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FORAGE CROPS IN RELATION TO THE AGRICULTURE OF THE SEMI-ARID PORTION OF THE NORTHERN GREAT PLAINS.[1]

By R. A. OAKLEY and H. L. WESTOVER, *Agronomists, Office of Forage-Crop Investigations, Bureau of Plant Industry.*

CONTENTS.

	Page.
Introduction	1
The region defined	2
History	2
Climate	3
Soils	10
Agricultural resources	12
Experiments with forage crops	17
Fodder and silage crops	18
Hay and pasture crops	25
Miscellaneous crops	44
A summation of the possibilities of forage production	46
Ratio of forage crops to grain and the size of the farm unit	50
Possibilities of combining livestock production with grain farming	51
Economic conditions and the need for a change in the type of farming	52
Summary	52

INTRODUCTION.

The raising of livestock is generally considered essential to successful dry farming in regions where the production of cereals or other crop plants is uncertain. Where crop failures come frequently and sometimes successively for two or more years, some feature must be included in the farming system that will insure a more dependable income for the farmer. The hazardous conditions under which crop production is being attempted in the drier parts of the northern Great Plains make livestock necessary not only to stabilize the income of the farmer but to provide for him a respectable living. The experience of the past five years has shown that grain farming alone will not do this. However, few, if any, sections of the northern Great Plains where dry farming is now practiced have a supply of native forage sufficient for livestock needs throughout the year. Forage crops must therefore be grown if the raising of livestock is to be successfully conducted. Each kind of livestock requires a different minimum quantity, but all are dependent to some degree upon harvested forage.

In this bulletin, the relation of cultivated forage crops to the agriculture of the northern part of the Great Plains region will be considered, with special reference to the need for harvested forage.

[1] The writers wish to express their appreciation for data and help given by the Bureau of Soils, by the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry, and by the Bureau of Agricultural Economics.

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The forage crops that seem to offer the greatest possibilities for the region are also considered. The data and conclusions presented are for the most part drawn from carefully planned experiments conducted at various points in South Dakota, North Dakota, Montana, and northeastern Wyoming.

THE REGION DEFINED.

The region under consideration includes northwestern Nebraska, the western two-thirds of South Dakota, that part of North Dakota which lies south and west of a line extending approximately from Minot to Jamestown, eastern Wyoming, and the greater part of Montana (fig. 1). The points at which most of the experimental data were collected are Sheridan, Wyo.; Ardmore, Newell, and Redfield, S. Dak.; Edgeley, Mandan, Hettinger, Williston, and Dickinson, N. Dak.; and Moccasin and Havre, Mont. The conclusions relative to specific forage crops are more directly applicable to the parts of the region having conditions similar to those which obtain in the vicinity of these points. Redfield, S. Dak., and Edgeley, N. Dak., are just outside the area discussed; but the data from these stations have been included because they give an idea of the climatic conditions and of the results that may be expected from the various forage crops in the eastern part of the region. Generally speaking, the precipitation is somewhat higher along the eastern border of the area, and the forage-crop problems are by no means so difficult as they are in the western part of the region.

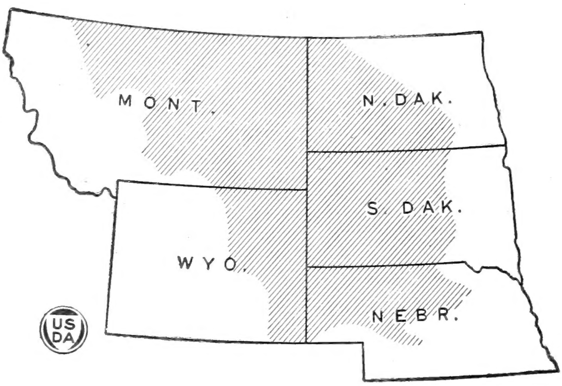


FIG. 1.—Outline map, showing by shaded lines the region considered in this bulletin.

HISTORY.

The Territory of Dakota, designated as such in 1861, originally included Montana and Wyoming. Montana Territory was organized in 1864 and Wyoming in 1868. Early in their settlement these Territories attracted stockmen because of the opportunities they afforded for cattle raising. The establishment of western frontier outposts by the Government, largely as a feature of its Indian administration, and the discovery of gold in the Black Hills in 1874 aided materially in making the region available to stockmen. The extension of the Northern Pacific Railway into western North Dakota in the early eighties and the Great Northern Railway a little later gave a great impetus to stock raising.

From the days of the first rangers to the invasion of the dry-land farmers, the region was one of the most extensive ranges in the United States. The Belle Fourche country tributary to the Black Hills; the Missouri Valley in the Dakotas; the several areas of Bad Lands in Nebraska, Wyoming, the Dakotas and Montana; and the Missouri, Yellowstone, and Milk River Valleys and the Judith Basin in Montana were the big centers of range settlement.

The history of the cattle industry in the Dakotas and Montana includes many economic romances, not the least interesting and important of which was the effort of Marquis De Mores, in 1883, to establish a packing industry in the Bad Lands of North Dakota at Medora, a point just reached at that time by the Northern Pacific Railway. A lone smokestack marks the remains of De Mores' folly; but the project, though a failure in itself, contributed appreciably to the development of the country. Cattle raising increased steadily for some time afterward.

The progress of grain farming westward from the Red River Valley was characterized by a succession of waves. The largest wave of homesteaders which invaded the last stand of the stockmen started in 1908. Many good pieces of range land were broken up for wheat and flax; but stock raising, although interfered with from the standpoint of old range practice, has continued to be one of the chief agricultural pursuits of that part of the northern Great Plains lying west of the ninety-eighth meridian. That small-grain farming has not been an unqualified success in much of this part of the region is shown by the crop records of the past five years, but what effect the results of these years will have on the agricultural development of the region can only be conjectured.

CLIMATE.

The annual precipitation of the northern Great Plains ranges from about 20 inches in the eastern part of the region to less than 12 inches in the triangle section of north-central Montana. About three-fourths comes as rain during April to September, inclusive, and the region is therefore regarded as one of summer rainfall. In this respect it differs from the intermountain region. The dry farming problems and practices of the two regions, therefore, are somewhat different, owing to the difference in the season of maximum precipitation.

The extreme variability of the rainfall is the factor of greatest hazard in dry-farming operations. Seasons with a precipitation of only about half the normal occur occasionally. Comparatively wet years and comparatively dry years singly or in series occur with no regularity, and there is no way of foretelling when they may be expected. Generally speaking, the irregularities are more frequent and more extreme to the westward. During the growing season the rains are usually of short duration and more or less local. Single downpours of rain sometimes exceed the average total precipitation for the month. On the other hand, most of the precipitation for the season may occur in the form of a series of showers so light that they are of little benefit to the growing crops.

The northern Great Plains is a region of temperature extremes. The temperatures during the long winters may reach a minimum of −20° to −30° F., the lowest recorded at any of the stations considered in this bulletin being −57° F. at Havre. Very high temperatures occur during the comparatively short summers. A temperature of 100° F. or more at least once during the season is not uncommon, the highest recorded being 110° F. at Redfield, Edgeley, and Mandan. These extremely hot periods are usually of short duration, and except in the eastern and southern parts the nights are generally cool. Extreme fluctuations occur during the growing season. Temperatures of 102° and 32° F. were recorded at Redfield during September, 1922. Because of the dry atmosphere, however, the extremes of heat and cold are less severe on man and beast; but the winds, which blow with considerable regularity, are discomforting to man and beast, especially during the winter, and may be destructive to crops during the summer, particularly when accompanied by high temperature. High winds during the growing season greatly increase evaporation from the soil and transpiration from the plant. Were it not for the relatively high latitude of the region and the concomitant factors which produce what is commonly known as an intensive growing season, the annual precipitation would not be sufficient for cereal production except in limited localities.

Frosts have been known to occur at the higher altitudes every month of the year, but are rare in July. Early June and late August frosts are not uncommon in much of the region. The average length of the frost-free period ranges from 106 to 137 days at the station given. Never a year passes that more or less damage is not done to growing crops in the northern Great Plains by hail, but such damage is usually more or less local and in many cases is covered by insurance.

The climatological data for Redfield, S. Dak., and Moccasin and Havre, Mont., are given in detail in the following pages. These points have been chosen particularly because most of the forage-crop data have been obtained from experiments conducted at or near these stations and also because they represent the climatic extremes of the dry-farming section of the region.

Table 1 gives the precipitation data at Redfield, S. Dak. The average annual precipitation for all years from 1898 to 1922 exclusive of the years 1912, 1913, and 1921 is about 20.33 inches, while that for the last 10 years, exclusive of 1913 and 1921, is 21.1 inches, or about three-fourths of an inch more. The average difference in seasonal [2] precipitation for the same periods is a little less than half an inch in favor of the longer period. About three-fourths of the total precipitation, or approximately 15 inches, occurs from April to September, inclusive. The greatest annual precipitation (30.76 inches) was recorded in 1900, and the minimum (11.98 inches) in 1898. The highest and lowest seasonal precipitation occurred during the same years.

[2] The term "seasonal" as used in this bulletin includes the months from April to September, inclusive.

TABLE 1.—*Monthly, seasonal, and annual precipitation at Redfield, S. Dak., during the years 1913 to 1922, inclusive, with averages for certain years.*

[Data in inches; T = trace; NR = no record.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr. to Sept.	Total.
1913	0.01	0.55	NR	1.23	2.89	1.68	3.45	0.66	0.62	0.39	0.60	0.02	10.53	......
1914	.30	.54	0.29	5.22	2.84	6.72	1.17	1.67	3.12	1.00	0	.60	20.74	23.47
1915	.85	1.89	.99	2.13	2.87	3.58	4.86	1.89	2.02	1.82	.28	.58	17.35	23.76
1916	1.15	.47	1.16	1.11	5.13	3.56	2.01	5.19	1.42	.55	T	2.12	18.42	23.87
1917	2.38	.80	2.25	3.25	1.48	1.93	1.00	.79	1.97	0	0	.08	10.42	15.93
1918	.17	.14	1.15	2.17	3.59	2.56	1.68	2.77	.46	.20	2.50	1.48	13.23	18.87
1919	0	1.16	.97	2.18	2.90	4.70	1.71	.77	.44	2.77	2.03	.30	12.70	19.93
1920	.26	.21	2.14	3.00	4.35	4.60	3.73	1.35	.99	.80	.60	T	18.02	22.03
1921	.03	T	.85	1.72	1.61	.19	4.47	3.08	6.05	1.64	1.11	NR	17.12	......
1922	.67	3.65	2.04	2.60	4.44	2.67	.80	.13	.30	.40	2.83	.40	10.94	20.93
Average,[1] 1914 to 1922	.72	1.11	1.37	2.71	3.45	3.79	2.12	1.82	1.34	.94	1.03	.70	15.23	21.10
All years,[2] 1898 to 1922	.46	.67	1.11	1.97	3.15	3.27	2.63	2.83	1.77	1.30	.65	.52	15.62	20.33

[1] The year 1921 is not included in computing the averages, as data are not complete.
[2] The years 1912, 1913, and 1921 have not been included in computing the averages, as data for these years are incomplete.

Table 2 gives the dates of the last frost in the spring and the first in the fall at Redfield, S. Dak. June frosts are rare, only three being reported during the past 25 years. The latest spring frost was recorded on June 21 and the earliest autumn frost on September 9. The shortest frost-free period reported is 83 days, in 1902, and the longest 172 days, in 1922. The average for all years is 136 days.

TABLE 2.—*Dates of killing frost, the last in spring and first in fall, with frost-free period at Redfield, S. Dak., in each year from 1898 to 1922, inclusive.*

[Data from the records of the United States Weather Bureau.]

Year.	Last in spring.	First in fall.	Frost-free period.	Year.	Last in spring.	First in fall.	Frost-free period.
			Days.				*Days.*
1898	Apr. 25	Sept. 10	138	1912	May 16	Sept. 25	132
1899	May 13	Sept. 26	136	1913	May 6	Sept. 21	138
1900	May 3	Sept. 27	147	1914	May 14	Oct. 14	153
1901	June 7	Sept. 18	103	1915	May 19	Oct. 5	139
1902	June 21	Sept. 12	83	1916	May 3	Sept. 15	135
1903	June 11	Sept. 17	98	1917	May 2	Oct. 5	156
1904	May 14	Sept. 21	130	1918	May 13	Sept. 16	126
1905	May 13	Oct. 11	151	1919	May 9	Sept. 25	139
1906	May 9	Oct. 9	153	1920	Apr. 28	Sept. 30	155
1907	May 27	Sept. 28	124	1921	May 15	...do....	138
1908	May 8	Sept. 27	142	1922	Apr. 19	Oct. 8	172
1909	May 16	Oct. 12	149				
1910	May 12	Sept. 9	120	Average	May 14	Sept. 27	136
1911	May 4	Oct. 4	153				

The mean seasonal temperature for all years at Redfield was 61.4° F. The averages for the various months during the growing season for the years 1899 to 1922, inclusive, were as follows: April, 44.7°; May, 56.2°; June, 66.2°; July, 71.5°; August, 69.8°; and September, 60° F. July has the highest average and also holds the record for the maximum temperature of 110° F. in 1919. The lowest temperature recorded is −44° F. in January, 1912.

Table 3 gives the monthly, seasonal, and annual precipitation at Havre, Mont., for 1915 to 1922, inclusive, and the averages for the same period. The averages are also shown for the 43 years from 1880 to 1922 and the two shorter periods from 1916 to 1922 and from 1917 to 1922. The forage-crop experiments at Havre cover the years 1916 to 1922, inclusive. The average seasonal precipitation for this period (8.76 inches) and the average annual precipitation (11.72 inches) are about 1 inch and 1½ inches less than the corresponding averages for the 43-year period. In 1916, however, the precipitation was abnormally high; and when this year is excluded the annual average for the years from 1917 to 1922 is about 3 inches and the seasonal average 2 inches less than the averages for the long period. About 75 per cent of the total precipitation occurs during the growing season. The greatest annual precipitation was 25.67 inches, in 1884, and the least 6.76 inches, in 1905. The average monthly evaporation [3] in inches during the past seven years was approximately as follows: April, 3.4; May, 5.8; June, 7; July, 8; August, 7.2; and September, 4.4; a seasonal average of nearly 36 inches.[4] This is a ratio of precipitation to evaporation of 1 to 4.

TABLE 3.—*Monthly, seasonal, and annual precipitation at Havre, Mont., during the years 1915 to 1922, with averages for certain years.*

[Data (in inches) from the records of the United States Weather Bureau and of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr. to Sept.	Total.
1915	0.67	0.44	0.10	0.24	1.95	3.35	3.17	0.94	2.05	0.42	0.12	0.77	11.70	14.22
1916	1.75	.47	.59	.57	2.69	4.32	5.20	.20	1.90	.82	.15	.58	14.88	19.24
1917	.51	.20	.04	.86	.42	1.59	.43	.70	5.33	.38	.08	1.32	9.33	11.86
1918	.75	.25	.40	.44	.08	1.51	.74	2.10	.64	1.17	.42	.05	5.51	8.55
1919	.38	.56	.50	.31	1.09	1.99	.19	.60	.67	.48	.56	.23	4.85	7.56
1920	.88	.30	.40	1.71	1.39	2.20	1.36	1.26	.35	1.04	.01	.30	8.27	11.20
1921	.05	.06	1.81	.80	2.83	2.68	2.16	.53	1.45	.19	.70	.11	10.45	13.37
1922	.19	.76	.27	1.43	2.37	.90	1.90	.92	.54	.11	.31	.56	8.06	10.26
Average: 1915 to 1922	.65	.38	.51	.80	1.60	2.32	1.89	.91	1.62	.58	.29	.49	9.13	12.03
Crop years, 1916 to 1922	.64	.37	.57	.87	1.55	2.17	1.71	.91	1.55	.60	.32	.45	8.76	11.72
1917 to 1922	.46	.36	.57	.92	1.36	1.81	1.13	1.02	1.50	.56	.35	.43	7.74	10.47
43 years, 1880 to 1922	.74	.48	.51	.88	1.92	2.72	1.79	1.20	1.27	.66	.60	.51	9.78	13.27

TABLE 4.—*Dates of killing frosts, the last in spring and the first in fall, with frost-free period at the Northern Montana Substation, Havre, Mont., in each year from 1910 to 1922, inclusive.*

[Data from the records of the United States Weather Bureau.]

Year.	Last in spring.	First in fall.	Frost-free period.	Year.	Last in spring.	First in fall.	Frost-free period.
			Days.				*Days.*
1910	June 3	Aug. 25	83	1918	June 3	Sept. 9	98
1911	Apr. 30	Aug. 27	119	1919	May 14	Sept. 29	138
1912	May 13	Sept. 15	125	1920	May 4	...do....	148
1913	May 20	Sept. 11	114	1921	May 3	Sept. 11	131
1914	May 13	Oct. 12	152	1922	May 14	Oct. 6	145
1915	May 20	Sept. 14	117				
1916	May 14	Sept. 14	123	Average, 1910 to 1922	May 17	Oct. 19	125
1917	June 3	Oct. 11	130	Average, 1899 to 1909	May 16	Oct. 16	123

[3] The evaporation is recorded by measuring the open water surface in a tank sunk in the ground at about the general ground level.
[4] From the records of the Biophysical Laboratory of the Bureau of Plant Industry.

The mean temperature for the months from April to September ranges from 40° F. in April to 69° in July, the average being 58°. The average mean maximum for the same period is 72° and the mean minimum 45°. The highest temperature recorded is 108° and the lowest −57°.

Table 4 gives the dates of the last and first killing frosts for the years from 1910 to 1921, inclusive. The average date of the last killing frost in spring for this period was May 17 and for the first in fall September 19. The latest killing spring frost reported during this period occurred on June 3 and the earliest in autumn on August 25. July is the only month that has been entirely frost free. The average number of days between killing frosts was 125. The shortest frost-free period reported during the years 1910 to 1922, inclusive, was 83 days, and the longest 152 days, for the years 1910 to 1922. This is 2 days more than the average for the years 1898 to 1909. The prevailing wind is from the northwest, and the average seasonal velocity for the years 1916 to 1922 was approximately 5½ miles per hour. The highest average velocities occur in April and May.

Moccasin, with an elevation of 4,300 feet, has the highest altitude of any of the stations at which experiments were conducted in this region. As shown in Table 5, the average annual precipitation for the years 1898 to 1922 was 16.52 inches, and for the years 1912 to 1922, 16.3 inches. The average seasonal precipitation for the longer period was 11.99, and for the shorter period 11.3 inches. The maximum seasonal precipitation was 23.76 inches, in 1909, and the minimum 9.9 inches, in 1919. The average monthly evaporation for the years 1909 to 1922 is 33.4 inches.[5] The ratio of seasonal precipitation to seasonal evaporation was 1 to 2.8. The mean monthly temperature for the years 1909 to 1921 varies from 41° F. in April to 64° in July, with an average of 55° for the months from April to September. The average mean maximum for the same period is 68° and the average mean minimum 41° F. The highest temperature recorded is 103° and the lowest −37°.

