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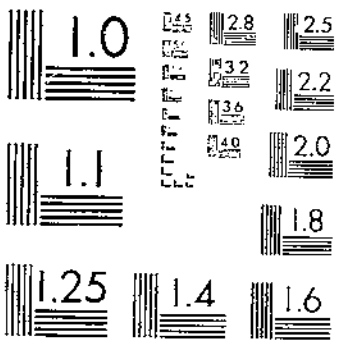

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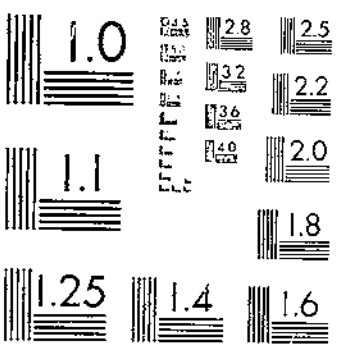

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TECHNICAL BULLETIN No. 454 OCTOBER 1934

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By

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

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AGRICULTURAL INVESTIGATIONS AT THE BELLE FOURCHE (S. DAK.) FIELD STATION, 1926–32

By BEYER AUNE, *associate agronomist* and *superintendent, Division of Western Irrigation Agriculture, Bureau of Plant Industry;* L. A. HURST, *biochemist, Division of Soil Fertility, Soil Investigations, Bureau of Chemistry and Soils;* and ALBERT OSENBRUG, *associate agronomist, Division of Dry Land Agriculture, Bureau of Plant Industry*

The Bureau of Plant Industry in cooperation with the South Dakota Agricultural Experiment Station

CONTENTS

INTRODUCTION

The Belle Fourche Field Station includes 360 acres, located on the Belle Fourche reclamation project, near Newell, S.Dak. The station is maintained cooperatively by the Division of Western Irrigation Agriculture of the United States Department of Agriculture and the South Dakota Agricultural Experiment Station. Facilities are provided and utilized by certain bureaus and divisions of the Department of Agriculture.

The work of the station is devoted mainly to investigations in the production and utilization of the chief crops grown on the Belle

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Fourche project and adjacent areas. The experiments in crop production include crop rotations and tillage experiments on both dry and irrigated land; experiments with pasture grasses; varietal tests with small grain, corn, potatoes, and silage crops; tests of trees for windbreak and ornamental plantings; orchard and small fruits, and the growing of garden vegetables. Figure 1 shows the location and arrangement of the fields and the experiments for the year 1932. The crop-utilization experiments were conducted with sheep and hogs. With sheep this work includes pasturing tests, the maintenance of a farm flock, and lamb feeding as related to the utilization of the by-

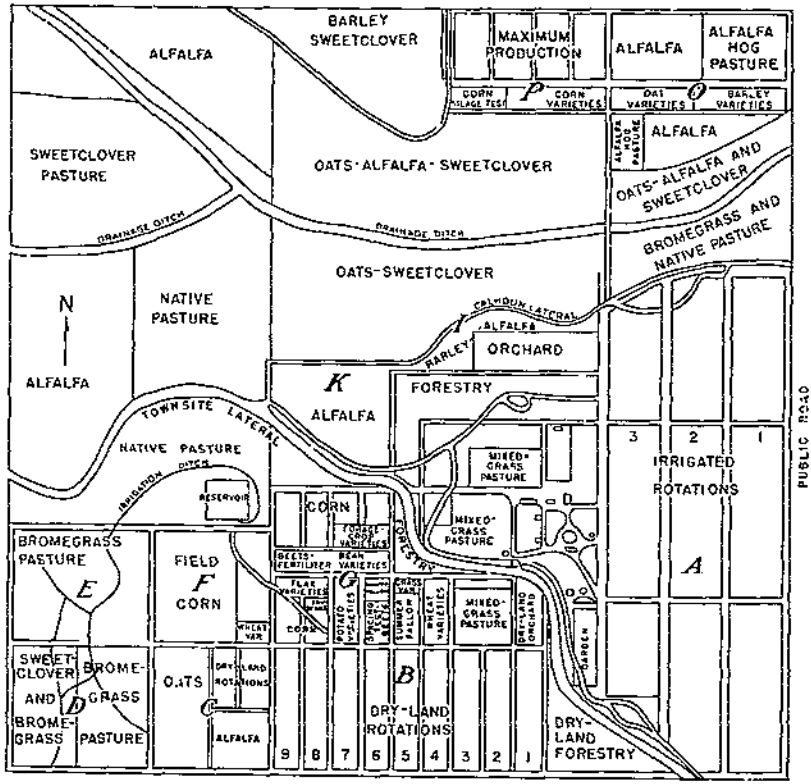

FIGURE 1.—Diagram of the Belle Fourche station, showing arrangement of fields and location of crop experiments in 1932.

products of the sugar-beet industry. With hogs it covers pasturing tests and the methods of finishing hogs for the market. This report summarizes the more important features of the station's activities since it was established in 1907 and discusses somewhat in detail the results for the years 1926–32.

WEATHER CONDITIONS

The climate of western South Dakota is characterized by relatively cold winters with temperatures often as low as 30° F. below zero. The summers are pleasant, with temperatures rarely exceeding 100°.

The average frost-free period for 25 years has been 137 days. The last killing frost in the spring during this period ranged from April 19, in 1922, to May 31, in 1917. For the same period the earliest killing frost in the fall ranged from September 7, in 1929, to October 13, in 1931. The frost-free period ranged in days from 110 in 1929 to 170 in 1922. The average date for the last killing frost in the spring was May 13, and the first in the fall was September 28. A temperature of below 32° F. is considered a killing frost.

The climatological data as recorded at the Belle Fourche Field Station are given in table 1.

TABLE 1.—*Summary of climatological observations at the Belle Fourche Field Station, 1908–32*

PRECIPITATION (INCHES)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Average for 25 years, 1908–32	0.45	0.35	0.71	1.51	2.92	2.05	2.44	1.46	1.41	1.26	0.52	0.47	16.15
1926	1.67	.19	.24	.10	4.60	4.56	1.96	1.48	.72	.63	.98	.05	17.16
1927	.36	.13	1.14	3.92	6.96	2.81	4.26	2.13	1.17	.39	.63	.56	24.46
1928	.16	.07	.79	.35	1.81	3.33	4.89	1.44	1.65	.80	.57	.04	15.95
1929	.19	.47	2.00	1.36	4.45	3.05	3.23	.82	4.01	2.25	.41	.11	22.35
1930	.28	.10	.52	1.52	2.09	2.18	1.23	1.53	.31	1.46	.62	.27	12.11
1931	.11	.20	1.08	.47	1.48	1.42	1.31	.36	.45	.96	.31	.45	8.80
1932	.33	.07	.57	3.16	5.77	3.76	1.17	2.28	.57	1.42	.07	.07	19.24

