarily for observation and not for yields, smaller areas were often used, generally $\frac{1}{100}$- or $\frac{1}{50}$-acre plots for sorghums and annual legumes. Numerous nursery trials of grasses, sweetclover, and alfalfa were made in rows either 1 or 2 rods long and usually 36 to 42 inches apart.

It has been a regular practice to seed the sorghum, Sudan grass, and millet experiments on some uniform upland field that grew small grain, usually winter wheat, the preceding year (fig. 4). Rotation of the land has been irregular as to the legumes.

Forage yields are reported for the total crop on an air-dry basis, including the seed crop, if any. All sorghum grain yields are on a basis of 56 pounds per bushel. Acre yields for each year of the experiment are usually shown throughout this publication; these yields are the averages for all replications.

SORGHUMS

VARIETY TESTS

The comparisons of sorghum varieties were conducted in two general classes of experiments: Tests of the more important varieties in plots of sufficient size to afford reliable yield data; tests of selections, introductions, and other minor varieties in single rows, primarily for observation and further selection.

The varieties for these tests were obtained from local sources, from State experiment stations in the Great Plains area, and from the United States Department of Agriculture. The list varied considerably from year to year as new varieties were constantly obtained, and some of the older ones were discontinued as being unworthy of further attention. Changes of the serial number identifying a variety were sometimes made as improved selections became available. Since Hays is in the northern part of the sorghum belt, most attention was given to early and midseason varieties. Both forage and grain-producing types were included, but without attempting to include all of the grain sorghums. Through an informal agreement with the Division of Cereal Crops and Diseases, the sorghum varietal tests were conducted cooperatively with that unit in 1919 and in the period 1924–28.

The sorghum variety tests were begun on a small scale in 1913, but due to extreme drought and to insect attacks they were almost a failure. The project was more fully organized in 1914 and was conducted on duplicate $\frac{1}{20}$-acre plots for 1914–23. Both plots were usually seeded at the same date, but in 1915 and 1921, 2 weeks or more elapsed between the first and second replications. This latter method lessened the risks in obtaining a stand and also permitted each variety to show more fully its reactions to the season. In 1924 the experiments were placed definitely on a plan of three replications, seeded, respectively, about May 15, June 1, and June 15. This plan was continued in succeeding years.

The sorghums were seeded regularly in 40-inch rows, usually 6 rows 110 feet long to each plot, only the inner 4 rows being used in determining yields. Tillage methods (fig. 5) calculated to permit maximum yields were followed uniformly within any 1 year's tests, but varied from year to year. Usually the varieties were seeded with a 2-row planter in shallow listed furrows. In a few seasons the crop was surface planted, with or without the use of disk-furrow openers. Satisfactory stands were the rule, due to extreme care in tillage practices (fig. 6) and to the use of hand-selected seed (fig. 7). Varieties brought in from outside sources ordinarily consisted of bulk seed and were generally at a marked disadvantage the first year. Kernel smut was rarely, if ever, noted in plots seeded with home-grown hand-selected seed, but often developed in varieties grown from untreated bulk seed not produced on the station. In the later years

FIGURE 5.—Sorgo fodder in shock in late autumn, with a part of the field blank-listed in preparation for the succeeding crop and to prevent soil blowing.

of the tests all varieties were treated uniformly with copper carbonate to insure freedom from kernel smut.

Head smut first appeared on the general farm of the station in 1919 in a large field of Red Amber sorgo. This smut was occasionally noted in the experimental projects in succeeding years, mainly in 1924, when there was enough to warrant noting the percentage. In 1924 the average percentage of head smut to total heads was highest in Red Amber, S.P.I.[5] 17548, with 19.9 percent; second highest in Leoti Red, F.C. 6610, with 12.6 percent; and third in Colman, F.C. 9134, with 6.3 percent. Other varieties with 0.6 percent or more were as follows: Early Sumac, F.C. 6611, 1.8 percent; Freed, F.C. 9033, 1.4 percent; Western Orange, F.C. 9073, 1.2 percent; Schrock, F.C. 1481, 1 percent; Black Amber, F.C. 7038, 0.8 percent; Sumac, F.C. 9130,

[5] C.I. indicates accession number of the Division of Cereal Crops and Diseases, F.C., of the Division of Forage Crops and Diseases; S.P.I., of the Division of Seed and Plant Introduction. In July 1926 the last named became F.P.I., indicating of the Division of Foreign Plant Introduction.

0.6 percent. Other sorgos and kafirs ranged from none up to 0.3 percent; but it was entirely absent in the milos and feteritas. With the discontinuance of Red Amber as a general field crop on the station about 1925, head smut again became rare and was rogued from the plots without being recorded.

Other plant diseases and insect problems were of relatively minor importance in these experiments. After 1913 grasshoppers, though present, were readily controlled. Chinch bugs damaged milo seriously and feterita to a lesser extent in 1917. In other years they were often present, but did not do appreciable damage. In the last years of the tests, subnormal milo plants were sometimes noted, and the question arose whether this was due to some disease or to chinch-bug injury.

FIGURE 6.—Snow retained in the lister furrows. This is one of the advantages derived from fall preparation of the seed bed.

The long duration of the sorghum varietal experiments permitted a study of these crops under a wide range of climatic conditions. The first 6 years, 1913–18, were relatively adverse and the last 10 years, 1919–28, rather favorable except in 1926. In the very severe drought of 1913, the highest forage yield was from Red Amber, 1.04 tons per acre. Certain other varieties yielded as follows: Western Orange, 0.84 ton; Black Amber, 0.61 ton; Sumac, 0.51 ton; Dwarf Yellow milo was a complete failure. The only grain yield from this group was from Black Amber, 3.2 bushels per acre.

The next most severe droughts occurred in 1916 and 1926. A very severe midsummer drought in 1917 ended in early August in time to permit good forage growth of those varieties having time to mature. A less severe drought through the latter part of the 1918 season cut the crop short and hastened maturity. The earliest killing frost of the 16 years occurred that year on September 20. The seasons of 1914, 1919, 1921, 1922, and 1924 were more nearly normal, the sorghums usually starting out favorably, but suffering to some degree from limited moisture toward the close of the season. In 1923 a

severe hailstorm on June 29 cut all plants to the ground (fig. 8). The hail left irregular stands, but was offset considerably by a wet fall and a late killing frost. There were 5 wet years—1915, when excessive moisture prevented seeding until several weeks after the normal date,

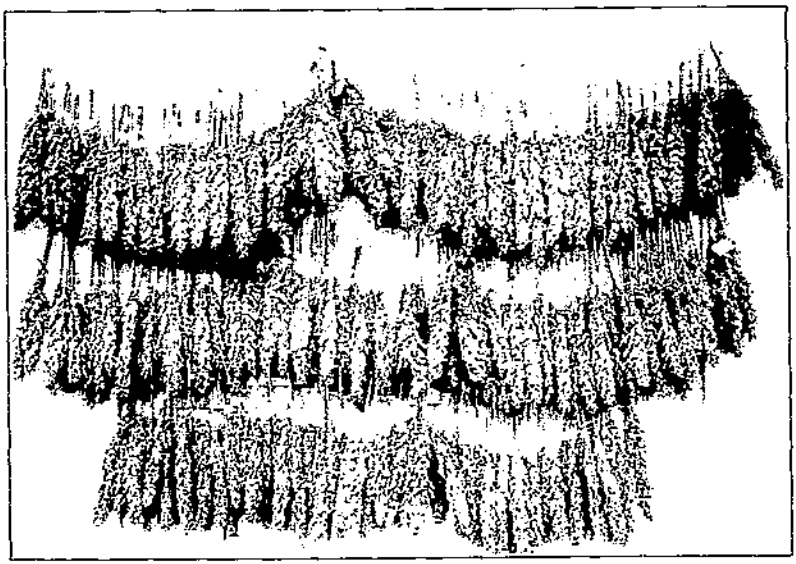

FIGURE 7.—Selected seed heads of sorghum hung up to cure. Handling the seed in this way improves the germination and does much to insure good stands.

FIGURE 8.—Hail damage to sorghum (left) and to corn (right), June 29, 1923. The sorghum recovered with only a slight loss of stand.

and a killing frost occurred while many varieties were still immature; 1920, the best season up to that time; 1925, when after a very wet summer a severe drought and high winds occurred in September, causing much lodging of the rank growth; and 1927 and 1928, the outstandingly favorable seasons of the entire period.

TABLE 4.—*Average row space per plant and stalk, average height, and annual and average forage yields of sorghum varieties and 1 variety of corn (included for comparison), 1914–28*

[Yields of each variety compared with those of a composite check derived from the average yields of 10 varieties for the same years in which the variety was grown]

Variety	Average row space		Average height	Forage yields (air-dry) per acre															Average of—		Relative yields[1]
	Plant	Stalk		1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Variety	Check	
	Inches	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Percent*
Sumac	6.9	4.1	70	3.31	5.43				3.01	5.09	7.03	3.93	3.23	3.01	3.14	4.86	1.28	6.23	5.68	4.25	3.27	130
Kansas Orange	7.3	4.6		3.83	4.97	2.91	3.86	2.61	2.57	7.30	3.86	2.85	3.44	3.18	4.60	1.56	6.12	5.63	3.95	3.09	128
Colman	6.1	4.2			5.60	2.45	2.93	3.27		6.69	3.82	2.81	3.41	2.61					3.68	2.97	124
Atlas	9.5	5.2												3.75	4.66	1.60	6.02	5.09	4.22	3.41	124
Sourless	7.1	4.6												3.40	3.30	4.68	1.29	5.60	5.34	3.91	123
Straightneck	7.4	4.7							3.20	7.22	3.58	2.90	5.08	3.06	5.10	1.50	5.85	5.23	4.07	3.32	121
African "millet"	8.4	4.9											3.40	3.30	4.68	1.29	5.60	5.34	3.91	3.27	117
Dakota Amber×sumac	7.6	4.5									3.27	2.37	3.32	3.51	4.84	1.44	5.94	5.09	3.72	3.18	115
Early Sumac	6.7	4.3								6.45	3.58	3.41	2.63	3.03	4.48	1.52	5.53	5.35	3.91	3.39	114
Red Amber	6.6	3.9		2.93	5.72	2.52	3.13	3.14	2.43	5.56	3.57	2.68	2.78	2.79	4.19	1.38	4.82	4.69	3.43	3.01	112
Leoti Red	10.0	6.4					2.91	3.13	3.45	5.07	3.11	2.74	3.41	2.88	3.71	1.56	4.47	4.42	3.47	3.09	112
Western Orange	7.9	5.2								4.92	3.57	2.82	2.55	3.10	4.76	1.49	5.22	5.16	3.73	3.39	110
Black Amber	6.8	4.6		2.90	5.30	1.61	2.31	2.46	3.01	5.61	3.49	2.60	3.43	2.98	4.48	1.48	4.72	4.49	3.40	3.09	110
Sunrise kafir	8.9	6.2		2.51	4.88	2.78	2.87	2.44	3.28	4.41	3.14	3.13	2.98	2.50	4.14	1.48	4.23	4.25	3.23	3.09	105
Pink kafir	9.8	8.2		3.60	1.01	1.35	1.95	2.49	2.18	5.18	3.42	2.66	2.61	3.15	3.83	1.24	4.78	4.53	3.14	3.09	102
Schrock	9.2	6.3			5.43	1.53	2.74	1.92	1.51	4.37	3.29	2.36	2.37	2.94	3.51	1.28	4.98	4.76	3.07	3.11	99
Blackhull kafir	9.8	7.7		2.26	3.45	1.11	2.33	1.98	2.36	5.42	3.16	2.12	2.21	3.01	3.51	1.11	5.09	4.65	3.05	3.09	99
Pink kafir	9.1	6.9		3.35	1.15	1.38	3.01	1.72	2.12	3.60	3.23	2.45	1.90	3.22	3.74	1.12	5.61	4.70	3.03	3.09	98
Western Blackhull kafir	10.1	7.8										2.39	2.27	3.15	3.51	1.33	4.39	4.84	3.13	3.19	98
Dwarf hegari	12.3	6.0		3.14	3.53	1.90		2.16	2.44	1.94	2.57	2.36	2.04	3.10	3.59	1.31	5.07	4.31	3.05	3.18	96
Dawn kafir	9.1	7.4		3.17	3.42	1.04	2.90	1.78	2.37	5.05	2.83	2.72	1.82	3.09	3.31	1.35	4.52	4.39	2.94	3.09	95
Standard Yellow milo	11.5	7.1		2.45	3.40				3.11	4.90	3.01	3.06	2.15	2.73	3.95	1.17	3.51	4.40	3.18	3.36	95
Spur feterita	12.5	7.3							2.78	4.49	3.08	2.74	1.99	3.17	3.65	1.16	4.33	3.96	3.11	3.31	94
Premo	13.6	11.8										2.61	1.47	2.78	4.21	1.20	4.48	4.05	2.97	3.19	93
Dwarf Yellow milo	10.7	6.8		2.41	4.88	1.32	.66	2.11	2.74	3.91	2.79	2.93	1.88	2.87	3.60	.87	3.63	4.68	2.75	3.09	89
Darso	10.4	8.1							2.05	3.50	2.87	2.42	1.52	2.52	4.17	1.20	4.33	4.21	2.95	3.31	89
Red kafir	8.6	6.9		2.93	4.02	1.21	2.60	2.01	2.02	4.22	3.05	2.35	1.77	2.57	2.95	1.10	4.09	3.97	2.73	3.09	88
Chiltex	14.2	7.0												2.37	3.58	.99	4.31	3.30	2.92	3.41	86
Dwarf White milo	10.2	7.8					.61	2.10	2.54	4.20	2.75	3.19	1.98	2.47	3.42	.97	3.95	3.87	2.67	3.13	85
Feterita	11.0	6.6	62	2.45	3.52	1.01	1.23	2.17	2.19	4.18	2.89	2.50	1.76	2.80	3.80	1.30	3.67	3.33	2.59	3.09	84
Early White milo	9.1	6.3	60	2.51	4.33	1.26	.26	2.01	2.40	3.99	2.39	2.17	1.89	2.67	3.35	1.17	3.42	4.14	2.60	3.09	84
Freed	8.0	4.9	68	2.34	3.50	1.15	.86	1.28	1.96	4.40	2.45	2.87	1.69	2.33	3.18	1.50	3.51	3.46	2.43	3.09	79
Dwarf feterita	20.4	9.7	47						1.12	4.21	2.66	2.47	1.13	2.50	3.97	1.02	2.95	2.57	2.45	3.31	74
Corn (Bloody Butcher)	18.4	14.6	62	1.11	2.62	1.18	.41	.98	2.70	4.67	2.09	3.05	1.29	1.21	3.25	1.01	3.24	3.83	2.19	3.09	71

[1] Ratio of yield of a variety to that of the check; check equals 100 percent.

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TABLE 5.—*Average length of season and annual and average grain yields of sorghum varieties and 1 variety of corn (included for comparison), 1914–28*

[Yields of each variety compared with those of a composite check derived from the average yields of 10 varieties for the same years in which the variety was grown]

Variety	Season[1]	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Average of[2]— Variety	Average of[2]— Check	Relative yields[3]
	Days	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Percent*
Western Blackhull kafir	111-A								36.7	21.7	25.1	46.3	42.3	6.2	61.3	64.8	37.7	28.7	131
Spur feterita	104						31.9	31.6	33.4	27.1	24.1	37.5	52.3	3.3	55.4	45.7	36.5	30.1	121
Pink kafir	111-B									15.3	26.1	45.1	37.0	0	46.6	70.0	34.4	28.7	120
Feterita	100	25.7	27.0	1.5	8.2	11.3	31.1	19.3	33.4	26.8	24.1	38.4	31.7	6.8	17.3	42.1	28.9	24.1	120
Chiltex	109-A											38.3	46.4	1.3	55.2	48.2	37.9	31.5	120
Early White milo	95	31.9	12.1	5.0	2.0	17.9	37.0	19.1	27.1	40.1	18.6	40.6	27.7	5.7	40.9	55.5	28.7	24.1	119
Pink kafir	114-E		17.1	0	0	.5	24.1	55.8	41.5	16.1	22.0	25.3	38.0	0	59.1	71.4	29.0	24.4	119
Dawn kafir	112-D	30.6	24.7	2.7	1.3	1.6	34.1	53.9	33.6	19.3	21.3	15.2	34.8	.9	50.7	60.9	27.8	24.1	115
Western Orange	101	37.4	48.5	5.2	13.9	7.3	28.9	51.4	28.9	22.4	27.0	38.7	34.1	1.0	38.9	44.3	27.4	24.1	114
Dwarf Yellow milo	108-A	14.2	10.9	2.0	2.4	1.3	41.3	46.7	28.1	30.2	15.6	40.2	39.3	1.6	39.5	68.8	27.5	24.1	114
Dwarf feterita	106						20.4	56.0	33.6	33.7	19.0	37.7	53.5	3.4	40.0	35.0	33.9	30.1	113
Dwarf White milo	106-A				3.9	1.3	38.2	15.8	30.3	33.1	16.6	31.1	41.2	2.6	31.6	56.6	28.8	26.1	110
Darso	113-A						32.2	24.1	20.9	20.9	20.9	41.5	54.6	5.4	46.4	65.7	32.9	30.1	109
Black Amber	96	28.8	36.2	7.4	10.8	5.5	31.7	14.1	33.4	27.1	21.8	28.9	40.1	5.0	32.9	33.1	25.8	24.1	107
Premo	112-A									12.2	47.7	38.6	40.2	1.1	50.0	18.6	29.8	28.7	104
Dwarf hegari	106-D	11.2	40.7	0		4.9	27.8	64.1	32.1	11.3	5.4	45.9	33.6	0	73.0	40.4	25.8	25.4	102
Schrock	116-C	7.5	8.5	1.8	.5	3.1	31.6	36.8	21.4	14.6	29.1	21.8	39.0	0	59.4	63.8	24.0	24.1	100
Red kafir	111-F	7.1	0	0	0	5.6	27.6	49.1	13.1	22.7	21.8	33.8	33.8	.4	53.9	60.0	24.0	24.1	100
Sunrise kafir	111-E	26.7	0	0	.6	6.8	24.1	46.6	32.3	16.8	26.8	31.6	32.7	.4	50.4	51.6	23.6	24.1	98
Leoti Red	108-A							39.4	28.0	24.1	27.7	32.2	31.7	.5	37.0	15.4	29.5	30.1	98
Freed	93	25.4	29.5	7.7	4.6	7.2	22.4	52.5	30.3	25.3	21.8	23.2	21.2	12.2	29.8	35.5	23.4	24.1	97
Standard Yellow milo	108-A	13.8	13.9				31.4	15.9	30.4	23.1	19.1	31.6	38.5	1.5	34.2	19.8	27.9	28.8	97
Early Sumac	107-B			0	.9	3.5	34.2	46.4	26.7	10.6	23.3	31.0	36.8	1.6	12.9	15.9	23.4	24.2	97
Dakota Amber×Sumac	107							17.5	26.3	18.0	19.9	31.7	31.2	.3	35.7	47.5	28.7	30.1	95
Atlas	120-B											11.9	25.4	0	42.9	53.0	26.6	31.5	84
Red Amber	100	15.4	26.8	3.0	17.5	7.1	29.6	33.2	21.4	21.2	20.5	20.3	16.3	.9	30.9	32.7	20.0	24.1	83
African "millet"	116-B								23.0	5.9	10.9	.6	27.7	0	52.7	57.9	22.4	28.7	78
Colman	110-D		8.0	0	.5	3.9		15.5	17.7	11.4	20.7	31.4					15.8	20.5	77
Blackhull kafir	116-C	9.0	12.3	0	0	1.4	21.0	18.6	35.1	12.1	17.9	4.9	34.8	0	54.0	56.2	18.6	24.1	77
Sourless	115-C						18.8	0	18.2	10.9	11.6	12.0	22.3	0	41.3	18.7	18.7	30.1	62
Kansas Orange	115-C	3.9	6.7	0	1.1	0	18.7	0	14.7	9.7	12.1	10.9	25.2	0	18.6	43.2	13.0	24.1	54
Sumac	111-B	.2	.8			0	51.4	0	7.8	4.1	9.6	3.7	20.4	0	14.1	12.9	14.7	27.0	54
Garden City Honey	119-B										7.7	.3	10.2	0	13.4	22.9	9.1	30.0	30
Corn (Bloody Butcher)	102-D	2.8	13.8	0	0	0	17.4	15.9	2.9	19.3	10.1	13.4	26.6	0	52.1	38.6	18.2	24.1	76

[1] The number of years in which the variety designated did not fully mature is indicated by an attached letter as follows: A=1 year; B=2 years; C=3 years, etc.
[2] Average of 10 varieties for the same years in which a variety was grown.
[3] Ratio of yield of a variety to that of the check; check equals 100 percent.

The yields and other agronomic data for the principal sorghum varieties grown during the period 1914–28 are presented in tables 4 and 5. In table 4 the yields of air-dry forage, including heads, are presented by years, together with the average row space per plant and stalk and the average height. In table 5 the grain yields are given by years, together with the average length of season required for maturity. In each table the average yields of each variety are compared with those of a check for the same period. The check is a composite factor derived from the average yields of 10 varieties that were grown in all of the years. These varieties were Black Amber, Red Amber, Western Orange, Kansas Orange, Schrock, Sunrise kafir, Dawn kafir, Dwarf Yellow milo, feterita, and Freed sorghum.

The practice in testing varieties was to use as representative of the variety that strain which was most productive at Hays. This practice resulted in frequent substitutions and changes in the serial numbers. Strains developed by the Division of Cereal Crops and Diseases and the Kansas Agricultural Experiment Station, and new introductions of the Division of Foreign Plant Introduction were substituted for the strains originally included in the tests whenever such new strains appeared more desirable from any standpoint.

The statistical data show many significant differences among the varieties, of which only the principal points may be discussed. In the sorgo group, where tonnage is of the greatest importance, it is noted that the tonnage is in fairly direct proportion to the length of the season required for growth, but the late-maturing varieties suffered more from drought and were often injured by frost prior to normal maturity. Earliness is obtained at the expense of tonnage. In the more favorable seasons, the later and larger varieties can be most advantageously grown for forage. Among seven varieties of approximately equal yields and length of season, there developed wide differences in usefulness, due to qualities not apparent in a statistical study. Red Amber, S.P.I. 17548, for example, was considered the most desirable sorgo for general distribution from the Hays station until its susceptibility to head smut became apparent. Meanwhile Early Sumac (fig. 9) had been developed and was first grown for general distribution in 1922. It at once became popular with the station's seed buyers, and this popularity has continued among those who desire a fairly early sorgo of medium yield and height. To satisfy a demand for a heavier-yielding forage sorgo to be grown in the bottom lands and during the more favorable seasons Kansas Orange was recommended for many years, but apparently the recently developed Sourless × kafir cross, known as Atlas, has taken the place of Orange and has been widely distributed since 1928.

Besides Early Sumac and Atlas, three other sorghums have been grown at Hays for several years for general distribution. These varieties are Dawn kafir, C.I. 904, Pink kafir, C.I. 432, and feterita, C.I. 182-1. The two kafirs, particularly the Pink kafir, have attained wide popularity in the territory surrounding Hays as dual-purpose forage and grain crops. The experimental work suggests Western Blackhull kafir as possibly superior to the Dawn kafir; also Pink kafir, F.C. 9091, as preferable to C.I. 432, in that F.C. 9091 has uniformly juicy stalks, while many stalks in C.I. 432 are pithy. Feterita, C.I. 182-1, is much improved in uniformity and

apparently in germination over the earlier feteritas grown at Hays, and has met the comparatively limited demand there for a drought-resistant grain crop. The recent trend, however, is away from this type and toward shorter-stemmed grain sorghums that are more suited to harvesting with the header or the combine.

Several other varieties have made a good statistical showing, but on account of some defect they have not been recommended. Leoti Red and Colman, apparently related to Red Amber, for example, proved too susceptible to head smut. All the Ambers, as well as Western Orange and Black Dwarf, closely related to the Ambers, are generally considered less satisfactory in forage quality and much more subject to crossing than the Sumac. The standard Blackhull kafirs are not early and drought resistant enough for

FIGURE 9.—Early Sumac sorgo, the variety which replaced Red Amber in the seed distributions of the Hays station.

Hays. The milos are all poor forage and more or less gooseneeked. While Dwarf Yellow milo has been widely grown in the Southwest and is much superior to the old standard sorts, it may be replaced in the future by erect-headed crosses. In these tests, there were included a large number of hybrids, often under freak names, such as Fargo, Husser, Duallo, Husserita, Sudan corn, Wonder kafir, and Progressive kafir, which often yielded well but showed some decided weakness, such as lodging, smut susceptibility, nonuniformity, etc. For growers who have heretofore found Freed satisfactory, Modoc, C.I. 905, a Pink kafir-Freed cross, is worth noting as a promising dual-purpose crop for the northwestern fringe of the sorghum belt.

Some of the less-important varieties that were included in the varietal tests for a few years and then discarded because of low yields or other weaknesses are discussed briefly in the following paragraphs.

Dakota Amber, F.C. 1614, grown during the period 1915–20, is a dwarf early strain of Black Amber. It is one of the best varieties in the Dakotas but cannot compete with the later varieties at Hays, making only 81 percent of the check yield of forage and 151 percent of the check in grain. Its average growing season was 87 days, and its average height was 67 inches.

Early Amber, F.C. 8572-2, under test from 1915 to 1919, is a tall, slender strain of Black Amber, having an average height of 79 inches and an average growing season of 88 days. Its relative forage and grain yields were, respectively, 114 percent and 96 percent of the check. It was considered less valuable than no. 7038 because it was not so leafy.

Black Dwarf, F.C. 7085, a short, heavy-stemmed strain with black glumes, was under test from 1914 to 1918. Average height, 61 inches; average growing season, 100 days. Forage yield, 115 percent; grain yield, 108 percent of check.

Coles Evergreen, F.C. 01979, a rather dwarf black-glumed variety, tested at Hays, 1914–18. Average height, 70 inches; average growing season, 102 days. Forage yield, 136 percent; grain yield, 35 percent of check.

Red X, F.C. (commercial) 7179, an important sirup variety in western Arkansas, but not so valuable for forage. Average height, 73 inches; midseason; under test only 3 years, 1915–17. Forage yield, 133 percent; grain yield, 9 percent of check.

McLean, F.P.I. 34985, a tall, rather late, black-glumed variety not adapted to Hays. Under test, 1915–18. Average height, 73 inches; growing season, 104 days, not always maturing. Forage yield, 131 percent; grain yield, 31 percent of check.

Collier, F.C. 1461, a tall, late, black-glumed variety with a small panicle having a short rachis. Under test at Hays, 1915–18. Average height, 75 inches; growing season long, did not mature regularly. Forage yield, 120 percent; grain yield, 11 percent of check.

Dwarf Ashburn, F.C. 8011, a dwarf heavy-stemmed variety with seeds like Sumac, but larger. Under test at Hays, 1918–21. Average height, 50 inches; growing season, 109 days. Forage yield, 88 percent; grain yield, 73 percent of check.

Dawn kafir, C.I. 904, a selection made by A. F. Swanson, of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, has been under test at Hays since 1925. It is about 5 inches taller than C.I. 340 reported in the table and matures in practically the same time. The average forage yield, 1925–28, was 97 percent; average grain yield, 121 percent of the check. This selection was substituted for C.I. 340 on account of superior grain yields.

Dwarf Blackhull kafir, C.I. 330, tested from 1911 to 1918, was found inferior to both of the Dawn selections.

Blackhull kafir, C.I. 204, and Texas Blackhull kafir, C.I. 865, were both tested and proved inferior to Western Blackhull, F.C. 9098.

Reed kafir, C.I. 628, while producing good yields of both forage and grain, was too late and too subject to lodging to be recommended.

Several selections of Pink kafir were made and grown in the variety test for 6 or 7 years, but only F.C. 9091 proved equal to the regular station strain, C.I. 432.

Several hybrids produced by H. Willis Smith were included in the variety test for short periods.[6]

DATE-OF-SEEDING TESTS

Five varieties of sorghum were seeded in duplicate 1/20-acre plots in 40-inch rows at 15-day intervals from May 1 to July 1 during the period 1914–18. The experiment was then discontinued for several years and resumed in 1924 on a different basis. From 1924 to 1928 the entire variety test of about 50 lots was replicated regularly on the three intermediate dates in single 1/20-acre plots. A supplementary

[6] Mr. Smith, former plant breeder, formerly located near Garden City and Kismet, Kans., produced and named the following hybrids. The records of their performance may be found in unpublished reports on file in the Division of Forage Crops and Diseases: Dualio, F.C. 8528, reports for 1911–16; Progressive kafir, F.C. 02249, reports for 1916–19; Husser, F.C. 03108, reports for 1919–28; Husserita, F.C. 9085, reports for 1920–22; Sudan corn, F.C. 03127, reports for 1920–22. The parentage of these hybrids was not always clear in the mind of the originator, but Husserita, a supposed cross between Blackhull kafir and some sorgo, was perhaps the best of the group. It made heavy yields of forage and good grain yields, but was subject to lodging, and the grain did not thresh free from the chaffs.