TABLE 5.—*Monthly, seasonal, and annual precipitation (in inches) in the vicinity of Moccasin, Mont., from 1912 to 1922, with averages for certain years.*

[Data from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr. to Sept.	Total.
1912	0.88	0.60	0.81	1.43	3.94	0.64	1.92	1.27	1.63	1.68	0.14	0.06	10.83	15.00
1913	.89	.09	.20	.79	2.64	4.77	1.12	.51	1.01	1.63	.93	.38	10.84	14.96
1914	.47	1.35	1.12	1.19	2.91	4.64	.64	.65	1.11	.74	.64	.21	11.14	15.67
1915	.76	.08	2.69	1.43	2.12	3.97	3.54	.92	2.65	.85	1.01	.66	14.63	20.68
1916	.74	1.22	1.33	1.20	2.25	3.97	2.03	1.29	1.81	1.00	.64	2.39	12.55	19.87
1917	1.87	1.30	.85	1.18	2.79	1.81	.96	.75	2.91	.62	.09	2.56	10.40	17.69
1918	2.34	.62	.57	.44	2.69	1.55	2.95	1.48	1.25	1.09	1.14	.26	10.36	16.38
1919	.13	.71	1.20	.17	.73	1.08	1.02	.29	1.48	1.43	.93	.73	4.77	9.90
1920	.70	.63	.39	5.37	2.91	3.97	.89	1.83	.66	.65	.15	.21	15.63	18.36
1921	.06	T.	.60	.50	3.31	2.45	3.87	1.03	1.69	.03	1.47	.47	12.85	15.48
1922	.67	.69	.29	2.12	1.42	4.43	1.10	.68	.51	.77	1.19	1.51	10.26	15.38
Average: 1912 to 1922.	.86	.66	.91	1.44	2.52	3.03	1.82	.97	1.52	.95	.76	.86	11.30	16.30
All years, 1898 to 1922	.71	.48	.82	1.37	2.75	3.10	1.92	1.41	1.44	1.09	.68	.75	11.99	16.52

[5] From the records of the Biophysical Laboratory of the Bureau of Plant Industry.

Table 6 gives the dates of the last killing frosts in the spring and the earliest in the fall, with the length of the frost-free period for the years 1909 to 1922. The average date of the last killing frost in the spring was May 18 and the first in autumn September 20. The average length of the frost-free period was 125 days. The shortest period between killing frosts, 83 days, occurred in 1910. The longest period free from killing frost was 150 days, reported in 1922. The latest killing frost occurred on June 2 and the earliest August 24.

The average monthly wind velocity, in miles per hour, for the years 1909 to 1921 was as follows: April, 8.2; May, 7.9; June, 6.2; July, 7.9; August, 5.3; September, 6.1.[6] The seasonal average was 6.9 miles per hour.

TABLE 6.—*Dates of killing frost, the last in spring and first in fall, with the frost-free period at Judith Basin Substation, Moccasin, Mont., in each year from 1909 to 1922, inclusive.*

[Data from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Last in spring.	First in fall.	Frost-free period.	Year.	Last in spring.	First in fall.	Frost-free period.
			Days.				*Days.*
1909	May 17	Oct. 12	148	1917	May 30	Oct. 17	140
1910	June 2	Aug. 24	83	1918	May 28	Sept. 14	109
1911	May 6	Sept. 18	135	1919	June 1	Sept. 27	118
1912	May 12	Sept. 15	126	1920	May 25	Sept. 28	126
1913	May 19	Sept. 9	113	1921	May 2	Sept. 9	130
1914	May 12	Sept. 12	123	1922	May 8	Oct. 5	150
1915	May 5	Sept. 11	129				
1916	May 16	Sept. 13	120	Average	May 18	Sept. 20	125

The important climatic features from all stations for which crop data are given in this bulletin are summarized in Table 7. These data do not cover the same period of years at the various stations, which undoubtedly accounts for some apparent discrepancies. The highest average annual and seasonal precipitation is reported at Redfield, S. Dak. Edgeley, N. Dak., stands second in the seasonal average, with only about 1 inch less than at Redfield. The lowest average annual precipitation is recorded for Havre, Mont., and the lowest seasonal average for Sheridan, Wyo. The seasonal average of 13.25 inches, recorded for Ardmore, S. Dak., is undoubtedly above the normal, since the records for that station cover a period of only nine years, which included three or four years of abnormally high precipitation. Three stations, Redfield and Ardmore, S. Dak., and Mandan, N. Dak., record a maximum of slightly more than a 30-inch precipitation in one year. The lowest annual precipitation recorded is 6.64 inches at Belle Fourche, S. Dak. The maximum annual precipitation is nearly as great for the stations with the lowest as for those with the highest average annual precipitation. As would naturally be expected, the ratio of precipitation to evaporation is greatest in those sections where the rainfall is lowest, as is the case at Havre and Sheridan. The lowest ratio occurs at Edgeley, and while evaporation records are not available for Redfield, it is very likely that there is not much difference in this respect between Redfield and Edgeley. The highest mean seasonal temperatures are reported at Redfield,

[6] From the records of the Biophysical Laboratory of the Bureau of Plant Industry.

Ardmore, and Belle Fourche, and the lowest at Moccasin. Absolute maximum temperatures of 110° F. have been recorded at Redfield, Dickinson, Mandan, and Edgeley. The lowest temperature recorded is −57° F. at Havre. At the other stations the absolute minimum temperature ranges from −34° to −49° F. The average number of days between killing frosts ranges from 106 at Dickinson, N. Dak., to 137 at Belle Fourche. The shortest season, 47 days, is recorded at Dickinson and the longest, 173 days, at Williston, N. Dak. The average date of the last killing frost in spring occurs between May 8 and May 27, and the first in the fall between September 9 and September 27, thus giving a range of nearly four weeks in growing season between stations. The latest killing frost in the spring is reported as occurring on June 25, at Dickinson, and the earliest killing frost in the autumn on August 9, at the same station. At all these stations there is a wide range between the shortest and longest growing seasons reported. The average seasonal wind velocity ranges from 4.5 to 6.8 miles per hour.

TABLE 7.—*Summary of climatological data for all stations in the northern Great Plains region from which forage-crop data are reported.*

[Data marked with a star (*) are from the records of the United States Weather Bureau, those marked with a dagger (†) are from the records of the Biophysical Laboratory of the Bureau of Plant Industry, and those marked with both these signs are from both these sources. Data marked with a double dagger (‡) are from North Dakota Experiment Station Bulletin 158, being taken in part from records made at Fort Buford, Williston, and Williston substation in North Dakota. The seasonal data are for the months of April to September, inclusive.]

Stations.	Altitude.	Precipitation.					Seasonal evaporation.	Ratio of seasonal precipitation to seasonal evaporation.	Seasonal temperature.		
		Average annual.	Seasonal.		Annual.				Mean.	Mean maximum.	Mean minimum.
			Average.	Percentage of annual.	Highest.	Lowest.					
	Feet.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*		*°F.*	*°F.*	*°F.*
Redfield	1,295	*20.33	*15.62	76.8	*30.76	*11.98	......	....	*61	......	......
Havre	2,600	*†13.27	*†9.77	73.9	*†25.67	*†6.76	†35.8	1 to 4.0	†58	†72	†45
Moccasin	4,300	*†16.52	*†11.99	72.6	*†23.76	*†9.90	†33.4	1 to 2.8	†55	†68	†41
Dickinson	2,543	*15.41	*12.04	78.1	*22.74	*8.37	†32.9	1 to 2.7	*58	*72.6	*43
Mandan	1,750	*†17.04	*†12.99	76.2	*†30.92	*†10.31	†34.8	1 to 2.7	*59	*71.2	*47
Williston	1,875	‡14.76	‡11.12	‡75.3	‡23.25	‡7.37	†‡33	1 to 3.0	*58	*71	*45
Hettinger	2,675	*14.52	*11.86	81.7	*22.35	*7.37	†32.5	1 to 2.7	*58	†72	†44
Edgeley	1,468	*17.57	*14.51	82.6	*27.45	*10.41	†29.2	1 to 2.0	†58	†71	†45
Sheridan	3,790	*14.43	*9.36	64.9	*22.51	*7.98	†36.2	1 to 3.9	*57	*72	*43
Belle Fourche	2,850	†15.46	†11.74	75.9	†25.89	†6.64	†36.7	1 to 3.1	†61	†74	†47
Ardmore	3,567	†16.69	†13.25	79.4	†30.41	†12.78	†37.7	1 to 2.8	†61	†75	†47

Stations.	Absolute temperature for station.		Killing frost.				Growing season.			Average seasonal wind velocity per hour.
	Maximum.	Minimum.	Average date.		Latest in spring.	Earliest in autumn.	Average.	Shortest.	Longest.	
			Last in spring.	First in autumn.						
							Days.	*Days.*	*Days.*	*Miles.*
Redfield	*110	*−44	*May 14	*Sept. 27	*June 21	*Sept. 9	*136	*83	*172	......
Havre	*†108	*†−57	*†May 17	*†Sept. 19	*†June 3	*†Aug. 25	*†125	*†83	*†152	†5.4
Moccasin	†103	−37	†May 18	†Sept. 20	†June 2	†Aug. 24	†125	†83	†150	†6.5
Dickinson	*110	*−47	*May 26	*Sept. 9	*June 25	*Aug. 9[1]	*106	*47	*155	†6.7
Mandan	*†110	*†−45	*†May 12	*†Sept. 19	*†June 7	*†Aug. 23	*†130	*†98	*†170	†6
Williston	*†109	*−49	*May 17	*Sept. 18	*June 16	*Sept. 3	*124	*89	*173	†‡6.8
Hettinger	*†106	*−47	*May 27	*Sept. 17	*June 16	*Aug. 28	*113	*92	*129	†6.4
Edgeley	†110	†−38	*May 18	*Sept. 20	*June 9	*Aug. 20	*125	*85	*143	†6.6
Sheridan	*105	*−45	*May 20	*Sept. 20	*June 6	*Aug. 25	*123	*100	*156	†4.5
Belle Fourche	†109	−37	†May 12	†Sept. 26	†May 31	†Sept. 14	†137	†119	†171	†6.6
Ardmore	†103	−34	†May 8	†Sept. 20	†May 20	†Sept. 8	†135	†121	†149	†5.3

[1] July 19 is given in one table.

Further details explaining the periods covered by the data given in Table 7 for the several stations (all dates inclusive) are as follows:

Redfield, S. Dak.—All data are for the years 1898 to 1922.

Havre, Mont.—The precipitation data and absolute maximum and minimum temperatures are for the years 1880 to 1922; longest and shortest growing seasons and frost data, 1910 to 1922; other data, 1916 to 1922.

Moccasin, Mont.—Precipitation data, 1898 to 1922; other data, 1909 to 1922.

Dickinson, N. Dak.—Precipitation data, frost data, and absolute maximum and minimum temperatures, 1892 to 1920; evaporation data, 1907 to 1921; mean temperature, 1895 to 1920; mean maximum and mean minimum temperature, 1901 to 1920; wind velocity, 1908 to 1921.

Mandan, N. Dak.—Precipitation data, frost data, and absolute maximum and minimum temperatures, 1875 to 1922, these data for the years 1875 to 1913 being from records at Bismarck; mean temperatures from records at Bismarck for 1878 to 1920; other data, 1914 to 1922.

Williston, N. Dak.—Precipitation data, absolute maximum and minimum temperatures, 1879 to 1920; evaporation data, 1909 to 1918; mean, mean maximum, and mean minimum temperatures, 1882 to 1920; frost data, 1894 to 1920; wind velocity, 1909 to 1920.

Hettinger, N. Dak.—Precipitation data, 1907 to 1920; wind velocity, 1913 to 1920; mean temperatures, 1911 to 1921; absolute maximum and minimum temperatures, 1908 to 1920; frost records, 1909 to 1920; evaporation data, 1911 to 1921 (exclusive of 1913).

Edgeley, N. Dak.—Precipitation data, 1901 to 1920; evaporation data, 1909 to 1920; mean, absolute maximum, and absolute minimum temperatures, 1907 to 1921; wind velocity, 1910 to 1920; frost data, 1903 to 1920.

Sheridan, Wyo.—Precipitation data, 1893 to 1920; evaporation data, 1918 to 1921; mean, mean maximum, and mean minimum temperatures, 1908 to 1920; mean, absolute maximum, and absolute minimum temperatures, 1896 to 1920; frost data, 1900 to 1920 (exclusive of 1903 and 1904); wind velocity, 1917 to 1920.

Belle Fourche, S. Dak.—Precipitation data, frost data, and mean, absolute maximum, and absolute minimum temperatures, 1908 to 1922; evaporation data and wind velocity, same years; mean maximum and mean minimum temperatures, 1912 to 1921.

Ardmore, S. Dak.—Precipitation data, 1912 to 1922; other data, 1913 to 1922.

SOILS.[7]

In a region as extensive as the northern Great Plains the types of soil are so numerous that no attempt is here made to give them more than a general consideration. Each of the 12 groups shown on the accompanying map (fig. 2) includes numerous types varying in characteristics and ranging in texture from sand to clay.

In three of the divisions—the mountain areas, the sand hills, and the Yellowstone group—no attempt has been made to differentiate the soils. The mountain areas are for the most part outside the region here considered. The sand hills in the main are of little value except for grazing purposes, although interspersed with flats having a comparatively shallow water table on which alfalfa and other forage crops are successfully grown. The Yellowstone group includes the Bad Lands and other hilly areas with shallow soils, areas of relatively smooth land with shallow soils (as in eastern Wyoming), areas of shale outcrop (as in eastern Montana), and "slick-spot" areas. These lands in the main are not capable of cultivation, although they are of more or less value for grazing.

The other soils of the region, which for the most part are sufficiently smooth for the usual farming operations, appear on the map as a series of belts running north and south and interrupted by the

[7] Contributed by the Bureau of Soils of the United States Department of Agriculture.

ramifications of the Yellowstone group. The differentiation into belts is based on two characteristics: (1) The varying degrees of darkness in the color of the soil and (2) the depth to the zone of lime accumulation.

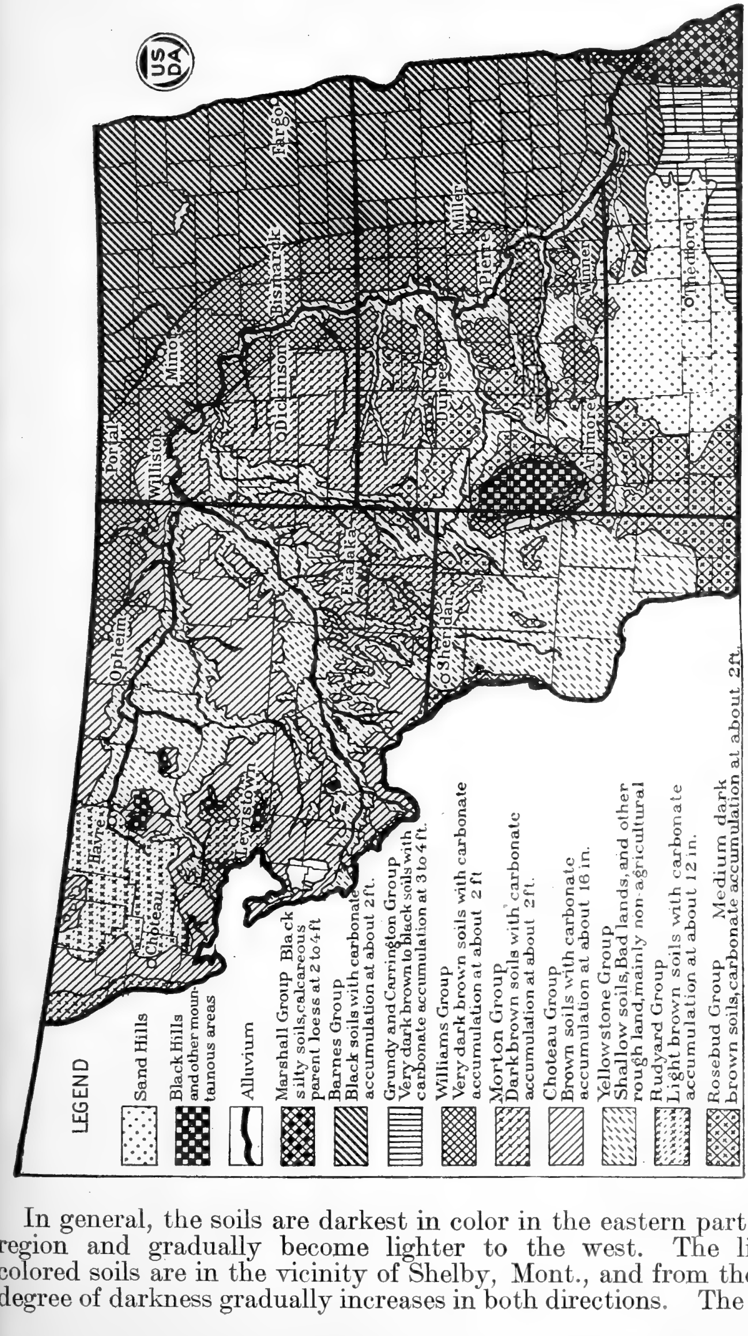


FIG. 2.—Generalized soil map of the northern Great Plains region. The black area, including the Marshall, Barnes, and Grundy and Carrington groups, has not been included in the area discussed in this bulletin because of the more favorable moisture conditions. (Map furnished by the Bureau of Soils.)

In general, the soils are darkest in color in the eastern part of the region and gradually become lighter to the west. The lightest colored soils are in the vicinity of Shelby, Mont., and from there the degree of darkness gradually increases in both directions. The degree of darkness indicates the proportion of humus in the soil. This, in turn, is dependent upon the grass covering, which bears a direct relation to the precipitation.

The relative depths of the zone of lime accumulations is also dependent largely upon the moisture supply. In the extreme eastern part of the region, where there is considerable moisture, the zone of lime accumulation is not well marked or else occurs at considerable depths. As the precipitation decreases to the westward the lime zone is found gradually nearer the surface.

The successive belts shown on the map are merely differentiations in the uniform or gradual change of these features in the soil, and the boundary lines are necessarily more or less arbitrary.

The black belt occupies the eastern part of the region and includes three groups: The Barnes, the Marshall, and the Grundy and Carrington. These soils are well supplied with humus, and the zone of lime accumulation occurs at 2 to 4 feet. The heavier textures predominate. This belt has not been included in the present discussion, as moisture conditions are such as to insure fairly satisfactory yields in most seasons.

The very dark brown belt lies just west of the black belt, and the soils have somewhat less humus. The zone of lime accumulation is found at about 2 feet. Here, also, the heavier textures predominate. This belt is indicated on the map as the Williams group.

The dark-brown group includes soils very similar in texture to the preceding group, but they are a shade lighter in color and the zone of lime accumulation is a little less than 2 feet from the surface. The Morton and Rosebud groups are included in this belt.

The soils of the brown belt, which are represented on the map by the Choteau group, are mostly confined to Montana, the largest areas lying in the eastern half of the State. These soils are lighter in color than any of the preceding groups and probably a little less productive. The zone of lime accumulation occurs at a depth of about 16 inches.

The light-brown soil belt—the Rudyard group—occupies an area north of Great Falls, Mont. These soils have less humus than any other of the soil belts in this region and are therefore lighter in color. The zone of lime accumulation is also nearer the surface, at an average depth of about 12 inches. Because of the low moisture supply these soils can hardly be considered agricultural, though exceptional farmers may be able to make a living under favorable conditions.

AGRICULTURAL RESOURCES.

As the first step in presenting a broad outline of the agricultural resources of the northern Great Plains, it may be stated that the total area involved is approximately 152,280,000 acres. In 1919 there were 26,838,000 acres of improved land in farms of which approximately 17,107,000 acres, or about 65 per cent, were in harvested crops, including native hay. Cereals are the chief crops of the region as a whole; but forage crops, especially native hay, contribute very largely to its agricultural resources, as they make stock raising possible. It is not so difficult to visualize the value of the grain resources, since grain is exportable to markets where it has a definite cash value. It is more difficult to evaluate the forage resources properly, since forage in the main must be used where it is produced and its value reckoned in terms of animals, animal products, and animal labor. Animal products contribute largely to the local food supply, while animal labor is largely the motive power necessary to agriculture generally. Neither appears in the inventory of resources to the extent its importance warrants.