EVAPORATION (INCHES)

Average for 25 years, 1908–32				4.178	5.529	6.579	7.885	6.823	4.911				35.905
1926				5.618	5.162	6.020	7.208	6.274	4.760				35.051
1927				3.884	5.197	5.131	7.054	5.177	4.887				31.330
1928				4.137	6.322	4.450	6.439	6.736	4.109				32.193
1929				3.637	4.765	5.735	7.649	6.558	3.895				32.239
1930				4.118	5.505	7.029	7.431	6.046	5.227				35.356
1931				4.410	5.857	7.024	8.460	6.195	5.067				37.003
1932				4.227	4.541	6.264	7.101	6.849	5.140				34.125

MONTHLY TEMPERATURE (°F.)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean:												
1908–32	16	21	31	45	54	65	72	70	59	46	33	20
1926	23	29	33	46	57	64	72	69	55	47	30	21
1927	16	24	34	41	51	62	69	66	52	50	28	4
1928	23	25	36	41	60	59	70	69	57	46	34	28
1929	6	11	34	45	52	62	73	73	54	49	31	32
1930	7	34	31	51	53	65	75	72	62	43	34	26
1931	28	33	31	46	55	72	75	70	65	49	32	26
1932	13	23	25	49	58	67	74	71	67	41	35	18
Absolute maximum:												
1908–32	70	72	87	89	95	103	109	105	105	92	78	66
1926	43	58	71	89	94	102	95	105	89	83	65	59
1927	52	52	70	78	83	95	93	88	92	85	57	41
1928	52	59	79	86	90	84	94	101	96	86	63	66
1929	42	46	72	78	93	93	101	99	101	79	63	57
1930	52	72	65	84	90	94	105	98	95	77	70	63
1931	70	61	64	84	95	106	108	102	100	84	75	54
1932	45	69	62	80	91	90	100	96	95	80	69	57
Absolute minimum:												
1908–32	−38	−36	−20	−3	21	32	40	32	9	−16	−18	−33
1926	−20	4	5	14	29	40	48	48	9	19	−10	−14
1927	−36	−6	3	1	27	41	48	42	25	24	2	−33
1928	−25	−12	5	9	33	37	50	38	23	21	0	−12
1929	−26	−31	5	11	23	38	45	48	30	13	−6	−10
1930	−27	4	−3	27	29	35	52	50	29	15	10	−4
1931	−9	5	−4	14	21	43	43	41	37	13	1	0
1932	−21	−13	−15	22	31	45	47	42	32	11	−7	−24

TABLE 1.—*Summary of climatological observations at the Belle Fourche Field Station, 1908–32*—Continued

WIND VELOCITY (MILES PER HOUR)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean:												
1908–32				7.7	7.5	6.1	5.0	4.6	5.1			
1926				7.1	5.2	5.3	4.1	3.7	5.1			
1927				8.5	8.6	5.2	5.1	3.7	5.4			
1928				8.2	4.8	4.8	4.2	4.2	3.9			
1929				6.9	5.6	4.6	3.7	3.4	4.1			
1930				5.5	7.0	5.0	3.5	3.4	4.5			
1931				6.0	6.8	4.5	5.3	4.7	4.7			
1932				8.4	5.0	4.3	4.0	4.2	4.1			
Highest daily:												
1908–32				26.8	31.5	20.7	19.4	17.6	26.3			
1926				16.3	12.2	15.1	9.3	8.9	15.1			
1927				13.8	24.4	11.1	9.4	8.1	10.4			
1928				15.9	16.8	8.9	13.3	7.1	11.9			
1929				14.2	13.9	9.7	7.0	6.8	9.3			
1930				13.7	17.2	12.3	7.2	8.7	8.1			
1931				12.4	16.8	8.7	12.6	14.2	11.5			
1932				16.6	12.0	8.7	9.7	9.2	8.1			
Lowest daily:												
1908–32				.5	1.0	.0	.8	.8	.9			
1926				3.0	2.2	2.0	1.0	1.0	1.0			
1927				1.8	2.5	2.0	.9	.9	1.7			
1928				3.5	1.7	2.8	1.4	1.4	1.9			
1929				1.7	1.7	.6	1.5	1.8	1.1			
1930				2.1	1.8	2.3	1.0	.8	1.5			
1931				2.2	1.0	1.8	.8	.8	1.5			
1932				2.5	1.6	1.5	1.2	1.3	1.1			

KILLING FROSTS[1]

Year	Last in spring	Minimum temperature	First in fall	Minimum temperature	Frost-free period
		°F.		°F.	*Days*
1908	May 20	29	Sept. 26	22	128
1909	May 17	28	Sept. 23	31	128
1910	May 23	31	Sept. 25	30	124
1911	May 11	30	Oct. 3	30	144
1912	Apr. 23	28	Sept. 24	29	155
1913	May 4	27	do	29	142
1914	May 12	30	Oct. 4	28	144
1915	May 17	30	Sept. 14	31	119
1916	May 16	31	do	28	120
1917	May 31	30	Oct. 7	29	128
1918	May 21	31	Sept. 18	28	119
1919	May 13	31	Oct. 8	23	147
1920	Apr. 29	29	Sept. 25	30	148
1921	May 14	25	Sept. 29	29	137
1922	Apr. 19	30	Oct. 7	25	170
1923	May 15	26	Oct. 12	25	149
1924	May 26	30	Oct. 25	31	151
1925	May 9	31	Oct. 5	25	148
1926	May 13	29	Sept. 23	23	133
1927	May 9	27	Sept. 19	28	132
1928	Apr. 20	31	Sept. 24	25	147
1929	May 19	29	Sept. 7	30	110
1930	May 13	31	Sept. 19	29	128
1931	May 29	21	Oct. 13	31	145
1932	May 26	31	Oct. 4	24	130
25-year average					137

[1] A temperature below 32° F. is considered a killing frost.

The climatic conditions for the period 1926–32 were about normal, except for the years 1927 and 1931. In 1927 the precipitation, evaporation, and monthly temperatures were abnormal. January, February, and March were about normal, and some field work was started the latter part of March. April had the highest precipitation for this

month on record for 25 years, amounting to 3.92 inches. Most of this occurred in the form of snow, totaling nearly 45 inches for the period. There were 16 days of snow and rain during April. In May there was a total precipitation of 6.96 inches and 21 days on which either snow or rain fell. For this reason practically no field work could be performed during these 2 months. The total precipitation for the year amounted to 24.46 inches, as compared with 16.15 inches for the 25-year average. Of this precipitation, 21.25 inches fell during the crop season, April to September, inclusive. The temperatures were below normal throughout the greater part of the growing season. The lowest temperature on record was January 22, 1927, −38° F. December 1927 had the lowest mean temperature of any month during which records have been kept at this station. The yields of all crops were poor in 1927. The spring weather was of a character which necessitated unseasonably late planting of all crops, and the climatic conditions occurring throughout the major portion of the growing season also were unfavorable for the maturing of satisfactory crop yields.