TABLE 6.—*Results from date of seeding tests with five varieties of sorghum, 1914–18 and 1924–28, inclusive*

Variety and dates of seeding	Forage yields per acre 1914	1915	1916	1917	1918	1924	1925	1926	1927	1928	Average for 5 years (1914–18)	Average for 10 years (1914–18, 1924–28)	Grain yields per acre 1914	1915	1916	1917	1918	1924	1925	1926	1927	1928	Average for 5 years (1914–18)	Average for 10 years (1914–18, 1924–28)	Average height 5 years (1914–18)	10 years (1914–18, 1924–28)	Average time from seeding to maturity 5 years (1914–18)	10 years (1914–18, 1924–28)
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*In.*	*In.*	*Days*	*Days*
Black Amber:																												
May 1	2.31	4.07	2.21	1.62	2.20						2.48		27.2	40.9	15.4	9.6	7.1			--			20.0		67		114	
May 15	2.51	3.59	1.83	1.76	2.65	2.63	4.26	1.19	4.16	4.11	2.47	2.87	28.8	35.1	7.0	9.8	3.6	32.7	39.5	1.0	28.9	33.2	16.9	22.0	65	70	107	106
June 1	2.33	4.22	1.86	1.65	2.78	2.03	4.77	1.32	4.44	4.25	2.57	2.97	26.3	37.6	6.8	11.8	7.3	27.2	36.0	7.4	41.3	35.4	18.0	23.7	67	73	95	97
June 15	2.45	4.73	2.35	1.81	2.47	2.84	3.39	1.94	4.08	4.40	2.76	3.05	31.9	40.8	12.5	10.9	9.5	26.9	14.8	8.4	28.4	31.6	21.1	21.6	71	77	90	91
July 1	2.46	4.41	1.89	2.05	2.29	2.45	2.37	1.70	2.75	2.93	2.63	2.53	30.0	32.1	7.7	15.7	0	19.3	4.0	1.8	20.1	31.9	17.1	16.3	68	72	88	88
Red Amber:																												
May 1	2.87	4.76	1.12	2.00	2.24						2.60		11.7	29.6	0	10.9	4.3						11.3		70		121	
May 15	2.93	4.32	1.26	1.86	1.91	2.82	3.77	1.17	4.43	4.50	2.46	2.90	15.4	20.5	0	10.2	0	20.6	16.6	0	25.7	33.2	9.2	14.2	65	70	111	110
June 1	3.81	4.82	1.81	2.34	2.07	2.46	4.17	1.48	5.07	4.31	2.97	3.23	19.3	16.6	0	11.1	0	18.6	21.5	1.4	35.4	37.0	9.4	16.1	66	72	101	102
June 15	3.48	5.50	1.86	2.60	1.73	3.36	3.18	2.01	3.90	4.44	3.03	3.21	15.9	25.8	0	10.5	3.6	21.7	10.7	1.5	31.6	27.9	11.2	14.9	68	73	95	96
July 1	3.64	4.51	1.70	2.87	1.95	3.30	2.97	2.31	3.00	2.82	2.91	2.91	23.9	9.5	0	5.2	0	16.1	2.8	0	23.0	21.5	7.7	10.2	65	69	95	92
Freed:																												
May 1	2.30	3.06	1.14	.99	.45						1.59		28.5	27.3	12.4	6.3	4.1						15.7		69		115	
May 15	2.34	2.95	1.01	1.35	1.42	2.48	3.54	1.73	3.36	3.06	1.81	2.32	25.4	23.1	9.6	5.2	15.2	26.5	19.3	12.0	23.6	30.0	15.7	19.0	67	64	106	104
June 1	2.22	3.43	1.21	1.44	1.57	2.48	3.05	1.23	3.99	3.20	1.97	2.39	26.5	22.3	11.6	7.3	13.9	21.8	19.8	10.0	31.6	35.9	16.3	20.1	68	66	91	95
June 15	2.46	3.83	1.54	.93	1.80	2.03	2.91	1.53	3.27	4.15	2.11	2.44	31.5	26.4	14.5	7.0	10.7	21.2	27.6	14.6	34.3	40.7	18.0	22.9	67	68	88	89
July 1	2.43	3.39	1.37	1.15	1.92	2.15	2.61	1.51	2.85	1.52	2.05	2.09	27.1	20.9	14.3	6.1	9.8	27.9	18.2	13.7	26.5	14.3	15.8	17.9	66	66	83	86
Feterita:																												
May 1	1.75	3.94	1.36	1.30	.70						1.81		16.8	29.6	9.8	8.6	6.3						14.2		60		119	
May 15	2.24	3.21	1.03	1.66	1.55	2.57	3.53	1.33	3.09	3.18	1.94	2.31	18.3	32.5	7.3	12.7	8.8	39.3	38.8	7.3	44.5	30.6	15.9	24.9	56	57	110	110
June 1	3.18	4.26	1.15	1.27	1.70	2.93	3.44	1.19	4.94	3.35	2.31	2.74	28.1	42.6	3.6	10.4	6.8	33.8	51.3	3.0	56.8	45.5	18.3	28.2	54	57	101	102
June 15	2.44	2.48	.87	1.60	1.79	2.90	4.44	1.37	2.97	3.45	1.84	2.43	19.1	19.7	5.9	11.8	8.9	41.3	64.9	10.2	40.7	41.3	13.1	26.4	54	58	94	95
July 1	2.86	2.78	.98	1.52	1.77	2.03	2.55	1.14	3.02	2.46	1.98	2.08	21.3	12.9	3.9	5.0	0	35.4	26.2	14.8	33.2	36.9	8.6	20.0	53	59	97	94
Dawn kafir:																												
May 1	3.08	4.35	.90	2.14	.22						2.14		7.2	20.1	4.3	1.8	3.0						9.1		50		120	
May 15	3.55	5.09	1.02	2.44	.76	2.37	3.54	1.06	4.62	4.74	2.57	2.92	9.0	62.9	3.2	1.8	5.9	36.1	39.8	0	49.2	67.0	16.6	27.5	50	50	120	120
June 1	3.29	6.10	.99	2.39	1.62	3.84	3.24	1.30	3.78	4.26	2.88	3.08	7.4	65.1	1.3	0	10.2	47.9	38.1	0	44.5	57.3	16.8	27.2	49	51	111	112
June 15	3.55	4.46	1.29	2.43	1.70	3.05	3.15	1.70	5.16	4.17	2.69	3.07	19.3	42.7	0	0	8.4	51.6	26.4	2.7	58.4	58.4	14.1	26.8	48	52	108	108
July 1	2.38	4.41	1.69	2.78	1.77	3.28	2.73	1.70	4.35	2.33	2.61	2.74	0	9.6	0	0	0	0	3.2	.9	42.4	28.2	1.9	8.4	46	50	95	96

test of numerous varieties was also conducted in single 2-row plots of smaller area seeded on July 1, 1923–28. The results thus available for 10 years with five of the varieties are presented in table 6.

Land for the entire experiment was always prepared in advance of the first seeding. The later the seeding, therefore, the greater the preliminary opportunity to kill weeds, conserve moisture, and secure ideal tilth. The experiments were conducted with the idea of getting the maximum possible results from each date. It seems that the yields thus obtained for different dates were more nearly equal and those from the extreme dates more satisfactory than they would have been if seed-bed preparation had been in accord with the usual farm practice of listing at seeding time, or perhaps disking a few days ahead of the lister. All the plots were handled on a weed-free basis by hoeing out such weeds as machinery could not reach. Much hand weeding was required with the May 1 seedings, considerable in the May 15 plots, a little for June 1 and 15, and a minimum amount in the July 1 seeding. The number of cultivations after seeding usually varied from 3 to 4 for the earliest dates down to 2 for June 15 and 1 for July 1. In about half the seasons the June 15 plots would have done very well with 1 cultivation and the July 1 plots with none at all.

Fairly good stands were usually obtained, regardless of the date or the variety, because enough choice seed was put on to allow for probable losses. When a stand was too thick, the plots were thinned to 6 or 8 inches row space per plant when a few inches tall. May seedings required an average of 14 days to come up, June seedings 7 days, and July 1 seedings only 5 days. Cold wet spells of 10 days or more were often encountered up to as late as June 20, and, in some cases, a period in May was therefore more favorable than in June for establishing sorghums.

A sharp decline in the number of days from seeding to maturity is noted as the date of seeding becomes later, but the average heights of the plants fluctuate but little.

It was concluded that sorghums could be seeded satisfactorily over a wide range of time, especially for forage production, but that for practical purposes seeding should usually be completed within the period of May 15 to June 15. For grain, the standard varieties should usually be seeded within the first half of this period, but early sorts, such as feterita and Freed, often give the best results from June 15 seeding. The possibilities shown for July 1 seeding are of great interest from the catch-crop standpoint, where an earlier seeding has failed and the land is in good condition. Freed, when seeded July 1, matured every year over an 11-year period.

Data obtained on date of seeding during 1924–28, by replicating the sorghum variety tests at 15-day intervals from May 15 to July 1, are presented in table 7. As each year's work included but a single replication of the varieties on each date, the data are presented by 5-year averages rather than by individual years. The July 1 seedings were supplementary to the main experiment and did not include the entire list of varieties. This table permits a broad comparison of results among variety groups of different seasonal length, but the general conclusions reached are similar to those already discussed in the 10-year test of five varieties.

TABLE 7.—*Average yields from different dates of seeding of sorghum varieties and one variety of corn (included for comparison), 1924–28*

Varieties, with serial numbers, grouped according to length of season	Season, average of first three dates	Average yields of forage and grain per acre from seeding of							
		May 15		June 1		June 15		July 1	
		Forage	Grain	Forage	Grain	Forage	Grain	Forage	Grain
	Days	*Tons*	*Bu.*	*Tons*	*Bu.*	*Tons*	*Bu.*	*Tons*	*Bu.*
Group 1.—season 96 to 105 days:									
Black Amber, F.C. 7038	99	3.27	27.0	3.36	29.3	3.23	21.8	2.41	15.1
Red Amber, S.P.I. 17518	102	3.31	19.2	3.50	22.8	3.38	18.6	2.88	12.7
Early Sumac, F.C. 6611	105	3.50	29.1	3.48	32.2	3.71	33.6	3.01	13.1
Early White milo, F.C. 5886	90	3.21	32.1	2.95	35.7	2.67	31.1	2.16	27.8
Feterita, C.I. 1824	103	2.74	33.9	3.17	38.1	3.03	30.7	2.19	31.3
Freed, F.C. 9033	96	2.83	22.3	2.80	23.8	2.77	27.1	2.13	20.4
Average	101	3.15	27.3	3.21	30.3	3.15	26.2	2.52	20.1
Yield ratios (May 15 = 100 percent		100	100	102	111	100	107	80	74
Group 2.—season 106 to 110 days:									
Leoti Red, F.C. 6610	109	3.02	31.5	4.01	29.1	3.91	27.1	2.91	8.6
Western Orange, F.C. 9073	106	3.53	31.0	3.53	32.2	3.83	30.9	3.23	12.3
Dakota Amber×Sumac, F.C. 8571	108	3.81	31.2	3.71	27.1	4.01	20.5		
Early Pink kafir, F.C. 9089	110	2.85	37.1	3.01	37.6	2.72	32.9	2.22	20.6
Dwarf Yellow milo, C.I. 332	109	3.29	38.1	3.32	42.6	2.77	33.0	2.22	12.7
Standard Yellow milo, C.I. 234	110	3.37	42.9	3.11	31.7	3.00	28.2		
Dwarf White milo, F.C. 8927	109	3.02	35.3	2.68	33.1	3.10	31.2	2.05	13.6
Spur feterita, F.C. 6631	108	4.01	34.3	3.59	12.5	3.32	30.6	2.61	26.0
Dwarf feterita, F.C. 9076	109	2.62	31.2	2.51	35.1	2.61	35.7	1.81	21.2
Red Amber×feterita, F.C. 9121	110	3.81	30.8	3.50	27.3	3.81	26.1		
Chiltex, F.C. 8917	109	2.65	33.2	2.98	38.5	3.10	11.9		
Average	109	3.27	33.6	3.27	31.4	3.29	32.1	2.41	16.1
Yield ratios (May 15 = 100 percent		100	100	100	102	101	96	77	48
Group 3.—season 111 to 115 days:									
Pink kafir, C.I. 432	115	3.41	46.6	3.51	49.9	3.55	40.6	3.16	21.7
Red kafir, C.I. 6608	114	2.82	37.0	2.90	35.7	3.08	36.5		
Dawn kafir, C.I. 340	111	3.27	48.1	3.28	37.6	3.45	39.5	2.88	14.9
Sunrise kafir, C.I. 472	115	3.67	35.0	3.17	39.8	3.68	37.8		
Western Blackhull kafir, F.C. 9098	114	3.50	44.0	3.53	43.1	3.42	44.6	2.75	12.6
Dwarf hegari, F.C. 9078	113	3.18	46.8	2.86	25.3	3.78	32.6		
Premo, F.C. 8929	113	3.31	38.3	3.35	39.7	3.36	29.2		
Weskan, F.C. 9126	112	2.76	48.9	2.95	48.3	3.30	15.2		
Darso, F.C. 6936	111	3.22	43.3	3.19	42.8	3.65	11.9	2.68	10.4
Average	114	3.24	38.7	3.19	37.4	3.51	38.3	2.88	14.2
Yield ratios (May 15 = 100 percent		100	100	98	97	108	99	89	37
Group 4.—season 116 to 120 days:									
Kansas Orange, F.C. 9108	118	1.37	34.3	1.01	23.2	1.24	19.2	3.15	0
Sourless, F.C. 9071	117	1.25	31.5	3.91	26.0	1.25	18.9	3.65	0
Blackhull kafir×Sourless, F.C. 9112 (Atlas 1928)	120	1.36	32.8	1.05	21.2	1.26	22.7		
African millet, F.C. 9111	119	1.11	31.1	1.09	20.2	1.29	23.1		
Garden City honey, F.C. 9105	119	1.25	10.2	3.92	9.7	3.96	8.2		
Sumac (standard), F.C. 9130 et al	117	1.06	28.1	1.32	25.1	1.33	18.8	3.53	0.8
Pink kafir, F.C. 9091	117	3.55	43.7	3.52	40.2	3.28	35.9		
Reed kafir, C.I. 628	116	3.10	36.1	3.62	38.6	3.71	33.7		
Blackhull kafir, C.I. 204	116	3.17	38.1	3.54	39.6	3.83	38.8		
Blackhull kafir (standard), F.C. 9119	120	3.59	33.2	3.61	28.1	3.81	27.8	2.73	0
Schrock, F.C. 1881	119	3.65	43.8	3.65	41.8	4.13	32.1	3.16	10.2
Average	118	3.01	33.0	3.85	29.6	1.01	25.1	3.36	3.1
Yield ratios (May 15 = 100 percent		100	100	98	90	103	77	84	10
Corn (Bloody Butcher)	109	2.31	20.2	2.52	31.5	2.73	28.8		

TABLE 8.—*Results of spacing experiments with feterita and Red Amber sorghum, 1914–18*

[Rows 40 inches apart except as indicated]

Variety and spacing between plants	Average row space per stalk	Average height of plants	Forage yields per acre						Grain yields per acre					
			1914	1915	1916	1917	1918	Average	1914	1915	1916	1917	1918	Average
	Inches	*Inches*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Red Amber:														
2 inches	1.9	66	3.69	4.98	1.44	2.89	2.77	3.15	9.9	27.1	0.6	10.7	2.7	10.2
4 inches	3.1	66	3.41	4.41	1.07	2.23	2.75	2.77	15.1	29.4	.9	6.4	4.2	11.2
6 inches	3.6	67	3.57	4.40	1.09	2.26	2.74	2.79	18.3	29.2	1.2	8.4	3.4	11.9
8 inches	4.2	68	3.66	3.78	1.08	1.89	2.62	2.61	20.2	21.3	1.8	8.0	4.0	12.3
12 inches	4.7	70	3.16	3.68	1.11	1.78	2.66	2.54	22.1	26.3	2.0	8.2	7.6	13.2
Feterita:														
4 inches [1]				2.18	1.36	1.72	1.98	1.76		22.1	11.4	11.4	16.5	15.4
Do	3.1	60	3.11	3.59	1.58	2.17	2.51	2.59	21.6	31.9	5.0	17.5	12.1	18.8
8 inches	4.3	60	3.16	3.28	1.43	1.82	2.45	2.43	28.9	33.9	10.5	13.2	19.2	21.1
12 inches	4.9	58	3.09	2.98	1.09	1.95	2.53	2.33	30.6	25.9	6.4	15.0	16.8	18.9
16 inches	5.9	58	2.95	2.81	.92	1.71	2.15	2.17	26.3	22.1	5.4	15.0	18.2	17.8
24 inches	7.2	57	2.25	2.50	.91	1.37	2.18	1.86	21.5	18.4	6.1	10.4	13.9	14.1

[1] Rows 80 inches apart.

SPACING EXPERIMENTS IN CULTIVATED ROWS

Spacing experiments in cultivated rows were conducted with Red Amber, S.P.I. 17548, and with common feterita during the period 1914–18. Further experiments on a different basis were begun with Pink kafir, C.I. 432, and continued from 1919 to 1928, inclusive. Actual spacings were almost always identical or very close to those outlined throughout both series of tests. To secure such stands, all plots were seeded relatively thick and were thinned by hand when the plants were a few inches tall.

Data for the experiments from 1914 to 1918 are assembled in table 8. They show that forage yields increased regularly with the thickness of the stands. The average yields and the quality of Red Amber sorgo seed were both best with the thinner spacings, though not varying much within the limits of 4 to 12 inches of row space. Feterita grain yields were largest at 8 inches of row space in the 40-inch rows.

The results with Pink kafir spacing tests (fig. 10) are given in table 9. Alternate 40- and 80-inch rows were a new feature here, involving a

FIGURE 10.—Spacing test with Pink kafir. In the foreground alternate 40- and 80-inch spaces with plants 16 inches apart in the rows are shown.

wide space on one side of each row and the regular interval on the other. The four respective rates of spacing in these rows and in the regular 80-inch rows provided for the same number of plants per acre as in the 40-inch rows. The results were unusually consistent throughout this experiment, but in interpreting them consideration must be given to the fact that the data, except in 1926, were obtained under a favorable series of soil and seasonal conditions. Regular 40-inch rows led in forage yields by about 10 percent over the alternate 40- and 80-inch rows and by about 20 percent over the 80-inch rows. The spread in seed yields among the three methods was much narrower but in the same order. In each of the three methods the yields of both forage and grain were in direct ratio to the closeness of spacing within the row.

TABLE 9.—*Results of spacing experiments with Pink kafir, 1919–28, inclusive*

Row and plant spacings	Average row space per stalk	Average height of plants	Forage yields per acre											Grain yields per acre										
			1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Average	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Average
	In.	*In.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
40-inch rows:																								
6 inches	5.7	59	3.27	4.13	4.36	3.19	2.73	2.83	3.44	1.06	4.93	4.46	3.44	39.3	49.6	58.1	31.8	27.7	30.3	33.6	0	62.1	67.1	40.3
12 inches	8.4	57	2.95	3.56	3.97	2.58	2.27	3.18	3.02	1.11	4.73	3.63	3.10	45.7	32.9	52.9	29.9	29.8	33.9	35.9	0	52.1	53.8	36.7
18 inches	11.2	55	2.63	3.52	3.40	2.08	1.91	3.25	3.86	1.39	3.67	2.86	2.86	35.7	31.8	41.9	21.2	28.1	29.6	47.5	0	40.4	41.6	31.8
24 inches	13.9	55	2.50	2.98	3.13	2.19	1.78	3.08	2.76	1.20	3.44	2.40	2.53	29.1	33.2	43.5	26.0	26.3	30.5	36.4	0	36.8	34.8	29.7
Alternate 40- and 80-inch rows:																								
4 inches	4.1	61	2.68	3.80	4.13	2.88	2.44	2.60	2.69	1.10	4.19	3.89	3.01	40.8	50.4	56.3	33.7	30.8	31.3	26.9	0	55.2	59.6	38.5
8 inches	6.3	60	2.68	2.88	3.49	2.41	2.15	2.77	2.85	1.16	3.82	3.35	2.75	44.8	33.9	49.2	33.0	30.7	35.6	36.6	0	48.6	48.6	36.1
12 inches	8.0	58	2.48	3.27	3.28	1.95	1.81	2.73	2.84	1.31	3.10	2.65	2.51	37.0	32.3	45.8	25.9	28.4	32.6	37.6	0	38.9	38.0	31.7
16 inches	10.1	57	2.12	2.71	3.10	1.85	1.52	2.56	2.32	1.33	2.62	2.13	2.23	30.4	31.6	44.2	25.9	24.0	30.5	31.5	0	32.0	32.0	28.2
80-inch rows:																								
3 inches	3.3	63	2.47	3.49	3.03	2.58	2.13	2.28	2.65	1.35	3.89	3.22	2.80	38.9	46.1	53.5	31.9	26.1	29.9	39.0	0	52.1	47.3	36.5
6 inches	5.3	62	2.26	2.84	3.21	2.26	1.92	2.22	2.31	1.21	3.36	2.99	2.46	36.8	34.6	46.3	31.8	30.4	33.5	29.6	0	41.3	41.8	32.6
9 inches	6.8	60	2.13	2.96	3.10	1.94	1.45	2.27	2.91	1.32	2.67	2.26	2.30	32.7	32.3	46.0	26.6	24.2	31.1	38.6	0	33.4	32.9	29.8
12 inches	8.7	59	1.85	2.39	3.00	1.73	1.20	2.41	1.99	1.21	2.59	2.04	2.01	28.0	30.2	45.3	24.7	18.9	31.4	25.1	0	29.5	31.8	26.5

RATE OF SEEDING FOR HAY PRODUCTION IN CLOSE DRILLS

Tests of five rates of seeding Red Amber sorgo, S.P.I. 17548, in close drills, were conducted from 1914 to 1918. The yields obtained (table 10) were surprisingly uniform among the different rates, but differences in quality were more noticeable. The 15-pound seedings usually produced the tallest and coarsest plants and were least affected by drought. At the other extreme, the 60-pound and 75-pound seedings were finest stemmed and shortest but were too much inclined to dry up prematurely. When the quality of the hay was considered, as well as the yields, rates of 30 and 45 pounds were the most desirable in this experiment, which encountered droughty conditions in 4 of the 5 seasons (fig. 11).

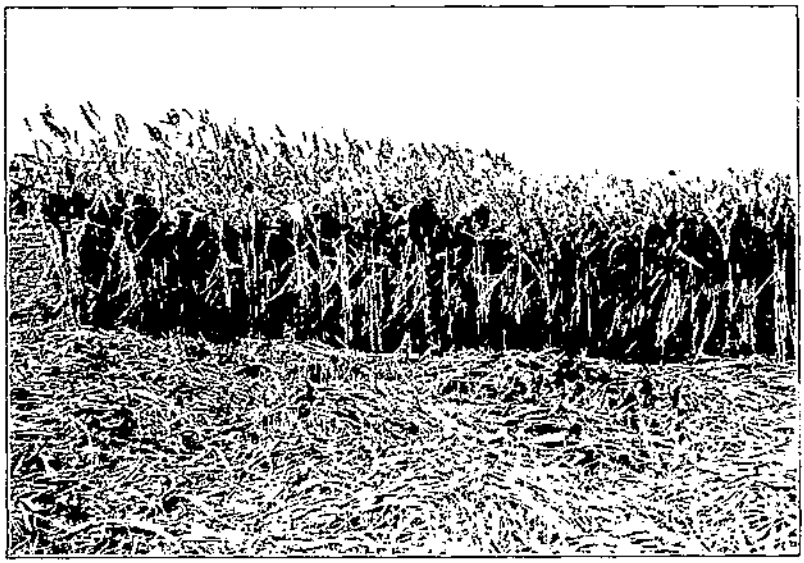

FIGURE 11.—Sorgo sown with a wheat drill at the rate of 45 pounds per acre, producing abundant hay crops

TABLE 10.—*Hay yields of Red Amber sorgo seeded at different rates in close drills 1914–18*

Rate seeded per acre (pounds)	Row width	Yields of hay per acre					
		1914	1915	1926	1917	1918	Average
	Inches	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
15	16	1.21	6.81	1.79	2.09	3.25	3.82
30	8	3.98	6.91	1.83	2.07	3.16	3.71
45	8	3.71	7.16	1.81	2.05	2.52	3.58
60	8	3.62	7.13	1.82	3.10	2.53	3.64
75	8	3.75	7.17	1.61	2.59	3.17	3.66

VARIETY TESTS IN CLOSE DRILLS FOR HAY PRODUCTION

A few leading sorghums were compared in close drills for hay production during four or more years of the period 1922–28. Red Amber had already been grown in close drills since 1914, and 15 years' data on this variety are available which are presented in detail on page 48 in comparison with Sudan grass and millet.

The normal date of seeding was early in June, but two replications were often made about 2 weeks apart. The rate of seeding varied slightly with the season and the variety, but was usually from 2 to 3 pecks to the acre.

The yields for this experiment are presented in table 11. The relative yields in the last column of this table are considered a fair index of the capacity of the varieties. Kansas Orange led by a good margin, and Freed was definitely lower than the others. It is probable, however, that other factors, such as foliage, juiciness, earliness, height, coarseness, and lodging, are more important than the yield differences here shown.

FIGURE 12.—Early Sumac sorgo hay in stack. The Hays station has found that seeding sorgo in close drills is the best method of insuring an adequate supply of forage for the winter months.

TABLE 11.—*Yields of sorghum varieties seeded in close drills for hay production, 1922–28*

Variety and serial no.	Forage yield per acre							Average of 7 years	
	1922	1924	1925	1926	1927	1928		Yield	Relative
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Percent*
Red Amber, S. P. I. 17518	3.71	2.32	2.65	1.42	1.21	3.62	1.68	3.35	100
Leoti Red, P. C. 6610		2.29	3.10	1.91	1.39	1.58		3.33	100
Early Sumac, P. C. 6621		2.18	2.96	1.79	1.47	1.79	1.62	3.52	106
Pink kafir, P. C. 432				1.52	1.29	1.88	1.37	3.72	99
Kansas Orange, P. C. 9018			1.31	5.29	1.81	5.05		3.37	125
Freed, P. C. 9043	2.78	2.0	2.15	2.85	1.15	3.96	1.01	2.68	80

[1] The average yield of Red Amber for the same period of years covered by any other variety is used as 100 percent.

The medium-early sorgos, Early Sumac, Red Amber, and Leoti Red, appear best suited for close-drilled hay production under normal conditions. Early Sumac is perhaps the most favored for this purpose. The Hays station has grown Early Sumac hay extensively in recent years (fig. 12) and has found it particularly valuable in the

wintering of beef cattle. The hay is fine and leafy, very palatable, and is consumed with a minimum of waste, even when carried over in stacks until the second winter. Pink kafir is rather coarse for hay if seeded thinly enough to permit a normal development, but it carries heavy foliage and gives good results in wintering cattle. Kansas Orange is inclined to become coarse and to lodge in a wet season and is relatively low in drought resistance. Freed is suited for very late seeding, for the shorter season of extreme northwestern Kansas, for relatively adverse conditions, and where grain is desired with the hay.

VARIETY TESTS IN CLOSE DRILLS FOR GRAIN PRODUCTION

The possibility of producing sorghum grain economically from fine-stemmed plants and handling the crop with small-grain equipment appealed particularly to the late C. V. Piper, formerly in charge of the Division of Forage Crops and Diseases. He felt that special sorghums might be bred for this purpose, possibly by crossing Sudan grass with a grain sorghum. A hybrid, F.C. 03194, between Sudan grass and Freed, was sent to Hays and grown in 8-inch and in 16-inch drills in comparison with regular Freed in 1922 and 1923. Yields of this hybrid were disappointing, however, and the later experiments were continued mainly with Freed, Dwarf Freed, and feterita. These varieties were chosen because it was at once evident that maximum drought resistance, a quality associated usually with earliness, would be required if the sorghum were to head and fill well under close-drilled conditions.

TABLE 12.—*Yields of sorghums seeded in close drills for grain production, 1922–28*

Variety and serial no.	Row width	Rate sown	Grain yield per acre							Average of	
			1922	1923	1924	1925	1926	1927	1928	Variety	Relative yield
	In.	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Pct.*
Freed (Std. in 40-in. rows)	8	30	24.0	30.0						12.0	67
F.C. 03191	16	7	18.8	17.9						18.4	96
Freed, F.C. 9033	8	12			11.9	15.7				13.8	67
	8	28	17.7	11.7	20.5	18.9	9.7	15.7	10.3	16.5	81
	8	14			23.8	22.9				23.4	97
	8	7			24.3	23.7				24.0	96
	16	14	19.1	27.0	23.7	18.6	.9	30.9	8.2	19.8	130
	16	7	27.3	24.8	30.3	30.4	12.2	29.8	25.5[1]	26.8	118
	8	28				25.6	1	11.0	13.1[2]	20.4	133
Dwarf Freed, C.I. 971	16	14					1	31.6	30.3[2]	18.1	131
	16	7				31.7	12.1	33.7	12.4[2]	30.1	197
Feterita[3]	8	20				30.9	2.6	33.2	25.6	22.6	118
	16	10					2.1	32.4	18.7	17.8	126
	16	4	26.8	24.1	18.7	31.7	6.8	17.3	12.1	33.9	188

[1] The average of yields for Freed, F.C. 9033, in the same years in 8-inch drills at 28 pounds and in 16-inch rows at 7 or 14 pounds of seed per acre is taken as 100.