CEREAL CROPS.

The Dakotas have long been noted for their wheat fields, but it is not generally known that these States normally contribute upward of 12 million acres, or more than half, to the total acreage devoted annually to spring wheat in the United States.

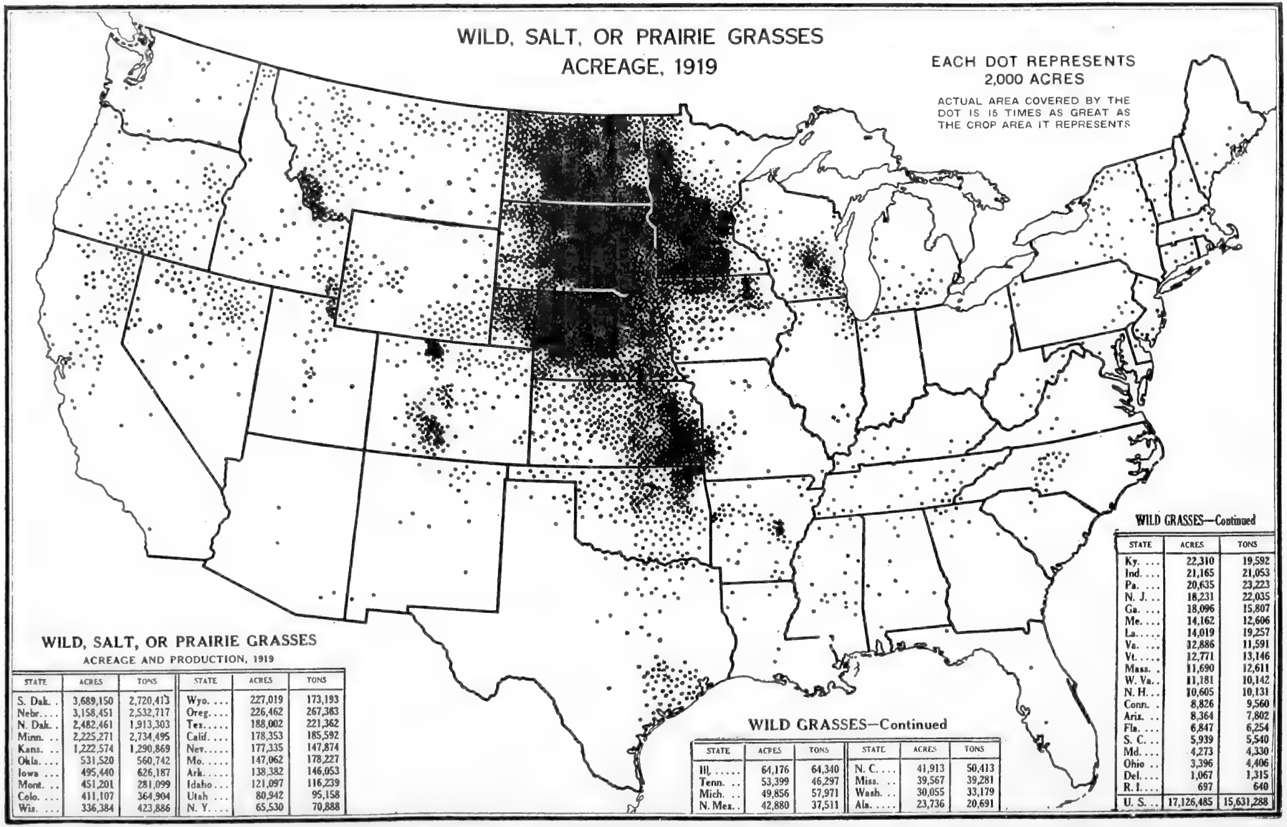
In 1919 there were in the northern Great Plains area, as here defined, about 4,813,000 acres of spring wheat, 600,000 acres of winter wheat, 1,218,400 acres of rye, 831,000 acres of oats, and 448,000 acres of barley. That the region is truly a small-grain region will be appreciated when it is noted that approximately half of the total acreage in crops in 1919 consisted of small grains. The region contributes one-fifth of all the spring wheat and one-seventh of the rye acreage of the United States. Corn is not important as a grain crop. However, it is relatively of much importance throughout most of the region as a crop to produce rough forage, and it is becoming increasingly more important.

FORAGE RESOURCES.

The native grasses constitute the greatest forage resource of the northern Great Plains. More hay is made from the wild grasses than there is roughage harvested from all the cultivated forage crops combined. This does not mean that native hay supplies more feed for livestock than do all the cultivated crops; for the cereal crops, including corn, supply feed or forage, but they are not commonly referred to as forage crops. In addition to grain, they supply straw and stover, bran, and other mill feeds. Native grasses, on the other hand, furnish pasturage as well as hay. They are an asset to the settlement of a new country, since they permit the pioneer to have livestock from the outset; and they have been especially important in the development of the northern Great Plains.

In this region a little less than 5,000,000 tons of native-grass hay are harvested annually. The map (fig. 3) shows that more than half of this tonnage must be credited to the Dakotas, and much of it is fed to livestock within the locality where it is produced. It is good forage, far better, in fact, than most of the native hay produced to the south. When fed in unlimited quantities it is decidedly more than a maintenance feed for cattle, horses, and sheep. Although the carrying capacity of the native grasses in the region is not high, the native ranges if properly managed turn off each fall cattle that are in excellent condition for the Corn Belt feed yard and thousands that are even in condition for slaughter. Furthermore, the native grasses cure on the stem and are a source of much excellent winter forage.

Two quite distinct types of grasslands—short grass and bunch grass—characterize the northern Great Plains. These types are determined very largely by the precipitation. The short-grass area



WILD, SALT, OR PRAIRIE GRASSES
ACREAGE AND PRODUCTION, 1919

STATE	ACRES	TONS	STATE	ACRES	TONS
S. Dak. .	3,689,150	2,720,413	Wyo. . . .	227,019	173,193
Nebr. . . .	3,158,451	2,532,717	Oreg. . . .	226,462	267,363
N. Dak. .	2,482,461	1,913,303	Tex.	188,002	221,362
Minn. . .	2,225,271	2,734,495	Calif. . . .	178,353	185,592
Kans. . .	1,222,574	1,290,869	Nev.	177,335	147,874
Okla. . . .	531,520	560,742	Mo.	147,062	178,227
Iowa . . .	495,440	626,187	Ark.	138,382	146,053
Mont. . .	451,201	281,099	Idaho . . .	121,097	116,239
Colo. . . .	411,107	364,904	Utah . . .	80,942	95,158
Wis. . . .	336,384	423,886	N. Y. . . .	65,530	70,888

WILD GRASSES—Continued

STATE	ACRES	TONS	STATE	ACRES	TONS
Ill.	64,176	64,340	N. C. . . .	41,913	50,413
Tenn. . .	53,399	46,297	Miss. . .	39,567	39,281
Mich. . .	49,856	57,971	Wash. . .	30,055	33,179
N. Mex. .	42,880	37,511	Ala.	23,736	20,691

WILD GRASSES—Continued

STATE	ACRES	TONS
Ky. . . .	22,310	19,592
Ind. . . .	21,165	21,053
Pa. . . .	20,635	23,223
N. J. . .	18,231	22,035
Ga. . . .	18,096	15,807
Me. . . .	14,162	12,606
La. . . .	14,019	19,257
Va. . . .	12,886	11,591
Vt. . . .	12,771	13,146
Mass. .	11,690	12,611
W. Va. .	11,181	10,142
N. H. . .	10,605	10,131
Conn. .	8,826	9,560
Ariz. . .	8,364	7,802
Fla. . . .	6,847	6,254
S. C. . .	5,939	5,540
Md. . . .	4,273	4,330
Ohio . .	3,396	4,406
Del. . . .	1,067	1,315
R. I. . . .	697	640
U. S. . .	17,126,485	15,631,288

FIG. 3.—Outline map of the United States, showing the acreage of wild, salt, or prairie grasses in 1919.

extends from the eastern boundary westward, although broken to a considerable extent in the drier parts of Montana by desert types. The bunch grasses grow chiefly on the breaks along watercourses and in sandy areas.

There are plants other than grasses that supply considerable forage on the native pastures and ranges, but the grasses are by far the most important. The data on the grazing lands of all kinds within this region are not accurate, but it is estimated that the entire region has 85,279,000 acres of grazing land. The estimates of the average carrying capacity are even less dependable, but from the data at hand it is reasonable to conclude that for the region as a whole 20 acres will supply grazing sufficient to carry one adult cow for a period of six months. The actual carrying capacity varies almost directly with the precipitation.

Tame pastures contribute almost negligibly to the total pasturage in the drier parts of the region. When it is recalled that the native grasses furnish approximately 3,000,000 tons of hay annually in addition to what they afford as pasturage, their value to the agriculture of the northern Great Plains will be appreciated. When broken, these native grasslands, even if left undisturbed, require fully a generation before they return, if ever, to their original productiveness.

The limiting factors in cereal-crop production are likewise the limiting factors in the growing of forage crops. Low rainfall and a short growing season very definitely limit the kinds of forage that can be grown, as well as the production. The fact that the total area of cultivated forage crops and of the cereal crops harvested for forage is less than 2,500,000 acres, or slightly more than half the area producing native-grass hay, shows clearly that these crops are not as yet a large factor in the agriculture of the region from the standpoint of either acreage or production. However, the cultivated forage should not all be credited to cultivated forage crops alone. A considerable part comes more or less incidentally from other cultivated crops, particularly the cereals, exclusive of the cereals cut for hay.

Of the strictly forage crops, alfalfa exceeds the others in acreage and tonnage, and yet very much less alfalfa is grown in this region than is commonly supposed. It is estimated that there are 786,000 acres which produce approximately 1,116,000 tons of hay annually. Much of the acreage, especially in Montana and western South Dakota, is under irrigation. The strictly dry-land acreage of alfalfa is small. Severe winters as well as dry summers are largely responsible for this.

Although corn is classed as a cereal, it is a true forage crop, and it is so regarded in all the northern Great Plains except that portion projecting into the Corn Belt. According to the census data, about 325,000 acres of corn were harvested for fodder and 17,000 acres for silage in this region in 1919. It is estimated that the forage produced from the total acreage on a dry-fodder basis would approximate 350,000 tons. In the drier sections corn for fodder is becoming increasingly important. For these sections corn may be regarded as a forage resource of very great potential value.

The last census lists a number of grasses under the heading "Other tame grasses," which includes those other than timothy and clover and certain grasses and legumes otherwise definitely specified.

For the northern Great Plains the millets are the chief members of this group. There are small acreages of awnless brome grass (*Bromus inermis* L.) and of slender wheat grass (*Agropyron tenerum* L.), but the millets exceed these many times both in acreage and production. They are short-season drought-resistant annual grasses that under reasonably favorable conditions produce fair yields of a very good quality of hay. The total acreage of "other tame grasses" in the northern Great Plains in 1919 was given by the census at 201,600 acres and the total production at 166,000 tons of hay.

The acreage of timothy and clover is small, and much of this is under irrigation. These forage plants are of little value where the annual precipitation is less than 20 inches, and consequently they can not be depended upon for forage production in the greater part of the region.

The sorghums, the chief cultivated forage dependence of the Great Plains region south of Nebraska and west of the ninety-eighth meridian, are grown only to a very limited extent in the northern Great Plains; but south of the latitude of Mandan, Sudan grass and early-maturing strains of the sweet sorghums offer possibilities for the future.

In North Dakota and Montana a considerable acreage of cereals is cut for hay. The area given by the census for 1919 was 356,500 and 432,000 acres, respectively. The total area for the region was 967,958 acres. From this area it is estimated that 399,000 tons of hay were produced. The acreage of small grains cut for hay in 1919 was appreciably higher than the normal annual acreage because of the shortage of forage due to drought conditions and to the fact that if left for grain it would not have been worth harvesting. On the other hand, the production per acre was lower because of the unfavorable season. For hay production cereals may be regarded as emergency crops, the acreage harvested each year depending largely upon the favorableness of conditions for the ranges, pastures, and the growing of forage crops. Furthermore, a cereal crop may not be profitable to harvest for grain and still be profitable enough to justify harvesting it for hay if forage is or promises to be scarce, as is commonly the case under such conditions.

It is interesting as well as significant that the total tonnage of grain produced in the northern Great Plains in 1919 was approximately equal to the total tonnage of harvested roughage. When it is considered that 1919 was a poor crop year and that much more grain was cut for hay that year than is normally the case, something of the relation of harvested roughage to the agriculture of this region may be appreciated. From the data here presented it is quite evident that there is not the proper relation between the production of harvested roughage and the production of grain when a really permanent system of agriculture is considered.

LIVESTOCK RESOURCES.

Forage is of value only as it is consumed by livestock. Therefore, in order that the forage resources of the northern Great Plains may be fully appreciated, the livestock resources will be briefly reviewed.

It is estimated by the Bureau of the Census that there were on farms in the northern Great Plains on January 1, 1920, a total of

3,713,780 cattle of all ages and of all kinds; 833,746 swine, 2,710,300 sheep, 1,510,298 horses (excluding colts and yearlings), 23,088 mules 2 years old and over, and 5,548,256 head of poultry. Considering the acreage and the production of cultivated crops, the number of cattle and sheep is very large. Beef cattle greatly outnumber dairy stock and furnish a large exportable surplus. Dairy cattle are relatively unimportant from a cash-income standpoint, and the quantity of dairy products produced is actually inadequate for the needs of the region. The number of swine is relatively small. Twenty-five States each produced more swine, according to the census, than the entire region. Iowa reported upward of 8,000,000, or more than nine times the number.

It is evident from an examination of the agricultural resources of the northern Great Plains that it is the range and native-grass lands and not the cultivated land that make the livestock industry what it is, notwithstanding the fact that a vast quantity of small grain is produced and that the grain tonnage is actually as great as that of the harvested forage. Livestock and forage have proved to be the foundation features of the agriculture of the region. This has been true since the first settlement, and from present indications livestock will be relatively more important as the country develops.

EXPERIMENTS WITH FORAGE CROPS.

The forage-crop data in this bulletin have been obtained from experiments conducted at various points in the northern Great Plains, chiefly at Redfield, S. Dak., Moccasin and Havre, Mont., Sheridan, Wyo., and Mandan and Dickinson, N. Dak. The work at Redfield has been conducted entirely by the Office of Forage-Crop Investigations, while that at the other stations has been in cooperation with the Office of Dry-Land Agriculture Investigations and the various State agricultural experiment stations. Additional data have been obtained from the records and bulletins of the Office of Dry-Land Agriculture Investigations and from various State publications, which give the experimental results at Belle Fourche and Ardmore, S. Dak., and at Edgeley, Hettinger, and Williston, N. Dak.

The weights recorded are of field-cured material, except as otherwise noted at Havre, Moccasin, and Redfield. To reduce the field-cured results to an air-dry basis it is estimated that a deduction of 10 to 15 per cent should be made for the finer stemmed forage plants, such as alfalfa and the grasses, and from 20 to 30 per cent for the coarser forages, such as sorghums, Sudan grass, and sweet clover.

The yields reported are considerably greater than a farmer can reasonably expect, largely on account of the greater care in preparing and sowing the various crops. Furthermore, some increase is attributable to the greater quantity of moisture available along the sides of plats.

Table 8 gives in condensed form the average yields of some of the leading forage and cereal crops at the various stations. It is believed that this table will be of some assistance in indicating the comparative productive capacity of the various sections over a period of years. The variations in yields are for the most part

82537°—24†——3

due largely to weather conditions, as the soils on which the tests have been conducted are capable of producing very large crops when moisture conditions are favorable. Variation and amount of precipitation account in a large measure for the fact that crop yields are in general higher in the eastern part of the region and decrease to the westward. The highest average yield of wheat is reported from Edgeley and the lowest from Havre. Slightly lower yields at Redfield than at Edgeley are doubtless attributable to the fact that the tests at the former station cover only three years, which included two abnormally poor crop seasons. The highest barley yields were obtained at Redfield and the lowest at Havre. The yields of oats are very similar at Redfield, Moccasin, and Dickinson and are appreciably higher than at most of the other stations. As is the case with other grains, the lowest average yield was at Havre. The average production of alfalfa at Redfield, as shown in the table, is about 1.8 tons per acre. At all the other stations except Havre the crop has averaged approximately 1 ton per acre. The acre production of corn fodder ranges from 3.4 tons at Redfield to 1.2 tons at Havre. Sorghum varies from 0.6 ton at Havre to 3.5 tons at Redfield and millet from 0.2 ton at Havre to 2.8 tons at Redfield.

TABLE 8.—*General average yields of the small grains and the more important forage crops at 11 stations in the northern Great Plains region.*

[Data from North Dakota bulletins and records of the Offices of Dry-Land Agriculture and Forage-Crop Investigations. The circled number following the yield average in each column shows the term of years considered in computing such average yield.]

Stations.	Yields per acre.						
	Small-grain yields (bushels).			Forage-crop yields (tons).			
	Spring wheat.	Oats.	Barley.	Grimm alfalfa.	Corn fodder.	Dakota Amber sorghum.	Kursk millet.
Redfield, S. Dak.	16.5 (3)	39.5 (3)	34.2 (3)	1.8 (5)	3.4 (4)	3.5 (7)	2.8 (9)
Ardmore, S. Dak.	17.2 (10)	32.1 (10)	18.1 (10)	.98 (10)	1.5 (10)	2.8 (5)	2.0 (5)
Belle Fourche, S. Dak.	16.9 (13)	31.1 (13)	17.2 (13)	1.0 (13)	1.8 (13)	2.3 (13)	
Edgeley, N. Dak.	17.2 (14)	34.0 (14)	20.3 (14)	1.0 (14)	2.0 (17)		
Mandan, N. Dak.	16.3 (8)	34.8 (8)	21.9 (8)	.93 (8)	1.9 (9)	1.8 (9)	2.0 (7)
Dickinson, N. Dak.	18.4 (15)	37.2 (15)	23.3 (15)	.85 (15)	1.8 (15)	1.6 (4)	1.2 (4)
Williston, N. Dak.	15.0 (11)	32.3 (11)	18.8 (11)		2.4 (11)	2.2 (6)	
Hettinger, N. Dak.	14.5 (11)	32.8 (11)	24.9 (11)			1.7 (5)	1.6 (6)
Havre, Mont.	7.3 (6)	13.5 (6)	9.0 (6)	.2 (5)	1.0 (7)	.6 (6)	.2 (6)
Moccasin, Mont.	16.7 (14)	36.2 (14)	18.9 (14)	1.1 (10)	2.4 (13)	.70 (6)	1.1 (7)
Sheridan, Wyo.	15.2 (6)	31.8 (6)	25.1 (6)	1.2 (5)	1.3 (6)	1.6 (6)	1.4 (6)

FODDER AND SILAGE CROPS.

Tonnage is an important factor in this region in the consideration of forage to be harvested and stored and in some degree takes precedence of quality. The list of the coarse fodder and silage plants for this region is small. Corn, the sorghums, and sunflowers are the only crops that are satisfactory from the standpoint of yield and palatability. Corn and sorghum are valuable for both fodder and silage, while sunflowers are useful mainly for silage.

CORN.

In gross tonnage, corn is the most dependable forage crop for much of the northern Great Plains region. In parts of the extreme North and at the higher altitudes it is at times forced to give way to the small grains and to a limited extent to sunflowers, where silage is considered. South of Redfield, Dakota Amber sorghum yields a gross tonnage equal to corn or possibly slightly greater, but corn seems to be preferred wherever it can be grown successfully. Corn is an excellent fodder plant and is unexcelled for silage. Furthermore, with the advent of better adapted varieties the matured grain produced by corn is of very great value to the region.