The year 1931 was unusual in many respects. It was the warmest and next to the driest on record at this station, and the precipitation was nearly negligible. Severe freezing weather, followed by periods of unusually warm weather in March, April, and May, did extensive damage to trees and crops. The summer was unusually warm, and exceptionally high temperatures were frequent. During 1931 there were only 5 days with temperatures below zero, and the minimum occurred on January 12 when −9° F. was recorded. July 25 was the hottest day of the season with a temperature of 108°. The yields of all crops were below average, caused by the extreme weather conditions and also shortage of irrigation water.

CROP ACREAGES ON THE PROJECT[1]

The total irrigable area of farms on the project as reported by the United States Bureau of Reclamation is 57,112 acres. The total cropped area in 1932 was 49,129 acres included in 975 farms, or 70 percent of the project. Table 2 shows the total acreage for all crops and the acreage devoted to each crop from 1913 to 1932.

Alfalfa is the principal crop on the Belle Fourche irrigation project and occupies about one-third of the cropped area. Sugar beets is the crop next in importance and is the chief cash crop. The sugar-beet acreage increased from 1,238 acres in 1925 to 8,472 acres in 1929, although since then the sugar-beet acreage has decreased. The remainder of the cropped area is devoted to corn, small grain, pasture, and miscellaneous crops.

In the early days of the project alfalfa and small grains, particularly wheat, were chiefly grown. The area devoted to alfalfa reached its peak in 1922 when 28,965 acres were devoted to this crop. Corn gradually replaced the small grains, so that by 1925 there were 10,698 acres, which ranked corn second to alfalfa. Since the building of the sugar factory in 1927 there has been a gradual reduction of alfalfa and corn acreage and sugar beets have been chiefly substituted.

[1] For a number of years the Bureau of Reclamation of the Department of the Interior has recorded annually crop and livestock statistics relative to the developments on the different Federal irrigation projects under its jurisdiction. The data recorded in tables 2 and 3 have been assembled from these reports and are included for the purpose of observing the trend in the various agricultural activities on the Belle Fourche reclamation project.

With the introduction of the sugar-beet industry, barley and oats have replaced corn as a feed crop to some extent, and sugar beets have replaced wheat as a cash crop. With the introduction of cucumbers as a commercial crop in 1925, they have been of some importance as a supplemental cash crop. In 1931, 183 acres were planted to this crop with a cash return of $27,509.

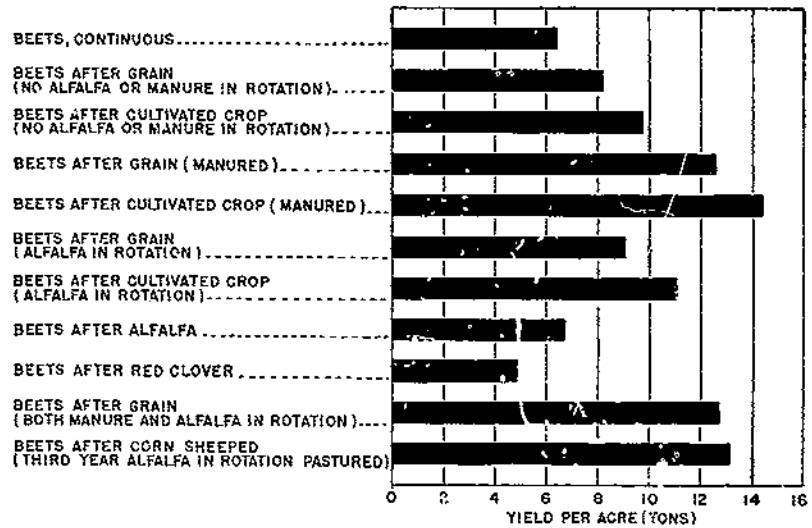

FIGURE 2.—Average yields of sugar beets grown at the Belle Fourche station, 1912-32.

TABLE 2.—*Acreage of the principal crops grown on the Belle Fourche reclamation project, 1913-32*

Year	All crops	Alfalfa hay	Alfalfa seed	Barley	Corn	Native hay	Oats	Pasture	Wheat	Sugar beets
1913	32,568	7,388	1,576	744	1,859	2,533	5,343	285	13,096	.....
1914	36,709	9,745	1,416	1,448	4,415	2,236	6,392	3,604	7,885	.....
1915	43,693	16,152	284	1,613	4,470	2,782	4,440	3,273	7,747	.....
1916	46,990	17,945	4,177	2,740	3,846	2,121	4,119	6,132	7,554	.....
1917	50,026	19,702	942	2,286	2,902	4,175	4,955	6,100	5,122	.....
1918	52,445	20,467	342	1,636	2,068	3,200	4,331	8,894	9,503	.....
1919	56,255	24,894	812	1,351	2,003	3,290	3,665	6,922	10,742	978
1920	59,856	26,040	752	1,695	3,272	2,820	4,864	8,390	9,850	1,103
1921	55,100	25,820	1,810	1,423	5,022	940	5,390	7,352	5,341	926
1922	56,920	28,065	883	1,284	7,130	2,388	5,051	5,230	5,482	324
1923	50,294	26,768	331	949	8,526	282	4,587	5,799	1,379	565
1924	49,813	21,824	1,111	553	8,638	1,242	3,229	9,822	689	1,281
1925	53,120	20,731	921	1,082	10,098	1,713	5,251	7,814	2,906	1,238
1926	47,729	19,945	521	1,507	7,612	1,085	5,198	4,044	5,071	2,184
1927	45,701	19,300	25	1,746	4,253	2,097	2,953	2,230	4,901	6,021
1928	46,696	16,686	.....	3,285	4,500	1,233	3,514	2,873	5,307	6,929
1929	47,953	16,500	311	4,756	2,634	2,044	4,437	3,956	2,180	8,472
1930	53,803	14,355	119	5,709	3,131	1,519	4,719	5,597	3,469	7,060
1931	44,372	12,040	42	4,976	2,448	1,704	2,415	6,004	1,534	5,815
1932	49,129	12,177	26	6,025	7,158	3,024	4,200	2,576	2,768	5,490

LIVESTOCK

Table 3 shows the livestock on the Belle Fourche irrigation project at the close of each year from 1913 to 1932, as reported by the Bureau of Reclamation. From the livestock census taken each year the indications are that there has been no material increase in numbers in

TABLE 3.—*Livestock on the Belle Fourche reclamation project at the close of each year for the 20-year period, 1913–32*