[2] 7 pounds in 1928 and 1925.

[3] S.P.I. 54478 in the 8-inch and 16-inch tests for 1925–27, an early slender type with small heads; S.P.I. 22320 in 40-inch row tests, 1922–24, C.I. 182.1 in 16-inch rows, 1926–27, and in all row widths, 1928.

The results of these experiments from 1922 to 1928, inclusive, are shown in table 12. The yields of the same varieties in 40-inch rows in the regular variety test are also shown as a check on the merits of the close drills. The yields of Freed in 40-inch rows in 1924 and 1925 were from special plots directly comparable with the close drills. The last column of table 12 is only a fair index rather than an exact

one of the possibilities of each variety and method. It is clear, however, that the 40-inch rows were definitely superior, and it seems that if close-drilled sorghums are to be grown economically for grain production, suitable varieties are yet to be developed. Such a variety must be early and resistant to lodging and drought.

NURSERY EXPERIMENTS

Sorghum nursery experiments were conducted throughout the entire period 1913–28, with a view to the improvement of the crop. The sorghums were usually grown in single rows from 4 to 8 rods long. Promising lots were advanced to yield tests in larger plots. Three general methods were employed in obtaining material: (1) Introduction of material obtained from foreign countries, principally by the Division of Foreign Plant Introduction, or from outside sources in this country, such as plant breeders, seedsmen, and farmers; (2) selection of seed chosen from apparently superior individual plants observed on the station or elsewhere; (3) by crossing, usually with a definite plan for combining the superior qualities of two or more varieties.

The three methods outlined have been followed largely in the order stated. These sorghums were then sent to stations of the Division of Forage Crops and Diseases for testing, the Hays project receiving mainly those of known or supposed early maturing tendencies. While this method earlier contributed some valuable plants, such as feterita in 1906 and Sudan grass in 1909, it did not develop any new crops of outstanding value from the work at Hays. By the time the Hays project was established, the possibilities appeared greater for the improvement of sorghums by selection among the many varieties already on hand. As long as a good deal of variation exists in a variety the selection method including head-to-row planting is effective in isolating the best types. When a variety is practically uniform, selection usually fails to yield much improvement. The outstanding contribution from the selection method on this project was Early Sumac sorgo, which has been widely distributed since 1922 by the pure-seed department of the Hays station. Many lots grown in the varietal experiments have been improved by the mass selection of heads used to continue the tests.

Since sorghums cross freely among themselves and usually show a marked increase of vigor in the F_1 generation, natural hybrids, either of known or unknown parentage, are constantly tempting sorghum growers and amateur breeders. As such hybrids ordinarily break up into a wide range of inferior forms, very little investigation of such types was undertaken at Hays except to determine the value of strains developed or promoted by other agencies. In the more recent years it was concluded that the most effective method of improvement in sorghums is by controlled crosses to combine certain definite qualities, and a start was made by the writer on several projects of this kind.

The work conducted by the various methods will be presented in detail in separate discussions of the different varieties or varietal groups studied.

SUMAC SORGO GROUP

The standard Sumac sorgo, widely grown throughout the southern Great Plains and the favorite forage sorghum in that section, is too large and too late a variety to mature regularly at Hays, Kans.

Sumac is preferred in the southern part of the sorghum belt not only because of its excellent forage quality and high yields but also because of the uniformity and attractiveness of the seed crop. Its compact heads show much less deterioration from natural crossing with other sorghums than do the loose-panicled varieties such as the Ambers. Black Amber has been widely grown in western Kansas, and Red Amber, considered superior to the Black, was the leading sorgo distributed from the Hays station during the early years of these experiments. Many growers, however, were not satisfied with the forage quality of either of the Amber sorgos and insisted on trying later-maturing and leafier varieties. Other growers were developing local strains of Sumac by continued selection for earlier maturity. The writer began collecting such strains in 1916 and obtained two lots: One was direct from the late H. W. Joy, a farmer living 10 miles northeast of Hays, to which F.C. 02552 was assigned, this number being superseded in 1924 by F.C. 6611. The other strain was obtained from shocks in a field near Hays and was assigned F.C. 02551. Both were placed in the sorghum variety test. The two lots were so similar that F.C. 02551 was soon discarded. In the fall of 1918, 38 head selections were made from the plots of F.C. 02552. These were included in duplicate head-to-row tests in 1919 along with 10 lots from other sources. The 38 were very uniform and the 15 lots showing heaviest forage yields were retained. These 15 were grown in duplicate $\frac{1}{50}$-acre plots in 1920 and were so uniform that no further selection appeared worth while. All were threshed together and furnished the foundation stock for the station's first general distribution of Early Sumac in the spring of 1922.

Early Sumac, F.C. 6611 (fig. 9), soon took the place of Red Amber in the station's pure-seed program and has been found particularly well adapted to the north and west of Hays. With the gain of two weeks or more in earliness, however, there was a corresponding loss in tonnage as compared with standard Sumac. F.C. 6611 did not make full use of the seasons of favorable moisture and late fall frosts at Hays and southward. Some growers in eastern Kansas commended F.C. 6611 for being adapted to the thinner soils; also, as it did not grow so large, it was less difficult to handle than the later varieties.

A Sumac sorgo of heavier foliage and tonnage, maturing not more than 5 days later than F.C. 6611, would be welcomed in many parts of Kansas and would probably supersede F.C. 6611 except in the northwestern section. Numerous commercial lots were tested within the period 1918–28, with a view to finding something midway between standard Sumac and F.C. 6611 from which a suitable strain could be developed. A study of types resulting from a cross of Orange and Sumac, F.C. 6617, was also made. None of the foregoing efforts produced a superior strain of the desired type. Meanwhile, beginning in 1923, a white-seeded Sumac, F.C. 9100, developed by I. N. Farr, of Stockton, Kans., was under investigation. This variety was developed from a cross of Sumac with feterita. The white-seeded character proved fixed, but the heads were rather late in maturing and did not fill satisfactorily, the seeds were small and uncertain in germination, and the forage quality was inferior to Sumac.

In 1924 the writer made crosses of Early Sumac with Dwarf Kegari, hoping to develop a more satisfactory white-seeded, smut-resistant

Early Sumac. When the F_4 generation was grown in 1928, several early, white-seeded strains had been developed, but none were particularly attractive, and all were susceptible to kernel smut.

AMBER SORGO GROUP

At the time the forage-crop work was begun at Hays in 1913, Red Amber was the most popular sorgo on the station and was being recommended and distributed to replace the Black Amber more commonly grown. Red Amber matured a few days later than Black Amber, but was leafier, heavier in tonnage, and more uniform. Black Amber, on the other hand, was noted for earliness and seed production, for its certainty of germination, and for drought and insect resistance, but was notably inferior in purity and forage quality.

More than 100 heads of Black and Red Amber, selected at the Akron, Colo., station in 1912, were included in head-to-row tests at Hays in 1913. Selection work was continued the following year with 26 of the Black Ambers and 10 of the Red. The wider variability in the black-seeded lots permitted ready improvement. F.C. 7038 was at once isolated because of its superior forage yield and its resistance to lodging. It is a little later and coarser than the average of the Black Ambers and was carried into the variety tests as a worthy rival of Red Amber, S.P.I. 17548. Later attempts to improve F.C. 7038 by further selection were unproductive. Likewise, numerous selections and commercial lots brought in from other places were inferior to F.C. 7038. This strain was never distributed, however, as the Red Amber already being recommended seemed to fill the same needs. Red Amber selection work throughout 1913 15 was not productive of a strain superior to the check, S.P.I. 17548.

Work was resumed on an extensive scale in 1919 with 128 head selections, mostly from the Hays station general field of S.P.I. 17548. These selections were reduced to 23 in 1920 and later to 15, which were carried in yield tests throughout 1921–23 in comparison with the check, S.P.I. 17548. The best three selections averaged 6 percent above the check in forage yields for the 4 years, 1920 23, but these yield differences were not considered significant. Selection work was then discontinued, Red Amber having lost its popularity because of its susceptibility to head smut and the development of Early Sumac. Attention was given throughout the period 1915 23 to a shorter, coarser-stemmed Red Amber, F.C. 6685, which in the variety tests proved lighter in tonnage but much heavier in seed yield than the relatively tall and slender S.P.I. 17548. This strain was finally discarded also, since forage quality rather than high-seed production was the objective.

WHITE-SEEDED SORGOS

Among the sorghum introductions there are several, like the White African, that have white seed and others, like Sourless, that have seed which is white tinged with brown on the exposed portions. The brown color in sorgo seed seems to be linked with the presence of a bitter principle resembling tannin. This bitterness has long been accounted the reason for the lower feeding value of sorgo seed as compared with the seeds of kafir, milo, and feterita. It seemed a

reasonable hypothesis, therefore, that a white-seeded, smut-resistant sorgo would be more valuable than the brown-seeded sorgos like Sumac and Amber. White African requires too long a growing season for Hays, Kans., conditions, and besides, it is susceptible to smut. Sourless matures in central Kansas, but is susceptible to smut and does not have pure white seed.

Crosses between Red Amber and feterita received considerable attention beginning in 1919. In that year the writer received two lots of bulk seed of these crosses from I. N. Farr, Stockton, Kans. and grew one twentieth of an acre of each. The wide range of variations produced and the interesting possibilities of isolating a white-seeded smut-resistant sorgo attracted the attention of John H. Parker, of the Agronomy Department, Kansas State College of Agriculture and Applied Science, and A. F. Swanson, of the Bureau of Plant Industry, who took over the material and made an exhaustive genetic study of it for several years. By 1923 several sweet-stemmed, white-seeded strains had been produced, the most promising being at Hays in the cooperative varietal tests of 1924 under F.C. 9120, 9121, and 9122. Eventually all of the material was discarded, mainly on account of lodging habits inherited from the Red Amber parent. The hybrid strains were more like Red Amber than feterita in vegetative habits, being relatively tall and slender stemmed. A factor in lodging probably was the seed head, which was heavier than that of Red Amber.

During the period from 1922 to 1928 several other selections of Red Amber × feterita were grown. These had been received from I. N. Farr and had already been carried through several generations to a white-seeded sorgo stage. Head rows were continued several years from the more promising lots, but no strains of superior value were found.

Work with the cross, Sourless × Blackhull kafir, though most actively conducted at the Manhattan station, will be included in this discussion because of the positive results of far-reaching value achieved by Mr. Farr through several generations of selection until he had a number of strains carrying a small kafir head on a relatively tall leafy stalk. Thirty-two heads of this material were received from Farr and grown in head-row tests at Hays in 1922. They were a promising group, 68 to 80 inches tall, with the forage quality of Sourless and carrying nonbitter kafir seed, rather light in grain yields, and a bit late maturing, but suggesting rivalry with Sunrise kafir as a dual-purpose crop. Two rows were selected for further study under F.C. 9102 and 9103. Farr also furnished heads of this cross to Parker at Manhattan, Kans., where it immediately appeared to be well adapted. Parker soon developed selections rivaling in forage value and excelling in resistance to lodging the Kansas Orange sorgo, then the leading sorgo at Manhattan. Among six of Parker's selections which he sent to Hays in 1924, one assigned F.C. 9112 appeared especially attractive and was continued in the Hays variety test. Meanwhile, selections continued at Manhattan until one of the larger and later types was decided on for dissemination in 1928 under the name of Atlas sorgo. This selection was recommended primarily for eastern and southern sections of Kansas, but in spite of its relatively late maturity, it is popular in the territory served by the Hays station. Earlier selections were under observation at Manhattan

and Hays in 1928 with a view to perfecting a type better suited to the northwestern section of Kansas, but these selections were not particularly attractive.

MISCELLANEOUS SORGOS

Several hundred varieties, selections, or commercial lots of sorgos were grown at Hays one or more seasons in single-row tests, and a few of the principal ones were carried in the variety tests of yield comparisons. Only limited breeding efforts were directed toward these miscellaneous sorgos, but an important point in these studies was to become as familiar as possible with the entire range of sorgos being grown in the country, and their trade names. The Orange group was one of the principal ones studied, including not only commercial lots but also crosses with Sumac made by H. N. Vinall, of the Division of Forage Crops and Diseases, and selections of Kansas Orange developed by Parker at Manhattan. The general run of this Orange

FIGURE 13.—The taller sorghums produce heavy yields of forage, but are subject to lodging badly in years of heavy rainfall. This is a factor to be considered in evaluating sorghum varieties.

and other material was rather late and tall for the Hays section (fig. 13). Many sorgos of good forage quality were observed in these plantings, but it seemed impossible to find any superior to the best standard types of Orange, Sumac, and Honey.

In 1926 the tests included 145 lots of sorgo collected under Vinall's direction in many of the sorghum-growing States. These sorgos carried a confusing list of local names. Some of the lots tentatively identified as Orange, for example, were received under such names as Honeycomb, Honey Drip, Silver Drip, Sugar Cane, Silvertop, Beckdale Cane, Orangetop, Klondike Cane, California Cane, Georgia Poorland, etc. Practically all of the lots were readily identified as belonging to a few standard varieties such as Orange, Colman, Planter, Sourless, Red Amber, Black Amber, and Honey.

KAFIR GROUP

Pink kafir.—Some attention was given to the improvement of Pink kafir by selection. Pink kafir, C. I. 432, had been developed at the Hays station and grown for distribution under the name Whitehull White kafir prior to the establishment of the forage-crops project. About 1915 it became known as Pink kafir, because the seeds were tinted with pink. This variety has continued very popular in Kansas wherever a kafir is needed that is somewhat earlier and more drought resistant than standard Blackhull kafir. Farmers seem to grow it fully as much for forage as for grain production. In 1919, 88 head selections and commercial lots of Pink kafir were assembled from various sources and grown in duplicate 4-rod rows. Two outstanding selections were developed. F.C. 9089 was a week or more earlier than C.I. 432, but pithy stemmed and deficient in leafiness. F.C. 9091 selected from a commercial lot of seed handled by the D. O. Coe Seed Co., Topeka, Kans., was 100 percent juicy stemmed, whereas only

FIGURE 11.—Pink kafir, a dependable grain and forage sorghum. Uniformity was attained by continued selection

22 percent of the stalks in the check plot of C.I. 432 were juicy. Otherwise, the merits of F.C. 9091 and C.I. 432 were apparently equal, and the substitution of F.C. 9091 for general distribution was considered (fig. 11).

Dawn kafir.—C.I. 340, a dwarf blackhull type developed at the Amarillo, Tex., cereal field station about 1908, was grown in the Hays variety tests regularly and distributed by the Hays station for several years, but showed too much variation to be classed as a pure strain, and indicated considerable opportunity for improvement by selection. Numerous head selections were made in 1918 and seeded in head rows in 1919. A. F. Swanson then took over this material and after several years developed a more uniform type, C.I. 904, slightly leafier and taller than C.I. 340. The selection was grown in the variety tests from 1925 on, and superseded C.I. 340 in the station's seed trade.

Western Blackhull kafir.—F.C. 9098 was developed from early local selections of Blackhull by P. E. Crabtree, near Scott City, Kans.

Beginning in 1921, it was included in the varietal tests regularly and found to be a very uniform attractive kafir, 10 days or so earlier than standard Blackhull kafir, and therefore much better adapted to western Kansas conditions (fig. 15). It proved a close rival of Dawn kafir throughout the tests, and finally in the spring of 1931 it was seeded in place of Dawn on the station farm for commercial distribution. Early local strains of Blackhull kafir have long been grown to the southwest of Hays, and Western Blackhull should appeal to growers who desire a pure uniform strain. Blackhull kafir, Texas No. 9195 (C.I. 865), developed and distributed from the Lubbock, Tex., station, was grown at Hays in 1927 and 1928 in the sorghum-variety tests and was

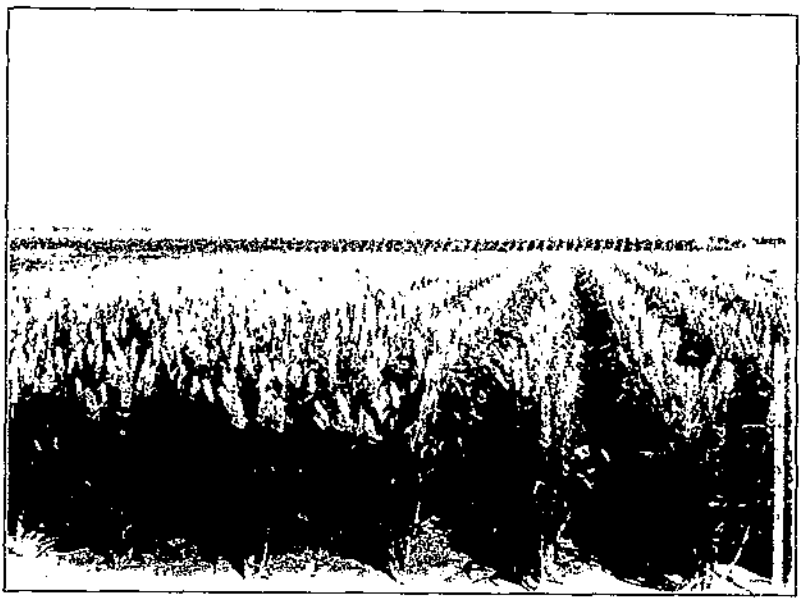

FIGURE 15.—Western Blackhull kafir, one of the new strains, showing its uniformity and productiveness.

found to be practically identical with the Western Blackhull kafir, F.C. 9098.

The name kafir has become rather loosely used, so that it is now attached to sorghums that are not true kafirs in the original sense. Such varieties are "Wonder kafir", described under the heading Feterita; Yellow kafir, C.I. 902, a milo-kafir hybrid developed by A. F. Swanson; Progressive kafir, F.C. 02249, an H. Willis Smith hybrid; and Schrock kafir, F.C. 1481, a sorgo-kafir hybrid designated in this bulletin merely as Schrock or Schrock sorghum.

FETERITA GROUP

On account of its newness, attractive white seeds, and unusual drought resistance, feterita became popular during the period 1913 to 1915 but has since declined to minor importance in Kansas. This decline was due to the soft seeds germinating poorly under unfavorable weather conditions, to poor forage quality, and to the fact that the improvement of the crop did not keep pace with that of other sorghums. The poor germination is so serious a difficulty with the

average farmer as to obscure the advantages of feterita in other respects.

Under the careful cultural methods used in the variety tests at Hays, obtaining feterita stands was not unusually difficult, and the tables presented show that the grain yields of several selections of feterita ranked with the best kafirs, Dawn and Pink, at about 20 percent above the average yield of the 10 varieties used as a check.

The experiments with feterita included the following introductions and selections: (1) Varietal tests of F.C. 811, S.P.I. 19517, and S.P.I. 22329, developed by H. N. Vinall and others at the Chillicothe, Tex., substation, for greater uniformity and a minimum of branching and stooling; Spur feterita, F.C. 6801, developed at the Spur, Tex., substation by R. E. Dickson; Dwarf feterita, F.C. 9076, selected by H. N. Vinall at San Antonio, Tex. (fig. 16); earlier selections superseded in

FIGURE 16.—A dwarf strain of feterita developed by the Division of Forage Crops and Diseases. This strain failed to achieve practical importance because of the low germination of the soft seed

1924 by C.I. 182-1, developed by A. F. Swanson on the Hays cereal crops project; (2) numerous Egyptian introductions tested from 1922 to 1927; and (3) testing of hybrids developed by several plant breeders, 1922-28.

The varietal-test tables show yields for the feteritas under class 1 and for some of the hybrids. C.I. 182-1 was used for distribution by the Hays station for a number of years but is too tall to meet the modern trend toward grain sorghums suitable for handling with the header and combine. Spur feterita is an improvement as to foliage but does not have the earliness and drought resistance which constitute the chief reasons for growing feterita in the Hays section. Dwarf feterita, F.C. 9076 and 8628, were pleasing from the standpoint of reduced height but had the softest and poorest germinating seed of all the feterita group.

Egyptian introductions of feterita were tested in single rows in 1922 under the following S.P.I. numbers: 54478, 54480, 54482, 54483, 55106, 55116, 55127, 55154, 55155, 55157, 55159, and 55163.

Other Egyptian feteritas received at Hays in 1926 after preliminary trials at Shafter, Calif., included S.P.I. 61448, 61450, 61458-A, and 61458-B. In 1927 the testing of the foregoing lots had narrowed to three—S.P.I. 54478, 61450, and 61458-B. All were relatively small-headed, slender types that might show up well in a dry year or perhaps be suited to growing in close drills. The 1927 season was wet, and these three feteritas grew 6 feet tall. They also tillered, branched, and lodged more than C.I. 182 1.

The results with Red Amber and Sumac crosses on feterita have been discussed. Otherwise the most extensive work on feterita crosses was done by Vinall and others at the Chillicothe, Tex., substation, and some of their crosses were sent to Hays for further test. Most notable of these creations were Chiltex, F.C., 8917, and Premo, F.C. 8929, crosses between feterita and kafir, both of which were

FIGURE 17.—Freed sorghum, an early variety that often matures grain in a dry year when late varieties fail

grown for several years in the Hays variety tests. Chiltex was uniform and productive and showed some gain over feterita in germination. It was less drought-resistant than feterita and lacked attractiveness either for forage or grain in competition with the best kafirs. Premo was later and less well adapted, and many heads were poorly exserted from the boot. Milo × feterita, F.C. 8926, appeared more drought-resistant and productive than feterita, but was not a well-fixed type. Other less advanced hybrids with feterita ancestry were grown in head rows in 1924 and later under F.C. 6612, 6618, 6619, 6620, 6621, 6622, 6623, 6627-1, and 6627-4.

Three feterita hybrids developed by amateur plant breeders are of sufficient importance to discuss here: (1) F.C. 9096, Red kafir × milo × feterita, by H. Willis Smith, obtained at his farm near Kismet, Kans., in September 1921, a medium dwarf, competing with Dwarf feterita, F.C. 9076, but was discarded after a trial of 3 years. (2) "Wonder kafir", C.I. 872, developed by C. A. Bowers, Wallace, Kans., from a

chance hybrid of feterita and kafir. This was an attractive type, medium dwarf and, under favorable conditions, prolific like Dwarf hegari. However, the varietal tests (1925–28) revealed three severe defects—weak germination, lodging, and susceptibility to kernel smut. (3) Feterita × kafir, C.I. 969, a true dwarf feterita, developed by I. N. Farr. It was included in the variety tests of 1925 to 1928. If developed further it might prove sufficiently valuable for local distribution.

FREED SORGHUM GROUP

Freed, a very early, white-seeded sorghum developed by J. K. Freed, Scott City, Kans., produced a light tonnage, with stalks medium fine, juicy, and slightly sweet, thus making Freed a dual-purpose forage and grain crop for extreme western Kansas and tributary areas in Colorado and Nebraska. It was grown throughout the Hays variety tests, first under S.P.I. 29166. This number, after a series of head-to-row plantings in 1913–14, was superseded by F.C. 9033, which was apparently more uniform, wind resistant, and productive of grain (fig. 17). Later, a true dwarf, Freed, C.I. 971, was developed through selection by A. F. Swanson and included in the variety tests. This selection was an improvement from the grain standpoint because of convenience in handling and resistance to lodging.

P. E. Crabtree crossed Freed with Pink kafir, hoping to combine some of the earliness and dependability of the Freed with the superior tonnage and grain-yielding habit of the kafir. In 1918 a plot of this cross in the F_2 generation showed many segregates. The writer was permitted to make numerous selections, which were carried forward in head-to-row tests for several years to fix desirable types. Finally these narrowed to Weskan and Modoc, which were included in the variety test. Weskan, an exceptional grain yielder under favorable conditions but too much subject to lodging, was near the Pink kafir type in forage habits, but with a more lax panicle. Modoc yielded less but was medium tall, stood up satisfactorily, had a small but attractive head that was fairly compact, and produced excellent grain yields. It appeared suitable to replace Freed as a dual-purpose crop.

KAOLIANG GROUP

Dwarf Brown kaoliang.—S.P.I. 38202, grown in 1922, was 5 to 6 feet tall and of no forage value. Kaoliangs introduced from Echo, Manchuria, were grown in 1924 under S.P.I. 57284 to 57295, inclusive. F.C. 11557 and 11571 were also in the collection. With three exceptions, all were true Brown kaoliangs 5 to 6 feet tall, maturing grain and shedding their leaves early, hence of no possible forage value. Nos. 11557 and 57286 differed in showing more of a broomcorn-head type. No. 57293 differed in having loose heads of the Amber type.

Five more kaoliang introductions from Peiping, China, were grown in 1925—S.P.I. 62608, 62609, 62428, and 63437, Brown kaoliangs, and S.P.I. 62610, White kaoliang. None of these was attractive. A new collection of 30 Manchurian kaoliangs were grown in 1926—S.P.I. 66368 to 66393, 63715, 63923, 64368, and 66741, and these were principally Brown kaoliangs of standard height, some partly white seeded. The only one of interest was S.P.I. 66384, a dwarf Brown kaoliang 48 inches tall, 1 to 2 feet shorter than other kaoliangs. In head type it was identical with C.I. 171, but a definite improvement. S.P.I. 66384 was, however, a relatively light grain yielder compared

with other grain sorghums and of no possible forage value. Crosses with Dawn kafir, Dwarf Freed, and White Durra were made at the suggestion of H. N. Vinall in 1927, and the F_2 generation was grown in 1928.

MISCELLANEOUS SORGHUMS

Several other sorghums not yet discussed are of sufficient interest to mention here. Schrock sorghum, F.C. 1481, originated and distributed by Roy Schrock, Enid, Okla., as Kafirine, later known as Schrock kafir, Kafir-sorghum, and finally as Sagrain by Mississippi growers, was grown throughout the sorghum-variety test because of its excellent forage habits and also because of the constant interest of the public in its performance. Its vegetative habit is that of a very leafy kafir, but the grain is bitter. Although it yields less forage it produces more in proportion to its height than the taller sorgos. Schrock was considered a desirable subject for crossing with a grain sorghum for the purpose of developing a plant combining its forage habits and a nonbitter grain. The writer crossed Schrock with Dwarf hegari in 1927 and grew the F_1 generation in 1928.

Fargo milo, C. I. 809, also known as Straight-neck milo and Manko maize, is a tall, late, rather leafy grain sorghum. Apparently developed locally at Fargo, Okla., it has spread rapidly north and west into southwestern Kansas. It was included for three seasons in the Hays variety tests and was considered very inferior, something like a very late standard milo, except the heads were looser and only partly inclined. Under the name Manko maize, it was extravagantly promoted in 1928, and the seed sold at a fancy price.

Algeria, a very late type of sorghum identified as Bishop kafir, was grown at Hays in 1928, on account of its promotion from the same source as Manko maize.

GRASS SORGHUMS

SUDAN GRASS

Among the numerous grass sorghums found growing naturally in Africa, Sudan grass is the only one which has proved useful in the United States as a cultivated crop. It is particularly suited to the semiarid conditions in the Great Plains and has been given a thorough test at the Fort Hays station. Naturally other grass sorghums when introduced were compared in preliminary tests with Sudan grass, and as they proved less valuable they were discarded.

DATE OF SEEDING FOR HAY PRODUCTION

Close-drilled seedings of Sudan grass for hay production were made at the rate of 20 pounds per acre at 15-day intervals from April 15 to August 1 for 1913–18. Land for the experiment was measured and prepared previous to the first seeding. Additional tillage was given the unseeded portion to kill successive crops of weeds and to get the land into as good tilth as possible for each seeding.