Generally speaking, only the early-maturing varieties can be satisfactorily grown on the northern Great Plains. There is, however, considerable variation in this respect, depending upon latitude and altitude. It is as a rule best to grow varieties that will mature or nearly mature whether the crop is to be harvested for grain, fodder, or silage. While the total tonnage may not be so great as from some of the later maturing varieties, the feeding value of the varieties that nearly mature is ordinarily enough greater to compensate for the difference in tonnage.

FIG. 4.—Corn varieties grown at Havre, Mont. Corn is one of the most important forage crops of the northern Great Plains region. The introduction of more suitable varieties has extended its area of production greatly in recent years.

Comparative tests have been conducted at Redfield with the Rainbow Flint, Northwestern Dent, Silver King, Minnesota 13, and Golden Glow varieties. Rainbow Flint has outyielded the other varieties both in grain and fodder. This variety is one of the best for silage, but the dent corns are preferred for grain. The common corn in this region is an early-maturing white dent.

At Dickinson and Mandan the Northwestern Dent variety has given about as satisfactory results as any, although Rainbow Flint has been quite satisfactory at Mandan. Triumph Flint has shown up well in comparison with the other varieties at Havre, Mont. (fig. 4). In 1922 Gehu Flint produced more grain than any of the other varieties tested, but Triumph Flint proved to be one of the best for silage and fodder.

Table 9 gives the annual and average yields of corn fodder at 11 stations on the northern Great Plains.

TABLE 9.—*Annual and average yields of corn fodder at 11 stations in the northern Great Plains region in stated years.*

[Data in pounds per acre. H=Destroyed by hail—not included in the averages. The yield stated for Redfield in 1922 is the air-dry weight.]

Year.	Highmore.[1]	Edgeley.[2]	Mandan.[3]	Belle Fourche.[4]	Ardmore.[4]	Dickinson.[3]	Williston.[3]	Havre.[3]	Redfield.	Moccasin.[3]	Sheridan.[3]
1906		4,912									
1907		2,420									
1908		2,010				2,535					
1909		7,170		4,695		5,815	6,718			9,456	
1910		1,610		2,887		3,506	1,791			2,641	
1911		4,630				4,070	3,574			5,981	
1912	7,060	6,350		4,375	3,187	H					
1913	6,360	5,731		1,605	927	3,589	10,841			4,215	
1914	2,811	5,085	4,210	1,151	1,018	2,980	7,639			4,310	
1915	633	5,900	4,070	5,900	6,343	3,330	2,419			6,198	
1916	3,768	4,525	4,770	4,570	4,572	4,358	6,825	4,450	8,755	4,423	
1917		1,840	3,760	3,601	2,369	1,316	2,919	1,040		3,368	2,358
1918		2,879	4,300	5,077	3,671	3,320	5,807	1,497	H	7,152	5,022
1919		4,382	2,560	259	2,168	2,074	2,778	447	4,131	937	249
1920		2,383	2,000	4,813	3,107	4,958	1,384	3,198	7,752	5,565	3,028
1921		4,364	3,050	2,155	2,563	3,154		2,861	9,549	4,294	1,290
1922		3,713	5,130	6,549	2,422	4,963		2,697	3,787	4,161	3,445
Average	4,126	4,112	3,761	3,664	2,941	3,569	4,790	2,313	6,795	4,823	2,565

[1] Data from South Dakota Agricultural Experiment Station Bulletin 174.
[2] Data from United States Department of Agriculture Bulletin 991 for the years 1906 to 1919 and from the records of the Office of Dry-Land Agriculture Investigations for the years 1920 to 1922.
[3] Data from the records of the Office of Dry-Land Agriculture Investigations.
[4] Data from Farmers' Bulletin 1163 up to and including 1919 and from the records of the Office of Dry-Land Agriculture Investigations for the years 1920 to 1922.

SORGHUMS.

The sorghums require a considerable period of warm weather for satisfactory growth, and as might be expected the greatest acreage is found in the southern part of the region. There are in those parts of South Dakota and Nebraska included in the area approximately 40,000 acres of sorghum. This acreage constitutes more than three-fourths of all the land devoted to sorghum in the area. In South Dakota most of the sorghum is found in the southern half of the State just west of the Missouri River. The average yield per acre is $1\frac{3}{5}$ tons of fodder. It is planted mostly in rows, although there is a small acreage sown broadcast in the eastern part of the region, where the moisture conditions are more favorable.

The leading variety for this region is Dakota Amber, although Minnesota Amber and Red Amber have given good results in the southern part. The acreage of grain sorghum is insignificant.

The average yields of sorghum gradually decrease west of Redfield (fig. 5) until the lowest yield is reached at Havre, where it falls below 1 ton per acre. At Mandan, Redfield, Sheridan, and Ardmore, the Red Amber variety has given the largest yields, but over most of the region Dakota Amber has proved most popular, as it is better adapted to a short growing season. At Redfield the average for this variety is about 3.5 tons per acre and at Belle Fourche, Ardmore, and Williston from 2 to nearly 3 tons per acre. The yields reported for Highmore are too low as compared with those from other stations, probably because the data were obtained during a period of years when conditions were not especially favorable. The light yields at Moccasin are largely due to the relatively short and cool growing season.

Table 10 gives the results of tests that have been conducted at various points in the region.

TABLE 10.—*Forage yields of sorghum varieties at 11 stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that yields marked with a star (*) are air dry weights. F=Killed by frost—not included in the averages. H=Destroyed by hail—not included in the averages.]

Varieties and stations.	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Dakota Amber:											
Redfield	......	8,904	......	7,777	4,996	H	6,142	8,437	6,693	*5,826	6,968
Mandan[1]	......	5,680	2,700	4,880	1,410	3,300	3,085	2,660	4,850	3,105	3,519
Dickinson[2]	......	......	......	5,626	......	......	1,350	2,900	2,635	......	3,128
Havre	......	......	......	2,023	......	0	0	0	*3,546	*1,606	1,196
Sheridan	......	......	......	......	3,000	4,740	0	4,230	1,050	5,580	3,100
Belle Fourche[3]	3,[illegible]00	1,725	6,450	9,650	3,300	7,700	0	5,900	2,450	5,950	4,608
Ardmore[1]	......	......	8,300	6,860	......	5,850	3,930	3,650	......	......	5,718
Highmore[4]	2,300	2,600	2,866	3,002	......	......	......	......	......	......	2,692
Hettinger[5]	......	......	......	3,780	1,787	3,460	4,390	3,960	......	......	3,475
Moccasin	......	......	1,340	2,860	1,532	0	......	0	F	*2,613	1,391
Williston[6]	......	......	2,475	5,940	2,805	6,390	4,925	3,825	......	......	4,393
Minnesota Amber:											
Mandan[1]	......	6,370	1,830	4,160	3,220	4,240	4,115	2,950	......	6,345	4,154
Redfield	......	8,884	......	11,219	7,105	H	6,951	12,951	10,394	*6,322	9,118
Ardmore[1]	......	......	11,500	8,100	......	7,300	5,300	4,800	......	......	7,400
Red Amber:											
Havre	......	......	......	......	......	......	0	0	*2,611	*623	809
Sheridan	......	......	......	......	2,540	4,660	0	3,370	870	9,900	3,557
Mandan[1]	......	7,040	3,760	7,430	3,100	4,240	4,880	2,030	......	*6,705	4,898
Redfield	......	11,296	......	14,719	9,498	H	9,095	15,483	11,584	*6,028	11,100
Ardmore[1]	......	......	10,450	13,230	......	8,070	6,370	5,420	......	......	8,708

[1] Data from the records of the Office of Dry-Land Agriculture Investigations.
[2] Data from North Dakota Agricultural Experiment Station Bulletins 131, 138, and 160.
[3] Data from Farmers' Bulletin 1163 up to and including 1919; other years from the records of the Office of Dry-Land Agriculture Investigations. Besides those printed in the table, the following yields of the Dakota Amber variety at Belle Fourche are included in the average for that station: 1909, 5,920 pounds; 1910, 3,360 pounds; 1912, 4,100 pounds.
[4] Data from South Dakota Agricultural Experiment Station Bulletin 174.
[5] Data from North Dakota Agricultural Experiment Station Bulletins 130 and 150.
[6] Data from North Dakota Agricultural Experiment Station Bulletin 158.

FIG. 5.—Sorghum at Redfield, S. Dak. This crop withstands drought well and competes with corn as a silage crop in the southern part of the region.

Where tests have been made of sorghums sown broadcast they have given somewhat larger yields than in rows, but are more quickly affected by drought. Furthermore, in broadcast sowings weeds are more troublesome and the crop is more difficult to handle.

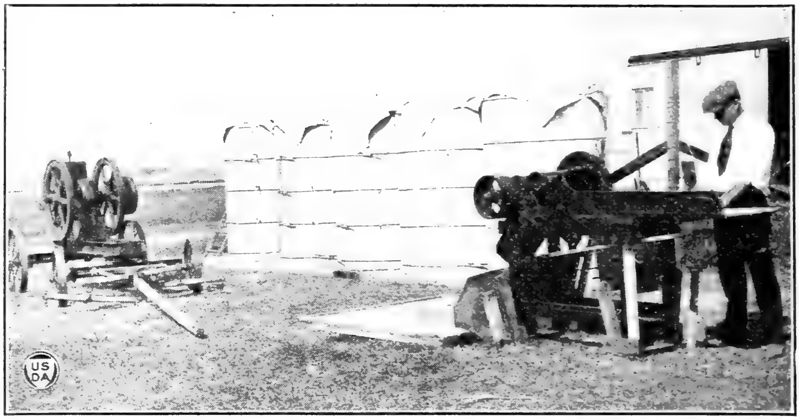


FIG. 6.—Experimental silos at Redfield, S. Dak., indicate that at least fairly good silage can be made from almost any herbaceous plant. Where the tonnage is sufficient common weeds may be used in time of necessity.

In dry seasons and in the drier sections sorghums in rows may be counted upon to give more satisfactory yields.

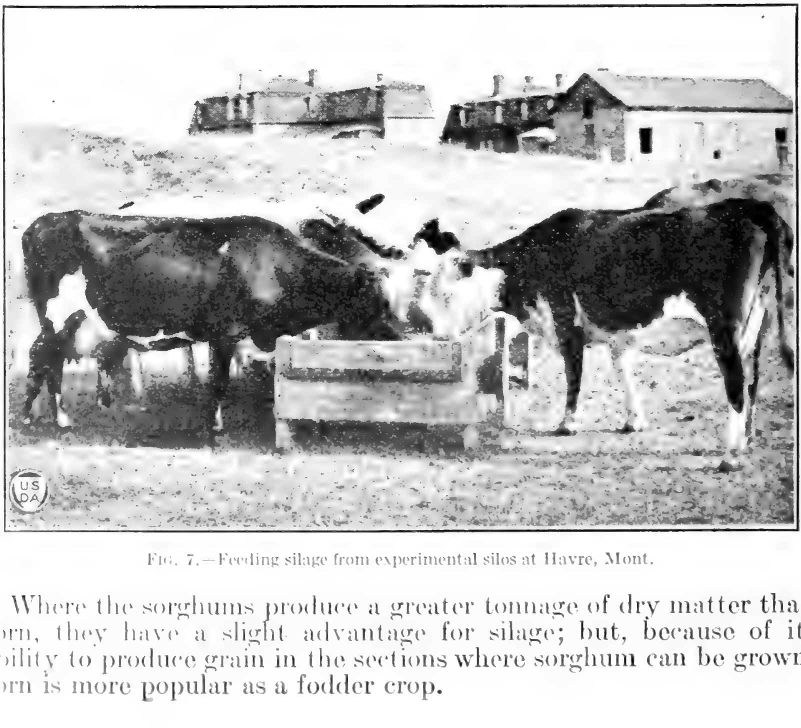


FIG. 7.—Feeding silage from experimental silos at Havre, Mont.

Where the sorghums produce a greater tonnage of dry matter than corn, they have a slight advantage for silage; but, because of its ability to produce grain in the sections where sorghum can be grown, corn is more popular as a fodder crop.

CORN, SUNFLOWERS, AND SORGHUM FOR SILAGE.

Silage is worthy of serious consideration for winter feed in any system of livestock farming, particularly dairy farming. (Figs. 6 and 7.) It has been shown that steers can be carried through the winter in good condition on corn silage alone, and when put on pasture they make rapid gains. The total acreage of corn for silage in the northern Great Plains area, as given in the census for 1919, was only about 17,000 acres; the total tonnage was approximately 46,000, an average of less than 3 tons per acre. The average yield per acre in South Dakota and Nebraska is somewhat greater than in Montana and North Dakota. The acreage of corn cut for silage in Montana is insignificant, and most of it is under irrigation.

In the northern Great Plains, as in many other parts of the United States, corn is the most popular silage crop, although sunflowers

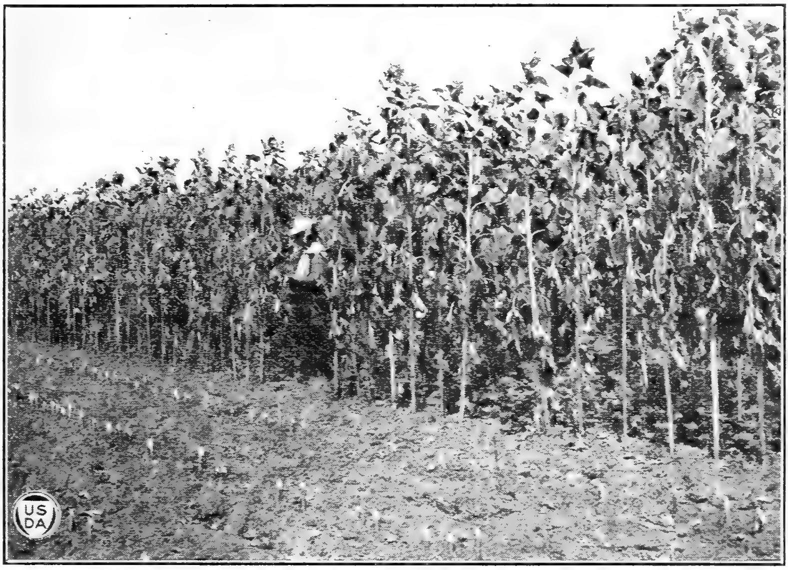


Fig. 8.—Sunflowers at Redfield, S. Dak. Sunflowers make a good silage and can be grown where the season is too short for corn.

have received increased attention for several years. Sunflowers thrive where it is too cool for corn, provided moisture conditions are favorable. The Mammoth Russian is the best variety available. (Fig. 8.)

The results of tests that have been conducted to ascertain the yields that may be expected of corn and sunflowers for silage in this region are shown in Table 11.

In most cases these comparative tests have not extended over a period long enough to give really conclusive data. The average annual yields of corn for silage range from about 2 tons at Havre to 10½ tons at Redfield. At Ardmore sunflowers outyielded corn in 1920, but the tonnage for both crops was about the same in 1919, 1921, and 1922. The green weight of sunflowers is somewhat higher than that of corn at Redfield, Havre, and Moccasin, but on an air-dry basis corn has exceeded sunflowers in all the tests at these points. Because corn silage is more palatable and probably slightly superior in feeding value to sunflowers and because tests have demonstrated clearly that sunflowers are no more drought resistant than corn, there appears to be little justification for growing sunflowers as a dry-land silage crop over most of this region. (Fig. 9.)

TABLE 11.—*Yields of corn and sunflowers for silage at six stations in the northern Great Plains region in stated years.*

Station and crop.	Yields of green material per acre (pounds).									
	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Redfield, S. Dak.:										
Corn	....	....	....	....	....	....	....	23,315	18,824	21,069
Sunflowers	....	....	....	....	....	....	....	24,392	28,745	26,569
Havre, Mont.:[1]										
Corn	....	....	....	....	....	2,670	2,495	6,170	4,300	3,909
Sunflowers	....	....	....	....	....	7,385	3,070	3,595	3,630	4,420
Moccasin, Mont.:[1]										
Corn	....	....	....	....	....	....	7,449	6,110	5,844	6,468
Sunflowers	....	....	....	....	....	....	8,266	8,110	5,620	7,332
Williston, N. Dak.:[2]										
Corn	....	....	....	....	....	10,255	8,680	....	....	9,468
Sunflowers	....	....	....	....	....	9,130	9,075	....	....	9,103
Hettinger, N. Dak.:[3]										
Corn	8,638	11,214	6,433	2,629	4,760	2,259	6,555	899	10,570	5,995
Sheridan, Wyo.:[1]										
Sunflowers	....	....	....	....	....	....	14,825	2,280	20,790	12,632

[1] Data from the records of the Office of Dry-Land Agriculture Investigations.
[2] Data from North Dakota Agricultural Experiment Station Bulletin 158.
[3] Data from North Dakota Agricultural Experiment Station Bulletin 130 and the records of the Office of Dry-Land Agriculture Investigations.

In the mountain valleys of Montana, where the seasons are comparatively short and the nights cool, and in the northeastern part of North Dakota, where rainfall is more abundant, the yields that can be obtained from sunflowers may be enough greater to offset any disadvantages.

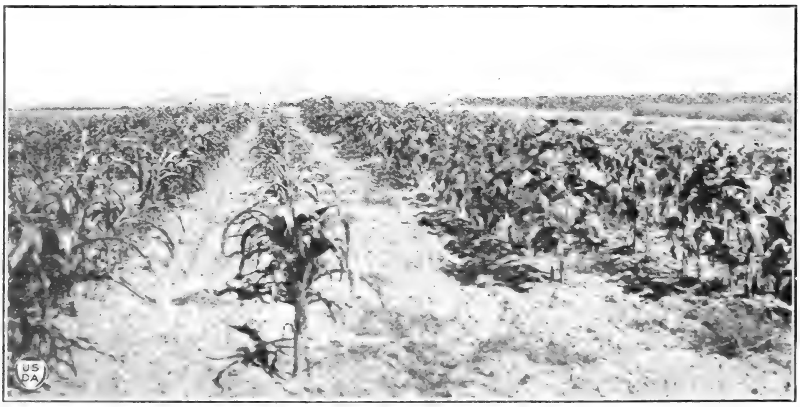


FIG. 9.—Corn and sunflowers at Havre, Mont., in 1920, showing the effect of hot, dry weather. Sunflowers will not produce profitable yields under conditions too dry for corn.

In the southern parts of the region, especially in the drier sections, certain sorghums, particularly Red Amber, ordinarily produce a greater tonnage of silage than corn, and it is practically as good for feeding purposes.

HAY AND PASTURE CROPS.

ALFALFA.

Much of the alfalfa of the northern Great Plains is produced under irrigation or has been given the advantage of favorable location along creek bottoms and elsewhere. Under such conditions fairly satisfactory crops may ordinarily be depended upon, even in sections where the rainfall is not sufficient to insure profitable yields on the uplands. (Fig. 10.) However, fields of alfalfa are not uncommon even where moisture conditions are so unfavorable that the yields secured are very light. The soils in most of this region are naturally well suited to the growing of alfalfa. They are generally well supplied with nitrogen-fixing bacteria and do not require the addition of lime, as do many of the soils of the more humid sections.