Item	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
Horses	2,460	2,818	3,135	3,514	3,731	3,877	4,238	3,608	[1] 3,890	[1] 3,418
Mules	89	59	65	86	88	97	80	100		
Cattle:										
Beef	[1] 2,758	2,514	5,524	8,178	6,616	4,801	8,896	3,751	5,300	4,907
Dairy		1,578	2,209	2,870	2,912	3,330	2,421	2,069	3,870	3,778
Sheep	12,872	25,740	20,210	32,152	36,450	35,607	75,308	34,781	48,510	40,028
Hogs	4,630	11,988	14,798	13,631	10,986	9,007	16,837	11,037	13,260	12,702
Fowls	23,125	20,186	21,415	27,004	24,028	18,975	20,699	20,584	26,508	33,171
Bees (hives)	139	129	326	541	541	852	900	243	510	685

Item	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
Horses	[1] 3,036	[1] 3,009	[1] 2,736	[1] 2,500	2,757	2,618	2,555	2,489	2,151	2,010
Mules					38	32	60	46	48	71
Cattle:										
Beef	3,507	2,415	3,277	3,245	2,903	3,005	2,980	3,378	3,788	4,247
Dairy	4,138	4,509	3,714	3,063	3,846	3,900	4,035	3,952	3,884	3,706
Sheep	55,233	46,350	46,461	51,727	55,052	70,325	76,469	67,101	61,926	69,201
Hogs	16,004	7,079	6,141	4,019	5,675	4,873	3,880	3,610	4,417	3,703
Fowls	32,549	32,706	35,730	34,540	35,358	40,301	38,209	43,217	41,595	44,583
Bees (hives)	685	685	855	3,323	2,598	2,546	2,845	2,809	2,750	2,277

[1] Not segregated.

TABLE 4.—*Carload lots of livestock shipped from 5 shipping points on the Belle Fourche reclamation project, 1916–32*

Year	Newell				Belle Fourche				Nisland			
	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses
1916	102	118	81	11	406	231	50	81	28	12	43	2
1917	233	131	77	5	709	216	35	68	92	39	29	1
1918	202	56	48	11	641	174	15	94	51	10	17	24
1919	208	87	79	89	1,361	318	36	281	28	22	30	1
1920	109	91	79	37	310	164	25	37	25	32	13	1
1921	72	135	92	3	354	263	28	14	18	42	24	1
1922	131	180	177	9	378	188	13	9	57	33	14	2
1923	157	151	132	30	468	316	21	31	30	36	39	4
1924	171	202	133	15	418	260	58	5	50	63	49	0
1925	131	172	51	16	649	246	78	35	69	81	32	2
1926	156	141	38	10	550	260	62	41	48	15	25	0
1927	106	130	32	15	507	221	63	28	41	47	19	2
1928	173	126	15	16	863	283	108	59	36	62	41	6
1929	92	125	6	8	692	243	101	47	51	46	10	0
1930	99	173	5	8	565	302	86	23	48	95	6	1
1931	79	260	14	50	742	456	82	101	52	109	8	0
1932	45	101	1	7	170	209	16	24	6	70	5	2

Year	Fruitdale				Vale				Total				All stock
	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	Cattle	Sheep	Hogs	Horses	
1916	28	10	19	2					624	371	193	99	1,287
1917	72	35	13	7					1,107	421	154	111	1,843
1918	37	21	3	0					921	273	83	129	1,406
1919	17	24	3	0					1,617	451	148	371	2,587
1920	22	33	7	1					577	320	124	76	1,097
1921	16	19	2	0					460	459	140	18	1,053
1922	27	11	7	1					595	412	211	21	1,240
1923	21	7	8	0					676	510	200	65	1,451
1924	11	24	11	0					680	558	251	20	1,509
1925	35	9	7	0					884	458	171	52	1,565
1926	49	26	7	0					803	432	132	51	1,418
1927	54	25	4	0	3	15	3	1	711	438	121	46	1,316
1928	42	29	7	0	9	26	16	0	1,122	523	187	81	1,914
1929	32	21	0	0	5	16	3	0	782	451	128	55	1,426
1930	36	50	1	1	8	37	3	0	759	657	101	33	1,550
1931	40	106	4	0	25	38	5	0	938	960	113	154	2,165
1932	8	59	0	0	2	31	2	0	237	464	24	33	758

recent years except in the case of sheep, fowls, and bees. The sheep census as reported in 1926 was 51,727 while in 1932 the number was 69,291, an excess of about 33 percent. Lamb feeding has come into practice since the building of the beet-sugar factory, and the number of farm flocks of 100 ewes or more has increased.

Table 4 gives the number of carloads of cattle, sheep, hogs, and horses shipped from the five project towns during 1916 to 1932, inclusive. These figures were obtained from the office of the Chicago & North Western Railway Co., at Rapid City, S.Dak.

The total number of carloads of all livestock shipped out of the project towns in 1926 was 1,418 and increased to 2,165 in 1931. The increase in movement of stock in 1931 was caused by severe drought and a short year on the range, which is again reflected in the smallest shipment of livestock in 1932, a total of 758 cars.

ROTATION EXPERIMENTS WITH IRRIGATED CROPS

The rotation experiments, the results from which are herein recorded, were started in 1912, and the season of 1932 completed the twenty-first year of these investigations. Certain new rotations have been added from time to time, so that the investigations could more adequately meet new demands for information. These experiments now occupy 131 quarter-acre plots and 4 plots of 0.39 acre each, in field A (fig. 1). The purpose of these experiments is to ascertain the following: The effect of various crop sequences, as compared with crops grown continuously on the same land; the influence of manure on crop yield; the effect of sweetclover and alfalfa on the productivity of the soil; and the effect on subsequent crop yields when these crops are harvested for hay, as compared with other similar rotations when they are harvested with livestock. With the exception of alfalfa, each crop is planted at the same time on the various plots. The same variety of seed for each crop was used on all plots, and cultural treatment has been as nearly the same as conditions would permit at the time the operations were performed.

ALFALFA

Because of the limited demand for alfalfa hay on the local market and the distance from large markets, the percentage of this crop sold for cash is small. The crop has served chiefly on the project as a source of feed for livestock kept on local farms or brought in from adjoining ranges, but it has been valuable also in stimulating yields of subsequent crops grown in rotations. In view of these conditions, in outlining these rotation experiments, the crops, their sequence, and particularly the length of time alfalfa was continued before being turned under, follow only in a general way the program which would have been adopted had the chief aim been to measure the effect of different systems of rotations on the yields of alfalfa. However, an opportunity is afforded in table 5 of observing the yields in different crop sequences, together with the yields from the first, second, and third year from seeding.