The April 15 seedings suffered badly from cold weather. Poor stands grew so slowly that they were partly or wholly smothered by pigweeds. The May 1 and May 15 seedings were also subject to weed competition in certain seasons, to an extent indicated by percentages of stand in table 13, but these seedings, favored by warmer weather, soon grew vigorously. In seedings made after May 15 weeds were not an important factor, for successive crops of them had been

TABLE 13.—*Results from seeding Sudan grass in close drills at different dates for hay production, 1913–18*

Year and date of seeding	Stand	First cutting			Second cutting			Total yield per acre
		Date	Time after seeding	Yield per acre	Date	Time after first cutting	Yield per acre	
1913:	*Percent*		*Days*	*Tons*		*Days*	*Tons*	*Tons*
Apr. 16	10	July 9	84	0.03	[1]			0.03
May 1	20	do	69	.12				.12
May 14	100	do	56	1.08				1.08
May 30	100	Aug. 13	75	.26				.26
June 16	100	do	58	.10				.10
July 2								
July 15			[2]					
Aug. 1			[2]					
1914:								
Apr. 14	10	[3]						
May 6	100	July 20	75	2.17	Sept. 15	57	0.25	2.42
May 21	100	July 28	68	2.30	do	49	.31	2.61
June 4	100	Aug. 5	62	2.18	do	41	.26	2.44
June 19	100	Aug. 19	61	1.65	do	27	.47	2.12
July 3	100	Sept. 15	74	1.66	None			1.66
July 16	100	do	61	1.08	do			1.08
Aug. 1	[4]							.45
1915:								
Apr. 15		[3]						
May 6	60	Aug. 3	90	1.81	Sept. 28	56	2.50	4.31
May 14	60	Aug. 14	92	2.46	Oct. 20	67	1.15	3.61
June 1	90	Aug. 18	78	2.42	do	61	1.12	3.54
June 15	100	Aug. 31	77	3.79	do	50	.80	4.59
July 6	100	Sept. 11	67	3.25	None			3.25
July 17	100	Sept. 28	73	2.46	do			2.46
Aug. 4	100	Oct. 20	77	1.25	do			1.25
1916:								
Apr. 13	50	July 4	76	.46	Sept. 6	64	.77	1.23
May 1	40	do	64	.34	do	64	.67	1.01
May 15	80	do	50	.21	do	64	.54	.75
May 31	95	July 28	58	.90	Oct. 1	65	.29	1.19
June 17	80	Aug. 1	45	.52	do	61	.34	.86
July 1	100	Oct. 1	92	1.01	None			1.01
July 15	50	do	78	.93	do			.93
Aug. 1	50	do	61	.10	do			.10
1917:								
Apr. 20	20	Aug. 18	120	.18	do			.18
May 1	40	do	109	.33	do			.33
May 16	100	Sept. 4	111	1.75	do			1.75
May 31	100	do	96	2.11	do			2.11
June 15	25	do	81	2.15	do			2.15
June 29	100	do	67	2.63	do			2.63
July 12	95	Sept. 11	61	1.61	do			1.61
Aug. 1	90	Oct. 13	73	1.17	do			1.17
1918:								
Apr. 18	60	Aug. 1	105	.76	do			.75
May 2	75	do	91	.85	do			.85
May 15	75	do	78	1.21	do			1.21
June 1	100	do	61	1.49	do			1.49
June 15	100	Aug. 14	60	1.42	do			1.42
July 1	100	Aug. 23	53	1.13	do			1.13
July 15	100	Sept. 22	69	1.06	do			1.06
July 31	100	do	53	.56	do			.56
Average [5], 1913–18:								
Apr. 17	25	July 23	96	.24		64	.77	.37
May 3	56	July 25	83	.94		59	1.14	1.51
May 16	79	July 31	76	1.51		60	.66	1.84
June 1	98	Aug. 12	72	1.58		56	.53	1.84
June 16	84	Aug. 19	64	1.61		46	.54	1.87
July 2	83	Sept. 11	71	1.61				1.61
July 15	74	Sept. 21	68	1.30				1.30
Aug. 1	68	Oct. 6	66	.59				.59

[1] Extreme drought prevented second growth on all plots.

[2] Last actual seeding was made July 2, but increasing severity of drought prevented the later seedings from germinating.

[3] Smothered by weeds.

[4] Seeding omitted; yield interpolated.

[5] Averages include only those years in which a cutting was actually made; 1 year in the case of the second cutting from the earliest seeding; 4 years from second cuttings for the next 4 dates of seeding. This accounts for the sum of first and second cutting averages being greater than the amounts given for the respective dates in the total-yields column. This apparent discrepancy could be avoided if all second-cutting yields were averaged strictly on a 6-year basis, but the average number of days since first cutting should not be so handled.

killed, and the grass had vigor enough to develop steadily through cold wet periods. From July 1, 1913, on, the surface soil was too dry for seed to germinate, and there was some irregularity of stands from this cause in the two latest seedings of 1916 and 1917.

The first cutting of hay was generally made from the first head to the full-bloom stage. Seedings as late as July 15 were generally able to produce one such cutting. The August 1 seedings developed poorly. Second cuttings were obtained in three seasons from the May 1 to June 15 seedings, but only in the very wet season (1915) were these cuttings of much value. Because of shortage of soil moisture, the second growth was generally slow starting and became stunted when 6 to 30 inches tall.

The earlier the seeding the greater the tendency for the Sudan grass to exhaust the soil moisture and suffer a noticeable loss in the quality of the first cutting. Later seedings derived much advantage from a reserve of moisture usually accumulated during their longer soil-preparation period, but the danger of the immediate surface soil becoming too dry at seeding time increased after June 15.

No definite optimum date of seeding was shown from these experiments. The optimum 10-day period for each season was noted as follows: 1913, May 10 to 20; 1914, May 20 to 30; 1915, June 10 to 20; 1916, May 29 to June 8; 1917, June 20 to 30; 1918, June 1 to 10. It was concluded that there was nothing to be gained by seeding before May 15, but that seeding might well be done as soon after this date as warm weather and a good seed bed were available. It was better to wait several weeks if necessary rather than seed Sudan grass under unfavorable soil or climatic conditions. As with early-maturing sorghums, this crop has a wide seeding range, and a fair crop is possible if 80 to 90 days remain before the normal date of the first killing frost. Cold nights usually prevent normal development of the grass at Hays, Kans., after September 25.

It is often desirable to seed relatively early in order to get the hay or pasture as soon as possible, but it may be noted in table 14 that prior to June 1, seeding 2 weeks earlier permitted cutting only 1 week earlier. It may be desirable, especially for pasture, to spread the seeding over several dates, in order to have new areas in full growth in August and September after the earlier seedings have exhausted their moisture supply. The poorer the physical condition of the soil, as, for example, after sorghums or Sudan grass, the later a following crop of Sudan grass should be sown, for the land needs more time to acquire moisture and good tilth.

RATE AND METHOD OF SEEDING FOR HAY PRODUCTION

Experiments were begun in 1913 with seeding Sudan grass in close drills at four rates, 35, 25, 20, and 15 pounds per acre; seeding in alternate drill rows 16 inches apart at 10 pounds per acre; also in 24-inch and 40-inch cultivated rows at 7 and 4 pounds per acre, respectively. All seedings were made with a grain drill equipped with press wheels. The land was prepared intensively, and the seedings made at as nearly an optimum date as possible. The average date was June 4, but varied between May 14 and June 25. Duplicate $\frac{1}{20}$-acre plots were used, except that in five seasons the replications were put in about 2 weeks apart. The scope of this experiment was gradually reduced after 1918, as results became fully established.

The annual yields from this experiment are shown in table 14, including average yields for the different periods that each method was tested. No consistent differences in yield were obtained among the noncultivated seedings. There is more assurance of a good stand and freedom from weeds if every drill row is sown than if only alternate ones are seeded, but the expense for seed is greater. The 24-inch rows led by 5 to 10 percent, as compared with either the 20-pound rate in close drills or the 40-inch cultivated rows. This difference agrees very closely with results from all sections of the United States.[7]

TABLE 14.—*Results from seeding Sudan grass for hay production at different rates and in different widths of rows, 1913–28*

Year	Acre yields for rates and row widths shown						
	Close-drilled seedings					Cultivated rows	
	5 pounds	15 pounds	20 pounds	35 pounds	40 pounds	7 pounds in 24-inch rows	4 pounds in 40-inch rows
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1913	0.77	0.100	0.70	0.50	[1] 0.60	0.76	0.61
1914	4.14	4.87	5.80	5.16	4.18	4.17	4.32
1917	4.12	4.15	4.26	4.22	4.23	4.39	3.77
1918	3.81	3.76	2.07	2.03	1.95	2.16	2.59
1927	1.85	1.92	2.02	2.23	2.09	2.31	1.65
1928	1.26	1.29	1.96	1.91	1.95	1.91	1.70
1929			2.20		2.80	3.17	3.20
1920			3.13		3.25	3.20	3.29
1921			2.85		2.61	2.47	2.77
1922			3.29		3.07	2.98	2.71
1923			1.70		1.80	2.21	2.26
Average:							
1913–18	2.45	2.30	2.45	2.30	2.18	2.65	2.45
1913–23			2.53		2.59	2.75	2.63

[1] Grain drills were used in 1913 and 1914, a one-horse drill in other years.
[2] Interpolated.

In the earlier years of Sudan-grass culture when seed was unduly expensive it appeared advisable to economize on seed and to regard forage merely as a side line to the production of seed. In such a case the use of cultivated rows may have been justified. But now with seed available at reasonable prices it seems preferable to use from 15 to 25 pounds per acre in close drills and to save the expense of cultivation. Yields by separate cuttings have been studied, showing that close drills at 20 pounds per acre averaged for 8 years a yield of 2.16 tons at the first cutting and only 0.76 at the second. The 24-inch rows yielded 2.03 tons the first cutting and 1.12 for the second; the 40-inch rows 1.86 at the first and 1.26 at the second. For the three methods the percentages of total yield in the first cutting were as follows: Close drills 74, 24-inch rows 64, and 40-inch rows 60 (fig. 18). A close-drilled stand that occupies the land fully at the outset seems to exhaust most of the available moisture by the time of the first cutting. The cultivated rows, requiring longer for their roots to occupy all the space, do not keep up with the close drills at first in volume of growth and seem to have enough available moisture left after the first cutting to start a vigorous new growth.

If circumstances are not entirely favorable for seeding, as in using seed of less than 90 percent germination or in seeding on poorly pre-

[7] VINALL, H. N., and GETTY, R. E. SUDAN GRASS AND RELATED PLANTS. U. S. Dept. Agr. Bull. 981, 68 pp., illus. 1921.

pared land, the rate should be increased. The use of press wheels on a drill appears important in getting uniform stands. The seed should have a firm but shallow covering about half as deep as that of wheat. The grain drills used in these tests sowed about 20 pounds of Sudan grass per acre when set at the 2-peck rate for wheat.

MIXTURES WITH ANNUAL LEGUMES FOR HAY PRODUCTION

Mixtures of Sudan grass with cowpeas and also with soybeans were tried in close-drilled seedings for hay production at Hays in 1914 and 1915. Results were entirely negative, for the Sudan grass rapidly outgrew the legumes and smothered them. The Sudan grass and legumes were drilled at the same time in alternate drill rows in the ratio of 4 pounds of Sudan grass to 40 of legume seed; also in the ratio of 5 and 50 pounds per acre. The number of legume plants per square foot in the early stands varied from 0.5 up to 5.9. That of Sudan grass was always greater, ranging from 0.9 up to 12.2 plants

FIGURE 18.—Sudan grass. In regions of low rainfall this crop is often more productive of hay and seed when grown in rows and cultivated.

per square foot. Apparently the legumes are unable to survive in close-drilled Sudan grass under dry-land conditions regardless of the seeding ratio. The purpose of this experiment, namely, to secure a forage of higher protein content than Sudan grass alone, can be attained in considerable degree by cutting Sudan grass itself at an earlier stage of growth.

STAGES OF CUTTING FOR HAY PRODUCTION

Experiments relative to the stage of cutting Sudan grass for hay were conducted for the 5 years 1915-19. Seedings were made in close drills at 20 pounds per acre at an average date of June 3. Duplicate $\frac{1}{20}$-acre plots were mowed at each of four stages: (1) Just before heading; (2) at the first head; (3) at full head; and (4) with the seed in the milk stage. Any second growth that developed was mowed at about the date of the first killing frost or shortly afterward. The

TABLE 15.—*Results obtained from cutting Sudan grass for hay at different stages of maturity, 1915-19*

Year	Plot nos.	Cutting	Stage of maturity	Height	Date cut	Period after seeding or cutting	Average weight per acre air-dry hay	Composition (water-free material)				
								Ash	Ether extract	Protein	Crude fiber	Nitrogen-free extract
				In.		*Days*	*Tons*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1915	1 and 5	First	Before heading	10	Aug. 3	50	0.90	12.52	1.66	15.81	30.98	38.60
		Second	do	12	Sept. 11	39	1.72	10.72	1.23	11.82	32.72	40.51
		Total					2.62					
	2 and 6	First	First head	70	Aug. 18	65	2.48	11.90	1.15	11.51	37.12	37.90
		Second	Very young, frosted	21	Oct. 20	48	3.16	10.12	1.15	15.51	20.81	43.48
		Total					5.51					
	3 and 7	First	Full head	78	Aug. 31	78	3.31	8.98	1.19	10.16	35.27	44.40
		Second	Very young, frosted	18	Oct. 20	35	.67	10.56	1.30	17.21	29.06	42.07
		Total					1.98					
	4 and 8	First	Seed in milk	81	Sept. 28	109	3.67	8.86	1.21	7.67	37.11	44.85
1916	1 and 5	do	Before heading	24	July 15	15	1.10	10.28	2.39	13.21	21.85	49.27
		Second	do	24	Sept. 6	53	.75	9.92	2.51	13.90	23.94	49.73
		Total					1.85					
	2 and 6	First	First head	51	July 29	36	1.21	9.57	1.96	10.12	21.37	53.18
		Second	Very young, frosted	18	Oct. 1	67	.18	9.81	1.79	11.23	22.47	54.81
		Total					1.72					
	3 and 7	First	Full head	96	Aug. 11	72	1.15	9.96	1.15	9.31	25.70	53.78
		Second	Very young, frosted	52	Oct. 1	53	.19	11.31	1.76	11.95	21.20	50.05
		Total					1.41					
	4 and 8	First	Seed in milk	96	Sept. 6	98	1.59	9.37	1.66	8.67	27.76	52.62
1917	1 and 5	do	Before heading	34	Aug. 18	86	.61	11.77	1.70	16.86	29.28	40.08
		Second	do	28	Sept. 26	39	1.21	10.29	2.12	13.96	26.53	47.72
		Total					1.82					
	2 and 6	First	First head	80	Aug. 28	96	1.41	10.96	1.58	14.04	29.45	44.00
		Second	Very young, frosted	15	Oct. 14	46	.57	9.20	1.82	11.98	25.21	51.79
		Total					1.98					
	3 and 7	First	Full head	11	Sept. 11	110	1.10	10.04	1.18	13.05	30.55	45.98
	4 and 8	do	Seed in milk	12	Sept. 26	125	2.22	7.98	1.70	9.15	20.68	54.49
1918	1 and 5	do	Before heading	12	July 27	53	1.03	11.65	2.21	14.87	28.31	42.96
	2 and 6	do	First head	18	Aug. 1	56	1.72	10.53	2.40	14.39	28.61	44.07
	3 and 7	do	Full head	50	Aug. 14	69	1.25	10.31	2.05	10.92	30.32	46.27
	4 and 8	do	Seed in milk	50	Aug. 24	78	1.78	9.32	1.80	9.81	30.61	48.45
1919	1 and 5	do	Before heading	12	July 21	47	.99	9.18	1.77	9.31	29.18	39.76
		Second	First head [1]	30	Sept. 27	68	1.00	9.11	1.31	10.05	31.21	47.29
		Total					1.99					
	2 and 6	First	First head	36	July 26	70	1.51	9.18	1.46	6.71	31.17	51.48
		Second	do [1]	30	Sept. 27	63	.88	9.31	1.41	10.05	31.21	47.29
		Total					2.39					
	3 and 7	First	Full head	30	Aug. 2	57	1.13	8.33	1.14	5.30	31.48	53.45
		Second	First head [1]	30	Sept. 27	56	.77	9.11	1.41	10.05	31.21	47.29
		Total					2.30					
	4 and 8	First	Seed in milk	50	Aug. 18	73	2.11	8.12	1.50	5.00	32.22	52.55

[1] Days to killing frost, Oct. 5.

[2] Same sample used for analyses of these three cuttings.

yield and composition of the hay from each cutting was determined, the analytical work being done by the then Bureau of Chemistry, United States Department of Agriculture. The data obtained are shown in detail in table 15.

Marked increase in yields generally resulted from letting the Sudan grass stand an additional 10 days, the average interval from the just-before-heading to the first-head stages. The dry-matter content increased greatly, even though the outward appearance of the crop showed but little change. The percentage of protein was highest in the first stage, but the largest amount per acre for the season was obtained from the second stage. After the first-head stage, the chief increase is in the carbohydrates. The hay becomes rather stemmy and woody at the seed stage.

Some growers advocate the cutting of Sudan-grass hay whenever it is as tall as the mower wheels (about 3 feet) because of convenience in curing and handling the fine quality of hay, and the higher annual tonnage supposed to result from more numerous cuttings. The experimental data here presented indicate that the high-protein hay from such an early cutting is obtained at a considerable reduction in annual tonnage. In a season like 1916, when the growth was checked by drought at about the first stage of cutting and when grasshoppers were attacking the leaves, the earliest stage was decidedly the best. In the wet season of 1915, when conditions at the first stage were ideal for continued growth, the yield more than doubled during the 15-day interval from August 3 to 18, between the first and second stages. It continued to increase from the second to the third stages, adding more than a ton per acre during the period August 18 to 31. The hay at the full-head stage, in 1915 and other seasons of favorable growth, appeared to be of good quality and not so difficult to handle as to offset the higher tonnage.

The conclusions reached were that (1) Sudan grass should usually be cut for hay at the first-head to the full-head stage; (2) earlier cutting may be justified when the crop is being checked in growth or when high-protein hay is sought rather than maximum tonnage and food nutrients; (3) the crop may be cut satisfactorily over a wide range of time, even to the seed stage, but it becomes woody after the seed begins to form.

SUDAN GRASS FOLLOWING ALFALFA

Sudan grass has been widely used in Kansas for seeding in the irregular areas around the edges of alfalfa fields where stands of the latter crop have been lost because of grasshoppers or other causes. It has also been grown successfully on numerous fields where the entire alfalfa stand has declined and has been plowed up and where new stands of alfalfa have been hard to get. Plots of Sudan grass were grown at Hays in 1927 and 1928 on a bottom-land field where a 20-year-old stand of alfalfa had become too thin to leave. Table 16 compares the yields on alfalfa land with those obtained in the same seasons after winter wheat on upland that had been in cultivation about 25 years. The tests were not strictly comparable as to dates of seeding for the two locations, but the data are believed to represent the possibilities fairly well in each case.

TABLE 16.—*Yields of Sudan-grass hay on bottom land after alfalfa and on upland after winter wheat, 1927 and 1928*

Year	Acre yield (tons)		
	On bottom land after alfalfa		On upland after winter wheat
	First year	Second year	
1927	4.39	4.11	3.60
1928	4.40	3.92	3.48
Average	4.40	4.02	3.54

COMPARISON OF SUDAN GRASS WITH SORGO AND MILLET FOR HAY PRODUCTION

Sudan grass, sorgo, and millet compete with each other as annual crops for hay production, and it is therefore of interest to compare their yields and rates of growth. The data obtained from normal dates of seeding are assembled in table 17. These dates on the average were Sudan grass June 4, sorgo June 5, and millet June 7. The crops were all seeded in close drills under comparable soil conditions.

TABLE 17.—*Comparison of hay yields and season (time required for hay production) of Sudan grass, Red Amber sorgo, and two varieties of millet from normal dates of seeding for 1914–28*

Year	Hay per acre				Season				
					Sudan grass[1]				
	Sudan grass	Red Amber sorgo	Golden Kursk millet	German millet	First cutting	Second cutting	Red Amber sorgo	Golden Kursk millet	German millet
	Tons	*Tons*	*Tons*	*Tons*	*Days*	*Days*	*Days*	*Days*	*Days*
1914	1.80	3.58	3.08	4.12	65	59	108	64	68
1915	1.26	6.90	5.98	3.32	78	50	106	72	66
1916	2.07	1.83	4.27	4.17	78	65	98	70	70
1917	2.02	2.67	1.80	1.95	103		123	68	70
1918	[illegible]	[illegible]	1.61	1.87	79		88	67	73
1919	2.20	1.30	1.38	1.68	57	56	73	53	73
1920	3.14	4.17	2.72	2.00	78	70	97	66	80
1921	2.83	3.37	2.23	2.14	63	61	91	62	75
1922	3.20	1.73	3.07	3.27	73	55	86	70	60
1923	1.70	2.32	1.57	1.27	60	79	108	62	65
1924	2.08	2.65	.77	1.86	62	51	108	63	65
1925	3.03	4.12	3.02	4.00	70		92	67	64
1926	1.15	[illegible]	.77	.67	67		84	67	67
1927	3.60	1.65	1.75	2.00	67	29	106	63	77
1928	3.48	1.08	1.74	2.08	80		80	59	75
Averages	2.73	3.53	1.91	2.12	67	58	96	63	70
Relative yields,[2] percent	77	100	54	60					

[1] Days from seeding to first cutting and days from first cutting to second cutting. There was no second cutting of Sudan grass in 4 of the years and only one cutting each year for sorghums and millets.
[2] Relative yields, taking Red Amber as 100 percent.

Sorgo leads decidedly in tonnage, but is much the coarsest (fig. 19). This coarseness is not an objection, however, and the hay is excellent, especially for wintering cattle. To be fed effectively, sorgo hay requires a protein supplement, such as 1 pound of cottonseed cake or 3 to 4 pounds of alfalfa hay daily per head. It also leads in the following: Ease in obtaining a good stand, resistance to drought and

insects, and withstanding deterioration in field and stack. Sorgo requires the longest growing season, but this is not an objection at the normal date of seeding; in fact, it is economical to secure the entire season's growth in one cutting.

Sudan grass is finer stemmed and therefore subject to less waste in feeding. When cut relatively early, about the first head stage, its protein content is sufficient so that cattle may be wintered on this hay alone as successfully as on sorgo hay plus the protein supplement. Sudan-grass hay probably has the widest range of usefulness among all kinds of livestock, and the grass excels as a pasture crop. Objections to Sudan grass have been the high price of seed, lack of resistance to grasshoppers and chinch bugs, and the expense of two cuttings. In 10 of the 15 years there was a second cutting, which was usually very light.

All things considered, millet is the least valuable crop of the three, and its continuous decline in acreage since 1885 seems justified.

FIGURE 19.—Comparison of Sudan grass and Early Sumac sorgo seeded in close drills for hay production.

Millet makes the lowest yields of the group, but as it sends up no moisture-consuming second growth, dying as soon as it is mowed, it has the advantage of permitting the farmer to follow the crop with winter wheat. It must, however, be cut at the proper time, that is, before seed has formed. It has certain limitations as a feed, especially for horses.

Comparisons of Sudan grass, Red Amber sorgo, and some variety of millet seeded about July 1 for hay production were conducted regularly for the period 1921 to 1928, inclusive. The actual dates ranged from June 24 to July 4, depending on soil conditions. The seedings were made on land that had been fallowed throughout the spring months, a very important factor in the success of late catch crops. Such soil conditions often exist where a row crop of corn or sorghums has failed to produce a stand or has been destroyed by insects or storms. Late-prepared land or fields on which small grain has just been harvested are likely to result in failures when seeded

about July 1. It is necessary to have an abundant supply of stored moisture and a good tilth of surface soil, such as are obtained by a spring fallow.

The results from July 1 seedings are shown in table 18. The plants reached a satisfactory hay stage regularly, and in some cases the hay was of better quality than that obtained from normal dates of seeding. The July 1 seedings are inclined to grow off rapidly and continuously with the minimum of interruption from drought, and they incline especially to production of succulent leafy forage. July 1 is about the latest practical date for seeding sorgo, but Sudan grass and millet may be sown up to July 15 in most seasons.

TABLE 18.—*Comparison of hay yields and season time required for hay production of July 1 seedings of Sudan grass, Red Amber sorgo, and millet in close drills 1921–28*

Year	Sudan grass		Red Amber sorgo		Millet	
	Season	Yield per acre	Season	Yield per acre	Season	Yield per acre
	Days	*Tons*	*Days*	*Tons*	*Days*	*Tons*
1921	75	1.84	89	2.89	70	1.32
1922	70	1.51	76	2.63	60	1.17
1923	58	1.35	58	1.66	50	1.21
1924	57	2.22	59	3.61	60	1.79
1925	65	2.74	65	3.79	65	2.51
1926	65	1.20	97	1.25	61	.52
1927	50	1.15	101	3.00	73	1.92
1928	58	2.48	77	1.72	62	1.51
Average	64	1.78	81	2.47	63	1.38

White Wonder, 1921 and 1922; Siberian, 1923; Goldmine, 1924 to 1928.

The data obtained from normal and late seedings of Sudan grass, sorgo, and millet may be examined from the standpoint of rate of growth as well as for total amount of hay produced. The number of pounds of air-dry hay per acre produced per day of growing season is presented in table 19, both for the normal and the July 1 dates of seeding. The results indicate that the second cutting of Sudan grass grew very slowly as compared with the first, also that the differences between Sudan grass, sorghum, and millet were less on a daily than on a seasonal basis.

TABLE 19.—*Weight of hay produced per day by Sudan grass, sorgo, and millet in close-drilled seedings at two different dates for the years indicated*

Normal date of seeding—average late May to early June		Late date of seeding—average July 1	
Crop	Daily production per acre, 1921–28	Crop	Daily production per acre, 1921–28
	Pounds		*Pounds*
Sudan grass, first cutting[1]	65.1	Sudan grass[2]	68.1
Sudan grass, second cutting[1]	26.9	Red Amber sorgo	78.3
Red Amber sorgo	73.1	Millet	51.0
Goldmine millet	62.6		
German millet	58.6		

[1] Average of 10 years, when a second cutting was made.
[2] White Wonder, 1921 and 1922; Siberian, 1923; Goldmine, 1924–28.

SEED PRODUCTION

Experiments with Sudan grass in different widths of rows for seed production were conducted during the period 1913–23. The plots were surface planted with a grain drill on land intensively prepared, often including fall plowing or fall listing in the preparation. The grass was seeded from May 23 to June 6, except in 1915 and 1923 when wet weather delayed the work. Good stands and satisfactory vegetative growth were generally obtained, but the seed yields were usually disappointing. Drought in July and August was a limiting factor in seven seasons, and wind shattering the seed heads reduced yields in at least 6 years. In four seasons, when the crop was injured in midseason by drought or hail, it approached maturity late in September when the nights were cold; ripening therefore was very slow. In nearly all seasons the prolific tillering of the Sudan grass, accompanied by a long-continued period of heading, resulted in very uneven maturity. Less than half the seed was ripe enough to cut at any one time, and if harvest was delayed, the early heads were usually subject to severe shattering. In 1921, the only season of really satisfactory results, the plots were seeded May 21 and harvested August 18. Drought checked vegetative growth after the main heads came out and encouraged them to mature rapidly and evenly. The month also was one of continuously low wind velocity.

The results given in table 20 show that yields from 486 to 602 pounds of seed per acre were produced in the best season, 1921. In four other seasons the yields ranged from 200 to 400 pounds. The averages, around 200 pounds, are too low to be profitable at the prices now received for seed.

TABLE 20. *Seed yields with accompanying yields (air-dry) of the total crop of Sudan grass grown in rows variously spaced, 1915–23*

Year	Seed yield per acre from row widths of			Total crop yields per acre from row widths of		
	24 inches	40 inches	80 inches	24 inches	40 inches	80 inches
	Pounds	*Pounds*	*Pounds*	*Tons*	*Tons*	*Tons*
1915	98	75	15	2.93	3.21	2.36
1916	15	15	28	1.19	1.01	.85
1917	300	260	260	3.06	3.35	2.32
1918	62	75	92	1.11	1.28	.98
1920	500	217	205	2.59	2.20	1.13
1921	486	401	529	2.50	2.36	2.32
1922	507	602	186	3.84	1.98	1.68
1923	240	201	318	1.59	1.59	1.15
	0	0	0	1.88	2.00	1.67
Average	302	217	195	2.05	2.00	1.71

When the prices of seed were as high as they were prior to 1915, a good profit was realized by most growers irrespective of yields. The Sudan-grass seed industry now seems stabilized at prices usually less than 5 cents a pound to the grower, and seed production is therefore profitable only to growers who, by reason of favored conditions and special skill, can produce high yields at a minimum cost. Sudan-grass seed growing is now of very limited interest to most farmers in western Kansas under dry upland conditions. Numerous small fields for this purpose are noted in years when the winter-wheat crop

has failed and left more land than usual for spring crops, but low prices usually follow these increased acreages.

Sudan-grass straw left after threshing has considerable feeding value, but is so coarse and contains so much crude fiber that it compares rather unfavorably with hay cut at or before the heading period. The quantity of straw to be expected from a seed crop is indicated by the yield of the total crop in table 21. The total crop minus the seed yield would represent the approximate yield of straw.

SORGO-SUDAN GRASS HYBRIDS

Several natural hybrids of Red Amber and Sudan grass were grown in 1915 and 1916. Hybrids of these same two plants were later received from H. Willis Smith under the names Ford sorgo and Supersorghum. A Sudan-Freed sorgo hybrid was received from Smith under the name Kansarita. Sudamber and Sudureane were Black Amber crosses with Sudan grass received in 1919 from M. G. Mueller, Colome, S.Dak. These hybrids were intermediate between the sorghum and Sudan grass in yield and coarseness, but inferior to either in forage quality and were not promising.