In the eastern part of the region little difficulty is experienced in getting a stand; but toward the west the lack of sufficient moisture frequently results in the failure of new sowings, and repeated attempts

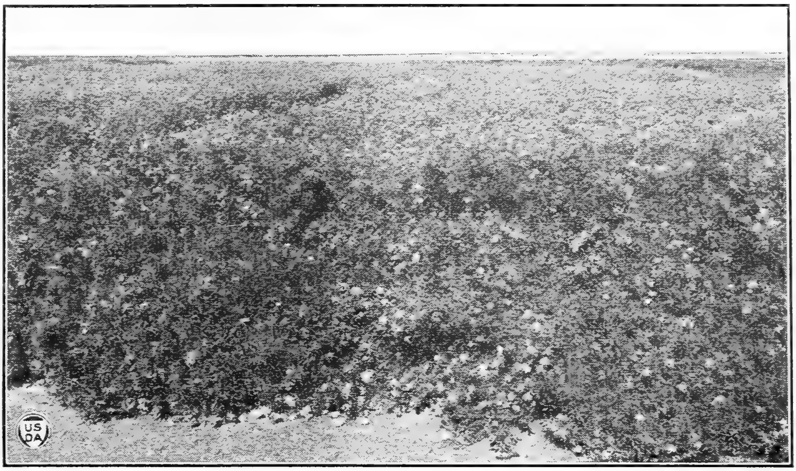


FIG. 10.—A field of alfalfa at Moccasin, Mont. Under average conditions in the Judith Basin alfalfa maintains a good stand for several years.

are sometimes necessary before success is attained. After the plants get well established they will stand considerable drought even though they do not make much growth.

To insure success it is best to sow alfalfa in the spring, when moisture conditions are more likely to be favorable. Formerly early sowing was advised, but recent tests indicate that better stands are obtained where sowing is delayed until from May 1 to 16. This gives an opportunity to work up the land and to destroy the weeds, which give considerable trouble in most of this region. Russian thistles are frequently troublesome, but cultivation destroys them to a large extent. (Fig. 11.)

VARIETIES OF ALFALFA.

The vicissitudes of climate under which alfalfa is grown on the northern Great Plains make the subject of variety a very important one. Early in the history of alfalfa culture in this region, interest became manifest in varieties possessing winter hardiness. It was soon found that common alfalfa, especially regional strains from Utah, Kansas, and States southward, would not withstand the very severe winter conditions that often obtain. This was quite a handicap to the extension of alfalfa growing. In 1904 the Minnesota Agricultural Experiment Station called attention to what is now the well-known Grimm alfalfa. This variety, a hybrid of the common blue-flowered alfalfa (*Medicago sativa* L.) and the yellow-flowered species (*M. falcata* L.) and apparently adjusted to the severe winters of Carver County, Minn., where it had been grown in a small way for years, has gone far toward filling the need for a hardy alfalfa. It is a superior variety for the region from all agronomic standpoints. Since the advent of the Grimm variety other hybrid alfalfas have been introduced and are apparently becoming more or less popular. Among these the Cossack seems to be the best known; but carefully conducted tests have not indicated their superiority to the Grimm in any important respect.

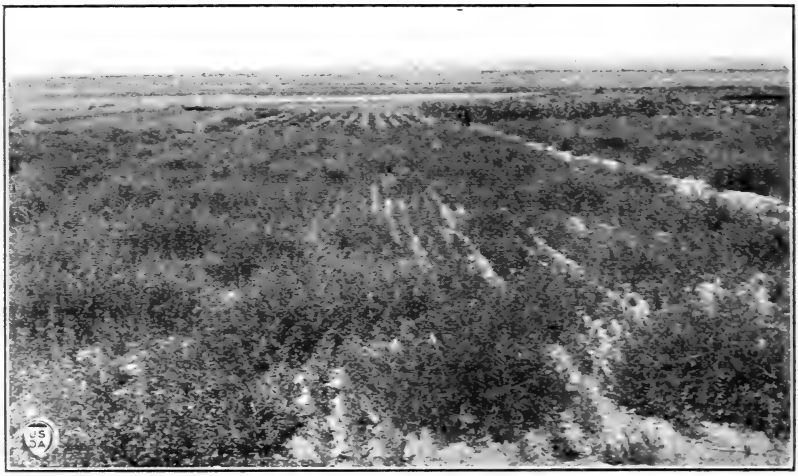


FIG. 11.—An alfalfa field invaded by Russian thistles at Havre, Mont. Russian thistles are a serious menace to young stands of alfalfa.

A careful study of alfalfa on the northern Great Plains discloses the fact that inability to produce satisfactory yields under conditions of low rainfall is much more of a handicap to its extension than a tendency to succumb to winter conditions. The list of alfalfas purporting to be varieties or strains suitable for the region is quite large, but the number of those actually in general use is relatively small. A great many varieties of alfalfa have been introduced from many parts of the world and have been tested at the various stations. As might be expected, a large proportion of them have shown no advantages over the varieties already established. Hay-yield data are not given here for all the varieties and strains in general use. In most cases data are given only for the typical representatives of the important groups. In addition to possessing differences in winter hardiness, alfalfa exhibits a latitude relation which, stated briefly and generally, is that strains exhibit a tendency to produce the best results in the latitude where they are developed. Data are given in Table 12 from what have proved to be the four leading varieties or strains of the groups they represent, namely, the Grimm, northern-grown common, Kansas common, and Turkestan.

One of the striking things shown in Table 12 is the small difference in the average yields of hay of the four leading alfalfas. The Grimm variety leads at all the stations except Moccasin, Mont., where it is slightly exceeded by the northern-grown common. As might be expected, the Kansas-grown common strain has been one of the lowest producers.

TABLE 12.—*Hay yields of the leading commercial varieties of alfalfa sown broadcast or in close drills at four stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the material at Moccasin from 1916 to 1922 and at Havre from 1920 to 1922 was air dried.]

Station and variety.	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Moccasin, Mont.:											
Grimm	2,300	4,100	3,100	2,275	2,040	773	0	2,171	2,130	2,430	2,132
Northern-grown common	2,350	4,600	2,550	2,238	2,320	943	0	2,647	2,400	2,440	2,249
Kansas	2,400	4,400	2,450	2,228	1,910	773	0	2,242	2,043	2,240	2,070
Turkestan	2,130	3,650	2,650	2,056	2,110	946	0	2,372	2,106	2,330	2,035
Havre, Mont.:											
Grimm	......	......	......	......	600	513	0	(1)	0	1,019	426
Northern-grown common	......	......	......	......	254	213	125	(1)	0	1,042	327
Kansas	......	......	......	......	187	258	0	(1)	0	978	285
Turkestan	......	......	......	......	162	233	225	(1)	0	901	304
Sheridan, Wyo.:											
Grimm	......	......	......	......	......	3,180	600	2,040	1,410	4,140	2,274
Northern-grown common	......	......	......	......	......	2,940	360	2,130	1,370	2,940	1,948
Kansas	......	......	......	......	......	3,460	300	2,350	1,050	3,060	2,044
Redfield, S. Dak.: [2]											
Grimm	......	......	......	5,780	3,340	3,590	3,400	1,855	4,125	3,706	3,685
Northern-grown common	......	......	......	5,240	2,840	2,770	3,400	1,494	2,712	3,250	3,101
Kansas	......	......	......	5,080	2,800	2,510	2,740	1,190	......	3,637	2,993
Turkestan	......	......	......	4,860	3,400	3,280	2,410	2,040	......	3,131	3,187

[1] Crop very light and scattered by winds, so that no yields were obtained; not included in the averages.
[2] Yields in 1916 to 1920 from 1914 sowing; yields in 1920 of second cutting only; yield of Grimm alfalfa in 1921 represents one cutting from treatment plat sown in 1920; yields of northern-grown common are from uncultivated plat in cultivation test sown in 1917; yields in 1922 are from the variety test sown in 1921, second cutting only.

Table 12 brings out one important fact. In several instances there are years of deficient rainfall and low yields followed by one or two years of favorable moisture when the yields run very high. This brings the average yield up to what is generally considered as fairly satisfactory, but the lack of dependable yields is one of the big drawbacks to forage-crop production over much of this region. As might naturally be expected, because of the relatively high precipitation the best results have been consistently obtained at Redfield. A good crop has been produced there every year since 1916, when the first crop was harvested. The tests at Moccasin have been running since 1913, and during this time the plats have yielded at the rate of more than a ton per acre in all but two years. The crop was a complete failure in 1919, and less than half a ton per acre was harvested in 1918. At Sheridan between 1918 and 1922 the yields exceeded a ton in three years out of five, and the average for the whole period was slightly more than a ton. At Havre about half the years from 1917 to 1922 have resulted in practical failures, and the yields for the other years have been far from satisfactory; but there was an abnormal deficiency of precipitation during this period.

The following varieties and strains have been or are being tested in connection with these investigations:

(1) Common strains from the various States, such as California, Arizona, Nebraska, and Kansas.

(2) Alfalfas of the northern-grown common group, including Montana common, Dakota common, Liscomb, and Black Hills.

(3) Utah irrigated and Utah nonirrigated.

(4) Variegated alfalfas—Grimm, Baltic, Cossack, Cherno, and Ladak.

(5) *Medicago falcata* (Siberian or yellow-flowered alfalfas), several strains.

(6) Alfalfas from various foreign sources, including Turkestan, Argentina, Italy, Spain, Sweden, France (Provence), Germany, South Africa, Peru, Arabia, Chile, Mongolia, Australia, New Zealand, Palestine, Ecuador, Guatemala, and India.

ALFALFA IN ROWS.

A few years ago the growing of alfalfa in rows sufficiently wide to permit of cultivation was very generally advocated, not only for the production of seed but also for hay. This method has been tested

FIG. 12.—Alfalfa in cultivated rows at Havre, Mont. This method of culture has shown no appreciable advantage over broadcast stands either for seed or hay.

very thoroughly, and there are now sufficient data to show that there is no advantage in following it where there is sufficient moisture to produce a fair crop in thin broadcast or closely drilled sowings. (Fig. 12.) The results of the tests at Havre, Moccasin, Sheridan, and Mandan are given in Table 13.

At Moccasin, Sheridan, and Mandan there has been practically no difference in the average yields of alfalfa grown in rows or in broadcast plats, and what little difference there is favors close drills. It is true that seasons occur when the moisture supply is so limited that the broadcast or close-drilled sowings produce no crop while the rows do make some growth, but under such conditions yields from row sowings are usually not sufficient to pay for the cost of harvesting. During favorable seasons the growth from broadcast or close-drilled sowings is enough greater to make up for the smaller crop in the dry seasons.

TABLE 13.—*Comparison of hay yields of alfalfa grown in rows and close drills at four stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the material at Moccasin in all years and at Havre in 1920 to 1922 was air dried.]

Station and method of sowing.	1916	1917	1918	1919	1920	1921	1922	Average.
Moccasin, Mont.:								
Close drills	3,234	2,868	2,249	0	2,938	2,126	2,840	2,322
Rows 12 inches apart	2,896	2,661	2,146	0	2,973	2,028	2,702	2,201
Rows 24 inches apart	2,866	2,846	2,218	476	2,927	2,142	2,280	2,251
Rows 30 inches apart	3,069	2,662	2,843	582	3,032	2,329	2,486	2,429
Rows 36 inches apart	2,882	2,310	2,859	843	2,771	2,333	2,530	2,361
Rows 42 inches apart	2,938	2,831	2,812	668	2,618	2,394	2,321	2,369
Sheridan, Wyo.:								
Grimm, close drills			3,180	600	2,040	1,410	4,140	2,274
Grimm, 35-inch rows			2,780	640	2,550	1,410	3,720	2,220
Kansas, close drills			3,460	300	2,350	1,050	3,060	2,044
Kansas, 35-inch rows			3,100	700	1,830	1,550	3,160	2,068
Local seed, close drills			2,940	360	2,130	1,370	2,940	1,948
Local seed, 35-inch rows			2,760	640	1,890	1,090	2,540	1,784
Mandan, N. Dak.:[1]								
Close drills	8,350	3,900	4,610	3,640				5,125
Rows 42 inches apart	6,350	4,750	5,290	3,880				5,068
Havre, Mont.:								
Close drills		266	178	140	474	945	1,290	549
Rows 24 inches apart		613	37	32	198	1,098	1,381	560
Rows 36 inches apart		1,060	199	285	744	1,177	1,211	779
Rows 48 inches apart		1,311	444	524	940	1,020	1,191	905
Rows 60 inches apart		1,200	726	421	710	940	1,165	860

[1] Data from the records of the Office of Dry-Land Agriculture Investigations.

At Havre, during the period of very dry years from 1917 to 1922, the results have been in favor of row sowings, but in every instance the best yields have not been more than half a ton per acre, which is below the point of profitable production. The cost of keeping the rows free from weeds and the poorer quality of hay due to the greater quantity of dust and dirt are objections to be considered seriously in growing alfalfa in rows.

Alfalfa is probably grown in rows to a greater extent for seed than for hay. However, it has been quite fully proved that where the soil and climatic conditions are not favorable for seed production very little more seed will be produced from rows than from broadcast or closely drilled stands. Where the moisture supply is so scant that no seed is obtained from drilled alfalfa the yield from rows will ordinarily not be sufficient to assure a profit, except in the case of unusual varieties the seed of which commands a high market price.

CULTIVATING ALFALFA.

At one time disking, harrowing, or similarly cultivating alfalfa was generally recommended, in the belief that such treatment prolonged the life of the stand, kept down the weeds, and increased the yields of hay. As a result of careful observations and a few definite plat tests it has been found that disking is actually injurious in humid districts, but the use of the so-called alfalfa harrow is still quite generally recommended. For the purpose of determining whether any sort of cultivation is justified on the northern Great Plains, tests have been carried on at Redfield and Moccasin for several years. The results of these tests are shown in Table 14.

TABLE 14.—*Hay yields of alfalfa in cultivation tests at Moccasin, Mont., and Redfield, S. Dak., in stated years.*

[Data in pounds per acre (except as stated) for field-cured material except that the material at Moccasin in 1916 to 1920 was air dried.]

TESTS AT MOCCASIN, MONT.

Treatment.	1913	1914	1915	1916	1917	1918	1919	1920	Average.
Disked once in early spring	2,100	3,400	3,050	2,450	2,360	1,016	0	2,072	2,056
No cultivation (check)	2,575	3,300	2,925	1,940	2,075	923	0	1,797	1,942
Disked twice in season	3,450	3,550	2,950	2,165	2,000	1,136	0	2,009	2,158
Disked once and harrowed in early spring	3,550	3,900	2,825	2,045	1,860	887	0	2,112	2,147
No cultivation (check)	3,300	3,450	2,600	1,940	2,145	1,059	0	2,327	2,103
Disked twice and harrowed in early spring	3,325	3,650	2,850	2,100	2,085	1,189	0	2,602	2,225

TESTS AT REDFIELD, S. DAK.

Treatment.	1917	1918	1919	1920	1921	1922	Average, all years.	
							Pounds.	Tons.
No cultivation (check)	6,025	2,612	2,837	5,100	2,712	4,052	3,890	1.9+
Harrowed (spring tooth) in early spring	6,175	3,025	2,562	5,162	2,525	4,025	3,912	1.9+
Harrowed (spring tooth) in early spring and after each cutting	6,175	2,875	2,425	4,887	2,387	3,671	3,737	1.8+
Disked twice in early spring	6,325	2,875	2,562	4,987	2,425	4,386	3,927	1.9+
Disked twice in early spring and after each cutting	6,775	2,850	2,162	5,012	2,137	3,547	3,747	1.8+

These data show quite clearly that the cultural treatments in the cases here recorded have practically no effect, since the differences in the yields of all the plats, whether treated or untreated, are easily within the limits of experimental error. It therefore appears that there is nothing to be gained by cultivating alfalfa grown without irrigation in this region.

TIME OF CUTTING ALFALFA.

It is important that the proper treatment be given alfalfa after a good stand has been obtained. Some of the tests indicate that it is better to let the alfalfa go throughout the first season without cutting, regardless of the weed growth. Under such treatment a larger root system is developed the first year, and the growth of weeds and alfalfa furnishes winter protection. Such treatment appears especially beneficial in a very dry period. With an abundance of moisture it apparently makes little difference whether or not the plants are clipped during the first season. After the first year the time of cutting is of considerable importance. Cutting very early in the stage of development or too frequently is quite certain to shorten the life of the stand. Better yields are obtained over a period of years and the stand is maintained in better condition where the cutting is delayed until the plants are well in bloom. It is true that cuttings made at an early stage have a higher feeding value, but there is compensation in the better yields where the cuttings are made later. Care should also be taken to avoid cutting too late in the season. In many parts of the region the winter injury is often severe when a cutting has been made so late in the season that the plants do not have time to recover before the growing season ends.

ALFALFA SEED PRODUCTION.

The production of alfalfa seed is a rather important industry in various parts of this region. In the vicinity of the Black Hills, S. Dak., and in the Milk River Valley, Mont., fair to good crops are usually obtained. More or less seed is produced over most of the region when seasonal conditions are favorable. In the eastern part of the area, however, satisfactory seed crops can not be depended upon.

ALFALFA WITH AND WITHOUT A NURSE CROP.

For several years experiments have been conducted to determine whether a nurse crop can be profitably used in sowing alfalfa in this region. The general conclusion reached is that where the ultimate object is to obtain a good stand of alfalfa it is safer to sow it alone. While good results follow the use of the nurse crop in many cases, complete failures are not uncommon. Everything depends upon the season. If there is an abundance of moisture in the soil the chances are in favor of practically as good a stand with as without a nurse crop. But if the season is dry the results are likely to be disastrous. Table 15 gives the results of tests that have been conducted with nurse crops at the various stations.

TABLE 15.—*Hay yields of alfalfa with and without a nurse crop at three stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, weights at Moccasin being those of air-dry material. Yields in each case are from sowings made the previous year except that those at Sheridan in 1919 were from sowings made in 1917 and all yields at Moccasin were from sowings made in 1915.]

Station and method of sowing.	1916	1917	1918	1919	1920	1921	1922	Average.
Redfield, S. Dak.:								
Alfalfa alone	....	3,695	1,925	1,500	(1)	2,025	6,087	3,046
Alfalfa with wheat	....	4,450	0	0	(1)	1,837	6,475	2,552
Alfalfa with oats	....	4,360	0	0	(1)	2,012	6,256	2,526
Alfalfa with barley	....	4,140	0	0	(1)	1,575	5,943	2,332
Alfalfa with flax	....	....	....	....	....	1,475	6,375	....
Sheridan, Wyo.:								
Alfalfa alone	....	....	3,200	80	2,380	760	800	1,444
Alfalfa and barley	....	....	2,620	40	2,760	490	0	1,182
Moccasin, Mont.:								
Alfalfa alone	3,080	2,780	1,800	0	3,283	....	....	2,189
Alfalfa and oats	3,040	2,640	1,592	0	3,031	....	....	2,061
Alfalfa and wheat	2,900	2,500	1,546	0	3,139	....	....	2,017
Alfalfa and barley	2,970	2,640	2,051	0	3,099	....	....	2,152
Alfalfa and flax	2,780	2,460	1,604	0	3,257	....	....	2,020

[1] Sweet clover volunteered to such an extent that yields were not obtained.

At Redfield in two years out of five as good results have been obtained with as without a nurse crop, but there were two years (1918 and 1919) when no stands were obtained where a nurse crop was used. At Sheridan sowings made alone gave better yields in every case but one. At Moccasin only one sowing was made, but the plats sown alone gave a higher average yield during the years 1916 to 1920 than any of the nurse-crop plats.

At all the stations the average yield over a period of years was enough greater where the alfalfa was sown alone to make the use of a nurse crop appear inadvisable. There is no consistency in the results obtained with the various nurse crops, but the general observations point to flax as being the least harmful.

MILLETS.

Millets are grown to some extent in nearly all parts of the region, but they can not be classed with the major forage crops. They evade drought because of their short growing season and make a hay of good quality although apparently less palatable to livestock than most forage crops common to this section (fig. 13).