TABLE 5.—*Mean acre yields of alfalfa from the irrigated rotations, 1918–32*

Rotation no.	1930	1931	1932	5-year average, 1913–17	6-year average	
					1918–23	1924–29
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
8–a	3.04	2.80	.....	4.14	3.03	3.33
8–b	5.64	3.89	.....	4.51	5.25	5.40
40–1	1.67	1.03	1.03	1.20	1.33	1.35
40–2	3.17	2.91	3.22	3.24	3.19	3.70
42–1	1.73	1.13	1.70	1.10	1.19	1.42
42–2	4.04	3.17	3.47	3.22	3.19	3.75
44–1	2.46	2.45	1.27	2.56	2.12	2.33
44–2	3.73	3.55	3.52	4.21	4.12	3.70
46–1	2.38	2.26	1.66	.....	1.44	1.77
46–2	2.31	2.72	3.01	.....	2.58	2.84
48–1	3.57	2.13	2.32	3.51	2.34	2.05
48–2	4.76	3.74	3.08	4.92	4.36	4.22
60–1	1.77	.92	1.40	1.36	1.15	1.17
60–2	3.14	3.22	2.67	3.40	3.04	3.75
60–3	4.08	3.54	3.30	3.08	4.23	4.43
61–1	1.85	1.31	2.32	1.52	1.27	1.42
61–2	4.40	3.50	3.22	3.95	3.82	3.88
61–3	5.24	3.48	3.61	3.88	3.84	4.20
62–1	1.40	.83	1.47	1.26	.87	1.00
62–2	3.70	2.78	2.75	3.74	2.89	3.37
62–3	4.61	3.23	2.92	3.69	3.66	4.17
64–1	2.78	3.03	2.32	.....	1.69	2.10
64–2	3.87	3.22	3.20	.....	3.49	3.86
64–3	3.58	2.82	3.11	.....	3.08	4.04
65–1	2.42	2.23	2.04	2.18	2.32	2.30
65–2	3.53	2.94	2.95	3.80	3.01	3.16
69–1	1.09	2.52	3.28	.....	1.84	2.73
69–2	3.48	2.83	3.98	.....	3.56	4.15
71–1	2.19	3.09	2.07	.....	1.98	2.39
71–2	2.76	4.40	4.20	.....	3.06	3.82
First year	2.18	1.96	2.03	1.85	1.63	1.92
Second year	3.57	3.25	3.27	3.82	3.51	3.90
Third year	4.53	3.27	3.23	3.55	3.85	4.23

The alfalfa yields are recorded separately according to the age of the crop. As an illustration, 60–1 indicates the yield of the first year of alfalfa from rotation 60, 60–2 the yield the second year, and 60–3 the yield the third year. Thus from table 5 the average yields for the first, second, and third year may be observed for the 5-year period 1913–17, the 6-year period 1918–23, and the 6-year period 1924–29, as well as the average yields for 1930, 1931, and 1932. No yields were harvested in 1912.

The lowest mean yield from all the rotations for the 20 years is from the first year after planting, as would be expected. The second-year mean is next, and the highest is from the third-year period. The highest yield was harvested from plot 8–b, which received an annual application of barnyard manure since 1916. This plot produced an average since that date of 1.61 tons per acre more than plot 8–a, also continuously cropped but not manured. The mean yield of third-year alfalfa in rotations has proved to be in excess of plot 8–a left continuously in crop. On the other hand, the continuously cropped plot 8–a, not manured, shows a higher yield than the average of the first-, second-, and third-year alfalfa planted in rotation with other crops. These results indicate that continuously cropped alfalfa will yield as well as alfalfa grown in rotation with other crops as long as a good stand is maintained. With proper management, alfalfa fields may be expected to return satisfactory yields for from 10 to 15 years. There are less fluctuations in yields of alfalfa than any other crop

grown in the rotation experiments. The average for 20 years was 3.61 tons for 2-year-old alfalfa to 4.06 tons per acre for 3-year-old alfalfa.

Two methods have been used in establishing stands of alfalfa: (1) Seeding alfalfa alone in the spring and harvesting two crops the first year, and (2) seeding alfalfa in the spring with a nurse crop, harvesting the grain in the usual manner, and then harvesting the first cutting the following year. Satisfactory stands have been obtained by both methods in normal years, but planting with a nurse crop has proved to be a better farm practice, as the yield of grain has been of more value than the alfalfa harvested the first year without a nurse crop. If grasshoppers are prevalent, as often occurs, about the only way that a stand can be obtained is to sow the alfalfa alone in the spring. This will give the crop a chance to become well established before the insects become sufficiently numerous to cause serious damage.

SUGAR BEETS

Sugar beets are grown in 26 rotations. On two plots the beets are grown continuously, one without manure and the other with the application of barnyard manure every year, as well as in 2-, 3-, 4-, and 6-year rotations. Some of these rotations are manured and include alfalfa or sweetclover. In others, certain of the crops are harvested with livestock. In general, in rotations in which manure, alfalfa, or both are used the yields are improving from year to year, while in those without manure or alfalfa the yields are declining.

It has been the generally accepted belief that to grow sugar beets at a profit a yield of 12 tons or more per acre is necessary. In the first 6-year period, 1912–17, only one rotation, no. 21, gave a yield of 12 tons or over per acre. During both the second and the third 6-year periods there were 10 rotations that produced 12 tons or more per acre.

The sugar-beet yields recorded in table 6 give the annual yields in 1930, 1931, and 1932 and the averages in the three 6-year periods—1912–17, 1918–23, and 1924–29. The season of 1930 was normal for all crops. The year 1931 was exceptional, both as to high temperatures and drought and shortage of irrigation water. On June 5, 1932, replanting of all the beets was necessary because of torrential rains which occurred May 30. These facts account for the low yields harvested in 1931 and 1932.

The 1930 results with sugar beets are worthy of special consideration. Growth conditions throughout the season appeared to be favorable to bring out the differences to be expected from the various rotational practices. From 7 rotations in which neither manure nor a legume crop such as alfalfa or sweetclover was included in 1930, the average yield was 8.37 tons per acre. The average yield for the same rotations during the third 6-year period was 7.81 tons per acre. On the other hand, 9 rotations in which manure, alfalfa, or both were included returned an average yield in 1930 of 16.19 tons per acre, or a difference of 7.82 tons in favor of the better cropping program. The average yield for the 6-year period 1924–29 for the same 9 rotations was 13.7 tons per acre. This shows plainly that in treated rotations the tendency is for the yields to improve, while the yields from untreated rotations are declining or are barely maintained.