Sudan-sorghum was grown in 1922 under F.C. 04263 and F.C. 11530, also under the name Mammoth Forage, and in 1923 it was grown under the name of Sweet Sudan. In all cases it stooled and headed much like Sudan grass, but its stems were as coarse as those of close-drilled sorghum.

MISCELLANEOUS GRASS SORGHUMS

Tunis grass (*Sorghum virgatum*) (S.P.I. 26301), which was grown at Hays from 1913 to 1915, is an annual closely related to Sudan grass. It was introduced into the United States from Algiers, Algeria, in 1909,[8] but has never reached commercial importance because it shatters its seed too quickly, is less leafy than Sudan grass, and tillers less freely. In addition, the awned seed is difficult to feed through a grain drill. Tunis grass is about 5 days earlier and makes a more vigorous early growth than Sudan grass. It is slightly more resistant to grasshopper attacks and to the red-spot leaf disease.

Several crosses of Tunis grass and sorgo were grown in 1916, but they were not promising enough at Hays to receive more than a preliminary test in cultivated rows. Those tested were F.C. 7471-1-3, 7475-4, and 7476-2-7.

At Hays a cultivated row of Tunis grass grew 3 to 4 feet tall, sent up a few heads, and retained some of its leaves in the very dry grasshopper year of 1913, when most other plants in the nursery were entire failures. A close-drilled plot of one twentieth of an acre dried up with scarcely a foot of growth in the main body of the plot.

Tunis grass and Sudan grass were compared in 40-inch rows at Hays in 1914 and 1915, two rather favorable seasons. The high yields in 1914 were due in part to seeding on fallowed land. Abnormal rainfall in 1915 was a favorable factor. Two cuttings were made each season and the average yields were: Tunis grass 4.18, Sudan grass 4.42 tons per acre of air-dry hay.

The grass sorghums tested in 1925 were as follows: Perennial Sudan, S.P.I. 56801, from Rhodesia grew 5 to 8 feet tall, was coarse

[8] VINALL, H. N., and GUTTY, R. E. Op. cit. (see footnote 7, p. 44.)

and stemmy and did not survive the winter. Black Sudan grass (*Sorghum versicolor*), S.P.I. 56802, from Rhodesia grew only 3 feet tall and proved to be a poor forage type, with freely shattering seed. Black Sudan grass, S.P.I. 61683, from South Africa grew only 2 feet tall, was not promising and was similar to S.P.I. 56802. Tabucki grass (*S. verticilliflorum*), S.P.I. 61674, from South Africa grew 6 feet tall with stems one half inch or more in diameter, each plant with 12 to 15 tillers lacking in leafiness. It did not mature seed at Hays.

MISCELLANEOUS GRASSES

About 50 grasses, including both annuals and perennials, were grown at Hays, usually in nursery rows, for one or more seasons. Most of them are definitely unsuited to dry-land conditions, and none has been recommended for farm use. Bromegrass, apparently as good as any of these grasses, usually made a good normal growth 2 to 3 feet tall in cultivated rows or hills, but in close-drilled seedings on the dry-land agriculture project it showed up very poorly.

BROMEGRASS

Bromegrass (*Bromus inermis*) received the most thorough test of the perennial grasses at Hays. A general field of 10 acres, partly on bottom land and partly on upland, was successfully seeded to bromegrass about 1902, and was promising during a few wet years early in its growth, but it produced very little growth later on because of drought and diminishing stands. The last of this grass was plowed up in 1913, and no other seedings of it on a field scale have been attempted.

The most extensive plot tests of bromegrass at Hays have been conducted in rotation no. 141 on the dry-land agriculture project, which was begun in 1906 and is still continued. This is a 6-year rotation of (1) oats, (2) corn, (3) winter wheat, and (4–6) bromegrass. The bromegrass is seeded in early spring at sowing time for oats on fall-plowed wheat stubble. It is usually drilled at 10 to 25 pounds to the acre, but often fails to produce a stand. In 11 years out of 22, 1906–27, a satisfactory stand was not secured during the first season that the plot was due to be in bromegrass. In 6 years a stand had not been established the second year, and in two cases a plot went through the full 3-year period without the establishment of a stand. It requires 1 to 3 clippings the first season to keep down weeds. It also requires several applications of poison to prevent grasshopper damage, and even if a stand is secured there is no return the first year. Growth sufficient to harvest for hay was not obtained from second- or third-year stands in the first 10 years of this test. Hay yields were obtained in 1916, 1919–22, and 1925–27. During these 8 years the yields varied from 0.27 to 1.10 tons annually, with an 8-year average of 0.59 ton per acre. There is not much chance of sufficient growth to cut for hay after the third year. An attempt to maintain a permanent stand of bromegrass around the laboratory was eventually given up in favor of buffalo grass.

Bromegrass is one of the earliest grasses to start growth in the spring, and an established stand would furnish a few weeks of excellent early pasturage; this possibility, however, does not warrant attempts to grow the crop. While bromegrass is fairly drought-resistant, it suffers too much from heat at Hays. It has been grown by farmers

with success farther northeast in Kansas, notably in Washington County.

Bromegrass was grown successfully in hills and cultivated nursery rows at Hays, along with other miscellaneous grasses, for several years, but from an economic standpoint it is a failure under field conditions.

JOHNSON GRASS

Johnson grass (*Sorghum halepense* var. *miliformis*), S.P.I. 34704, was grown in a single row test in 1913, but when the field was fall listed none survived the winter. Seeded again in another row in 1914, it survived one winter when undisturbed by tillage, but died out the second winter following deep plowing in December. Johnson grass was inferior to Sudan grass in forage quality and yield. While Johnson grass, because of its creeping rootstock habit, is a serious perennial weed pest in the South, it apparently can be controlled easily in the latitude of Hays by fall plowing.

FUNDI

Fundi (*Digitaria exilis*) is an annual and a close relative of crabgrass. It was introduced from Africa, where it is said to have been cultivated considerably by the natives as a grain crop. Preliminary tests of it at McNeill, Miss., and Lubbock, Tex., in 1920 indicated much promise for it as hay and perhaps as pasture. It was then grown at Hays in 1921 and 1922, both in close drills and in cultivated 40-inch row plots of one twentieth of an acre each. It was seeded rather shallow, with a grain drill, on well-prepared land and with favorable conditions prevailing. The seeding dates were May 23 and June 7 for the respective years, and in each case the grass required 2 to 3 weeks to come up. Meanwhile, pigweeds came up, which would have smothered the fundi except for clipping in 1921 and hand weeding in 1922. The grass reached a height of about 8 inches in both seasons, while sorgos, Sudan grass, and millet were making excellent yields under the same conditions. Fundi would not even have made good pasture at Hays, for the plants were shallow rooted and would have been pulled up or tramped out easily.

RYEGRASS

Plot tests of the following ryegrasses (*Lolium* sp.) were attempted in 1924: F.C. 2361, Italian ryegrass; F.C. 2362, perennial ryegrass; F.C. 2379, Westerwold ryegrass; F.C. 2383, Wimmera ryegrass; and F.C. 2425, Tystofte Danish ryegrass. Uneven stands were obtained, and the grasses suffered from drought and weed competition, produced very little, and did not survive the dry winter. Square-rod plots of these ryegrasses seeded in 1925 were equally poor. Similar land, however, produced from 2 to 3 tons of Sudan grass per acre.

NURSERY EXPERIMENTS

Attempts to establish a nursery in 1913, principally of *Bromus* and *Agropyron* selections, were unsuccessful, due to insects and severe drought. In 1914, nursery rows of the following were established: *Agropyron elongatum*, S.P.I. 25084; *A. intermedium*, S.P.I. 25085; *A. tenerum*, S.P.I. 23264; *Agrostis alba*, S.P.I. 25638 and 34887;

Bromus inermis, F.C. 468, 469, 473, 481, 492, and 1441; *Elymus sibiricus*, F.C. 6903 and S.P.I. 24470; *Lolium italicum*, S.P.I. 34277; *L. perenne*, S.P.I. 34278; *Phleum pratense*, S.P.I. 29492; *Festuca* sp., S.P.I. 32387. Seeded May 11, in cultivated rows 2 feet apart, all of these made 8 to 10 inches of growth in 1914, which was a normal season. *Lolium italicum* and *L. perenne* did not survive the winter. The others made a remarkable growth (30 to 50 inches) in the very wet season of 1915. The *Bromus* selections varied as to erectness and spreading habit, showing the possibilities and the need for selection work. Bromegrass was rated first in the above collection of grasses, both as a hay and a pasture possibility. *A. tenerum* was rated second as a pasture prospect. *A. elongatum* and *A. intermedium* were heavy-yielding hay types. Timothy and redtop made a growth similar to that made by the grasses in the eastern United States. Such results, of course, far exceed any possibilities the grasses would have under normal field conditions.

The following grasses were established in the nursery by setting out rooted plants in the springs of 1926 and 1927. This is a much more satisfactory method than attempting to start a nursery direct from the seed, especially if the seed is of low germination and the land foul with weeds.

Aeluropus littoralis, S.P.I. 61388.
Agropogon strigosum, S.P.I. 66341.
Agropyron repens, S.P.I. 58866.
Agropyron ciliare, S.P.I. 64765.
Ampelodesma bicolor, S.P.I. 60319.
Arundinella villosa, F.C. 04141.
Brachypodium japonicum, S.P.I. 59353.
Bromus erectus, S.P.I. 68066 (from seed).
Bromus sp., S.P.I. 64914.
Calamagrostis epigejos, S.P.I. 57279.
Calamagrostis sp., S.P.I. 68408.
Eragrostis fascicularis, S.P.I. 54404.
Festuca interrupta, F.C. 03281.
Festuca ovina sulcata, S.P.I. 57517.
Heteropogon contortus, F.C. 04615.
Koeleria cristata, F.C. 04626.
Nassella sp., F.C. 04682.
Panicum repens, S.P.I. 51158.
Poa australis, S.P.I. 56910.
Poa sp., S.P.I. 53117.
Sorghastrum sp., F.C. 05049.
Sporobolus sp., S.P.I. 58779.
Stipa pubescens, S.P.I. 56569.
Stipa papposa, F.C. 05040.
Stipa sp., F.C. 03074.
Trisetum carpaticum, S.P.I. 59700.
Zoysia japonica, S.P.I. 29016.

Two aggressive, rapidly spreading grasses, *Agropyron repens* and *Calamagrostis epigejos*, have attracted favorable attention as pasture possibilities. Work with these and several of the next most promising types has been continued at Hays under varied conditions. The collection as a whole, aside from the two just mentioned, has been disappointing. The following were annuals, under Hays conditions, and of no particular interest:

Arundinella villosa, *Heteropogon contortus*, *Nassella* sp., *Stipa papposa*, *Sorghastrum* sp., *Panicum* sp., *Poa* sp., *Eragrostis fascicularis*, *Stipa* sp., *Sporobolus* sp., *Stipa pubescens*, *Ampelodesma bicolor*, and *Bromus* sp.

Festuca interrupta, *Koeleria cristata*, *Brachypodium japonicum*, *Poa australis*, and *Festuca ovina sulcata* were wiry, scanty-leafed bunch grasses. *Aeluropus littoralis* (died 1928) and *Zoysia japonica* made only a small growth.

Five others are of some promise as follows: *Stipa* sp., F.C. 03074, competing with bromegrass as a hay grass; *Agropyron ciliare*, S.P.I. 64765, and *A. strigosum*, S.P.I. 66341, vigorous, erect, and apparently palatable pasture or hay types during early spring, but nonspreading in habit; *Bromus erectus*, S.P.I. 68066, a flat-growing pubescent-leafed bromegrass, possibly a pasture type, but likely inferior to regular *B. inermis*; *Calamagrostis* sp., S.P.I. 68408, a fine-stemmed vigorous type with abundant tender leaves, best quality in the whole

collection, but its usefulness is doubtful on account of its nonaggressive habit.

The problem of securing a perennial grass suitable for seeding for hay or pasture under dry-land conditions has been of much interest ever since the native sod was extensively broken up. While it has been solved to some extent in the northern half of the Great Plains, the demand is still unsatisfied in the Hays section, and it is doubtful if any of the foregoing grasses will withstand successfully the adversities of general field and pasture use. In the opinion of the writer, it is more practicable to get land back into pasture in this section through the use of sweetclover than through the use of tame grasses. Interesting possibilities exist, however, in reestablishing buffalo-grass sod alone or in combination with sweetclover, and these possibilities are now being investigated at Hays.

MILLET

NURSERY EXPERIMENTS

Nursery work with millet included the testing of (1) 19 selections received from Akron, Colo., when the Hays project was establishd, and (2) introductions from foreign countries. A total of 127 lots were grown one or more seasons,[9] and detailed notes were included in the annual reports with respect to the more important vegetative and head characters. The results are negative from the standpoint of developing improved varieties, but will be discussed at sufficient length to show the results obtained. Millet breeding appears to offer very little promise as compared with the breeding of other forage crops, because of the declining importance of millet and the uniformly poor forage quality of most of the introductions.

The 1913 millet nursery was destroyed by drought when the plants were a few inches tall, but in other years they had opportunity to make normal development. In 1914, Goldmine millet selections F.C. 6910 and 6913 were noted as superior in leafiness to the other lots from Akron, Colo. From 1 to 4 selections each of the varieties Proso, Kursk, Goldmine, Hungarian, Siberian, Japanese, and Common were included in the Akron collection. These tests indicated the possibility of some improvement in the ordinary varieties by selection, if the millet crop was considered of sufficient importance to warrant several years of detailed head-to-row work.

There was a wide variation among the introductions tested, but nearly all were more or less coarse stemmed, and many were deficient in leafiness. Those of sufficient leafiness to attract favorable attention were often late maturing and suffered more from drought than the earlier sorts. The introductions came largely from Manchuria, Siberia, and other sections of China and Russia, but a few were received from scattered points in Asia, Europe, and Africa. The millets of the world have been rather thoroughly studied, and apparently they are less developed as forage than as seed crops.

[9] The following lots were tested and detailed notes may be found in the unpublished reports for the years indicated on file in the Division of Forage Crops and Diseases:
1913, F.C. 6841, 61523, 61926, 61930, 61951, S.P.I. 18622, 20856, 22189, 27756, 27801, 27803, 27901, 27905, 27883, 27891, 27896, 28029, 28018, 28735, 28737, 29002, 29030, 29132 29036, 29028.
1914, F.C. 6841, 61523, 61926, 61930, 61951, 6001, 6006 6915, 8509 8512, 8514, 8516 8518, S.P.I. 18505, 20856, 22189, 22400, 27889, 27899, 27901, 27903 27905, 27903, 27894, 28735, 29000, 29002, 29030, 29132, 29033, 29035, 29306, 29028, 34771, 35327, 35339, 35340, 35312, 36673, 36796.
1922, F.C. 64250; S.P.I. 48001, 53047, 53048, 54438.
1924, F.C. 64250, 11536 11536, 11538 11503, 11570; S.P.I. 48001, 53047, 53048, 54438, 56399, 57684, 57867, 59328
1925, F.C. 64250, 11536-11540, 11551 11556, 11559 11561; S.P.I. 48001, 53047, 56399, 57684, 57867, 60337, 60338, 60339, 62406, 62407, 62603, 62604, 63700.
1926, S.P.I. 62603, 63700, 64351, 65519, 65562, 67923, 67924, 66347 66365.

VARIETY TESTS

Eight varieties of millet were included for 5 years or more in duplicate 1/20-acre plots for hay production during the period from 1914 to 1928. Seed yields were taken from the same plots from 1920 to 1928. The land was thoroughly prepared throughout the spring and the average date of seeding was June 7. The yields obtained, together with averages of the heights and of the lengths of season, are given in table 21.

Kursk and Siberian are two orange-seeded types noted for early maturity. Like common millet, they produce dependable but light forage yields and relatively high seed yields under dry-land conditions. Hungarian and Goldmine, while differing in seed color, appear practically equal in forage and seed-production habits, and intermediate in yields and maturity among the varieties here discussed. White Wonder and S.P.I. 56398 are very much alike, coarser, taller, and

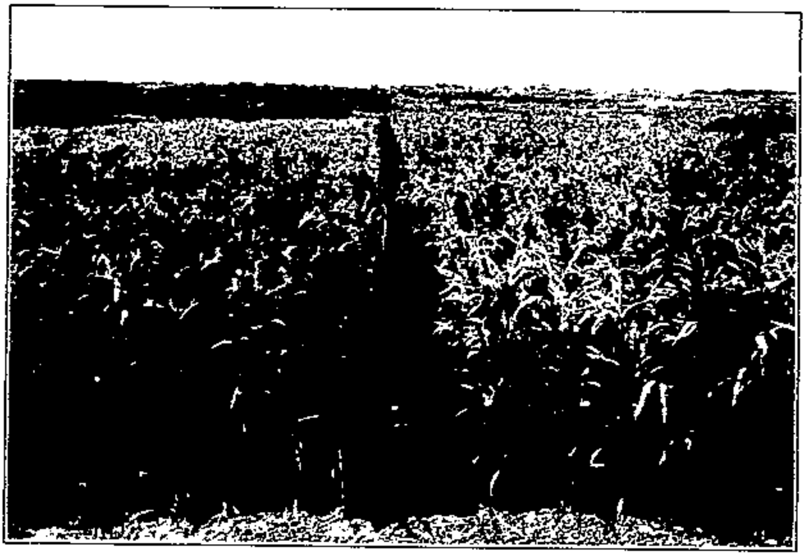

FIGURE 20.—German millet (right), White Wonder millet (left). The latter, a new variety, is a heavy seed producer but not as leafy as the German.

later than the first five named. The seeds are larger, rougher, and more nearly round than the other millets grown. The plants have a longer, heavier head than most millets and lodge more readily. They are too stemmy in proportion to foliage to rank high as forage crops (fig. 20). German is also coarse, but it is much leafier and is the best millet for more humid conditions. Because it is lacking in earliness and drought resistance, it is not well adapted to the climatic conditions at Hays in most seasons.

Siberian, Common, Hungarian, and German are well-known commercial varieties. Siberian or a selected strain known as Kursk are favorites in extreme western Kansas. Common is also grown in that section to some extent. The heads of German and Common are much different in shape, but the seeds of both are light yellow, and it is very difficult to distinguish the seed of one variety from that of the other.

TABLE 21.—*Yields and agronomic data of millet varieties grown at Hays, Kans., 1914–38*

Variety	Acre yields of air-dry hay															Average		Relative yield
	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Variety	Check	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Percent*
S.P.I. 56898										1.88	0.97	3.10	0.76	2.37	2.19	1.86	1.58	117
White Wonder							3.28	3.00	2.57	1.45	1.60	2.91	.77	2.49	2.15	2.18	1.96	111
German	3.11	3.41	1.17	1.95	1.85	1.68	2.09	2.41	3.25	1.27	.86	3.00	.67	2.09	2.08	2.05	1.91	107
Goldmine	3.08	1.98	1.45	1.86	1.69	1.76	2.52	2.51	3.05	1.35	.77	3.02	.73	1.75	1.73	1.91	1.91	[1]100
Hungarian		2.06	1.27	1.52	1.61	1.37	2.28	2.32	3.01	1.29						1.90	1.95	97
Siberian						1.17	1.08	2.16	2.69	1.36						1.89	2.16	87
Common	2.57	1.57	1.02	1.61	1.79	1.34	1.93	1.97	2.59	1.60						1.80	2.05	88
Kursk	2.64	1.67	1.29	1.39		1.03	2.04	2.14	2.89	1.37						1.81	2.11	86

Variety	Average height of plant	Average period from seeding to full harvest	Average period from seeding to maturity	Acre yields of seed									Average		Relative yield
				1920	1921	1922	1923	1924	1925	1926	1927	1928	Variety	Check	
	Inches	*Days*	*Days*	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Bushels* [2]	*Percent*
Kursk	31	51	71	15.4	22.3	32.8	12.1						20.7	17.2	120
Siberian	31	54	74	16.2	22.1	28.0	9.5						19.9	17.2	116
White Wonder	39	69	87	27.2	22.8	10.1	11.6	7.6	25.1	0	25.1	11.3	16.1	15.0	109
S.P.I. 56898	35	65	85				11.9	8.6	23.0	0	25.0	11.3	13.6	13.4	101
Common	32	57	77	10.8	18.1	29.7	11.9						17.1	17.2	101
Goldmine	33	61	79	11.8	18.3	23.7	11.9	5.8	33.0	0	11.6	13.2	15.0	15.0	[1]100
Hungarian	31	58	80	14.6	13.0	21.3	11.3						15.1	17.2	88
German	36	70	93	10.6	3.3	5.1	0	1.2	11.8	0	14.7	10.4	6.7	15.0	45

[1] Check or 100 percent yields of Goldmine for the same years in which the varieties being compared were grown.
[2] Bushel=50 pounds.

ALFALFA

ESTABLISHING ALFALFA ON BOTTOM LAND

Alfalfa in western Kansas is largely produced on bottom lands and is generally valued more highly than any other crop that can be grown on such land. Its success has depended largely on the ability of the long taproots to penetrate to ground water at 10 to 30 feet. During the period of rapid expansion in acreage from 1890 to 1910, no particular difficulty was encountered in establishing a stand. Then followed two of the most severe droughts in the history of this section (1911 and 1913) which, together with a heavy grasshopper infestation, destroyed many alfalfa fields. In the efforts to start alfalfa again, complaints arose even from the most experienced growers that new stands could not be obtained, especially on former alfalfa fields. Since that time the alfalfa acreage in the 46 western counties of

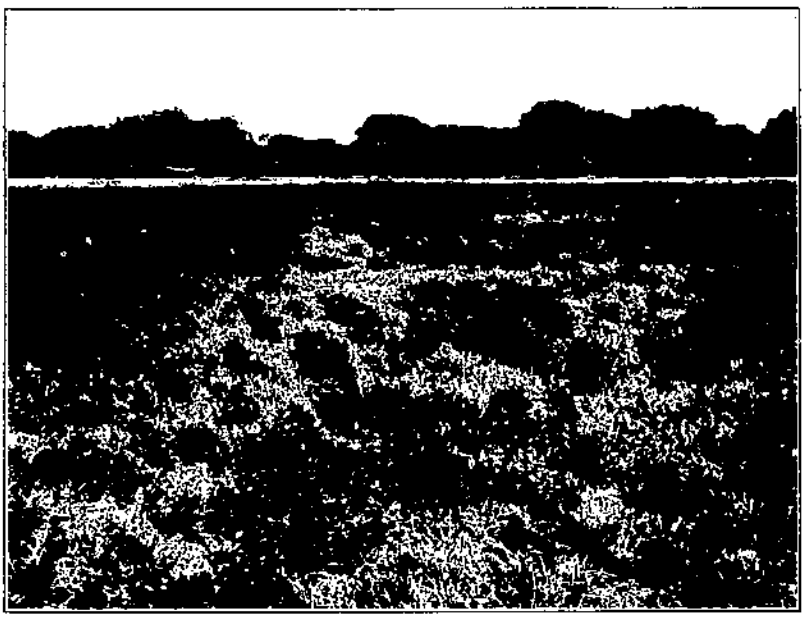

FIGURE 21.—A 20-year-old stand of alfalfa, showing an unsatisfactory stand. Effective methods of establishing good stands on such fields are being studied.

Kansas has declined steadily until in 1926 it was less than half that of 1910.

Other factors contributing to the decline have been the intense interest in wheat production from 1914 to 1920 and careless treatment of the alfalfa fields in the matter of cutting and pasturing.

With the founding of the Fort Hays Branch Station in 1902, alfalfa at once assumed an important place in the general bottom-land fields of the station along Big Creek, and eventually occupied more than 300 acres. About half was seeded before 1910, though one field of more than 100 acres was not sown until May 1914. Several smaller areas were put in about that time, and others as late as April 1919. From 1920 to 1928, alfalfa seedings on the station were insufficient to indicate whether any new difficulty in getting stands had arisen.

Meanwhile the older fields of the station began to thin out rapidly and by 1928 some of them had been plowed up and the others, including the 1914 and 1919 seedings, were failing.

As a result of this situation and of the growing conviction among farmers and scientific workers that the reestablishment of stands of alfalfa required detailed investigation, a new project was laid out for this purpose at the Hays station. A thin, grassy, 18-year-old field, where the water table stood at a depth of 20 to 24 feet, ample for 50 plots of one tenth of an acre each, and where the alfalfa was formerly excellent, was utilized for this test (fig. 21).

Beginning in 1926, enough land was plowed up each spring to seed 10 plots yearly from 1928 to 1932, inclusive.

The 10 treatments intervening between the plowing up of the old alfalfa and reseeding were planned as follows:

1. Sudan grass 2 years.
2. Sudan grass 1 year; fallow 1 year.
3. Kafir 1 year; fallow 1 year.
4. Corn 2 years.
5. Fallow 1 year; Sudan grass 1 year.
6. Fallow 1 year; kafir 1 year.
7. Fallow 1 year; small grain 1 year.
8. Fallow 2 years.
9. Fallow 1 year.
10. No intervening treatment.

The Sudan grass and small grains were sown in close drills and the corn and kafir in 40-inch rows. The first series of 10 plots was seeded on April 23, 1928, to Kansas Common alfalfa at the rate of 18 pounds to the acre. The season was unusually wet, and in spite of severe weed infestation fair stands were obtained from all treatments except no. 10, although the abundance of weeds necessitated reseeding nos. 1 and 7 on June 9.

On July 30, 1928, Big Creek rose and flooded this field from 1 to 2 feet deep, the water draining off within 24 hours. As soon as the land was dry enough, five plots of the second series, nos. 12, 13, 17, 18, 19, were seeded to alfalfa on August 6, instead of waiting until 1929. Excellent stands from this seeding went into the winter with a growth of 6 to 8 inches.

Practically all of the successful seedings of alfalfa recorded on the Hays station from 1902 to 1928 were made within the period from April 15 to May 15, but about once in 3 years good stands may be obtained from seedings made in August, preferably early in the month, and shortly after a good rain. If August seeding is to be attempted west of the line where alfalfa is a profitable upland crop, the land should be summer-fallowed and the seedling plants protected from grasshoppers.

ESTABLISHING ALFALFA ON UPLAND

Since 1906, alfalfa has been seeded at Hays each year on one or more plots in rotation no. 142 of the Division of Dry Land Agriculture. This is a 6-year rotation, consisting of alfalfa 3 years, oats 1 year, corn 1 year, and winter wheat 1 year. The alfalfa seedings have been made on fall-plowed wheat stubble on a well-prepared seed bed which was usually packed twice before seeding. Seedings have usually been made in April and in case of failure to secure a satisfactory stand have been reseeded a few weeks later, and if this failed further at-

tempts to get a stand were made in the fall. The land occupied by this rotation is some of the highest and best drained on the project, and is therefore typical of adverse rather than favorable upland locations.

The results as to stands and yields obtained are presented in table 22. A stand as tabulated here indicates that the alfalfa lived through the first season. Numerous cases are classed as failures where a satisfactory number of plants came up but died within a few months because of weeds, insects, or adverse climatic factors. From 1906 to 1913 the results were mostly negative, but from 1914 on improvement was shown, due to a more favorable cycle of seasons and to accumulated experience. More or less satisfactory stands were obtained in ordinary years, but only in very wet seasons such as 1915, 1920, 1927, and 1928 did the hay yields exceed a ton to the acre.

TABLE 22.—*Results as to stands established and yields obtained from alfalfa seedings on upland, 1906–28*

[Adapted from records of the Division of Dry-Land Agriculture]

Plot	Period in rotation that associated to alfalfa	Date of and obtained	Kind of stand	Tract-hands	Acre-yields of hay			
					First year	Second year	Third year	Total
				Number	Tons	Tons	Tons	Tons
A	1906–08	Apr. 15, 1906	Poor	2	--	--	--	0
F	1907–09	None	None	2	--	--	--	0
F	1908–10	Apr. 16, 1910	Thin	2	--	--	--	0
D	1909–11	do	do	3	--	--	--	0
C	1910–12	do	do	1	--	--	--	0
B	1911–13	Apr. 25, 1912	do	3	--	--	--	0
A	1912–14	do	do	2	--	--	0.48	0.48
F	1913–17	May 14, 1914	Good	8	--	0.46	3.19	3.65
F	1914–16	do	do	2	0.30	1.74	.85	2.89
D	1915–17	Apr. 27, 1915	do	2	--	.82	.10	.92
C	1916–18	May 11, 1916	do	1	--	--	--	0
B	1917–19	do	do	1	--	--	.81	.81
A	1918–20	do	do	2	--	.77	1.95	2.72
F	1919–21	May 28, 1919	do	2	--	1.91	.97	2.91
E	1920–22	Apr. 7, 1920	do	1	--	.80	.98	1.78
D	1921–23	Apr. 8, 1921	do	1	--	1.00	.78	1.78
C	1922–24	May 4, 1922	Thin	1	--	--	.10	.10
B	1923–25	Apr. 30, 1923	do	2	--	--	.40	.40
A	1924–26	do	do	1	--	.78	.27	1.05
F	1925–27	Apr. 21, 1925	do	1	--	.43	1.32	1.75
E	1926–28	Apr. 30, 1926	Fair	1	--	1.15	--	--
D	1927–29	Apr. 25, 1927	Good	2	1.30	--	--	--

[1] Stand present, abandoned, but to be worth cultivating.
[2] Failure to get or maintain stand. In some cases the first seeding failed but later seedings produced a stand.