At Redfield the average yield runs from 2½ to nearly 3 tons per acre of field-cured hay. There has been little difference in the yields of Kursk, Gold Mine, and Siberian. Common millet has given the lowest average yields. At Ardmore and Mandan the yields are very similar and range from about 1½ to 2 tons per acre.

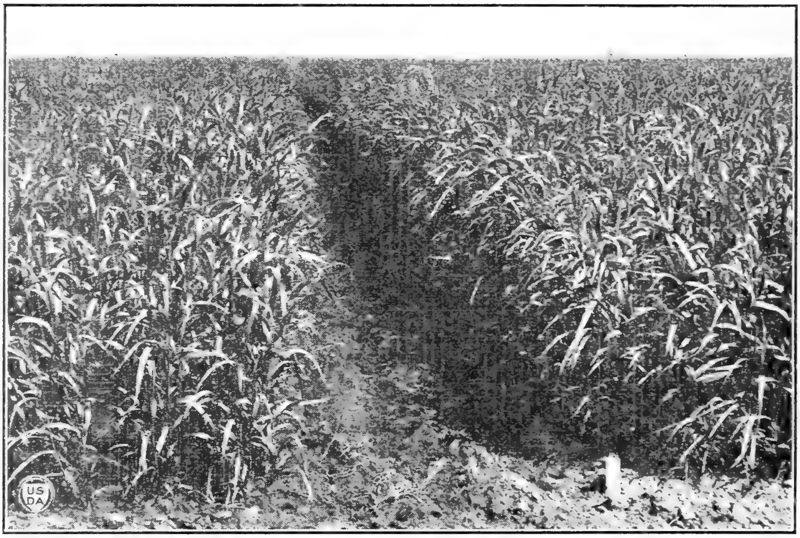


FIG. 13.—A field of millet at Redfield, S. Dak. Millet is one of the best-known annual forage crops in the northern Great Plains. The introduction of better varieties has increased its popularity appreciably.

Here, again, the yields of Kursk, Gold Mine, and Siberian are almost identical, and common millet is at the bottom of the list.

The average of yield at Hettinger has been a little less than at Mandan. At Sheridan only three varieties have been tested, all of which have yielded a little more than a ton, and Kursk has so far been the best. The average at Havre for six years is only about one-half ton per acre, partly owing to the fact that the crop was a failure in three of the years in which it was tested. At Moccasin and Dickinson the average yield is a little better than 1 ton. In 1917 the yield at Moccasin was less than half a ton; in 1920 there was a complete failure, and in 1921 a frost killed the crop before it was ready to be harvested.

Table 16 shows the results of millet tests that have been conducted at the various stations.

TABLE 16.—*Hay yields of millet varieties at eight stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the material at Moccasin in 1922 and at Havre in 1921 and 1922 was air dried. The yield stated for 1922 at Moccasin was that of the Gold Mine variety. The yield stated for 1919 at Hettinger was that of German millet. F=Killed by frost—not included in the averages.]

Station and variety.	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Redfield, S. Dak.:										
Kursk	4,500	7,300	5,450	2,600	6,350	5,150	7,400	7,475	3,325	5,506
Gold Mine	3,400	6,860	7,325	1,800	6,775	5,200	7,900	7,700	3,464	5,603
Common	4,600	6,880	5,550	2,350	5,700	4,700	7,700	6,300	2,700	5,164
Siberian	......	......	4,700	3,150	6,287	5,700	8,225	7,775	4,245	5,726
Sheridan, Wyo.:										
Kursk	......	......	......	0	3,400	0	4,800	1,720	6,660	2,763
Common	......	......	......	0	3,200	0	3,970	1,280	5,140	2,265
Gold Mine	......	......	......	0	3,800	0	4,330	1,380	3,700	2,202
Mandan, N. Dak.:[1]										
Kursk	4,300	4,800	6,260	1,510	5,320	2,970	2,365	......	......	3,932
Siberian	4,300	4,230	6,330	2,010	4,970	3,095	3,410	......	......	4,049
Common	3,000	2,800	5,500	1,930	3,990	2,120	1,980	......	......	3,046
Gold Mine	......	3,700	7,100	1,400	4,270	4,200	2,695	......	......	3,904
German	......	6,230	10,000	1,650	2,380	3,430	1,760	......	......	4,242
Havre, Mont.:										
Kursk	......	......	4,280	......	0	0	0	1,583	1,425	1,215
Gold Mine	......	......	2,380	......	0	0	0	1,955	1,311	941
Moccasin, Mont.:										
Common	......	3,350	3,380	883	3,310	......	0	F	2,558	2,247
Dickinson, N. Dak.:[2]										
Kursk	......	......	......	......	......	1,600	3,000	1,580	3,480	2,415
Hettinger, N. Dak.:[3]										
Kursk	......	1,500	4,500	3,438	5,620	1,920	2,800	......	......	3,296
Ardmore, S. Dak.:										
Kursk	......	4,670	3,420	......	4,330	3,870	4,370	......	......	4,132
Siberian	......	5,030	3,970	......	4,170	3,630	4,180	......	......	4,196
Common	......	3,630	3,200	......	4,270	3,330	3,970	......	......	3,680
Gold Mine	......	4,630	3,350	......	3,780	2,770	4,670	......	......	3,840

[1] Data from the records of the Office of Dry-Land Agriculture Investigations.
[2] Data from North Dakota Experiment Station Bulletins 138 and 160.
[3] Data from North Dakota Experiment Station Bulletins 130 and 150.

SUDAN GRASS.

There are no data on the acreage of Sudan grass in the region, but it is grown to some extent, particularly in southern South Dakota and northern Nebraska. Like the other members of the sorghum group it does not thrive in cool weather. The yields of Sudan grass for the most part have been less than those of sorghum or millet. Table 17 gives the results that have been obtained at various experiment stations during the past few years.

The highest average yields, 3 and 4 tons per acre, have been obtained at Redfield and the lowest average, about one-fourth ton per acre, at Havre. The average yields at Moccasin are also very low, less than one-half ton per acre. Results reported at other points for the most part range from about 1 to 1½ tons per acre, which in general is appreciably less than the millet yields for the same stations. Except at Redfield, Ardmore, and Williston the yields from row sowings and from broadcast or close-drilled sowings are very similar. In dry seasons Sudan grass gives the best results when sown in rows, but when moisture conditions are favorable broadcast or close-drilled sowings give better yields. While a longer season than is found in most of the region is required for the best growth of Sudan grass, it possesses possibilities in the more favorable situations south of North Dakota. (Fig. 14.)

TABLE 17.—*Comparison of hay yields of Sudan grass when sown broadcast or in closely drilled plats and in cultivated rows at 10 stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the material was air dried at Redfield and Moccasin in 1922 and at Havre in 1921 and 1922. F=Killed by frost—not considered in the averages.]

Station and method of sowing.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Moccasin, Mont.:												
Rows	.....	.....	.....	1,100	1,640	589	0	.....	0	F	1,706	839
Broadcast	.....	.....	.....	1,140	1,800	707	0	.....	0	F	1,733	897
Redfield, S. Dak.:												
Rows	.....	.....	.....	3,211	7,220	1,767	4,117	5,161	5,537	7,100	2,860	4,622
Broadcast	.....	.....	.....	7,200	8,090	5,625	6,725	5,775	7,775	8,281	4,562	6,754
Mandan, N. Dak.:[1]												
Rows	.....	.....	3,215	1,830	4,180	1,460	4,950	2,560	1,110	.....	.....	2,758
Close drills	.....	.....	3,140	2,730	3,380	1,650	2,940	3,310	1,265	.....	.....	2,631
Sheridan, Wyo.												
Rows	.....	.....	.....	.....	.....	820	2,660	0	2,330	490	3,550	1,642
Close drills	.....	.....	.....	.....	.....	890	3,140	0	2,370	260	4,150	1,802
Dickinson, N. Dak.:[2]												
Rows	.....	.....	.....	.....	.....	.....	.....	.....	2,800	1,100	.....	1,950
Close drills	.....	.....	.....	.....	.....	.....	.....	.....	2,600	1,080	.....	1,840
Hettinger, N. Dak.:[3]												
Rows	.....	.....	.....	.....	5,180	2,188	5,160	1,800	1,580	.....	.....	3,182
Close drills	.....	.....	.....	.....	4,050	1,768	4,820	1,940	2,920	.....	.....	3,100
Havre, Mont.:												
Rows	.....	.....	.....	.....	1,180	.....	F	0	0	934	1,143	651
Close drills	.....	.....	.....	.....	1,020	.....	F	0	0	1,017	1,080	623
Highmore, S. Dak.:[4]												
Rows	3,057	4,255	2,358	5,320	2,625	.....	.....	.....	.....	.....	.....	3,523
Williston, N. Dak.:[5]												
Rows	.....	.....	.....	2,750	5,115	2,255	4,590	3,295	2,100	.....	.....	3,351
Broadcast	.....	.....	.....	4,510	6,300	0	3,980	1,990	0	.....	.....	2,797
Ardmore, S. Dak.:												
Rows	.....	.....	.....	.....	3,660	.....	4,180	2,430	2,820	.....	.....	3,273
Drilled	.....	.....	.....	.....	3,980	.....	3,670	1,880	5,830	.....	.....	3,840

[1] Data from the records of the Office of Dry-Land Agriculture Investigations.
[2] Data from North Dakota Experiment Station Bulletin 160.
[3] Data from North Dakota Experiment Station Bulletins 130 and 150.
[4] Data from South Dakota Experiment Station Bulletin 174.
[5] Data from North Dakota Experiment Station Bulletin 158.

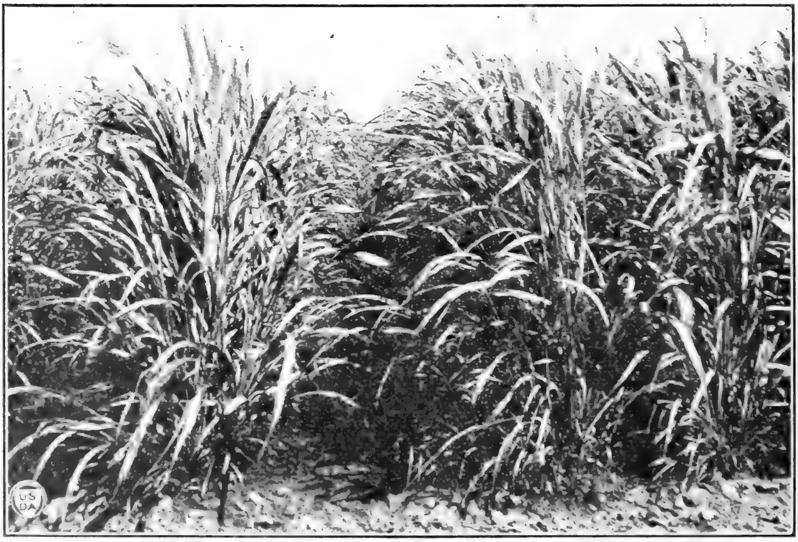


FIG. 11.—Sudan grass at Redfield, S. Dak. This crop withstands drought well and will compete with millet as far north as the southern part of North Dakota

SWEET CLOVER.

No statistics are available on the total area of land in sweet clover, but the acreage of all clovers in the region is not great. However, more and more attention is being given to sweet clover, and in the drier sections it is practically the only clover used. Its chief value in this region is as a pasture crop (fig. 15). Ordinary white sweet clover (*Melilotus alba*) is the species most commonly grown, though one of the yellow-flowered species (*M. officinalis*) is of considerable importance in some sections. The latter variety is apparently more hardy and seems capable of withstanding more drought. It has the additional advantage of producing a finer growth, which is a very desirable characteristic where hay is considered. There are, however, strains of white sweet clover, such as the Arctic, which appear fully as hardy as the yellow-flowered species.

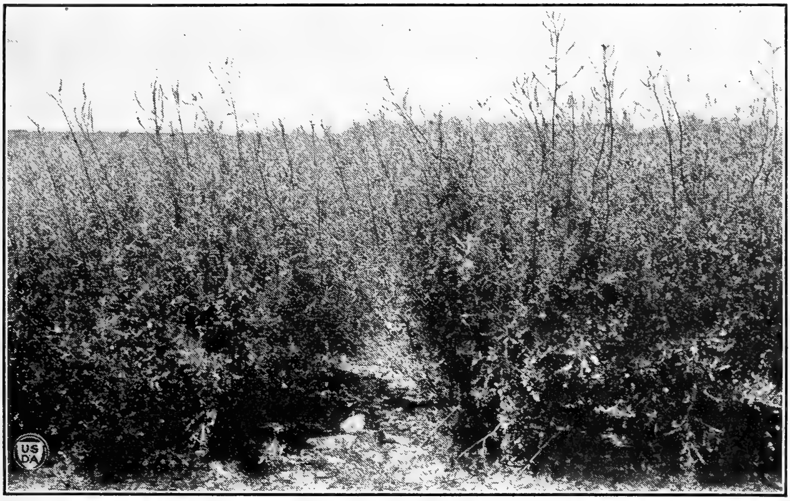


FIG. 15.—A field of sweet clover at Moccasin, Mont. This crop is increasing in popularity for forage. It is somewhat too coarse for first-class hay, but makes excellent pasturage.

As sweet clover in this region normally does not produce much of a hay crop until the second season it is advantageous to sow it with some nurse crop which will give at least a small return from the land the year the seed is sown. For this reason nurse crops have been used in most of the experiments. Table 18 gives the results that have thus far been obtained. It is shown clearly that better yields are obtained and failures to get a stand are less frequent where sweet clover is sown alone. However, it is questionable if the difference in average yields over a period of years is sufficient to offset the failure to get any return from the land the year the seed is sown. As a nurse crop for sweet clover, barley appears to be the least desirable of all the small grains. Flax is probably the safest, since such evidence as is available indicates that flax is not so hard on the sweet-clover seedlings as the grains.

TABLE 18.—*Hay yields of sweet clover sown alone and with nurse crops at four stations in the northern Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the material at Moccasin was air dried in 1921 and 1922.]

Station and method of sowing.	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Redfield, S. Dak.:									
Sweet clover alone	......	......	[2]3,700	2,087	1,900	0	4,862	7,587	3,556
Sweet clover with wheat	......	......	4,452	0	1,150	0	2,850	6,487	2,490
Sweet clover with oats	......	......	4,417	0	1,225	0	4,137	7,612	2,899
Sweet clover with barley	......	......	3,643	0	875	0	3,500	4,062	2,013
Moccasin, Mont.:									
Sweet clover alone	......	4,500	2,960	3,441	798	0	7,114	4,029	3,263
Sweet clover with oats	......	2,700	1,680	2,499	605	0	6,619	3,148	2,464
Sweet clover with barley	......	3,020	1,660	2,381	715	0	5,203	2,228	2,172
Sheridan, Wyo.:									
Sweet clover alone	......	......	......	5,420	2,200	0	560	0	1,636
Sweet clover with barley	......	......	......	1,680	800	0	170	0	530
Williston, N. Dak.:[1]									
Sweet clover alone	7,380	7,485	2,250	675	835	840	......	......	3,244

[1] Data from North Dakota Experiment Station Bulletin 158.
[2] A crop of hay which yielded at the rate of 3,235 pounds per acre was taken in the fall of 1916 from the plats sown alone. The late harvesting of these plats accounts for the low yield obtained on them in 1917 as compared with the plats sown with a nurse crop.

There seems to be an impression that sweet clover is more drought resistant than alfalfa, but when given the same conditions it is doubtful whether there is any appreciable difference. Sweet clover ordinarily has more moisture to draw on, as it usually follows some shallow-rooted or a clean-cultivated crop, while alfalfa remains on the land several years and draws heavily on the soil moisture. There is, however, little difference in the average yields of sweet clover and alfalfa. At Redfield sweet clover sown alone has averaged about 1¾ tons per acre and at Moccasin and Williston about 1½ tons. At Sheridan the average yield is about three-fourths of a ton per acre, but in 1920 and 1922 there were complete failures. At Havre the results have been even less satisfactory than at Sheridan. The failures have been so frequent and the yields have been so light during the past five years that the crop has not been profitable. At Ardmore sweet clover has been unable to compete with alfalfa.

Some tests have been conducted comparing sweet clover in close drills and in rows. While the results are slightly in favor of sowing in rows, the difference is not great enough to be really significant. As is the case with alfalfa, where the moisture supply is so light that the drilled plats do not make any growth, the yield from rows will not ordinarily be enough to justify the additional labor involved in keeping down the weeds. Furthermore, the hay from rows is often objectionable because of the dirt and dust collected with it. Comparative results from these two methods of sowing are given in Table 19.

TABLE 19.—*Comparison of hay yields of sweet clover grown in rows and close drills at Mandan and Sheridan in stated years.*

[Where no yields are recorded, no stand was obtained the previous season or else the plants were winterkilled.]

Station and method of sowing.	Yields per acre, field cured (pounds).									
	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Mandan, N. Dak.:[1]										
Rows	2,500	0	1,600	1,300	0	2,470	0	4,215	......	......
Close drills	2,200	0	5,150	0	0	2,510	0	1,815	......	......
Sheridan, Wyo.:										
Rows	......	......	......	......	7,000	2,100	0	1,200	0	2,060
Close drills	......	......	......	......	5,420	2,200	0	560	0	1,636

[1] From the records of the Office of Dry-Land Agriculture Investigations.

FIELD PEAS.

The acreage of field peas cut for forage in the northern Great Plains is very small. According to the last census, only 30,000 acres were harvested for this purpose. Most of this acreage is credited to North Dakota. The area grown for seed outside of the irrigated districts is practically negligible. Early hot weather is a decidedly detrimental factor to the field-pea crop in the southern part of the region, and to the west the rainfall is too low to make profitable yields reasonably certain.

Table 20 gives the results with field peas at the various experiment stations.

TABLE 20.—*Forage yields of field-pea varieties at five stations in the northern Great Plains region in stated years.*

[W=Yields not taken because of weeds—not considered in the averages.]

Station and variety.	Yields per acre, field cured (pounds).								
	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Havre, Mont.:									
Kaiser	......	......	0	......	515	1,950	W	1,550	1,004
Carleton	......	......	0	......	330	1,350	W	1,400	770
Paragon	......	......	0	......	345	1,775	W	1,300	855
Golden Vine	......	......	0	......	165	2,175	......	980	830
Redfield, S. Dak.:									
Kaiser	......	1,927	2,132	2,650	3,125	4,125	2,262	4,787	3,001
French June	......	1,677	2,486	3,050	2,875	......	2,150	4,421	2,777
Golden Vine	......	1,225	2,887	2,000	2,900	3,537	2,287	5,256	2,870
Moccasin, Mont.:									
Kaiser	3,630	3,718	1,767	3,988	358	1,636	1,651	3,507	2,532
Carleton	2,800	3,432	1,555	3,823	303	2,076	1,307	2,475	2,221
Paragon	......	3,652	1,720	4,400	309	1,856	1,169	3,300	2,344
Golden Vine	......	2,376	1,461	2,970	172	1,746	1,100	2,476	1,757
Dickinson, N. Dak.:									
Kaiser	......	......	......	......	......	4,389	1,309	4,040	3,246
Paragon	......	......	......	......	......	4,150	1,067	4,103	3,107
Gregory	......	......	......	......	......	4,256	1,232	4,437	3,308
Sheridan, Wyo.:									
Kaiser	......	......	1,113	966	0	......	846	1,640	913
Golden Vine	......	......	567	667	0	......	880	1,060	635
Paragon	......	......	833	1,333	0	......	752	1,340	852
Carleton	......	......	730	1,370	0	......	710	1,160	794

The best average yields of field peas cut for forage have been obtained at Redfield and Dickinson. At Redfield the average production for the past seven years is about $1\frac{1}{2}$ tons per acre, which is appreciably less than the average yield of alfalfa at that point. The yearly range there varies from about $\frac{3}{4}$ ton to $2\frac{1}{2}$ tons per acre. The yields at Dickinson are a little better than at Redfield. This is considerably above the average yields of alfalfa at that station. At Moccasin the average yield of most varieties for the past eight years has been somewhat over a ton per acre, which corresponds very closely to the alfalfa yields.