TABLE 6.—*Annual acre yields of sugar beets for each year 1930–32, together with average yields by 6-year periods from 1912 to 1929*

Rotation no.	Crop sequence	1930	1931	1932	6-year average 1912–17	6-year average 1918–23[1]	6-year average 1924–29
		Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
2-a	Sugar beets, continuous	5.7	4.7	4.7	6.5	8.3	5.9
2-m	Sugar beets, manure	13.0	11.7	12.2			
18	Wheat, sugar beets	7.6	4.5	7.3	8.5	7.9	7.4
19	Barley seeded to sweetclover plowed under in fall, sugar beets.	8.9	5.0	7.3			
20	Potatoes, sugar beets	14.7	6.4	8.7	11.0	13.1	12.7
21	Potatoes, sugar beets (manure)	21.6	10.9	16.7	12.8	16.3	17.6
22	Oats, sugar beets	10.8	9.0	9.5	9.6	11.4	11.4
23	Oats (manure), sugar beets	15.8	15.2	14.1	11.2	15.5	15.9
29	Barley seeded to sweetclover pastured in fall with lambs, fall-plowed, sugar beets.	7.9	6.6	6.6			
30	Potatoes, oats, sugar beets	8.9	7.1	6.1	7.7	8.1	6.8
31	Potatoes, oats (manure), sugar beets	12.8	8.3	12.3	11.4	12.2	13.0
32	Oats, corn, sugar beets	8.0	5.4	6.0	7.0	6.8	6.9
34	Oats, potatoes, sugar beets	14.8	9.1	10.3		14.6	12.8
35	Oats (manure), potatoes, sugar beets	16.5	11.7	13.1		15.4	14.8
40	Alfalfa 2 years, potatoes, sugar beets	14.0	9.4	9.9	10.6	12.3	12.8
42	Alfalfa 2 years, oats, sugar beets	13.1	8.4	7.9	8.4	9.5	9.1
46	Oats, alfalfa 2 years, sugar beets	6.7	3.3	8.2		6.9	7.2
47	Sweetclover (pastured), corn (harvested with lambs), sugar beets, barley seeded to sweetclover.	14.4	7.2	10.0			
49	Barley seeded to sweetclover, sweetclover pastured, sugar beets.	[2]12.2	[2]9.9	[2]11.2			
49	(Manure), sugar beets	[3]14.2	[3]9.4	[3]11.2			
60	Alfalfa 3 years, potatoes, oats, sugar beets	13.8	10.7	11.0	9.5	11.5	10.4
61	Alfalfa 3 years, potatoes, oats (manure), sugar beets	20.2	15.5	13.7	10.5	13.5	14.1
62	Alfalfa 3 years, corn, oats, sugar beets	12.8	9.6	9.3	7.8	9.1	9.1
64	Alfalfa 3 years, potatoes, sugar beets, oats	16.3	7.2	7.8		12.4	12.6
66	Flax, barley, corn, winter wheat, red clover, sugar beets	2.3	3.5	4.6	6.8	5.2	4.5
71	Oats, alfalfa (third year pastured), corn (sheeped), sugar beets.	15.9	10.9	10.4		13.5	16.0
	Annual mean	12.3	8.5	9.6	9.3	11.2	11.0
	Maximum	21.6	15.5	16.7			
	Range	19.3	12.2	12.1			

[1] Exclusive of 1919.
[2] Sugar beets first year.
[3] Sugar beets second year.

The average sugar-beet yields during the 21-year period are shown graphically in figure 2 for different crop sequences and treatments combined.

It should be noted that in an alfalfa rotation where 2 of the crops out of 6 are pastured with sheep and lambs and the beets follow a cultivated crop, the yield was 12.5 tons per acre and next to the highest yielding rotation in the series. Beets following red clover have given uniformly low yields during the entire period.

CORN

In the irrigated rotations corn is grown in 10 different rotations, one of which contains 2 years of corn. In three 6-year rotations where the third-year alfalfa is pastured with hogs or sheep, the corn crop is also harvested with hogs or lambs in three instances. The annual yields, 1930–32, together with the average yields by 6-year periods, 1912–29, are given in table 7.

These corn yields are divided into two sections, the first part being from 7 rotations where the crop is harvested in the usual manner, and the second is from 3 rotations where the crop is harvested with livestock and the yields are estimated. In the case of the 4 plots har-

vested by livestock, the method of arriving at the acre yield was as follows: The stand is determined by actual count on the plot. The ears are harvested from 100 plants. If there are 2,360 plants on the plots, the ears are harvested from every twenty-third plant. The total air-dry weight of the ears from the 100 plants multiplied by 23.6 equals the total weight of corn on the plot, and this divided by 70 would give the number of bushels on the plot.

The highest yield from any of the rotations where actual yields were obtained during the 21-year period was 63.9 bushels per acre from rotation 66 in 1922, and the lowest was 14.7 bushels from the continuously cropped plot 6–a in 1927. The rotation producing the

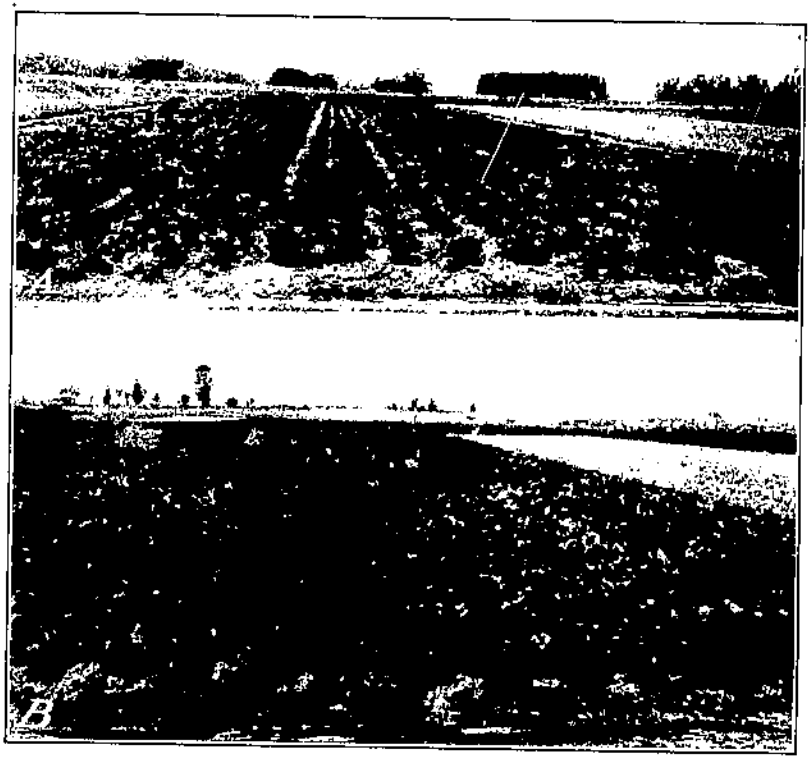

FIGURE 3.—*A*, Sugar beets after alfalfa, rotation 46; *B*, sugar beets after oats and manure, rotation 61. (Photographed Aug. 8, 1931.)

highest yield for the last 6-year period was no. 37, which included corn, barley, and sweetclover pastured with dairy cows.