Many upland farms having areas low enough to benefit from the run-off water from adjacent land may grow alfalfa successfully, but such favored areas usually may be utilized more profitably for the production of sorghums, Sudan grass, and perhaps other crops.

GROWING ALFALFA IN CULTIVATED ROWS

Seven unsuccessful attempts were made to establish alfalfa in cultivated rows on the Hays station during 1907-12. Agricultural authorities of that time hoped that the row method of alfalfa culture would extend the crop's usefulness throughout dry-farming sections, but the difficulties in getting stands immediately became apparent. Weed competition has been the leading cause of failure, but drought, torrential rains, soil blowing, and grasshopper attacks also have been

factors. The seven attempts were made as follows: September 28, 1907; April 27, 1908; September 7, 1908; June 17, 1909; May 17, 1910; September 1, 1911; and sometime in April 1912.

When the cooperative experimental work with the Division of Forage Crops and Diseases began in 1913, more detailed work with row alfalfa was outlined. Seedings made on April 14 and 15, 1913, were destroyed by rain and hail on May 2. As soon as dry enough, the land was cultivated lightly and harrowed on May 7, then reseeded on May 8 and 9, 1913. Excellent stands were obtained, but weeds, grasshoppers, and drought would have ruined them had not an excessive amount of effort been devoted to hand weeding and grasshopper poisoning. The alfalfa stems were bare of leaves during the late summer, but they remained green, and the plants revived promptly following the September rains. These stands were successfully maintained until the dry winter of 1916-17, when a noticeable thinning took place. The remaining plants occupied the land fairly well, however, for several years more until the dry winter of 1922-23 brought a second sharp decline in stands. Three of the four replications in this experiment were plowed up at the close of 1923, and the fourth at the close of 1927.

The experiments included cultivated rows 24, 30, 36, and 42 inches apart as compared with 12- and 6-inch drills. Four replications of the 12- to 42-inch rows were seeded in $\frac{1}{10}$-acre plots, with 6-inch drills occupying every third plat as a check. The 42-inch rows included both single and double rows, the latter consisting of two rows 6 inches apart, with 36 inches intervening for cultivation.

All plots were sown with a wheat drill, by stopping up such holes as necessary. Bran was mixed with the alfalfa seed to reduce the seeding rate. With a mixture of 2 parts of bran and 1 of alfalfa by bulk, and with the drill set to sow $2\frac{1}{2}$ pecks of wheat per acre, the seeding rate for alfalfa was 12 pounds per acre, with all holes in use. The amount sown to the row remained constant, the rate, for example, in 36-inch rows being only 2 pounds to the acre.

Cultivations were given only at such depths and frequency as necessary to control weeds. All plots were often cultivated lengthwise just as weeds started in the spring, using an alfalfa renovator of the hoe-drill type. The 24- to 42-inch rows were cultivated usually three or four times a season, using sweeps or small shovels. Weed control was not difficult after the first year, but, if neglected, the vacant spaces were quickly occupied by Russian-thistles or foxtail.

Grasshopper poison had to be applied every year except one to protect the crop. The applications varied from 1 or 2 to 6 or 8 a season, thus incurring additional expense.

The alfalfa produced a first cutting regularly in June, a second cutting in half of the years, and a third one in 1915. After 1915 the alfalfa made good growth when current rainfall was plentiful, but very little during dry periods as the roots were unable to reach ground water. The plants usually showed considerable bloom by June 1 and reached full bloom between June 5 and 10. The first cuttings were made between June 7 and June 27, the average date being June 15. The first cuttings were often delayed a week or two beyond the intended time because of rain and the demands of other work.

In 1916 and 1922, with timely rainfall, the alfalfa produced a good second cutting, after which, on account of drought, it made very

little recovery. During each of these dry autumns it suffered losses of about one third of the remaining stand. By contrast, the second growth in 1918 and in 1921, almost enough for a light cutting, was not harvested, and though the winters were medium dry, no noticeable losses of stands occurred.

The alfalfa in cultivated rows was difficult to mow, as the crowns were high and many stems tended to recline. Extra guards of the type used for pea vines were often used on the mower with fair results. The wider the row interval, the greater was the difficulty in harvesting. The cultivated rows produced somewhat coarser hay than the close-drilled seedings, and the hay was sometimes dusty. These two factors were not serious, however, for upland alfalfa in this section is never very rank and coarse, and the hay gathers little dust if cultivated only in the early spring or just after a cutting.

The original plan in this row experiment was to use two replications primarily for seed production, but this idea was given up on account of unfavorable climatic conditions and insect damage. Information on the seed problem was gained mostly from 10 years of observation of an additional acre block of 36-inch rows, rather than from these plots. The wet and dry periods seldom occur at the proper time to produce a first-class crop of alfalfa seed, and, furthermore, it is very difficult to prevent grasshopper injury during the late bloom and early maturity.

TABLE 23.—*Dates of cutting and yields of alfalfa hay grown on uplands in row widths of 6 to 42 inches, 1914–27*

Date of cutting	Acre yields of hay (tons) for row widths named						
	6-inch rows	12-inch rows	24-inch rows	36-inch rows	36-inch rows	12-inch rows, single	12-inch rows, double
June 11, July 17, 1914	1.02	1.16	1.22	1.18	1.26	1.02	1.05
June 19, Aug. 4, Sept. 30, 1915	2.39	2.63	2.40	2.52	2.57	2.02	2.11
June 16, July 7, 1916	.65	.66	.56	.53	.47	.62	.37
June 12, Sept. 11, 1917	.76	.76	.70	.65	.71	.62	.74
June 10, 1918	.29	.24	.26	.31	.26	.30	.35
June 17, 1919	.34	.62	.36	.30	.36	.33	.41
June 7, Aug. 30, 1920	1.46	.62	.91	1.03	1.02	1.03	1.12
June 22, 1921	.67	.61	.57	.51	.50	.61	.50
June 12, July 18, 1922	1.81	1.86	1.62	1.78	1.89	1.80	1.16
June 10, 1923	.29	.45	.39	.33	.32	.65	.26
June 14, 1924	.77	.76	.80	.79	.71	.78	.78
June 15, 1925	.24	.27	.28	.42	.36	.39	.35
June 8, 1926	.36	.45	.42	.30	.32	.47	.62
June 27, Sept. 20, 1927	.48	.56	.54	.52	.50	.64	.62
Average, June 15 (first cutting	.80	.84	.83	.83	.83	.77	.83

In table 23 the data on hay production for 1914–23 are based on the averages for four replications and from 1924–27 on the one remaining replication. The 6-inch check plots for the two periods consisted of 10 and 4 years, respectively.

Very little difference in yields is shown among the different row widths for any year or in the 14-year averages. It appears that the yield is dependent on the total moisture available, irrespective of the distribution of the plants within the limits tested. In this section the close-drilled method seems preferable on account of quality of hay and economy in management.

It is evident that all methods were unprofitable in most seasons, for in only 4 years did the yields amount to as much as a ton per acre. For those 4 years, 1914, 1915, 1920, and 1922, the averages for different methods ranged from 1.34 to 1.61 tons per acre. In the same 4 years Sudan grass close-drilled at the rate of 20 pounds per acre averaged 3.65 tons per acre. For the 10 poorest years the average alfalfa yields were 0.52 to 0.61 ton and that of Sudan grass 2.26 tons per acre.

Alfalfa was tested in cultivated rows for several years prior to 1918, by seven of the best farmers in western Kansas. Four of these farmers were located in Gove County, and one each in Cheyenne, Wallace, and Stanton Counties. The writer observed the results from time to time and noted that all obtained good stands in rows 30 to 42 inches apart. They were generally well pleased with their results in 1914 and 1915, but in the 3 following years yields were low and Russian-thistles either crowded the alfalfa out or caused more trouble than the alfalfa seemed worth. The only grower of the 7 who is known to have continued growing alfalfa in rows seeded 20 acres in 32-inch rows on recently broken prairie upland in western Gove County in 1923 and 1925 and obtained results satisfactory to him by irrigating the alfalfa from a large windmill. He gets larger yields from a broadcast plot also watered from the mill but finds the row method better for the even distribution of the water. Very close attention is given to keeping the middles clean, also to destroying rabbits which, if left unchecked in winter, would soon destroy the alfalfa.

EFFECT ON STANDS AND VITALITY OF ALFALFA REMAINING UNCUT OR BEING HARVESTED FOR SEED

Part of a 4-acre bottom-land field of alfalfa seeded in May 1914 was used for experiments to determine the effect on the alfalfa plants of allowing them to mature seed and of leaving the fields entirely uncut for as long as 3 years. The following schedule of cuttings was carried out on duplicate plots of three-fortieths of an acre for the 3-year period 1915–17: (1) Hay each year; (2) cut for seed first year, hay second year, seed third year; (3) cut for hay first year, seed second year, seed third year; (4) no cutting first year, then cut for seed 2 years; (5) no cutting until end of third season. Plots cut for hay only were used as checks in every third plot and were harvested three times in 1915, twice in 1916, and four times in 1917. Those being left for seed were cut twice in 1915, once in 1916, and twice in 1917. The cuttings for hay were made as nearly as possible at the one third bloom stage; those for seed stood until seed had formed, though not necessarily matured.

The growth on the four plots unharvested in 1915 was so heavy that the stand was thinned, probably due to smothering through the winter, recovering slowly in the spring of 1916. The loss was estimated at one third, though enough plants remained to be considered a satisfactory stand. The two plots left uncut 3 seasons were not injured particularly by the dead vegetation, except that this attracted numerous field mice to winter there and to do noticeable but not serious injury to the alfalfa. At the close of 1917 all plots were cleared off with the intention of cutting them regularly for hay and to thus measure the effect of the previous treatments on the vitality of the plants.

The season of 1918 was relatively dry, and for the first time in this experiment the growth was exceedingly spotted, with no apparent relation to previous treatments, nor uniformity within any one plot.

The average yields of hay, in tons per acre, for 1918 following the five treatments outlined were as follows: (1) 3.29; (2) 4.26; (3) 3.49; (4) 2.18; and (5) 3.80. These differences were wholly without significance, but observations made during the experiment indicated that allowing the crop to stand beyond the hay stage appeared neither to have injured nor stimulated the vitality of the plants at any time.

CULTIVATION OF CLOSE-DRILLED ALFALFA ON BOTTOM LAND

Cultivation of some sort had often been given to general fields of alfalfa of various ages and stands on bottom land at the Hays station during a period of several years ended in 1913. A limited amount of experimental plot work with different types of machines had also been carried on prior to this date, but the results did not warrant recommending any of the cultivation methods tried. Among the machines used were the ordinary disk, the spike disk, a spring-tooth harrow, and a patented renovator with hoe-drill type of teeth.

When cooperative work was begun with forage crops in 1913, further work on this subject was outlined. For this purpose a field of 4 acres was seeded to common alfalfa in May 1914, and a good stand was obtained. Cultivation treatments were given for the 4 years 1915–18 on duplicate three-fortieths-acre plots. On account of the lack of soil uniformity apparent in the results obtained from 1916–18, and also because of the lack of response, favorable or otherwise, to the treatments, the experiment was then discontinued. The tillage methods employed and the yields obtained are shown in table 24.

TABLE 24. *Yields of hay from close-drilled alfalfa on bottom land under different forms of cultivation, 1915–18*

Cultural treatment	Acre yields—tons				
	1915	1916	1917	1918	Average
No cultivation (check)	1.60	1.75	1.38	1.37	2.13
Double disked and harrowed in early spring	4.59	2.02	1.65	1.57	2.21
Single disked and harrowed in early spring	4.27	1.97	1.43	1.43	2.15
Single disked in early spring and after each cutting	4.79	1.41	1.60	1.86	2.17
Single disked only in early spring	5.65	1.36	1.69	2.12	2.26
Renovator with hoe-drill type of rounded shovels used in early spring and after each cutting	3.69	1.80	1.47	1.31	2.41
Same renovator as above, used only in early spring	4.95	1.51	1.36	1.11	2.39
Spring-tooth harrow with 2-inch teeth, used in early spring	4.11	1.51	1.22	1.18	2.08
Spring-tooth harrow with 2½-inch flat shovels, used in early spring	4.71	1.28	1.61	1.82	2.29

In a relatively new thick stand like this, with no weed or grass problem involved, it is not surprising that cultivation had little effect on yields. Disking seemed to thin the stands to a limited but not injurious extent. The other forms of cultivation had no appreciable effect on the plants.

From the experience with older stands previous to 1914 and with a new stand from 1915 to 1918, it was concluded that cultivation of close-drilled or broadcast stands of alfalfa was not profitable. The best field of alfalfa yet grown on the station, 100 acres seeded in 1914, never received cultivation, but remained in first-class condition until 1927–28. When alfalfa becomes grassy, it may appear to be helped by cultivation, but generally it might as well be plowed up.

VARIETY TESTS

Several commercial lots of alfalfa were compared in duplicate one-tenth acre plots on upland, using Kansas-grown seed of Common alfalfa as a check. One experiment was conducted in 36-inch rows, and another in close drills. About 175 small lots, including importations from many alfalfa-growing sections of the world, were also grown in nursery rows for several years.

The results of this work were negative from the standpoint of finding a variety superior to the Kansas Common alfalfa. Several commercial varieties noted for winter hardiness, such as Grimm, Canadian variegated, Baltic, and regional strains of Common from northern latitudes or high altitudes, were close rivals of Kansas Common in yields, but showed no greater longevity or other qualities to warrant paying the higher prices usually asked in this area for the seed.

TESTS IN 36-INCH ROWS

This experiment was sown on May 9, 1913, at 2 pounds per acre on a well-drained area adjoining the width-of-row tests and was subject to the same early difficulties with weeds, drought, and grasshoppers. The yields of Kansas Common alfalfa were taken from the width-of-row experiment. These varieties differed comparatively little in yields. Such differences as occurred seemed more largely due to inequalities of stand than to varietal characteristics. Noticeable losses of stand occurred in all varieties following the dry winters of 1916–17 and 1922–23, but the crowns of the surviving plants spread out gradually and still occupied the rows reasonably well at the time the experiment was plowed up in December 1923. Yield data are shown in table 25.

TABLE 25.—*Yields of five varieties of alfalfa grown on upland in 36-inch rows, 1914–23*

Year	Kansas Common, S. P. I. 31116	Utah Common, S. P. I. 29758	Grimm, Dry Land 32	Brady, Dry Land 33	Turkestan, S. P. I. 21652
	Acre yield of hay tons				
1914	1.26	0.91	0.93	0.81	0.76
1915	2.25	2.06	2.05	2.16	1.71
1916	.71	.80	.72	.67	.53
1917	.51	.56	.59	.56	.52
1918	.78	.68	.67	.60	.51
1919	.36	.32	.34	.28	.19
1920	1.02	1.10	1.30	1.20	1.06
1921	.50	.46	.56	.53	.41
1922	1.10	1.30	1.31	1.19	1.25
1923	.72	.97	.87	.90	.71
Average	.96	.95	.94	.92	.78

TESTS IN CLOSE DRILLS

Seven varieties were included in the close-drilled variety tests of alfalfa seeded May 11, 1915. While this test was located in the same upland field as the row trials, most of the land was a little lower, especially at the north end of each series. The close-drilled experiment started out under very favorable soil conditions, a wet season following a year of fallow on one replication and of partial fallow on the other. The plots were drilled at 15 pounds per acre in rows 4 inches apart, using a regular alfalfa drill. Excellent stands were

secured and maintained for about 10 years, when they began to fail rapidly (fig. 22). Certain plots at the south end of each series were plowed up in the spring of 1927 and most of the others in the spring of 1928.

The yield data, together with the dates of cutting, are shown in table 26. The varieties are named in the order in which they occurred in the field, beginning at the north or more favorable end. Comparing each variety with its adjacent checks of Kansas Common, it is evident that there were no significant differences in yielding capacity of the varieties. But since the series as a whole averaged around a ton of clean, fine hay to the acre, with no expense after seeding except for putting up hay and for grasshopper control, the results were more encouraging than in the other upland alfalfa-growing experiments reported in this bulletin.

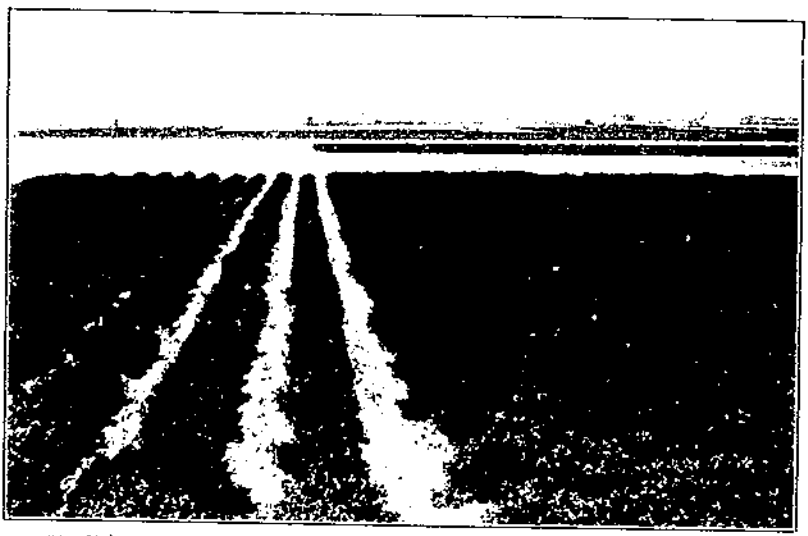

FIGURE 22.—Dakota Common alfalfa maintained a good stand in the row and close-drilled seedings for 10 years.

TABLE 26.—*Results of variety tests of alfalfa in close drills on upland, 1916–28*

Date of cutting	Acre yields of hay (tons)								
	Canadian variegated	Kansas Common	Baltic	Grimm	Kansas Common	Utah Common		Kansas[1] Common	Black Hills Common (S. Dak.)
						Nonirrigated	Irrigated		
June 16, July 6, 1916	1.17	1.31	1.50	1.29	1.20	1.17	0.96	1.13	1.09
June 12, Sept. 11, 1917	1.49	1.43	1.29	1.76	1.45	1.40	1.40	1.21	1.12
June 30, 1918	.86	.81	.89	.81	.74	.70	.69	.72	.77
June 17, 1919	.95	.90	1.06	1.02	.90	.96	.92	1.05	1.07
June 7, Aug. 30, 1920	1.79	1.70	2.03	1.79	1.71	1.59	1.13	1.55	1.51
June 22, 1921	.85	.83	.80	.73	.77	.70	.72	.73	.71
June 12, July 19, 1922	1.87	1.98	2.05	1.85	1.88	1.75	1.58	1.71	1.71
June 18, 1923	1.00	1.08	1.13	1.04	1.11	1.06	1.04	1.13	1.19
June 11, 1924	.81	.72	.79	.74	.65	.58	.59	.64	.68
June 15, Aug. 17, 1925	.99	.96	.87	.85	.68	.92	.89	.89	.88
June 8, 1926	.60	.58	.65	.59	.48	.41	.46	.44	.42
Average	1.13	1.12	1.19	1.06	1.01	.95	.89	.92	.96

[1] Grown as checks.

NURSERY EXPERIMENTS

The principal nursery project undertaken with alfalfa was with regional strains collected by the United States Department of Agriculture from many parts of the world. The nursery was seeded in 1914 and 1915 on upland in rows 40 inches apart, and either 1 or 2 rods long. The seed was dropped in hills 18 inches apart, and the plants were thinned to one in the hill. Detailed records are available from 1914 to 1918 in the annual reports of the project for those years, with respect to such matters as number of plants, green weights of hay, habits of growth, survival, and value compared with that of Kansas Common alfalfa grown as a check.

The nursery included alfalfas from the following sources: Siberia, China, Turkistan, India, Turkey, Africa, Australia, Germany, Russia, Spain, Italy, France, Argentina, Ecuador, Peru, Canada, and the States of Utah, Kansas, the Dakotas, and a few others. The list included also 35 selections from the Akron, Colo., station and such varieties as Baltic, Canadian variegated, Grimm, and the yellow-flowered species, *Medicago falcata*.[10]

As a net result of this work, it was concluded that Kansas Common is as desirable as any, and superior to most varieties for conditions at Hays. It is sufficiently winter-hardy, yields with the best, and has good growth habits. Only a few lots suffered serious winter-killing, namely, those from Spain, Ecuador, Peru, Italy, and Australia. Such varieties as Grimm, Baltic, and Canadian variegated were excellent ones in these tests, but showed no qualities warranting payment of a premium for the seed. Several introduced alfalfas were coarser stemmed and less leafy than Kansas Common. The prostrate habit of the yellow-flowered ones was objectionable.

While some of the lots were probably as good as Kansas Common and excelled it in one or more particulars, the results were negative from the standpoint of bringing out any new varieties for distribution. Since this work was completed, alfalfa wilt, a bacterial disease, has become a limiting factor to alfalfa culture in eastern Kansas, though not as yet a problem in the semiarid territory.

SWEETCLOVER

Experiments with sweetclover were conducted extensively on upland at the Hays station during 1910–28. They included: (1) Cultural requirements, with special attention to date of seeding and to use of nurse crops; (2) effect of harvesting practices on hay yields; (3) use of sweetclover as pasture, and (4) trials of varieties, mostly on a nursery-row basis. Experiments under (1) and (2) were conducted mainly on duplicate $\frac{1}{20}$-acre plots or their equivalent. Pasture data as to carrying capacity were obtained on small fields of several acres each.

[10] Space does not permit a detailed report here on the different alfalfas grown in the Hays nursery, but a list of the serial numbers grown is given, showing the scope of the work:

F.C. 910, 914, 915–919, 923–927, 929, 930, 974, 976–985, 5701–5703, 6501, 6931–6935, 6971.

S.P.I. 3507, 3508, 3550, 9150, 12540, 12604, 12605, 13130, 13769, 13857, 13909, 14786, 16308, 17092, 18620, 18751, 19531, 19822, 19968, 20137, 20718, 20722, 20726, 20806, 20988, 21022, 21032, 21195, 21217, 21242, 21247, 21260, 21735, 22001, 22117, 22784, 22788, 22789, 22790, 22918, 23203, 23391, 23396, 23451, 23781, 23625, 23658, 23752, 24451, 24452, 24455, 24603, 24635, 24835, 24836, 24837, 25022, 25115, 25102, 25537, 25605, 25606, 25607, 25632, 26612, 27217, 27231, 27246, 27247, 27267, 27305, 27307, 27371, 27372, 28070, 29116, 29212, 29087, 35760, 31116, 35085, 35086, 35435–35438, 35451–35460, 38461, 38843, 38852.

In addition 31 lots of seed representing, for the most part, commercial varieties from different parts of the United States were included.

Except when discussing varieties, the term sweetclover as used here refers to the biennial white sweetclover, *Melilotus alba*. This species was grown in all the cultural experiments and is outstanding in commercial importance in this section.

CULTURAL PRACTICES

The problem of obtaining a stand of sweetclover is much more difficult under dry-land than under humid or irrigated conditions. Uncertainty of germination, along with delicate early growth, has been a great handicap to farmers in establishing stands of this legume, which, in its second year, is noted for its hardiness. This difficulty is reflected in sharp advances and declines of the sweetclover acreage in the central Great Plains area. Following wet years, when new seedings are successful and old stands yield well, interest in sweetclover increases and the acreage expands. With the advent of a dry or adverse season many stands fail and interest in the crop subsides for a time.

Weather, therefore, is the most important single factor in sweetclover production in the Great Plains area and, in seasons of poor or badly distributed rainfall, causes a large percentage of stands to fail, regardless of the cultural methods used. Nevertheless, some cultural practices are very much better than others, and while good practices do not guarantee a stand of sweetclover in poor years they unquestionably reduce the mortality and practically insure a stand if the conditions are fair or better.

In 158 plantings of sweetclover at the Hays station during the period 1910–28, 88 stands were classed as good or fair at the end of the first season and 70 as poor or failures. The percentage of successes was, however, much higher toward the end of the experiments than at the beginning. During the 4 years 1925–28, 47 successes were recorded against only 7 failures. Each of the failures followed the use of a practice that was known at the time to be risky, 3 being due to August seeding, 2 to the use of wheat as a companion crop, and 2 were the result of allowing a 6-peck seeding of oats to stand too long. While it is true that the weather during this time was, on the whole, favorable, the good results can be attributed in large part to the increased skill with which the plantings were managed.

Next to weather, the most important requirement in sweetclover culture is a firm seed bed. This requirement, long recognized in the East, is doubly necessary in dry farming. Without exception, and regardless of weather or of other cultural practices, sweetclover failed at Hays when seeded on soil in a loose condition. The requirement of a firm seed bed was so obvious that proof by experiment seemed unnecessary. All experimental areas were plowed shallow, if at all, the seedings were made with a drill equipped with press wheels, and the soil was firmed with a surface packer before or after seeding, or both.

DATE OF SEEDING TESTS

The date of seeding test has long been a standard project in agronomic work in the western United States, since success or failure of a crop frequently hinges on this point alone. Accordingly, plantings of sweetclover were made at Hays at various seasons for several years. Definite schedules of planting were adopted and seedings were made as close to those dates as circumstances permitted. In

practice the dates were often advanced or retarded a few days to allow the seed to be planted in freshly moistened earth, since it was found that when the schedule was followed arbitrarily, as in certain months of 1913, 1914, and 1916, failure often could be foreseen on account of dry surface soil.

So far as sweetclover is concerned, the calendar alone does not suffice as a guide to planting. Successes, and also failures, were obtained over a wide range of dates. Furthermore, some dates having the greatest number of successes had also the largest number of failures. At no time of the year were results either consistently good or consistently poor. Since no definite tendency is apparent, the logical conclusion is that the date of planting is less important than the other conditions of culture.

Some phases of this matter need special comment. Recently popular support has been given to the idea that the most reliable method of obtaining a stand is to sow in February, or earlier, with unscarified seed. Apparently the supposition is that this is nature's method of seeding, thus subjecting the seeds to freezing and thawing, which ruptures the hard seed coats and allows moisture to enter the seeds, permitting germination of the 30 to 90 percent of hard seeds which occur in most lots of sweetclover.

There was opportunity in these experiments for only two early seedings; both were in February and both produced good stands.

In the Great Plains, however, there is often a serious drawback to such early planting. Practically all of the soils of the Great Plains are more or less heavily infested with Russian-thistle and pigweed. When sweetclover is planted in February it starts growth at about the same time as these weeds. The combined crop makes a heavy demand on the limited soil moisture. The result then is likely to be the exhaustion of the reserve moisture by midsummer, whereupon the weeds, being hardier, gain possession, and a promising stand of sweetclover is lost.

A more practical plan appears to be to defer sowing until early or mid-April and to use scarified seed and a companion crop of spring grain. By delaying the planting a little beyond the most favorable time for the grain the latter does not make the maximum growth, yet is strong enough to take the place of weeds. Most farmers are entirely willing to sacrifice a few bushels of grain for the sake of a good stand of sweetclover.

The first 10 days of May have frequently offered the best conditions of the year for sowing sweetclover seed. By this time one or more crops of weeds could have been killed, good rains may have provided an ideal condition of surface moisture, and the ground can be worked as finely as desired and packed to minimize the risk from soil blowing. The soil is also warm enough then for the clover to start off rapidly; yet since the growth is behind that of earlier seedings, the plants do not run out of reserve moisture so early in a dry summer. May seedings should be made without a companion crop, and then only if suitable conditions are present.

June seeding is feasible only in a wet summer. July seeding offers little opportunity because of the droughty conditions usually prevalent, but late July seeding may be successful in certain seasons when August proves to be wet. Early August offers a reasonable chance of a stand about once in 3 years, depending on heavy rains just before

seeding. After late August the autumn is often too dry, and sweetclover seedlings do not make enough growth to withstand the winter.

Volunteer seedings have proved feasible for keeping a tract continuously in sweetclover. The seed germinates early and abundantly, so abundantly, in fact, that the stand often has to be thinned in May with an alfalfa renovator. These early volunteer seedings are rather likely, in dry years, to run out of moisture at midsummer, but if rainfall is ample they make more first-season growth than is generally obtained from hand seedings.