The yields of most varieties at Havre and Sheridan have averaged less than half a ton per acre. Such yields can not be regarded as satisfactory.

In general there is no marked difference in the yields of the varieties shown in Table 20. At every station except Dickinson the Kaiser variety has outyielded the others. Tests have also been conducted to determine the yields of seed that may be expected in this section. In these the highest average yield, about 15 bushels per acre, has been obtained at Redfield. The average yields at Moccasin range from 8 to 12 bushels per acre; at Havre, 4 to 6 bushels per acre; at Sheridan, 2½ to 3 bushels per acre; and at Dickinson, 12 to 14 bushels per acre. At all these stations the Kaiser has given the highest average yield of seed. At Edgeley field peas have given very satisfactory results as pasture for hogs.

FIELD PEAS WITH GRAIN MIXTURE.

The practice of sowing a mixture of field peas and one of the small grains for forage is common in some parts of the country. Tests have been conducted at Havre and Moccasin for several years to determine whether this practice has any advantages over peas sown alone. The results are shown in Table 21. At Havre the results favor sowing the peas alone, but at Moccasin the difference is in favor of the mixture. The difference between barley and oats in the mixture with the field peas is not enough to be significant.

TABLE 21.—*Hay yields of field peas alone and in small-grain mixtures at Havre and Moccasin in stated years.*

[Data in pounds per acre, field cured, except that the material in the years 1919 and 1922 was air dried.]

Station and crop.	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Havre, Mont.:										
Peas alone						468	1,952	1,430	1,530	1,345
Peas and oats						467	1,369	1,365	1,020	1,055
Peas and barley						482	1,370	1,130	880	966
Moccasin, Mont.:[1]										
Peas and oats		5,620	3,285	1,924	2,931	966	1,950	2,334	2,630	2,705
Peas and barley			2,891	2,250	2,145					2,429
Peas alone		3,460	2,376	1,461	2,580	309	1,856	1,169	3,300	2,064

[1] Golden Vine alone and in mixtures in 1915 to 1918; Paragon in 1919 to 1922.

SOY BEANS.

As a result of the introduction and development of shorter season varieties of soy beans, the crop has increased in popularity during the last few years (fig. 16). This interest has extended to the eastern part of North Dakota, South Dakota, and Nebraska. However, they have not as yet given promise of being of any great value in most of the region under consideration, as they do not appear to be sufficiently drought resistant to produce profitable yields where the rainfall is much less than 20 inches. While soy beans have produced fairly good seed yields at Redfield, S. Dak., the average production for a period of years is less than that of wheat. Because of this it would be necessary for them to bring a considerably higher price per bushel to offset the smaller yield, if they are to compete successfully with wheat as a grain crop. As a forage crop at Redfield they have not proved at all successful when sown broadcast, and in rows they can not compete with alfalfa and sweet clover from the standpoint of yield. Furthermore, they are a more expensive crop to produce.

In the extreme eastern part of this region soy beans are occasionally planted in corn for silage. For this purpose the Manchu variety is as satisfactory as any available. They are also grown in corn for hogging off. This is probably about the best way to utilize the crop when all things are considered. Table 22 gives the seed yields that have been obtained at Redfield from the most promising varieties.

TABLE 22.—*Seed yields of soy beans at Redfield, S. Dak., for the 9-year period from 1914 to 1922, inclusive.*

Variety.	Yields per acre (pounds).									
	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Manchu (30593)	943	551	860	364	222	916	1,293	517	775	716
Saskatoon (02108)	951	542	825	271	210	836	1,333	567	711	694
Mandarin (36653)	640	613	737	177	323	795	1,160	821	792	673
Aksarben (36576)	902	495	737	230	191	715	1,267	586	832	662

Wisconsin Early Black is a well-known variety generally grown in eastern South Dakota, but it does not appear to be so promising as Manchu and Mandarin, which are the most popular varieties. At Redfield in 1922, the only year Wisconsin Early Black was carefully tested, it yielded appreciably less than Manchu or Mandarin. Yields of the various varieties tested at Redfield have ranged from 3 to 20 bushels per acre. The average for all varieties for all years has been upward of 11 bushels to the acre.

FIG. 16.—A field of soy beans at Redfield, S. Dak. Early-maturing varieties have made it possible to utilize this crop as far north and west as Redfield.

In 1914, 1915, and 1916 soy beans were tested as a forage crop at Mandan. During this time the yield was only about half that obtained from field peas. In 1916 soy beans produced 1,645 pounds of forage to the acre, while alfalfa produced more than 3 tons.

Several varieties of soy beans were tested at Moccasin in 1915, but they did not make a satisfactory growth, owing to the comparatively short cool season. In a test at Williston in 1915 it was concluded that the forage possibilities were small, although two varieties that matured yielded at the rate of 10 bushels of seed per acre.

GRASSES.

The fact that cultivated perennial grasses constitute such a small proportion of the acreage of the northern Great Plains region is a good indication that the yields of the grasses have not been very satisfactory. According to the last census, the average yield of timothy alone is appreciably less and that of timothy and clover mixed is slightly more than 1 ton per acre. Most of the timothy, either alone or in mixtures, is grown in the eastern part of the region, or farther west under irrigation. Timothy has been tested under dry-land conditions at various stations, but the yields have generally been too light to justify a farmer in growing the crop. Awnless brome grass (*Bromus inermis* L.) up to the present time has proved most satisfactory in all the tests at the dry-land stations and is about

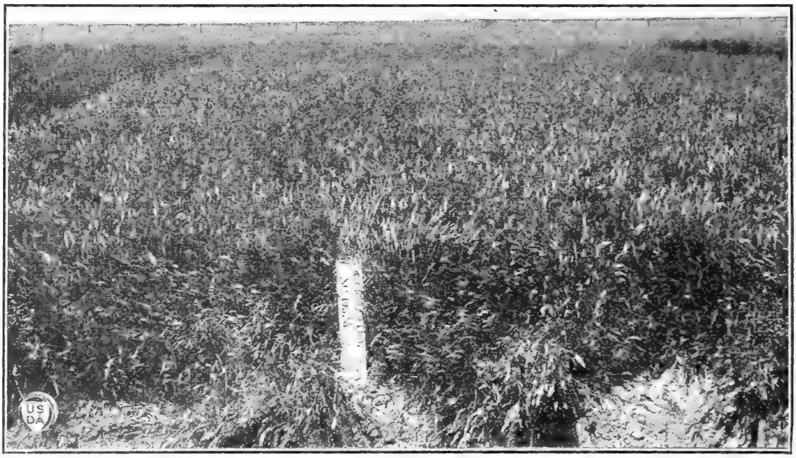


FIG. 17.—A field of crested wheat grass (*Agropyron cristatum*) at Moccasin, Mont., in 1920. This is one of the most promising perennial hay grasses for the northern Great Plains region.

the only perennial cultivated grass that is grown on dry land. Over much of the area even this grass is not capable of giving profitable yields, except in favorable locations that receive the benefit of additional moisture. Under such conditions brome grass gives the best yields the first two years. After this the grass becomes sod bound and the yields are inclined to fall off unless an abundance of moisture is available. No census figures are available concerning the acreage of brome grass, but it is undoubtedly considerably less than that of timothy, and the average yield of hay per acre is probably less than a ton.

Slender wheat grass (*Agropyron tenerum* L.), which has been grown to a limited extent in many parts of the region, has gained little headway in acreage.

Crested wheat grass (*Agropyron cristatum* L.) offers considerable promise as a hay crop (fig. 17). Its performance in the tests at the various stations indicated its possibilities. The results of the tests with these various grasses are shown in Table 23.

Table 23.—*Hay yields of the grasses at eight stations in the Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the results marked with a star (*) were based on air-dry material. H=Destroyed by hail—not included in the averages.]

Station and crop.	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average.
Edgeley, N. Dak.:[1]																	
Brome grass, close drills	3,000	2,313	4,288	1,125	1,238	3,950	2,588	3,538	2,800	4,750	1,713	1,775	2,663				2,749
Mandan, N. Dak.:[2]																	
Brome grass, rows										4,980	2,910	2,490	2,120	470	1,240	1,380	2,227
Brome grass, close drills										4,900	1,350	1,450	1,500	440	1,800	1,600	1,863
Slender wheat grass, rows										4,550	3,000	1,800	1,510				2,715
Crested wheat grass, rows										3,550	3,200	3,200	3,080	1,250	1,850	1,900	2,576
Hettinger, N. Dak.:[3]																	
Brome grass, close drills						980	900	1,126	1,870	2,684	1,370		0	0			1,116
Dickinson, N. Dak.:[4]																	
Brome grass, close drills		1,560	3,480	1,408	750	3,310	2,670	2,850		2,000	2,500	1,410			665	2,258	2,072
Slender wheat grass, close drills		2,120	3,780	900	776	H	1,272			1,800	800	950			758	2,198	1,535
Timothy, close drills		1,700	3,240	628	446		524			1,700	900	810					1,244
Moccasin, Mont.:																	
Brome grass, close drills												*1,768	0	*2,178	*2,844	*1,764	1,711
Crested wheat grass												*2,674	0	*3,159	*1,688	*1,144	1,733
Slender wheat grass												*2,907	0	1,144	1,851	*1,078	1,396
Havre, Mont.:																	
Brome grass, rows															*1,960	*2,152	2,056
Brome grass, close drills															*559	*887	723
Crested wheat grass, close drills															*978	*1,323	1,150
Slender wheat grass, close drills															*840	*1,197	1,019
Slender wheat grass, rows															*4,380	*2,118	3,249
Sheridan, Wyo.:																	
Brome grass, close drills													1,180	1,400	600	0	795
Williston, N. Dak.:[5]																	
Brome grass, close drills									1,730	2,170	683						1,528
Slender wheat grass, close drills									1,630	1,580	550						1,253

[1] Data from United States Department of Agriculture Bulletin 991.
[2] Data from the records of the Office of Dry-Land Agriculture Investigations.
[3] Data from North Dakota Agricultural Experiment Station Bulletins 130 and 150.
[4] Data from North Dakota Agricultural Experiment Station Report for 1910, from Bulletins 110, 131, and 160 of that station, and from the records of the Office of Dry-Land Agriculture Investigations.
[5] Data from North Dakota Agricultural Experiment Station Bulletin 158.

The average hay yields of brome grass and the wheat grasses range from 1 to 1½ tons at Mandan and Edgeley and about half a ton at Hettinger and Havre. The Ardmore results are not shown in the table, but the yield has averaged about 0.9 ton per acre. While complete failures are not common, there are years when the yields on the dry lands in the western part of the region are so low as hardly to justify harvesting.

There appears to be little difference in the yields obtained from slender wheat grass, awnless brome grass, and crested wheat grass, but crested wheat grass compares favorably with other grasses. Ordinarily, slender wheat grass gives its best yields the first year or two after sowing.

In the driest sections these grasses sown in rows produce slightly higher yields than in drilled plats, but the difference is seldom sufficient to compensate for the greater labor involved in keeping down the weeds. Furthermore, brome grass when sown in rows soon spreads until it approximates a broadcast stand. There is also more difficulty in harvesting the hay, which is likely to be dusty and dirty. The row method of culture for perennial grasses has not offered sufficient promise to make it popular.

BROME GRASS AND ALFALFA.

The opinion prevails that alfalfa and brome grass sown together will give a better yield than either sown alone. It is also claimed that when the alfalfa dies out the brome grass fills in the vacant places and maintains the stand. For the purpose of determining the advantages or disadvantages of such a practice, tests have been conducted at various points. The results of these tests are given in Table 24.

TABLE 24.—*Comparison of the hay yields of alfalfa sown alone, of awnless brome grass sown alone, and of these two crops sown as a mixture, at three stations in the Great Plains region in stated years.*

[Data in pounds per acre, field cured, except that the material at Moccasin was air dried in all years.]

Station and crop.	1916	1917	1918	1919	1920	1921	1922	Average.
Redfield, S. Dak.:								
Alfalfa alone		3,190	3,530	2,650	4,470	1,770	4,575	3,364
Alfalfa and brome grass		4,660	3,110	2,390	2,420	900	3,750	2,872
Moccasin, Mont.:								
Alfalfa alone	2,795	2,990	1,443	0	2,731	2,146	3,060	2,166
Alfalfa and brome grass	2,700	2,960	1,144	0	2,663	2,077	2,930	2,068
Mandan, N. Dak.:[1]								
Alfalfa alone	8,350	3,900	4,610	3,640				5,125
Alfalfa and brome grass	6,950	2,350	2,700	3,520				3,880
Brome grass alone	4,900	1,350	1,450	1,500				2,300

[1] Data from the records of the Office of Dry-Land Agriculture Investigations.

The table shows that the yields of alfalfa alone have been appreciably better than the mixture. The first year after sowing there is not much difference in the yields; in fact, in some cases the mixture yielded more than alfalfa alone. During the succeeding years at all the stations the results favored alfalfa alone. It is true the mixture cures more easily, but except in the extreme eastern part of the region curing seldom presents any serious problems in the northern Great Plains.

The mixture of alfalfa and brome grass in plat tests gave higher yields than brome grass alone at Mandan.

RED AND ALSIKE CLOVERS.

Comparatively little red clover or alsike clover is grown alone in the region; and most of this is found in the western part, where water is available for irrigation, and is generally grown in mixture with timothy. Neither of these clovers is suited to dry-land conditions, as they can not withstand any extended period of drought. At Edgeley, which with the exception of Redfield is the most favorably located with regard to moisture of any of the dry-land experiment stations in this region, the yields have been far from satisfactory. During the years 1908 to 1919 the average production of red-clover hay was only a little over half a ton per acre. Within this period there were five complete failures and only three years of satisfactory yields. The failures, for the most part, were due to winterkilling.

The results at Dickinson have been somewhat better, as no complete failures were reported during the years 1908 to 1914, but only one really good crop was obtained in that time. The average yield for the period was only slightly above four-fifths of a ton per acre. The results are shown in Table 25.

TABLE 25.—*Hay yields of red clover at Edgeley and Dickinson, N. Dak., in stated years.*

Station.	Yields per acre, field cured (pounds).												
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	Average.
Edgeley [1]	550	0	850	0	0	500	2,480	2,300	5,940	1,300	0	0	1,160
Dickinson [2]	4,500	460	1,250	300	1,340	1,860	1,900	......	......	......	......	......	1,659

[1] Data from United States Department of Agriculture Bulletin 991.
[2] Data from North Dakota Agricultural Experiment Station Bulletin 110.

TIMOTHY AND CLOVER.

Timothy and clover mixed are grown to some extent in some of the irrigated valleys in the western part of the region. The mixture can not compete with other crops under dry-land conditions.

GRAIN HAY.

Very few tests have been conducted with small grains for forage, since they are used for hay only incidentally. In normal seasons there are other crops that will produce as much forage, or perhaps more. However, there are seasons when the small grains are of considerable importance. Yields of hay from the various grains, obtained at Havre and Moccasin, are given in Table 26. These are the only points at which yield data have been obtained.

At Moccasin barley has given a higher yield of forage than any other small grain. The lowest yield was less than one-half ton, in 1919, a very unfavorable year, and the highest about 2 tons, in 1922.

At Havre the average yields during the past five years have been hardly enough to justify growing such crops. The lowest yield was one-fourth ton of barley in 1922 and the highest 1 ton of oats in 1918. It should be remembered, however, that these seasons have been extremely unfavorable. With normal seasonal conditions the results would be very different. The data available are not sufficient to determine with any degree of definiteness which of the small grains may be expected to give the best yields. Farther east, where moisture conditions are more favorable, proportionately greater yields might be expected. The total weights of grain and straw from crops harvested for grain may be taken as a basis for estimating the yields. These yields are probably 20 to 30 per cent greater than when the crop is cut in the very soft dough stage, which is generally considered the best stage for hay.

TABLE 26.—*Yields of grain cut for hay at Moccasin and Havre, Mont., in stated years.*

Station and crop.	Yields per acre (pounds).						
	Field-cured material.		Air-dry material.				Average.
	1917	1918	1919	1920	1921	1922	
Moccasin:							
Oats	2,098	2,983	1,073	1,224	2,294	2,915	2,098
Wheat	2,357	3,919	903	1,920	2,667	2,888	2,442
Barley	2,805	4,469	847	2,159	2,229	3,988	2,749
Havre:							
Oats		1,980	912	1,654	980	1,140	1,333
Wheat		1,760	842	992	1,040	630	1,053
Barley		1,850	664	1,528	775	540	1,071

The average total weights of grain and straw are approximately as follows: Havre—wheat three-fifths of a ton, oats one-half of a ton; Ardmore and Dickinson—wheat 1½ tons, oats 1¼ tons; Moccasin and Mandan—wheat 2 tons. These yields, in general, are somewhat less than those of corn fodder.

MISCELLANEOUS CROPS.

RAPE AND KALE.

Under favorable conditions rape and kale may have some value as pasture crops for hogs. They have produced fairly satisfactory yields when moisture conditions were favorable. Rape has outyielded kale early in the season, but kale appears to be able to withstand a longer period of dry weather. At Redfield, in 1920 and 1921, rape averaged 7.3 tons and kale 7.8 tons of green material per acre. At Dickinson rape when harvested in the fall averaged somewhat over 9 tons per acre in 1920, 1921, and 1922. In 1922 kale yielded at the rate of 9 tons per acre and rape at the rate of 7 tons per acre. Neither rape nor kale has so far done much at Havre or Moccasin.

ROOT CROPS.

Up to now root crops have contributed very little to the forage resources in the northern Great Plains region. With a view to procuring more definite data as regards the possibilities of root crops for winter forage, tests have been conducted at several points in the region. Table 27 gives the results by years for one of the best-known varieties each of mangels, rutabagas, and carrots.

TABLE 27.—*Yields of root crops at four stations in the northern Great Plains region in stated years.*

Station and crops.	Yields per acre (pounds).			
	1920	1921	1922	Average.
Redfield, S. Dak.:				
Mangel (Mammoth Long Red)	61,160	34,952	27,352	41,155
Carrot (Mastodon)	19,635	10,120	5,499	11,751
Rutabaga (Hurst's Monarch)	18,538	5,032	3,930	9,167
Sugar beet	27,390	16,995	10,192	18,192
Dickinson, N. Dak.:				
Mangel (Mammoth Long Red)	12,952	3,272	17,400	11,208
Carrot (Mastodon)	7,887	1,435	4,640	4,654
Rutabaga (Hurst's Monarch)	7,156	2,985	13,320	7,820
Sugar beet	8,517	1,835	10,000	6,784
Havre, Mont.:				
Mangel (Mammoth Long Red)	9,130	14,190	10,862	11,394
Carrot (Mastodon)	(1)	(1)	(1)	....
Rutabaga (Hurst's Monarch)	2,508	(2)	2,310	2,409
Sugar beet	7,260	11,660	8,727	9,216
Moccasin, Mont.:				
Mangel (Mammoth Long Red)	6,710	1,485	1,953	3,383
Carrot (Mastodon)	2,860	853	(1)	1,857
Rutabaga (Hurst's Monarch)	5,995	3,135	7,095	5,408

[1] Eaten by jack rabbits—not considered in the averages.
[2] Destroyed by aphis—not considered in the averages.