The corn yields from the rotations where the crop was harvested by livestock have been consistently higher than those obtained from other cropping systems. The mean yield for the last 6-year period is 51.7 bushels per acre from this group, or 15.3 bushels more than the mean yield for the same period for the 7 cropping systems in the first series. These results indicate that harvesting certain crops with livestock has had a definitely favorable influence on increasing the yields of corn. Corn yields following beets have been relatively low, but beets have returned satisfactory yields when corn has been the preceding crop. For best results, corn should follow alfalfa or sweet-

TABLE 7.—*Annual acre yields of corn for each year 1930–32, together with the average yields by 6-year periods, 1912–29*

ACTUAL YIELDS

Rotation no.	Crop sequence	1930	1931	1932	6-year average 1912–17	6-year average 1918–23	6-year average 1924–29
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
6-a	Corn, continuous	38.6	31.5	33.1	45.5	42.5	34.9
16	Oats, corn	33.3	18.2	25.8	37.5	36.4	30.5
26	Potatoes, corn	30.9	21.7	26.9	35.0	41.7	31.8
32	Sugar beets, oats, corn	25.3	25.7	25.7	35.3	30.5	30.2
37	Barley and sweetclover, sweetclover pastured with cows, corn.	45.6	33.7	41.1	.....	.....	40.7
62	Oats, sugar beets, alfalfa 3 years, corn	47.0	34.0	41.4	37.1	38.7	41.2
66	Winter wheat, red clover, sugar beets, flax, barley, corn.	38.4	18.9	40.5	41.7	42.3	39.3
	Annual mean	37.9	26.2	33.5	38.7	40.2	36.4
	Maximum	47.0	34.0	41.4	.....	.....	.....
	Range	21.7	15.8	15.7	.....	.....	.....

HARVESTED WITH LIVESTOCK AND YIELDS ESTIMATED

65	Flax, oats, alfalfa (third year hogged), corn (hogged)	45.9	45.3	52.1	44.1	56.0	52.2
69–a	Oats, alfalfa (third year hogged), corn 2 years (hogged)	[1] 64.3	34.0	50.7	.....	49.4	55.2
69–b		[1] 59.3	42.7	48.0	.....	55.9	50.2
71	Sugar beets, oats, alfalfa (third year sheeped), corn harvested with lambs.	63.7	37.2	43.3	.....	49.9	49.1
	Annual mean	58.3	39.8	48.5	44.1	52.8	51.7
	Maximum	64.3	45.3	52.1	.....	.....	.....
	Range	18.4	11.3	9.8	.....	.....	.....

[1] 5-year mean; no corn planted in 1912.

clover in a rotation. The uniformity of the corn yields each season from all rotations indicates that the crop may be expected to return fairly satisfactory yields every season and that it is less susceptible to unfavorable weather conditions and less subject to injury from insect pests and plant diseases than are cereals, sugar beets, and potatoes. These results further indicate that corn is well adapted to the irrigated lands of the Belle Fourche project.

OATS

In table 8 are recorded the yields of oats from the 24 different rotations for the years 1930–32, together with the average yields by 6-year periods from 1912 to 1929. The results show a marked difference in yields, although the preceding crop was the same. As a rule the best yields have been obtained where oats follow potatoes, beets, or corn. In the early years of the rotation experiments the yields of oats in rotations with alfalfa or manure were not increased, and in some cases they were even depressed. During the last 10 years these treatments have had a more favorable influence on the oat yields.

In 1932 the average yield for the 24 rotations in which oats were grown was 71.6 bushels per acre. Comparing 5 untreated rotations in 1932, the average yield of which was 55.5 bushels, with 5 rotations similar in every respect except that 2 or 3 years of alfalfa were added, the average yield was 76.1 bushels, a difference of 20.6 bushels in favor of the alfalfa rotations. Comparing the same rotations by 6-year periods, it is found that in the first 6-year period there was an increase of 8.0 bushels in favor of the alfalfa rotations, in the second

6-year period there was a difference of 2.8 bushels in favor of the rotations without alfalfa, but during the third 6-year period there was an increase of 15.1 bushels in favor of the alfalfa rotations.

TABLE 8.—*Annual yields of oats for each year 1930–32, together with average yields by 6-year periods, 1912–29*

Rotation no.	Crop sequence	1930	1931	1932	6-year average		
					1912–17	1918–23	1924–29
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1–a	Oats, continuous	48.9	30.0	57.8	66.8	37.8	39.5
16	Corn, oats	42.5	13.1	55.0	55.2	41.4	46.6
22	Sugar beets, oats	56.2	41.2	71.2	68.0	54.6	59.0
23	Sugar beets, oats (manure)	62.5	36.2	78.7	66.5	59.4	63.0
24	Potatoes, oats	71.2	37.5	67.5	68.2	63.0	59.0
25	Potatoes, oats (manure)	73.7	48.7	76.2	69.1	66.3	73.8
27	Potatoes, oats (seed rye in oat stubble, plowed under in spring)	58.2	30.0	50.0	66.6	61.2	59.9
28	Wheat, oats	22.0	34.2	32.5	35.2	26.7	17.0
30	Sugar beets, potatoes, oats	53.1	27.5	60.0	68.3	51.1	58.2
31	Sugar beets, potatoes, oats (manure)	72.5	33.7	71.2	76.3	61.5	68.7
32	Corn, sugar beets, oats	35.0	17.5	40.2	57.1	36.0	41.8
34	Potatoes, sugar beets, oats	54.7	23.7	57.5	.....	54.0	50.6
35	Potatoes sugar beets, oats (manure)	47.5	22.2	65.0	.....	56.5	50.8
42	Sugar beets, alfalfa 2 years, oats	41.2	21.2	62.5	47.9	36.6	40.7
44	Alfalfa 2 years, potatoes, oats	83.7	42.5	90.0	82.2	45.7	75.3
46	Alfalfa 2 years, sugar beets, oats	60.2	28.7	88.7	.....	38.6	64.6
48	Alfalfa 2 years, wheat, oats	67.5	35.0	64.6	80.9	47.9	67.3
60	Sugar beets, alfalfa 3 years, oats	63.7	27.5	95.0	65.0	40.8	68.4
61	Sugar beets, alfalfa 3 years, potatoes, oats (manure)	61.2	31.2	96.2	73.3	48.7	71.2
62	Alfalfa 3 years, corn, sugar beets, oats	53.5	26.2	68.2	61.1	37.6	53.0
64	Alfalfa 3 years, potatoes, sugar beets, oats	45.0	28.7	87.5	.....	50.4	54.4
65	Alfalfa (third year hogged), corn (hogged), flax, oats	61.2	36.2	83.7	72.0	45.4	59.8
69	Alfalfa (third year hogged), corn (2 years hogged), oats	81.2	37.5	97.5	.....	55.4	71.2
71	Alfalfa (third year sheeped), corn (sheeped), sugar beets, oats	71.2	60.0	95.0	.....	54.4	66.1
	Annual mean	58.0	32.1	71.6	65.0	49.2	57.7
	Maximum	83.7	60.0	97.5	.....	.....	.....
	Range	61.7	46.9	65.0	.....	.....	.....