USE OF A COMPANION CROP

The question of whether to use a companion crop (sometimes called a nurse crop) is quite as much of a problem in the Great Plains as in the East. If sweetclover is seeded in grain in the ordinary manner the latter is likely to use too much of the available soil moisture. If sweetclover is seeded alone, a weed crop arises which may use more moisture than would the grain. Furthermore, without grain there is

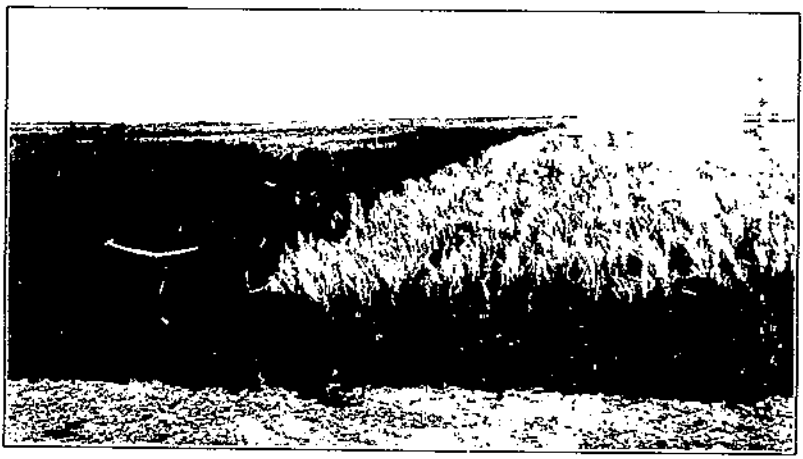

FIGURE 23.—The plot of sweetclover on the left was seeded March 27 without a companion crop; that on the right was seeded on the same date with 4 pecks per acre of barley.

no income from the land, since, except in unusual years, sweetclover does not make enough growth on dry land the first year to harvest.

In order to determine which, if any, grain to use, a series of tests with barley and oats was conducted at the Fort Hays station from 1915 to 1928. The results of these tests are shown in table 27. Winter wheat, the leading cereal crop of the section, was not used, because abundant practical experience had demonstrated that wheat is a very poor companion crop.

Winter wheat begins rapid growth early in the spring and, even when a thin stand, it soon becomes too rank and exhaustive of moisture to permit young sweetclover to survive. Spring grains, such as oats and barley, not only have a lighter, more open habit of growth, but the growth can be restrained by late seeding. A restrained crop of barley or oats is a real companion crop (fig. 23). Its growth is reduced to a point where it does not injure the sweetclover, yet it is large enough to suppress weeds. The grain yield of a restrained crop is lessened from 10 to as much as 50 percent, but this is usually considered worth while if a stand of sweetclover can be obtained thereby.

TABLE 27.—*Tests for stand of sweetclover grown with and without a companion crop, 1915–28*

Preceding crop	Date of seeding	Companion crop of						No companion crop	
		Barley			Oats				
		Rate of seeding	Early stand	Final stand	Rate of seeding	Early stand	Final stand	Early stand	Final stand
		Pecks			*Pecks*				
Fallow	Apr. 15, 1915	4	Good	Good	6	Good	Good	Good	Good.
Do	Apr. 23, 1921	7	do	do				do	Do.
Do	Apr. 16, 1926	3	Fair	do	3	Good	Good	do	Do.
Do	do	6	Poor	Fair	6	Fair	Fair		
Do	Mar. 27, 1927	3	Fair	Good	3	do	Good	Fair	Good.
Do	do	6	do	do	6	do	Fair		
Do	Apr. 13, 1928	3	Good	Fair	3	Good	None	Good	Good.
Do	do	6	do	do	6	do	do		
Total, good or fair number			7	8		7	5	5	5
Total, poor or none number			1	0		0	2	0	0
Lespedeza	Apr. 11, 1916	4	Good	Good	5	Good	Good	Good	Good.
Do	Apr. 20, 1917	3	Poor	None	3	Poor	None	Poor	None.
Do	May 5, 1917	3	Good	do	5	Good	do	Good	Do.
Do	Mar. 25, 1918	4	do	do	6	do	do	do	Do.
Do	Apr. 18, 1918	4	Fair	do	6	Fair	do	None	Do.
Do	Apr. 15, 1919				6	None	do	do	Do.
Do	May 2, 1919				6	do	do	do	Do.
Do	May 16, 1919				6	do	do	do	Do.
Do	Apr. 15, 1920	4	Good	None				Good	Fair
Do	Apr. 30, 1920	4	do	do				do	Do
Do	Apr. 26, 1922	6	Poor	do				Poor	None
Total, good or fair number			6	4		4	3	5	3
Total, poor or none number			2	7		4	7	6	8
Sorghum	Apr. 11, 1921	3	Good	Good	5	Good	Good	Good	Good.
Do	do	6	do	Fair	6	do	Fair		
Do	Mar. 27, 1925	3	Fair	Good	3	Fair	Good	Good	Good.
Do	do	6	do	do	6	do	do		
Do	Apr. 16, 1926	3	do	do	3	do	do	Good	Good.
Do	do	6	Poor	Fair	6	Poor	Fair		
Do	Mar. 27, 1927	3	Good	Good	3	Good	Good	Good	Good.
Do	do	6	do	do	6	do	Fair		
Do	Apr. 13, 1928	3	do	do	3	do	Good	Good	Good.
Do	do	6	do	do	6	do	do		
Total, good or fair number			9	10		9	10	5	5
Total, poor or none number			1	0		1	0	0	0

All experiments were handled to promote the welfare of the sweetclover rather than that of the cereal. However, the cereals were given every reasonable chance by the use of the earliest and best-adapted varieties. The soil was prepared as shallow and as firmly as practicable and the companion crop drilled first. The sweetclover was drilled immediately afterward, as shallow as possible, and the ground was thoroughly packed. The rate of seeding of the companion crop varied from 3 to 7 pecks per acre; the rate for the sweetclover was 20 pounds per acre except in 1915 and 1919, when 25 and 12 pounds, respectively, were used.

Barley as a companion crop showed an advantage over oats in greater openness of growth and in earlier maturity. A half seeding of barley often permitted a decidedly better start and a more even

final stand of the sweetclover than did the full rate of seeding. All the companion-crop treatments had an increasingly depressing effect on the growth of the sweetclover after the first week or two. The grain was mowed or bound at or just before maturity, leaving a 6-inch or 8-inch stubble, except in 1916 and 1918, when it was mowed more closely. With the higher stubble the clover was left almost unclipped, although in a critical condition temporarily because of dry soil and exposure to the sun. If the clover survived until a fair rain, it seemed to stand any sort of drought thereafter.

Companion crops were hardly profitable in themselves when seeded sufficiently late or sufficiently thin to allow the sweetclover a good chance. Hay yields of the companion crop were generally recorded, the average for 26 seedings of barley being 1.03 tons and for 23 of oats 1.09 tons per acre. From this it appears that a companion crop under dry-land conditions should not be used unless it seems likely to use less moisture than would a crop of weeds. Better than either a companion crop or weeds is to seed alone after one or more crops of weeds have been killed.

Seeding sweetclover without a companion crop usually resulted in severe competition from pigweeds, especially if the planting followed legumes or fallow. If the planting followed sorghum, weed competition was likely to be less severe than following legumes. In such cases the weeds were pigweed, Russian-thistle, and volunteer sorghum. While the weeds and spring grains grew less rapidly after sorghums, the sweetclover grew best on this land, evidently because the soil was firm. In dry seasons the sweetclover had a better chance on sorghum land than on any other plots.

On the whole, cultural methods had less influence on the growth of sweetclover than did the weather. In good seasons nearly all methods succeeded. In poor seasons all but the best methods failed. Perhaps the most practical method, all things considered, was to seed late with a thin seeding of barley on land that had previously been in sorghum.

HAY YIELDS AND EFFECT OF CUTTING

The yields of sweetclover hay for both years of growth have been obtained whenever possible each year from 1913 to 1928. The absence of yields for certain years is due to failures to get stands or to lack of sufficient growth in the first year to warrant cutting. The data obtained with respect to the first-year and second-year cuttings are shown in separate tables.

FIRST-YEAR CUTTING

Sweetclover hay production in the first season has not been encouraging. In only 7 out of 16 years was any cutting possible, and then only because of abnormal circumstances. In 1914 a 24-inch row method yielded 0.59 ton per acre, but row planting is impracticable because it requires hand weeding. The seedings of 1915 produced 1.26 tons per acre, but had the double advantage of being on fallow land and of having a very wet season. In 1918 and 1922 early spurts of growth produced a cutting, but the plants died later. Environmental conditions of 1925 duplicated those of 1915—a wet season with one replication on fallow and the other after cowpeas. Excessive moisture and volunteer stands accounted for excellent growth in 1927 and 1928, the yield of 1.55 tons in the latter year being the heaviest during the entire period. During the 16 years no hay yields with

stands surviving were produced by close drilled or broadcast sweetclover spring seeded on continuously cropped land, though it seems possible that about half a ton to the acre could have been taken from some of the plots seeded on sorghum land during the favorable cycle from 1924 to 1928.

Sweetclover was cut low for hay at different stages of the first season's growth in 1925, 1927, and 1928, and cuttings leaving a 6-inch to 8-inch stubble were also included in 1925. In the 3 wet years, results were much more favorable than is usually possible. Cutting with the 6-inch to 8-inch stubble showed no advantage to offset the loss in hay yields. The best time to cut was apparently when the growth reached 24 to 30 inches and before the leaves began to fall. In 1927 and 1928 the last cutting was of inferior quality, the plants

FIGURE 21.—Sweetclover of the second-year's growth being cut for hay.

having become more stemmy but less leafy since the preceding cutting. If cut at the right time, first-year sweetclover hay is fine and leafy and similar to alfalfa in value.

The plants generally survived cutting for hay or clipping for weed control at almost any stage during the first year, provided plenty of soil moisture was present. Otherwise, cutting or clipping at any time was attended with much risk. The effects of mowing new seedings of sweetclover in order to kill pigweeds have been noted in several seasons. In 1914 the plots were mowed closely when a thick stand of pigweeds was about half grown. The weeds sent out side branches and soon made a vigorous spreading growth, which was mowed again with difficulty. With dry weather following, the sweetclover did not survive such treatment. In 1915 the weeds were allowed to get more mature, and were mowed closely twice, on June 20 and July 28. In this very wet season the sweetclover survived. In 1916 the weeds were mowed closely on July 1 when 2 feet tall, and the sweetclover, with reserve subsoil moisture, survived the dry fall. The principle followed in recent years with respect to clipping weeds from young

sweetclover, and alfalfa as well, is to wait until the weeds are far enough along so they do not recover quickly and to mow high enough to leave a 6-inch or 8-inch stubble.

SECOND-YEAR CUTTING

Hay yields from the second-year growth of sweetclover were recorded for the 12 years in which such a cutting was possible (table 28). All yields were obtained from plots seeded in the spring of the previous year, unless otherwise noted (fig. 24). These cuttings were all mowed closely to the ground, except in 1920 and 1921, when a 10-inch to 12-inch stubble was left. Many of the cuttings were delayed by wet weather until too late for a good quality of hay.

TABLE 28. *Yields of hay obtained from sweetclover in its second year of growth, 1914–28*

Year	Hay yields per acre	Date cut	Height when cut	Degree of pet cent age of cut was at	Remark
	Tons		*Inches*		
1914	1.33	June 12			
1915	2.40	June 20	48 to 60		Data from 24 incl. rows
1916	2.62	May 26, July 1	48 to 60	None	
1917	.87	June 11	24 to 30	Thin	
1918	1.21	June 10		None	Seeded Aug. 8, 1917
1919					Stands failed in preceding year
1920	1.36	May 31	30 to 36	None	From volunteer plot
1921	.90	June 11	30 to 40	Thin	Seeded Aug. 8, 1920
1922	1.93	May 11	42	Thin	
1923					Stand failed in preceding year. Do.
1924					
1925	.98	June 15	20 to 28	Thin	
1926	1.31	May 25, June 2, June 9	24 to 41	20 to 60	
1927	1.47	May 24	24 to 30	75 to 90	
1928	2.22	July 4	60	None	Very woody, in full bloom.
Average	1.51				

In 1926 and 1927 a direct comparison was made between high and low cutting at different stages of growth (tables 29 and 30). The intention with the higher stubble was to leave several side branches near the base ready to continue growth, since sweetclover does not renew growth directly from the crown like alfalfa. While the estimated percentage of survival was higher from this method, it was gained at too much sacrifice in tonnage of the first cutting. There is apparently no need of leaving a high stubble if the hay crop is taken off at the proper time; that is, when the plants are 24 to 30 inches tall.

In general, second-year sweetclover was rarely attractive as a hay crop. If cut early, before it reached a height of 24 to 30 inches, the plants were leafy and only slightly coarser than alfalfa. But if cutting was delayed by bad weather, as often happened, the plants soon became very coarse and woody.

Survival after the first cutting was very uncertain. In 1916, a year of very favorable weather, two cuttings were obtained, each almost equal to alfalfa in quality. In other seasons the second growth was short, sparsely leafed, and came into bloom so quickly that there was no opportunity for a second cutting of hay.

TABLE 29.—*Yields and survival of sweetclover in its first year when cut for hay at different stages of growth, leaving low and high stubble* [1]

Year and date	Height of plants	Cutting low		Cutting at a height of 6 to 8 inches	
		Yield per acre	Estimated survival	Yield per acre	Estimated survival
1925:	*Inches*	*Tons*	*Percent*	*Tons*	*Percent*
July 10	15 to 21		100		100
Aug. 17	30 to 32	1.38	100	1.49	100
Aug. 31	30 to 36	1.47	100	1.20	100
Sept. 19	30 to 36	1.64	100	1.30	100
1927:					
June 27	18	.80	75		
Sept. 20	24 to 30	1.55	50		
Oct. 21	24 to 30	1.36	80		
1928:					
Aug. 11	24 to 30	1.45			
Aug. 25	30 to 34	1.77			

[1] Data are for favorable years, when there was sufficient growth to warrant cutting. These tests extended from 1913 to 1928, and in all but these 4 years (1925, 1927, 1928) no cutting was possible except as explained in the preceding text. The lack of a cutting the first year was due in many cases to failure to obtain a stand.

TABLE 30.—*Yields and survival of sweetclover in its second year when cut for hay at different stages of growth, leaving low and high stubble*

Year and date	Height of plants	Stage of growth	Cutting low		Cutting high		
			Yield per acre	Estimated survival	Height of stubble	Yield per acre	Estimated survival
1926:	*Inches*		*Tons*	*Percent*	*Inches*	*Tons*	*Percent*
May 10	6 to 12	Very young	0.09	98			
May 17	12 to 20	Medium young	.28	100			
May 25	24 to 32	Best hay	1.35	98	6 to 8	0.78	75
June 2	30 to 36	Getting stemmy	1.70	90	8 to 10	.77	70
June 9	36 to 44	First bloom	2.20	70	9 to 12	.74	30
June 17	36 to 44	Three fourths bloom	1.60	10	12 to 15	1.11	20
1927:							
May 12	18 to 20	Very young	.70	100	6	.13	100
May 23	24 to 30	Best hay	1.37	75	6 to 8	1.03	90
June 27	48 to 54	Full bloom	1.91	0	12	1.15	0

SWEETCLOVER AS A PASTURE CROP

The carrying capacity of sweetclover pasture has been determined on a few small general fields of the Hays station.

In 1925 a gently rolling upland field of 8.2 acres in second-year sweetclover was grazed by milk cows. Heavy grazing began on April 18 when the clover was 10 to 20 inches tall. Four calves had grazed here for 10 days up to this time and are counted equivalent to 2 cows. The full herd of 16 cows, 1 bull, and 4 calves grazed continuously on this field from April 20 to May 16, except for 2 wet days. During this time the sweetclover was completely eaten down and required a rest. The herd again grazed intermittently about half the time from May 22 to June 18, also for a few days in July.

The data from this test have been reduced to a unit-day basis per acre, a unit day being the equivalent of 1 cow grazing 1 day. In April grazing amounted to 29 unit days per acre; in May, 45; in June, 21; and in July, 12; a total of 107 unit days for the season. The pasture was able to carry about 2 cows per acre during the best three fourths of the grazing period and 1 cow during the poorest quarter.

This was in a relatively dry spring, and it seems probable that these results are somewhat below the normal possibilities. Considering that the grazing just described was the only return from the land occupied by sweetclover for 2 years, it does not appear a profitable way to use land that could be growing other staple crops. However, it is a matter of common information that sweetclover can generally be used to better advantage for grazing than for hay production and also that it can be grown on much land too thin, rolling, or sandy for other crops.

NURSERY EXPERIMENTS

Between 1913 and 1928 nursery trials were made of 56 lots of sweetclover collected by the United States Department of Agriculture in different parts of the world and representing most of the strains, types, or varieties of this plant known to be of agricultural value. Part of the material had been in the possession of the Department for several years, and some of it was grown at Hays as early as 1913. A few lots were grown at Hays during 1921 to 1925, but it was not until 1926 that a comprehensive study of the material was begun. Notes until 1930 were available to the writer, hence the observations which follow are based upon 5-years' experience with these varieties.

During the period 1913 28, 59 different lots of sweetclover were under test at Hays. A complete list of these may be found in the annual reports on file in the Division of Forage Crops and Diseases. Not all of these were distinct varieties, but the collection represented practically all the strains and varieties obtainable.

While considerable data in the form of notes on these nursery rows are now available, it appears that the subject of sweetclover varieties and strains has as yet been inadequately studied at Hays. The possibilities in growing sweetclover in the territory served by the Fort Hays station vary rather directly with the amount of rainfall, but there is some evidence that sweetclover will be of value as a soil-building and pasture crop wherever there is cultivated rolling land being impoverished by erosion.

The sweetclovers studied may be classified naturally into biennial white-blossom, biennial yellow-blossom, annual white, and annual yellow types. Of these, the common biennial white (*M. alba*) is the standard variety now being grown in Kansas. This was always grown as a check in the experiments. The biennial yellow (*M. officinalis*) also has some commercial importance, but it is generally criticized for lack of vigor and for not carrying its vegetative growth far enough into the second year. Some growers prefer it for adverse conditions or on account of its finer stems. The annual forms are of only passing interest. Hubam, an annual white, was grown from 1921 to 1927. It grew from 30 to 42 inches tall under favorable conditions but was deficient in leafiness. It showed quick maturity and good seed habits, but as a forage crop it appeared decidedly less useful than the first-year growth of the biennial white varieties.

The annual yellow (*M. indica*), grown only in 1913 and 1914, was least valuable of all, getting only a foot or so tall and producing less forage than a very light growth of alfalfa.

The principal interest in sweetclover varieties lies in the wide variations among different lots of the biennial white as compared with the kind commonly grown also among different lots of the biennial yellow, of which the *Melilotus officinalis* commonly grown is probably the least valuable.

Several strains of biennial white are finer stemmed, less vigorous, and 2 to 3 weeks earlier in blooming than the common. This class included F.C. 2427 (Grundy County), 05326 (Crystal Dwarf), and 12067 (Stone's Early), a selection from the Grundy County strain. It is not clear how such lots as these can be as useful under Kansas conditions as the common biennial white, especially for soil building and pasture.

A few strains of biennial white are apparently a little more vigorous, a few days later in blooming, and possibly coarser than the common. Chief among these probably is Chantland's F.C. 05647; next, Parker's F.C. 04883; then S.P.I. 19848, 27463, and 27465. These types should be more carefully studied, and perhaps subjected to several years of selection, with a view to distribution of the most vigorous possible type for soil building and pasture wherever the annual rainfall justifies a large-growing variety.

Among the biennial yellow lots there is one group grown under various botanical names and characterized by late growth in the fall of the first year. This group included S.P.I. 27291, 27474, 27475, 27476, and 27477. The second-year growth of this group was disappointing, the lower two thirds of the plant being coarse and scantily leafed. The blooming season was early, though about 10 days later than for *Melilotus officinalis*. Lots such as these might serve a valuable purpose for growers interested primarily in the production of sweetclover the first season, with the expectation of plowing it out the second spring.

Two lots of biennial yellow were noted for a long period of vegetative growth the second year. These were S.P.I. 40937, selected at the Redfield, S.Dak. station, and 61320 from Siberia. In 1927 S.P.I. 40937 reached full bloom at Hays by July 12, as compared with May 25 to 27 for the *Melilotus officinalis* group, June 6 to 10 for the *M. suaveolens* group, and June 18 for regular biennial white. In 1928 S.P.I. 61320 was also included in this comparison, and full bloom was recorded at the following dates: S.P.I. 61320, July 10, and 40937, July 4; *M. officinalis* group, June 6; *M. suaveolens* group, June 8; common biennial white, June 28; group of largest biennial white strains, July 2 to 6. S.P.I. 61320 is very similar to the common biennial white in size and coarseness, but continues vegetative growth a little longer than any other sweetclover so far noted in its second year. S.P.I. 40937 is just a little smaller, and somewhat earlier. This delayed blooming habit is a favorable quality from the standpoint of pasture, since it is desirable for a pasture to remain in a vegetative stage for the longest time possible. Unfortunately, both S.P.I. 61320 and 40937 are among the poorest lots with respect to vigor and late growth in the fall of the first year; also they seed less freely than earlier-maturing sorts, and therefore the seed would be more expensive. While there is a good deal of interest in these late-blooming, yellow-flowered types, it is a question whether one can afford to use a variety that makes an inferior growth through the first year, takes the maximum time in proportion to its growth the second year, and forms seed at a time when drought is more likely to be acute than if earlier.

Additional selections were added to the sweetclover nursery in 1929 and 1930, some of which are promising and different from anything previously included. Apparently a large field exists for further

survey of existing types and for the selection and testing of superior strains for the different purposes and geographical conditions under which the crop is or may be grown. There appears to be a need for more exhaustive, coordinated work on this project throughout the country, similar to that already done on such forage crops as the sorghums, alfalfa, and annual legumes.

ANNUAL LEGUMES

The following annual legumes have been tested sufficiently at Hays to supply data: Field peas, cowpeas, soybeans, tepary beans, and pinto beans. Other annual legumes grown on a limited scale were hairy vetch, chickpeas, mung bean, navy bean, Korean lespedeza, and the white and yellow annual sweetclovers. The annual clovers have already been discussed in the section on sweetclover.

Yield data for the first five crops named are presented in table 31. Beginning in 1915, one series of tests was usually conducted within a woven-wire enclosure fenced against rabbits. This precaution was very necessary for the soybeans, sometimes of value to tepary and pinto beans, but rarely, if ever, needed for field peas and cowpeas. The field peas were grown in close drills and the other four crops in 40-inch surface-planted rows.

The yields as a whole were disappointing, indicating that relatively little, if any, profit is to be expected from growing the crops under conditions similar to those at Hays. Even the yields reported here would scarcely be obtained under farm conditions, for these legumes were favored considerably in the experiments. Unusual care was taken in providing a good seed bed, keeping down weeds, and controlling grasshoppers.

Tepary beans ranked highest in the group as a forage crop. The merits of each crop are discussed under separate headings.

TABLE 31. *Yields of annual legumes, 1913–28*

ACRE YIELDS OF TOTAL CROP—TONS

Year	Field peas	Early Ruff cowpeas		Soybeans		White tepary beans		Yellow tepary beans		Pinto beans	
	Open field	Open field	Fenced	Open field	Fenced	Open field	Fenced	Open field	Fenced	Open field	Fenced
1913											
1914											
1915											
1916											
1917											
1918											
1919											
1920											
1921											
1922											
1923											
1924											
1925											
1926											
1927											
1928											
Average											

TABLE 31.—*Yields of annual legumes, 1913–38*—Continued

ACRE YIELDS OF SEED (BUSHELS)

Year	Field peas: open field	Early Buff cowpeas		Soybeans		White tepary beans		Yellow tepary beans		Pinto beans	
		Open field	Fenced	Open field	Fenced	Open field	Fenced	Open field	Fenced	Open field	Fenced
1913	1.5	0		0							
1914	7.0	3.1		3.1		2.7					
1915	1.6	1.8		0	18.0	10.7					
1916	8.0	7.8	7.4	0	9.3	7.1	6				
1917	0	2.9	8.5	0	1.5	0	2.2			0.5	6.8
1918	3.0	0	6.3	0	0	0	0			0	0
1919		1.6	3.8	0	4.3	3.8	7.0				11
1920		8.7	12.3	18.0	0	22.5	21.1	25.2	21.5	12.1	13.5
1921		15.9	6.8	0	8.7	16.2	15.7	29.2	18.3	0	0
1922		4.7	12.1	0	0	3.1	4.7	1.5	8.0	0	0
1923		0	0	0	0	0	0	0	0	0	0
1924		11.8			0.9	0	0	0	0	0	0
1925		23.1			3.7		18.1		20.7		3.1
1926		3.8			0		8.1		12.6		0
1927		7.5			12.0		13.8		17.2		
1928		13.9			9.1		10.2		9.7		1.5
Average	1.9	6.1	7.1	2.0	7.3	5.2	8.1	10.2	11.9	1.6	2.5

FIELD PEAS

The data for field peas in table 31 were obtained from the variety Hubert, S.P.I. 24893, seeded in close drills at 90 pounds per acre. This was chosen as the best among a list of spring-seeded varieties grown in 1913 and 1914 in duplicate $\frac{1}{10}$-acre plots. Hubert was relatively early with reddish-purple flowers. The other varieties tested in 1913 were White, S.P.I. 3179 and 3182; Speckled, S.P.I. 17006; Blackeye, S.P.I. 22044, and Golden Vine, S.P.I. 30134. Speckled and Blackeye were also grown in 1914, but only Hubert was continued through 1915 to 1918. The seeding dates ranged from March 25 to April 20 and harvest from June 22 to July 7. It seems that seeding should have been completed about April 1 or earlier, as field peas develop best in a cool humid climate and suffer greatly from dry hot weather such as they often encountered at Hays after early June. At best, field peas are poorly adapted to this section, and their culture was discontinued after 1918.

The Hubert was grown from 1915 to 1918 in cultivated 40-inch double rows for comparison with the close-drilled method. These double rows were seeded with an 8-inch drill, using two adjacent holes and stopping up the next three. The drill remained set at the same rate throughout both methods, thus putting on two fifths as much seed per acre on the double row plots as with the close drills. Both methods were total failures in 1917, and there was little difference between methods for the other seasons. The 4-year average yields per acre were as follows: Close drills, 0.73 ton hay and 3.5 bushels grain; 40-inch double rows, 0.56 ton hay and 4.0 bushels grain.

FALL-SEEDED FIELD PEAS

Fall seeding has been tried with several varieties of field peas, usually during the latter part of September. The Austrian Winter peas, obtained from Austria in 1911, proved 50 to 90 percent winter-hardy during the five winters following, but killed out during 1916–17, and only a few scattering plants survived in 1917–18, after which tests

of it were discontinued. The Austrian Winter proved similar to the spring-seeded variety, Hubert, in character of foliage, color of flowers, amount of growth, and date of maturity. Other field peas seeded in the fall were as follows:

October 8, 1913, Kaiser, S.P.I. 17006, Kovaleff, S.P.I. 20382, Grey Winter, S.P.I. 16436, Golden Vine, S.P.I. 34941.
September 26, 1914, Erfurt, S.P.I. 18606, Blue Imperial, S.P.I. 29367.
September 26, 1917, Sulo, F.C. 1703, Partridge, S.P.I. 16137-A, Pelsch-ka, S.P.I. 22079, Fraile, S.P.I. 24314, Golden Vine, S.P.I. 34941.

The only winter survival among these seedings for the three seasons consisted of a few scattered plants of S.P.I. 16436 in 1914. This variety is the same as the Austrian Winter pea.

COWPEAS

Cowpeas have received more attention than any other class of annual legumes in the experiments at Hays. One variety, Early Buff, was carried continuously in plot tests from 1914 to 1923 (fig. 25). The Groit and Blackeye varieties were also grown in plot tests,

FIGURE 25.—Early Buff cowpeas in cultivated rows. This variety was the most consistent seed producer but made light forage yields.

the former in 1914 and 1915 and the latter from 1920 to 1923. Work with numerous varieties in smaller plots of 0.01 to 0.02 acre were usually but not always duplicated.

In 1916 forage yields in tons per acre were reported from 10 varieties as follows: Brabham, 0.84; Catjang, 0.48; Early Buff, 0.72; Early Red, 0.80; Groit, 1.12; Iron, 0.52; Monetta, 0.68; New Era, 0.96; Taylor, 0.76, and Whippoorwill, 0.88. The only seed yields produced by these varieties were from Catjang, 2.7 bushels, and Early Buff, 5.3 bushels per acre.

In 1917, 12 selections, mostly Blackeye, were under observation in 22-foot rows in the nursery. This test indicated and afterward proved that the Blackeye group contains some of the best cowpeas for this section.

Blackeye cowpeas that had descended from the 1917 selections were grown in regular plot tests in comparison with Early Buff for

4 years, 1920 to 1923. The average yields per acre for eight tests were as follows: Blackeye, 0.96 ton of dry forage; Early Buff, 0.97 ton; Blackeye, 6.7 bushels of seed; Early Buff, 7.2 bushels.

A collection of cowpea varieties received by the agronomy department, Kansas State College of Agriculture and Applied Science, Manhattan, Kans., from the Arkansas Agricultural Experiment Station in the spring of 1924 was grown at Hays for the period 1924–28, inclusive. Data obtained from these tests are shown in table 32, mainly in averages. There appeared to be too much experimental error involved in results from plots of only 0.01 or 0.02 acre to warrant presenting the results separately for each season, but it is believed that the averages give a reliable index to the relative merits of the varieties.