The experiments here reported have covered a period not long enough to be conclusive, but they indicate that fairly satisfactory yields can be expected in much of the region. As root crops furnish succulent green feed for winter, they come in competition with corn and other silage crops. Corn silage has a higher feeding value than roots, and where a satisfactory yield of corn can be obtained it will ordinarily be grown in preference to them. Furthermore, the cost of growing root crops is much more than the cost of growing most silage crops. A good deal of hand labor is required in thinning and hoeing them, and unless the farmer has a family of children or can procure very cheap hand labor the cost of growing any considerable acreage is almost prohibitive. Where the soil continues to be dry for some time after planting, poor germination commonly results. Getting satisfactory stands in the drier parts of the region is an important agronomic problem.

At Redfield, Edgeley, and Havre the yields of root crops have considerably exceeded those of corn for silage. However, it is questionable if the difference at Redfield and Edgeley is sufficient to compensate for the lower feeding value and the greater cost of growing the root crops.

At Havre, regardless of the very dry seasons, mangels have produced much heavier yields than corn or sunflowers, and it appears worth while to give them serious consideration. While the yields of such silage crops as corn and sunflowers are low at Moccasin, they have given a greater tonnage on the average than any of the root crops. It appears from these tests that root crops can not be expected to contribute much to the forage resources of the Judith Basin.

Mangels have far outyielded all other root crops in all the tests except those conducted at Moccasin, and they have been free from attacks by insects and jack rabbits. Three varieties are being tested—Mammoth Long Red, Danish Sludstrup, and Golden Tankard.

(Fig. 18.) Mammoth Long Red has given the heaviest yields at Redfield and Moccasin, but it has been slightly outyielded by the Golden Tankard at Edgeley, Dickinson, and Havre. Sugar beets stand next to mangels in tonnage per acre at Redfield and at Havre.

The varieties of rutabagas tested at the various stations are American Purple Top, Carter's Hardy Swede, and Hurst's Monarch. Moccasin is the only station where rutabagas have produced greater average yields than mangels. The American Purple Top has given the best yields at Redfield, Hurst's Monarch at Moccasin, and Carter's Hardy Swede at Dickinson and Havre.

Sugar beets have not compared with mangels in yield but on the average have outyielded other root crops except at Dickinson.

Three varieties of carrots are being tested—Mastodon, Oxheart, and Improved Long Orange. At Havre and Moccasin, however, jack rabbits have destroyed the crop on several occasions.

The yields of field turnips have been so unsatisfactory that they have not been included in the table.

From all data available it appears that mangels show the greatest possibilities of any of the root crops for this region.

FIG. 18.—Mangels grown at Redfield, S. Dak. Root crops should be grown more extensively than at present. A small acreage of mangels may usually be depended upon to produce a satisfactory yield of good succulent forage even in very dry seasons.

A SUMMATION OF THE POSSIBILITIES OF FORAGE PRODUCTION.

The investigations herein recorded, covering as they do in some cases periods of 10 years, have gone far toward throwing light on the cultivated-forage possibilities of the northern Great Plains. It is evident that the native ranges and hay lands must be supplemented by cultivated forage crops if livestock raising is to become an important modification of grain farming. There are not many such crops from which to choose; but there are those which, when given as good conditions as can be provided, are sufficiently dependable in most of the region, even in the drier parts, to encourage at least to a moderate degree the inclusion of livestock raising in the present grain-farming system. Tonnage and palatability are about the only qualifications that are actually required. Any cultivated forage crop, therefore, that will produce a fairly good and dependable yield and is sufficiently palatable to be eaten by livestock with more or less avidity is regarded as suitable.

Corn meets these requirements and is the leading cultivated forage crop. Its increasing popularity is due to its performance during years of exceedingly unfavorable weather conditions and to the dissemination of early-maturing and otherwise better adapted varieties. For fodder, certain of the sorghums, especially strains of Amber, give a somewhat heavier yield than corn in the southern part of the region, but in general they can not compete with corn north of central South Dakota. Furthermore, the grain of sweet sorghums is not particularly valuable for feeding, and even in the sections where these sorghums yield in excess of corn, whatever advantage they may possess over corn in this respect is confined to the making of silage. Where corn will mature grain in average years—and this is the case over most of the northern Great Plains except at high altitudes—it is both a roughage and a concentrate. This makes it a highly desirable crop to raise.

Alfalfa is an excellent forage crop and in both acreage and production exceeds corn for forage in the region. However, the future increase in its acreage will doubtless be confined to relatively small areas of low-lying lands along creek and river bottoms and elsewhere, where the moisture conditions are the most favorable. With the advent of Grimm and other hardy varieties, the effect of winterkilling on alfalfa acreage is decreasing. It is its inability to produce satisfactory yields of hay on the dry uplands, even when the best cultural methods are followed, that prevents alfalfa from becoming much more generally grown. It would not be surprising if, in the next decade, corn for forage overtakes it both in acreage and production. At any rate, it is very probable that corn will make the more rapid growth of the two in the point of acreage. The advantages of corn as a silage crop will help it to gain the ascendancy if silos become more popular.

The extent to which grains are harvested for hay is determined largely by the weather conditions, principally the rainfall of the season and the scarcity of forage. There is usually a close relation between these two factors. Weather conditions cut short a grain crop and leave the farmer with no alternative than to cut what has been produced for forage. A cereal crop may be regarded as a failure for grain and yet be valuable for hay when there is livestock to be fed.

The millets, particularly the foxtail millets, are not very popular, but they contribute appreciably to the forage possibilities of the region. They withstand drought as well as any of the other forage crops, and under conditions of low rainfall they are capable of producing very good yields of hay. Another point in their favor is the short growing season required to mature them. Millet hay is neither especially relished by stock nor is it highly nutritious, but when fed properly it is eaten with a relatively small proportion of waste and is more than an actual maintenance ration. Millet seed is relatively cheap, and as a catch crop the millets will continue to be useful. It is hardly likely, however, that they will increase rapidly in popularity.

Sudan grass, while requiring a longer season than the millets for maturing and therefore not so well adapted to the higher latitudes, is a useful annual hay grass south of the latitude of Mandan. It withstands drought well and doubtless will be much more generally grown in the northern Great Plains than it is at present.

In the past few years much attention has been directed to sweet clover as a dry-land pasture and hay crop. It is a valuable forage plant; but, like alfalfa, its acreage on the farm will be confined very largely to situations having the most favorable moisture conditions. Some success has been had from stacking freshly cut sweet clover in large well-compacted stacks. Under such conditions it is possible to make good silage from it with comparatively little waste. If this method can be perfected to the point where it can be depended upon, it may replace to a considerable extent the making of sweet-clover hay, which in most cases contains a large proportion of hard, tough stems not relished by stock. In curing and handling sweet-clover hay it is a very difficult matter to preserve the leaves, but these can be saved by stacking green. On the other hand, the stacking of the freshly cut crop involves much hard labor. As a crop for the regular silo, sweet clover will probably never be generally used, since it does not produce a sufficiently heavy tonnage. Neither will it be used to a very large extent as a pasture crop on dry-land farms in the northern Great Plains, since the favorable locations suitable for it will be needed for the production of hay and fodder.

There are no annual legumes that can be depended upon to help materially in solving the problem of producing hay or fodder for the driest sections of the region. Field peas will make fairly good yields of grain or hay either alone or with oats in the northern part of the region or at the higher altitudes in good average seasons; but they will not withstand much hot weather or much drought. This limits very appreciably the range of their profitable use. Furthermore, the cost of seed per acre is greater than for the other common annual forage plants.

The enthusiasm for soy beans which is now so manifest in the Corn Belt has extended in a small measure to the eastern part of the northern Great Plains. The recently acquired early-maturing varieties have assisted in creating an interest in soy beans, particularly for mixing with corn for silage. None of the varieties so far available will produce attractive yields of grain or forage in most of the region. Redfield appears to be about the northern as well as the western limit of soy bean culture.

Little help may be expected from the cultivated perennial grasses in the drier parts of the region. Some hope was entertained for practical results from growing certain of the perennial grasses in cultivated rows, but this method of culture has not proved feasible. Awnless brome grass (*Bromus inermis* L.) is in use to some extent, but as a hay grass it falls short of making a profitable yield. As a pasture plant it is not sufficiently superior to the native pasture grasses to warrant its use, except in favorable locations on land that has been tilled. Slender wheat grass (*Agropyron tenerum* L.) is one of the few native American grasses that have been actually brought into cultivation. Its cultivation in this country is confined almost exclusively to the Dakotas. The total area of this species grown under cultivation is so small as to be almost negligible. Crested wheat grass (*Agropyron cristatum* L.), a close relative of slender wheat grass, was introduced by the Department of Agriculture from Siberia several years ago and is attracting some attention as a hay grass, and it is possible that it will ultimately become established as a hay grass in a limited way. From this time forward it will be given abundant opportunity to demonstrate its real merits.

The possibility of root crops for winter forage has not attracted very general attention in the United States, owing principally to the relatively large proportion of handwork incident to their culture and use. Nevertheless, they make an excellent quality of succulent feed particularly suited to the needs of dairy cows. Furthermore, root crops, especially mangels, produce a good tonnage even under conditions of very low rainfall, and because of this, by selecting favorable locations, such as low-lying land, it is possible to produce enough succulent feed for the family cows during the winter. If there are children in the family, the expenditure of cash for the handwork on a small area of root crops may be reduced to an unimportant item. Certainly root crops can scarcely be expected to play a large part in any farming system in the drier parts of the northern Great Plains, but their performance in these sections during exceedingly dry years suggests their regular utilization in a small way. It is the small, easily managed, dependable feature that must be given consideration in connection with farming under the precarious conditions incident to low rainfall. Root crops seem to be such a feature.

IMPROVEMENT OF RANGES AND PASTURES.

Most of the investigations conducted at the various points named in this bulletin have related chiefly to the growing of hay and fodder. This feature of the forage problem is of much greater importance than the improvement of ranges and pastures. Pasturage in the main has not been so great a limiting factor in livestock production in the northern Great Plains as have hay and fodder, but there has been much need for attention to the pastures and ranges with a view to developing means of increasing their carrying capacity and of making grazing more dependable.

Three principal lines of experimentation have suggested themselves: (1) Various systems of grazing, including fencing of the range, light and heavy grazing, alternate grazing, and deferred grazing; (2) cultural treatment, including cultivation by means of the disk or harrow accompanied or unaccompanied by the sowing of seed of pasture plants; and (3) the introduction of range plants from other countries. Some work has been done along these three lines, but the results thus far have not been highly encouraging. Probably the most hopeful line is that involving the introduction of plants from abroad. Introduced species have contributed immeasurably to the range resources of California and other parts of the West. Some of these species, although regarded as weeds, make good grazing plants. They are annuals and spread rapidly because of their excellent seed habits and also because of the impetus resulting from their new environment. There are many range plants which are superior to the weedy annuals in the quality of the forage they produce, but the latter fill a much needed place in droughty years when the better grazing plants succumb to the unfavorable conditions.

SILAGE.

The possibilities of the silo as a means of storing forage for indefinite periods have been given a great deal of attention. From exhaustive research and experiments conducted by the Office of Forage-Crop Investigations it has been shown conclusively that palatable and at least fairly nutritious silage can be made from nearly all common herbaceous plants, including native and introduced weeds. Low tonnage and the difficulty of harvesting are such decidedly limiting factors, however, that the plants which actually offer practical possibilities for silage making are relatively few. Notwithstanding this, in a year of drought it is of value to know that almost any kind of available herbage may be utilized for forage by means of the silo if the yield is sufficiently large. For most of the northern Great Plains region, corn is without question the best silage crop when tonnage and quality are considered. Much attention has been given to the silage possibilities of sunflowers, but they are not nearly so valuable as corn, except at altitudes too high for corn, or possibly under irrigation.

Both the aboveground and the pit types of silo can be used in the drier parts of the region. The relative merits of these types are too well known to require discussion here. The use of the silo of either type will increase the storage of feed for a single feeding season, but it is probable that only the exceptionally provident farmer will make a regular practice of using the silo to carry from one year to another sufficient feed to provide for years of shortage.

RATIO OF FORAGE CROPS TO GRAIN AND THE SIZE OF THE FARM UNIT.

Assuming that it is generally agreed that more cultivated forage is necessary if farming in the drier sections of the northern Great Plains is to be permanently successful, the question of the ratio of acreage of these crops to grains at once arises. It is not practicable to set forth a hard and fast system prescribing the number or kind of livestock, the relative acreage of the various crops, or the optimum unit of area. The precipitation of the section, the location and topography of the land, the character of the soil, market facilities, and the individual characteristics of the farmer are among the elements that must be taken into account. As a general proposition it will not pay the farmer to raise forage for his neighbors, therefore his forage acreage must be determined by the requirements of his own livestock. As a theoretical consideration, an ideal arrangement would provide pasturage and cured forage sufficient for enough livestock to make an income that would guarantee a living for the farm family. Added to this should be as much land and grain as a family can handle with additional labor only at harvest time. In such a scheme the livestock would be regarded as the main dependence and the grain as more of a speculative feature, without which dry-land farming would be exceedingly unattractive.

It is difficult to specify intelligently the size that should be adopted for the farm unit for the drier parts of the region. This must be governed by much the same factors as govern the determination of the optimum ratio of livestock and forage to grain crops. It is evident, however, that the total area of the farm unit, including range or pasture and tilled land, must be much larger than that now in general use. With helpful suggestions drawn from past experiences in dry farming elsewhere, the future will determine the size of the unit before many generations have passed.

POSSIBILITIES OF COMBINING LIVESTOCK PRODUCTION WITH GRAIN FARMING.

From the present knowledge of the possibilities of the region, it is evident that with the cultivated forage crops now available the raising of cattle is the feature of livestock production that fits in best with the possibilities of grain and forage growing, as well as with other agricultural and economic conditions. The limits of the profitable expansion of horse and mule raising are soon reached. Sheep raising, in the very nature of things, is best suited to the large ranges; and, while it is probable that this branch of animal production will be taken up more generally on farms, it is thought that the cost of fencing and necessary care will keep the industry for the most part where it is at present.

In dry-land farming swine can not range at large, as they do to a considerable extent in certain more humid parts of the country. Their feed must be grown for them. Swine must have corn or some similar grain. They must likewise have suitable cultivated pasturage. Barley has not done for swine raising in the drier parts of the region what corn has done, for example, in Iowa. There is not enough wastage of a kind suitable for swine on a dry farm to make the salvaging of it profitable. To be successful as a source of income, swine, except in some cases, as of breeding stock, must be fed a fattening ration from the time they are weaned until they are marketed. Under dry-farming conditions it is not always an easy matter to make provision for the necessary feed. All things considered, cattle fit into a system of dry-land farming better than any other kind of livestock under present economic conditions. Beef cattle are better suited to this type of farming than dairy cattle. The raising of beef cattle is more flexible and less exacting in its requirement of harvested forage, since in time of emergency they may be kept on a merely maintenance ration for short periods. In the case of dairying, unless the milk output is maintained, it ceases to be profitable. Furthermore, when feed is short, good dairy herds can not be quickly disposed of without great loss, nor can they be assembled quickly and profitably when feed is abundant. There is not enough flexibility in dairy farming to suit the needs of the drier parts of the northern Great Plains. That low returns are now obtained from the dairy cows of the region is evidenced by their ratio to human population. According to the census of 1920, there were 387,000 cows over 2 years old. The population at that time was estimated at 915,605. On this basis one cow supplied only 2.4 persons, or less than one-half the number for the United States as a whole. Even with this exceedingly narrow ratio between dairy cows and human population there is actually a large deficiency in the quantity of dairy products produced within the region. It is estimated that the total quantity of butter made on farms and in factories in the region supplies less than 30 pounds to each individual. A striking contrast exists between the returns from dairy cows in this region and in Minnesota, for example, where the ratio of dairy cows to human population is 1 to 2, and the total quantity of butter produced is approximately 70 pounds for each individual. Dairying, it would appear, is as dependent on rainfall for high production as is grain farming. It is largely because of a lack of sufficient and suitable harvested forage that dairying is such an inefficient enterprise under dry-farming conditions. That it can be improved can scarcely be questioned, but in general its requirements are not easy to meet.

ECONOMIC CONDITIONS AND THE NEED FOR A CHANGE IN THE TYPE OF FARMING.

The data previously presented under "Agricultural Resources" and other captions disclose the fact that farming is not highly diversified in the northern Great Plains and that grain growing is the principal type on tilled farms. Since the total area devoted to cultivated forage crops is less than 2,500,000 acres, which is less by 2,000,000 acres than the area normally devoted to spring wheat, and since this acreage is distributed over approximately 123,000 farms, it is quite apparent that the livestock industry must be largely credited to the range and native grasslands and only in a minor degree to tilled farms. Poor crop years have occurred so frequently in the drier parts of the northern Great Plains since 1916 as to bring about depressing economic conditions. The situation has been so acute at times in certain sections as to attract aid from the Federal Government in the form of loans for the purchase of seed grains. These loans have been three in number. The first one made in 1918 was used in part for fall sowings in that year and in part for spring sowings in 1919. Other loans for spring sowings were made in 1921 and 1922. These loans also covered sections outside the northern Great Plains region.

Economic emergencies calling for aid of this kind so frequently show beyond a reasonable doubt that the present type of agriculture does not meet the needs of the situation. Farmers, merchants, and bankers who have lived in sections where crop failures or partial failures have occurred with discouraging frequency are unanimously agreed that some change must be made to relieve the present precarious agricultural condition.

SUMMARY.

The part of the United States to which the data here presented applies includes northwestern Nebraska; the western two-thirds of South Dakota; that part of North Dakota which lies south and west of the line extending approximately from Minot to Jamestown; eastern Wyoming; and the greater part of Montana.

The average annual precipitation varies from about 20 inches in the eastern part of the region to 12 inches in the vicinity of Shelby, Mont. The region is noted for extremes in temperature.

The soils for the most part are capable of producing good crops where moisture is not a limiting factor.

Cereals are the chief crops, although forage, especially native grasses, contribute largely to the agricultural resources by making stock raising possible. The acreage of cultivated forage crops is only a little more than half that of native grasses cut for hay.

The extremely precarious conditions under which crop production is being attempted in the drier parts of this region make livestock necessary to stabilize the income of the farmer and provide a respectable living. Grain farming alone will not do this. To raise livestock successfully, forage must be grown.

The forage-crop data here presented are chiefly the results of experiments conducted at Ardmore, Belle Fourche, and Redfield in South Dakota; at Edgeley, Hettinger, Mandan, Dickinson, and Williston in North Dakota; at Havre and Moccasin in Montana; and at Sheridan in Wyoming.

The most important forage crops in the region are alfalfa, corn, and grain hay. Sorghum is grown extensively in northern Nebraska and southern South Dakota. Awnless brome-grass is an important grass in certain sections. Sweet clover is becoming increasingly important, particularly as a pasture crop. Millets are utilized to some extent as an emergency crop. Field peas, soy beans, and root crops are grown only to a limited extent.

Various attempts have been made to improve the ranges, but without much success. The most hopeful line seems to be through the introduction of plants from abroad.

The possibilities of the silo as a means of storing forage for an indefinite period is an important consideration.

In a well-balanced farming system the ideal ratio of forage to grain would appear to be enough forage and pasture for livestock to guarantee a living to the family and added to this as much grain as the family can handle with additional labor only at harvest time.

It is very evident that the farm unit must be much larger than the present general size.

Cattle fit into the system of farming better than any other class of livestock. Beef cattle are better suited to this type of farming than dairy cattle. The raising of beef cattle is more flexible and less exacting in its requirements.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

January 15, 1924.

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This bulletin is a contribution from

Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Office of Forage-Crop Investigations	CHARLES V. PIPER, *Agrostologist in Charge.*

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