TABLE 32. *Results from tests of cowpea varieties, 1924–28*

Variety	Kansas cooperative experiment no.[1]	Habit[2]	Season average days to maturity	Seeds per pound, 1927	Average yields per acre		Value[3]
					Total crop	Seed	
			Days	*Number*	*Tons*	*Bushels*	
Arlington	1001	S-E	104	3,980	1.19	9.6	A
Blue Goose	1003	S-E	116	1,480	1.02	1.1	C
Black Unknown	1015	S-E	106	2,960	1.27	2.1	C
Blackeye group:							
California Blackeye	915	S	88	2,570	1.17	10.1	A
Extra Early Blackeye	1021	S	94	2,540	1.23	9.6	A
Gallavant	1010	S	87	2,500	1.03	9.1	A
Forty-Day Blackeye	916	M-S	92	2,130	1.20	12.5	A
Blackeye (Local)		S	91	2,570	1.20	12.1	A
Brabham[4]	1000	E	111		1.01	.3	C
Cajang	1016	E	93	[5] 2,220	.93	1.1	C
Clay[4]	1025	V-S	107		1.25	.1	C
Columbia	1020	S-E	101	3,180	.91	2.5	C
Cream	1002	S	98	3,750	1.05	6.7	B
Crowder group:							
Sugar Crowder	1018	V-S	107	2,870	1.11	1.4	C
White Sugar Crowder	1005	S	102	2,870	1.25	6.1	B
Brown Crowder	1014	S-E	107	2,740	1.16	2.9	C
Large Brown Sugar Crowder	1007	V-S	108	2,100	1.13	2.1	C
Early Buff	1006	S-E	85	2,530	1.18	12.5	A
Early Red	995	S-E	103	3,300	1.24	1.9	B
Extra Early Black	1004	S-E	102	2,760	1.11	7.2	A
Groit	998	S-E	105	3,150	1.36	5.0	B
Holstein	1022	S	102	2,750	1.13	7.6	A
Iron	1024	S-E	101	3,640	1.29	2.2	C
Monetta	1011	E	105	3,320	1.21	1.5	C
New Era	913	S-E	101	3,710	1.01	1.2	C
New Era×Blackeye	1017	S-E	101	2,790	1.36	5.8	A
Oliver's Hybrid	1013	S	102	3,120	1.29	6.4	A
Oliver's White	999	S	92	2,780	1.02	9.1	A
Peerless	1019	S-E	101	3,770	1.11	1.1	B
Red Ripper	1023	M-S	102	2,730	1.21	5.0	B
Two-Crop	1012	S-E	102	2,960	1.33	5.1	B
Warren's New Hybrid	1008	S-E	101	3,090	1.33	5.3	B
Whippoorwill	914	S-E	105	3,020	1.38	3.8	B
White Hybrid	1009	S-E	94	1,010	1.37	8.5	A

[1] These numbers were assigned by the cooperative experiment section of the agronomy department, Kansas State College of Agriculture and Applied Science, Manhattan, Kans., in the spring of 1924, on receipt of the seed from the Arkansas Agricultural Experiment Station.

[2] E=Erect; M=medium; V=very; S=spreading.

[3] Seed=60 pounds per bushel.

[4] A=Best group, usually early varieties of good seed habits; Arlington was the best forage type in this class. B=Medium value and not of interest at Hays. C=Least attractive, often because of fault in the plant itself, such as very light scanty foliage in Cajang; coarse prostrate vines in Crowders.

[5] Three years, 1924–26.

[6] Two years, 1924 and 1925.

The varieties marked A in the last column of table 32 are considered to have made the best showing. Arlington was one of the better varieties for forage and also had fair seed habits. It was difficult to find satisfactory forage and seed production combined, as will be noted from the yields of other varieties in the A group. Varieties early enough to mature dependable and relatively high yields of seed usually are light in vegetative habits, as in Early Buff and Blackeye. Varieties such as Brabham, Groit, New Era, and Whippoorwill, that are standard in certain more humid sections, seem unable to develop fully at Hays. It is quite common for drought to make itself felt severely in these tests just about the time the earliest varieties have matured; the rest then dry up rapidly and somewhat prematurely, shedding their leaves if not harvested promptly.

The best average yields of forage and seed in this 5-year cowpea test are only about half the yield that should be produced in a section in which they are adapted. These 5 years were also relatively favorable, and the varieties were given more than average care. In view of the more satisfactory results readily obtained from other forage crops at Hays, it does not appear that the growing of cowpeas on a commercial scale in this section is justified.

SOYBEANS

The soybean tests in 1913 all failed entirely. They consisted of single-row tests of F.C. 6928, 6929, and 6930; S.P.I. 18227, 20854, 30745, 30746, and 30747. In 1914 open-field plot tests of one twentieth to one tenth of an acre were grown of three varieties, with yields per acre as follows: Green, S.P.I. 28050, 1.19 tons of forage, 10 bushels of grain; Black Eyebrow, S.P.I. 30744, 0.44 ton of forage, 3.3 bushels of grain; Tashing, S.P.I. 20854, seeded 13 days later, was destroyed by rabbits. The average of these three seedings was used in table 31 for the 1914 results with soybeans.

In 1915 S.P.I. 28050 and 30744 were seeded again in duplicate $\frac{1}{10}$-acre plots under open-field conditions, but rabbits left only a few stubs of plants. Ten S.P.I. numbers grown in 1915 in single 10-rod rows under fence did much better. The numbers grown, together with their lengths of season and their yields, are shown in table 33.

TABLE 33.—*Results with 10 S.P.I. numbers of soybeans, 1915*

S.P.I. no.	Season (days to maturity)	Acre yields		S.P.I. no.	Season (days to maturity)	Acre yields	
		Forage	Grain			Forage	Grain
	Days	*Tons*	*Bushels*		*Days*	*Tons*	*Bushels*
30593 (Manchu)	99	1.44	18.0	30744 (Black Eyebrow)	109	.92	11.3
30594	94	.84	9.3	30647	110	.80	10.0
30599	106	1.72	22.0	30648	114	1.88	18.0
30600 (Wea)	106	1.20	16.0	30917	105	.92	9.3
30601	100	1.68	20.0	35062	110	.80	10.0

The results in table 33 are of interest for showing practically the maximum possibilities of soybeans at Hays. The 20-day range in maturity and the wide fluctuations in yield illustrate the marked differences that exist even among early and medium-early varieties. S.P.I. 30599, 30601, and 30648 were continued into plot tests in

1916, with yields per acre, respectively, as follows: Forage 0.41, 0.28, and 0.80 ton; grain 5, 3, and 9.3 bushels. On the basis of the 1915–16 results, S.P.I. 36048 alone was continued in the plot tests, and the data presented for 1915 to 1923 in table 31 were from this variety.

In 1924 a new test of 16 soybean varieties was begun in 1-row or 2-row plots within a rabbit-proof enclosure. Several varieties were discarded within the first year or two, but 10 were grown for the full 5-year period, 1924–28, with average results as shown in table 34. This was a favorable series of seasons, and the soybeans received special care as to the control of weeds, grasshoppers, and blister beetles. The results, therefore, approach the maximum rather than the normal possibilities of soybeans for this locality. A.K. was considered the best, and its performance was used in completing the last 5 years of the soybean data in table 31.

TABLE 31. *Results with soybean varieties, 1924–28*

Variety	Kansas cooperative experiment no.	Season (days to maturity)[1]	Average height	Average acre yields		Relative value[3]
				Total crop	Seed[2]	
			Inches	*Tons*	*Bushels*	
A.K.	929	117	28	1.43	12.0	A
Arlington		121	33	1.31	9.8	B
Haberlandt		111	22	.97	9.2	B
Lucas	935	117	25	1.36	11.3	A
Manchu	936	111	23	1.02	9.9	B
Morse	931	119	29	1.15	7.8	B
Peking		121	25	1.08	7.7	C
Sable	934	121	26	1.10	7.1	C
Virginia	932	120	33	.95	7.1	C
Wilson	930	116	31	1.01	7.4	C

[1] 1925 to 1928.
[2] Bushel = 60 pounds.
[3] A = Best all-around varieties for both forage and grain; B = medium value; C = least promising.

The 16 varieties were grouped as follows as to practical value:

Best.—Well balanced as to vegetative and seed habits; good type of yellow seed—A.K., Lucas, Morse, Manchu, and Haberlandt. The latter two were noted for early maturity, but had lighter foliage than was desired. Morse was similar to A. K., except a little later and not so well filled.

Satisfactory.—Good vigor in most cases, but showing some objectionable feature, such as poor seed yields, wrong type of seed, or late maturity. This group contained the following:

(1) Tall vigorous types with only mediocre foliage and seed habits—Arlington, Wilson, and Virginia.

(2) Miscellaneous—Peking, small black beans; Sable, small black seeds and too late; Midwest and Chiquita, too late.

Poorest.—This group was discarded after one season's test, 1924, for lack of vigor and for scarcity of pods except in the lowest 6 or 8 inches of stem—Austin, Black Eyebrow, Lexington, and Wea.

The lengths of season shown for soybean varieties for 1924 to 1928 are comparable with those given for the tepary beans, but not with those of cowpeas. The reason for this is that the cowpeas had to be replanted in 2 years, while other legumes did not; the later the seeding the shorter the season required for maturity. The soybeans were seeded within the period from May 17 to May 29. While they are a warm-weather crop, they stand more cold than cowpeas, almost in the same proportion of corn to the sorghums. The soybeans could have been started 10 days or more earlier than was done in these tests,

although it seemed desirable to seed later in order to have time to take care of the weed growth. The advantage gained by soybeans over cowpeas by their resistance to cold wet soil was offset by the distinct superiority of the latter in pushing up through a hard crust.

Inoculation of soybeans has been considered unnecessary at Hays, since the crop grows very well when ideal conditions of moisture and protection are furnished. The only trial made on this subject was with Lucas soybeans in 1924, when Nitragin was used, and no apparent difference was noted between the crop from inoculated and that from noninoculated seed.

Soybeans are relatively coarse stemmed, and most of the leaves generally fall quickly in advance of the ripening of the grain. These factors limit the usefulness of soybeans as a hay crop. In the experiments, it was customary to determine the hay yields from one half of the plot and the grain yields later from the other half.

The main object in growing soybeans in this region would be for the grain which could be pastured off by hogs or sheep. However, the grain yields at Hays, even for the favorable period, 1924–28, are only one third to one half those reported for more humid sections of the United States. While soybeans can be grown to some extent anywhere in Kansas, the area of their profitable use in the State, according to the Kansas State College of Agriculture and Applied Science, is limited to the three eastern tiers of counties.

Rabbits are a decidedly limiting factor in soybean culture in the dry-land sections and often clean off exposed plantings before the plants are 6 inches tall. If soybeans were grown on a large-field scale, however, this factor would be minimized just as in the case of bird injury to grain sorghums. Because of such factors as soil depletion, alfalfa failure, the demand for something better than oats and barley as cash crops in the rotation, education in methods of livestock management, and the probable improvement in soybean varieties, it seems possible that farmers will gradually look with increasing favor on soybeans, and extend the area of their profitable use somewhat farther west than the three tiers of counties previously mentioned.

TEPARY BEANS

The tepary bean is outstanding in yield and quality of forage among the annual legumes tested. The stems are as fine or finer than alfalfa, and the leaves are abundant, thin, and scarcely one fourth the size of a cowpea leaf. The leaves are generally well retained until the seed is mature, and neither leaves nor seed pods shatter seriously. The vines spread freely to meet adjoining 40-inch rows, and they intertwine with adjacent plants in the same row (fig. 26). The plants grow only 1 to 1½ feet tall, and they spread out so much on the ground that apparently the only method of machine harvesting is with knives running under the surface soil. This is more feasible in sandy than in loam or clay soils.

The seed yields of tepary beans are also relatively high among the annual legumes at Hays. White is the commonest color, and the white tepary beans resemble navy beans very much in size and appearance. Yellow tepary beans have similar seed to that of the white except for the color. The limiting factor in the use of tepary beans as food for man is that they have a noticeable bitterness of flavor, otherwise they can be used the same as navy beans.

While tepary beans have no economic importance in Kansas at the present time, it appears that they could be used as a hogging-off crop, and might be harvested as a hay and seed crop, especially on lighter soils in the southwestern part of the State. The tepary bean is already grown to some extent in New Mexico and Arizona. While the plots in exposed locations were destroyed by rabbits in 1917, 1918, and 1924, these beans are not nearly so attractive to rabbits as soybeans, and in commercial fields they would likely escape serious rabbit injury.

Two strains of the white tepary beans have been grown at Hays. One of these, grown from 1914 to 1928, is later by about 10 days, and in some seasons it has barely matured at Hays. It is the one from which the data were obtained for the general comparison of legumes in table 31. An earlier strain, which was found adapted to conditions at Redfield, S.Dak., was tried at Hays from 1926 to 1928. It is rela-

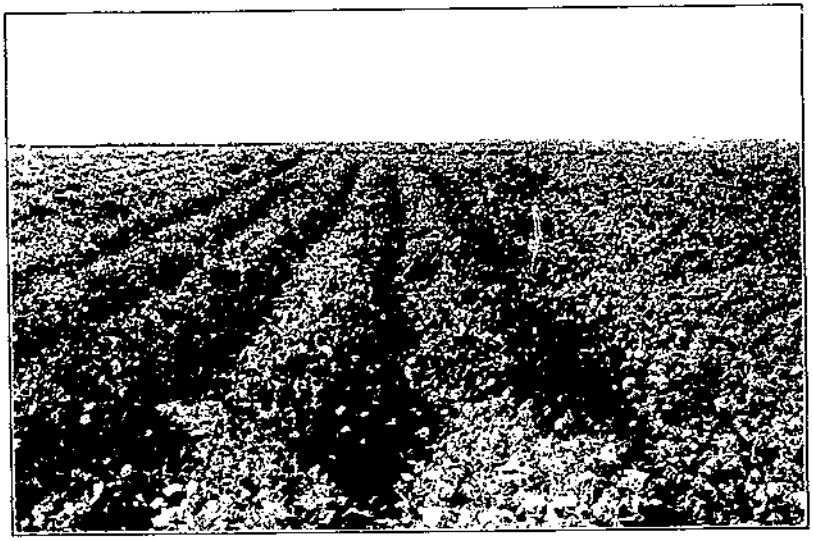

FIGURE 26.—Tepary beans, one of the most promising legumes for this section of the United States.

tively light in vegetative growth, but a prolific seed producer. The average results for three strains of tepary beans at Hays for 1926 to 1928 are shown in table 35.

TABLE 35.—*Results with three strains of tepary beans, 1926–28, inclusive*

Strain	Average season	Average acre yield	
		Forage (including seed)	Seed [1]
	Days	*Tons*	*Bushels*
White [2]	118	1.50	10.7
White [3]	110	1.54	17.6
Yellow	116	1.75	13.2

[1] Bushel=60 pounds.
[2] Local strain.
[3] Adapted to conditions at Redfield, S.Dak.

PINTO BEANS

Pinto beans can scarcely be considered as a forage crop, since their vegetative growth is light and their principal usage is food for man. They were taken on as a phase of the Hays forage-crop project in 1917 because of local interest. No one knew definitely how these beans could be expected to yield or what problems would have to be met in their culture. An unusually large abandonment of winter-wheat acreage that spring, and the war-time demand for food production together furnished the setting for the interest in growing the crop. The beans were not very widely planted, however, and because the season of 1917 was very dry in July, the crop was not good enough to encourage much further interest, except for limited use in gardens.

The data in table 31 on general comparisons of annual legumes at Hays show that pinto beans were grown from 1917 to 1928 and were the poorest legume on the list. While they have been observed growing extensively and standing considerable drought in cooler, higher sections of the Plains in northeastern Colorado, pinto beans set very poorly under the more severe extremes of heat usually associated with dry seasons at Hays.

In addition to the comparison with other legumes, pinto beans were also grown in a number of cultural-method experiments at Hays from 1917 to 1920, and the results are presented in table 36.

The seedings were made in surface-planted 40-inch rows except where a different method is indicated. The crops of 1917 and 1919 were very poor, and that of 1918 was an entire failure. In 1920, with a wet fall, results were fair, but, as in the preceding years, they did not show any one method to be superior. As popular interest in the crop no longer existed, the experiments were discontinued.

TABLE 36.—*Results with pinto beans grown under various cultural methods, 1917–20, inclusive* [1]

Cultural methods	Seed yields per acre (bushels)[2]			
	1917	1919	1920	Average
Date of seeding:				
Early, Apr. 30 to May 18	3.5	0	15.1	6.3
Late, June 1 to 12	4.3	0	12.1	5.5
Spacing in the rows:				
Thick, 6-inch row space	3.3	3.1	(3)	3.2
Medium, 12-inch row space	3.5	3.4	(3)	3.5
Thin, 18-inch row space	3.5	2.8	(3)	3.2
Space between rows:				
Narrow, 21 to 24 inches	4.4	0	11.9	5.4
Medium, 40 inches	3.1	0	12.1	5.4
Wide, 56 to 63 inches	1.6	0	8.6	3.4
Surface planting compared with listing:				
Surface planting	1.1	0	12.1	5.4
Listing	3.5	6.2	12.9	7.5

[1] Figures for 1918 are omitted because of the complete failure of all methods during that year.
[2] Bushel=60 pounds.
[3] Not conducted in 1920.

HAIRY VETCH

Seedings of hairy vetch were made in close-drilled plots at winter-wheat seeding time for 5 consecutive years. S.P.I. 24934, seeded October 8, 1913, came up to a fair stand, but winterkilled. D.L. 30, seeded September 26, 1914, survived well and made a vigorous

growth which was 2 feet tall and beginning to bloom by May 26, 1915. It lodged badly during the wet June of 1915, and the hay crop of 1.16 tons per acre was harvested with much difficulty.

On a neighboring farm a 5-acre field, formerly poor wheat land, was drilled on August 30, 1914, to a mixture of about 10 pounds of rye and 40 pounds of vetch per acre. On June 15, 1915, there was a heavy growth, the rye being 4 to 5 feet tall and supporting vetch 2 to 3 feet tall. Back from the edge of the field, however, the vetch did not do very well, as the rye was too thick for it. The two experiences of 1915 show the desirability of having the vetch supported, but the moisture supply in most years is not sufficient for the vetch to withstand rye competition.

Hairy vetch was not grown on the forage-crop project proper in 1916, but a strip of about ¼ acre on an adjoining field was observed. It came through the winter to just a fair stand and was scarcely a foot tall on May 26, 1916. Austrian Winter field peas beside the vetch were more than twice as rank. Hairy vetch was seeded in comparison with field peas on September 13, 1916, and on September 26, 1917. The only winter survival of vetch consisted of a few plants from the latter seeding. No further attempts were made at growing hairy vetch, as it did not appear hardy enough to justify attention in this section. The vetch in these experiments had more than an average opportunity, for it was usually seeded on summer-fallowed land.

CHICKPEAS

The growing of chickpeas was attempted at Hays in single-row tests in 1913, 1914, and 1924 with very poor results. In 1913 a seeding of 17 S.P.I. numbers was made on May 14. Germination was irregular, and early growth was slow; the best selections were only 8 to 10 inches tall on July 4, after which grasshoppers destroyed them. A $^1/_{10}$-acre plot seeded in 40-inch rows on May 28, 1914, germinated poorly and was discarded. Nursery rows of S.P.I. 24564 and 27513 seeded May 11, 1914, grew only a foot high, were very scantily leafed, and were only fair in seed habits. Single rows of S.P.I. 58038 and 58086 were seeded May 22, 1924, and replanted on June 9. They came up poorly, grew very slowly for a few weeks, and disappeared about July 1, owing to attacks of grasshoppers, blister beetles, and rabbits.

It may be that these experiments were not put in early enough for best results, as this crop, like the field pea, is said to need a cool season of growth. At best, however, the chickpea is not considered a good forage crop because its foliage is too light and it is unpalatable because of an acid secretion. The crop is said to be grown in winter in Mexico and to a limited extent in California, mainly as food for man. It apparently has no place under Kansas conditions.

MUNG BEANS

Mung beans received from an Atlanta, Ga., seed house were grown in a $^1/_{20}$-acre plot in 40-inch rows at Hays in 1921. They were seeded May 27, under fence and under comparable conditions with the other annual legume plots of that season. The mung beans made a very poor growth, 0.56 ton per acre, and failed in seed production. Their poor showing discouraged any further tests, especially as there is apparently no interest in mung beans in this territory. The crop is said to be similar in adaptation to the cowpea.

NAVY BEANS

Navy beans are almost wholly a crop for human consumption, but they are mentioned here because a plot of them was seeded May 27, 1921, under fence with the mung beans and other legumes. They produced very poor growth, yielding 0.16-ton forage and 1 bushel of seed per acre. Tepary beans in the same test averaged 1½ tons forage yield and 16 bushels of seed. Navy beans require cooler humid conditions.

KOREAN LESPEDEZA

Korean lespedeza has recently attracted favorable attention in the eastern United States for its pasture possibilities, as it matures farther north than Japanese lespedeza and produces seed freely. It was grown at Hays from 1923–28 in square-rod plots or in nursery rows, and in 1924 it was broadcast in a number of places such as in waste land around buildings, draws in native pasture, and on well-prepared farm land. Stands were readily obtained from March to May under the very favorable conditions of the nursery, usually on fallowed land, but other seedings failed. The plants in the nursery regularly grew 6 to 8 inches tall and set seed freely. Volunteer stands also came on readily after the first year. Korean lespedeza does not appear to have any considerable value in this territory as a forage crop.

OTHER LEGUMES

KUDZU

Six plants of kudzu were established at Hays in April 1927 by transplanting roots received from the agronomy department, Kansas State College of Agriculture and Applied Science. This perennial legume has been reported as producing a heavy growth of excellent forage when fully established at Manhattan. The crop has attained some popularity in Florida, and apparently would have a wider usefulness for hay, pasture, and ornamental purposes if it were not necessary to start it from roots and to wait until the third year for full production. The plants at Hays were located along a 5-foot woven wire fence with 20 feet of fallow ground on one side, and they also enjoyed very wet seasons in 1927 and 1928. In 1927 they sent out very scantily leafed runners to a length of 10 to 15 feet. The roots survived the winter of 1927–28 and produced much more abundant foliage in 1928 when the fence was well covered and vines again spread 10 or more feet. No blooming was noted in either season. It is not anticipated that kudzu will ever be of much value as a forage crop at Hays, but it may prove of some interest for growing in favored locations for ornamental purposes.

SAINFOIN

Sainfoin is a perennial legume that has long been of value in France and some other European countries for growing on calcareous soils subject to drought. It has been widely tested in the United States but has assumed no economic importance. On May 14, 1913, sainfoin was seeded at Hays in rows 36 inches apart. A poor stand resulted and the plants did not survive the severe season, whereas alfalfa and sweetclover seeded under comparable soil conditions survived. Another seeding of sainfoin was made in 42-inch rows on May 7, 1914. With a favorable season, three cultivations, and some hand weeding,

it grew 6 to 8 inches tall, which was much less than the growth of alfalfa or sweetclover under these conditions. The sainfoin evidently did not suffer through lack of inoculation, for nodules were found on the roots of a plant dug up on October 2, 1914. It was carried over to 1915, but rabbits ate it off repeatedly when it was 3 or 4 inches high, and by midsummer the plants apparently were killed by them. Two rows seeded in 1914, within a fenced nursery, practically escaped rabbit injury in 1915. The plants began to bloom May 26 and were cut on July 7, when 1 to 2 feet tall, with some flowers still appearing and with some mature seed pods. By September 9 they had made 8 to 12 inches of second growth. In this favorable year alfalfa made approximately three times the yield of sainfoin, and tests of the latter were discontinued.

TEDERA

A rod row of tedera (*Psoralea bituminosa*), S.P.I. 65033, was seeded at Hays on May 19, 1926. A good stand was obtained of this legume, which grew 1 to 2 feet tall, retained its leaves long after frost, and developed a strong root like sweetclover, resisting successfully any ordinary effort to pull it. No flowers or seed pods were noted, nor did plants appear in 1927. However, 10 plants came up as volunteers in the spring of 1928, possibly from hard seed that had remained in the ground since 1926. They grew rapidly like second-year sweetclover, and by August the largest plant suggested at a distance a coarse nonflowering rose bush 5 feet tall. This plant sent up 14 hard, woody, scantily leafed stems three eighths to one half inch in diameter. Seed pods matured in thorny clusters about 1 inch in diameter and 2 or 3 inches long. Each cluster contained many flat prickly pods, and each pod usually contained two greenish-black legumelike seeds. The leaves were compound, with 8 to 12 opposite leaflets and a terminal one. The plant did not bear flowers in the popular sense of the term, and it seemed to have no value for any purpose.

MISCELLANEOUS CROPS

SUNFLOWERS

Mammoth Russian sunflowers were tested at Hays in 1913 and 1914, and from 1920–24, inclusive. They were seeded between May 14 and June 2 in cultivated rows usually 40 inches apart. This may have been too late for best results, for it was noted that they came up and began growing vigorously under conditions too cold and wet for sorghums; it was also found that if more than one date of seeding was made, the sunflowers usually did best in the earliest one.

The size attained by the sunflowers varied from as little as 1½ feet in the severe season of 1913 to a maximum of 10 feet for individual plants under favorable conditions in 1922. Results were fairly uniform, however, in that the plants ceased growth on account of disease at or shortly after the first-bloom stage (fig. 27). The only seed crop obtained was in 1914, estimated at 200 to 300 pounds per acre, when heads developed before disease and insect attacks became too acute.

Forage yields were recorded only in 1921 and 1922. In 1921, about a normal year, the sunflowers were credited with 3.2 tons of silage per acre; in 1922, an exceptional year, the silage yield was 11.83 tons. In 1922 the forage yield was only 2.18 tons when reduced to an air-dry

basis. The crop was entirely destroyed by hail on June 29, 1923. An indication of relative yields for the other seasons may be gained from the average height of the plants, which was 1.5 feet in 1913, 5.5 feet in 1914, 5.5 feet in 1920, 4.5 feet in 1921, 8 to 9 feet in 1922, and 2 to 3.5 feet in 1924.

Other sunflower varieties tested were still less promising than Mammoth Russian. White Beauty, grown in 1921, was the earlier by 10

FIGURE 27.—Mammoth Russian sunflowers. The leaves are beginning to fall, due to attacks of disease and the effect of drought.

days, but less leafy and vigorous. S.P.I. 46757 and 46758 from Uruguay, grown in 1922, reached 7.5 feet in height, but yielded only 6.61 and 6.35 tons of silage per acre, respectively, as compared with 11.83 tons for Mammoth Russian. Burbank Prolific White, F.C. 04261, and Mantica, F.C. 04264, were also tested in 1922, but died early when only 2½ to 3 feet tall.

Failure of the sunflowers at Hays was caused in some degree by drought, grasshoppers, insects, and grubs within the stems, lodging

associated with an unexplained digging around the base of plants, and to a leaf rust.

The experiments at Hays indicate no profitable use for sunflowers in this section. If the plants escaped disease until matured, they could be used for silage, but even then they would have to exhibit some advantage over sorghums, which already serve this purpose adequately. Experiment-station reports from Montana and other high-altitude sections indicated for several years that sunflowers might be grown for silage in areas too cold and with too short a season for corn and sorghums, but even this prospect has faded on account of widespread attacks of the Sclerotinia wilt.

RAPE AND KALE

Dwarf Essex rape was grown during seven seasons at the Fort Hays station, usually for hog pasture, on small fields of a few acres. In 3 years of favorable climatic conditions, 1902, 1912, and 1915, rape was seeded on bottom land and made satisfactory growth. During three dry seasons, 1910, 1911, and 1916, when it was seeded on upland, the crop made a small and unprofitable growth, due to drought and grasshoppers. Rape on upland in a fairly good year, 1920, was ruined by hot winds and insect pests during July. Thousand-headed kale beside the rape also failed for the same reasons. For best results, rape and kale need a cooler and more humid climate than that of Hays. They cannot compete profitably with Sudan grass as a hog pasture under western Kansas conditions.

ROOT CROPS

Sugar beets, mangels, and possibly other root crops were grown on bottom land at the Hays station during most of the years from 1902 to 1909. They were usually irrigated, and yields of 10 tons or more were often obtained. Sugar beets were used satisfactorily as succulent winter feed for dairy cows and also for hogs and poultry. Their culture was discontinued, however, when silos came into use, for sorghums then furnished a more economical source of succulent feed. Sugar beets are considered about the most nutritious of the roots and mangels the highest in tonnage. Both do well under irrigation but are not suited to general dry-farming conditions.

In 1920 a $\frac{1}{10}$-acre plot of each of several root crops was seeded on upland in 40-inch rows. The test included three varieties each of mangels, rutabagas, and carrots. Weed competition was very severe. The rutabagas failed to stand the drought and insect attacks in July. The other crops, being thinner and more irregular in stands, suffered less. The carrots produced very little and were not harvested, but a quantity of mangels, sufficient to fill a barrel for a silage test, was harvested and produced a slimy unpalatable silage. Pigweeds, hemp, and tame sunflowers ensiled in separate barrels retained their color, showed acidity characteristic of corn and sorghum silage, and were palatable to cattle.

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