Comparing 4 untreated rotations with 4 similar rotations where barnyard manure was applied at the rate of 12 tons per acre once during the rotation, the average yield for the untreated rotations in 1932 was 64.0 bushels per acre. In the 4 rotations where barnyard manure was applied, the average yield was 72.8 bushels, a difference of 8.8 bushels in favor of the manured plots. Comparing the rotations by 6-year periods, the average for the first 6 years of untreated rotations was 68.1 bushels and for the treated rotations 67.6, a difference of 0.5 bushel in favor of the untreated rotations. During the second 6-year period there was a difference of 5.2 bushels and for the third 6-year period 7.4 bushels, respectively, in favor of the treated rotations.

The yields from the alfalfa rotations, both treated and manured, are practically identical for 1932 and in the three 6-year periods, 1912–29. The 3 rotations, nos. 65, 69, and 71, in which certain crops are harvested with livestock, are worthy of consideration. The average yield for these 3 rotations in 1932 was 92.0 bushels per acre, and rotation no. 69 in 1932 produced the highest yield of any rotation.

BARLEY

When the rotation experiments recorded in table 9 were started in 1912, barley was included in only 2 rotations, 1 continuously cropped and the other in a 6-year rotation where barley follows flax. Neither method has proved satisfactory. In 1923 a 3-year rotation

was included in the series, consisting of barley seeded with sweetclover, sweetclover pastured, and corn. The average yield for the 6-year period 1924–29 was 46.2 bushels per acre, and in 1932 this rotation produced a yield of 59.3 bushels per acre. The new barley rotations included in 1928 have produced satisfactory yields except in 1931 when all grain yields were low, due to unfavorable climatic conditions as well as a shortage of irrigation water.

Satisfactory yields of barley are obtained where the planting is on good ground and following a cultivated crop. When a nurse crop is to be used in seeding alfalfa or sweetclover, barley serves the purpose better than either wheat or oats. Under proper management barley is one of the most profitable grains for feed that can be grown locally under irrigation. Since the building of the sugar factory in 1927, barley to a large extent has replaced corn as a grain crop.

TABLE 9.—*Annual acre yields of barley for each year, 1930–32, together with the average yields by 6-year periods, 1912–29*

Rotation No.	Crop sequence	1930	1931	1932	6-year average		
					1912–17	1918–23	1924–29
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
10	Barley, continuous	25.0	8.2	22.1	23.1	10.3	16.4
19	Barley seeded to sweetclover, plowed under in fall, sugar beets.	37.5	28.3	57.5			
29	Barley seeded to sweetclover and pastured in fall with lambs, sugar beets.	36.7	24.2	60.0			
37	Barley seeded to sweetclover, sweetclover pastured with dairy cows, corn.	47.1	13.9	59.3			46.2
47	Barley seeded to sweetclover, sweetclover pastured with sheep, corn harvested with lambs, sugar beets.	42.2	26.7	53.4			
49	Barley seeded to sweetclover, sweetclover pastured with sheep, sugar beets (manured), sugar beets.	54.2	30.8	53.3			
66	Barley, corn, winter wheat, red clover, sugar beets, flax	24.2	6.2	22.5	35.4	24.4	30.5
	Annual mean	38.1	19.8	46.9	29.3	17.4	31.0
	Maximum	54.2	30.8	60.0			
	Range	30.0	24.6	37.9			

[1] 4-year mean yield, 1914–17

POTATOES

The yields of potatoes for the years 1930–32, together with the average yields by 6-year periods, 1912–29, are recorded in table 10. The annual fluctuations in the yields of potatoes have ranged within wide limits. Rotations with manure have given uniformly better yields than those without this treatment, and for the last 6 years the benefits of including alfalfa in the rotations are apparent in the form of increased yields. The season of 1930 was favorable for potatoes, whereas growth conditions in the 2 following years were less conducive to the harvesting of satisfactory yields. A poor stand of potatoes was obtained in 1931, largely due to unfavorable weather conditions at the time of planting and shortly thereafter. The low yields in 1932 were caused by blight. Three applications of bordeaux spray were applied, but in spite of this the disease was not effectively controlled. Heavy gumbo soils, such as predominate on the Belle Fourche project, are not favorable to high yields of potatoes. If weather conditions are favorable, fair yields may be expected, and these results indicate that over a series of years a farmer may expect returns justifying the inclusion of potatoes in his planting program if the crop is grown in well-planned rotations following alfalfa or manure.

TABLE 10.—*Annual acre yields of potatoes for each year, 1930–32, together with the average yields by 6-year periods, 1912–29*

Rotation no.	Crop sequence	1930	1931	1932	6-year average		
					1912–17	1918–23	1924–29
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
4	Potatoes, continuous	175.9	98.0	74.7	136.0	102.3	126.9
20	Sugar beets, potatoes	133.3	78.7	91.3	112.8	107.7	90.2
21	Sugar beets (manure), potatoes	177.3	216.0	151.3	143.6	181.7	151.0
24	Oats, potatoes	138.0	135.3	127.5	103.0	125.3	134.2
25	Oats (manure), potatoes	105.4	153.3	159.0	117.1	148.1	139.6
26	Corn, potatoes	163.3	127.3	87.0	115.6	125.3	138.3
27	Oats (seed rye in tubble, plowed under in spring), potatoes.	123.3	144.7	78.3	97.3	70.6	96.4
30	Oats, sugar beets, potatoes	193.3	133.3	67.7	92.7	121.4	127.0
31	Oats (manure), sugar beets, potatoes	220.3	124.7	146.5	135.6	175.0	180.4
34	Sugar beets, oats, potatoes	220.7	163.7	156.1		147.1	138.4
35	Sugar beets, oats (manure), potatoes	233.3	158.3	156.7		169.5	189.8
40	Sugar beets, alfalfa 2 years, potatoes	172.9	96.7	120.3	101 0	155.1	137.9
44	Oats, alfalfa 2 years, potatoes	220.0	176.7	172.7	137 1	146.6	183.8
60	Oats, sugar beets, alfalfa 3 years, potatoes	179.3	176.7	177.3	109.9	128.3	144.1
61	Oats (manure), sugar beets, alfalfa 3 years, potatoes.	164.0	187.7	176.0	105.9	122.0	133.2
64	Sugar beets, oats, alfalfa 3 years, potatoes	150.7	138.3	139.7		101.1	132.3
	Annual mean	179.5	141.3	128.9	116.5	133.3	142.0
	Maximum	233.3	216.0	176.0			
	Range	140.0	137.3	108.3			

[1] Exclusive of 1920.

WHEAT

Spring wheat is grown in four rotations. One plot is continuously in wheat, and there are two 2-year rotations where wheat follows another grain crop. In the other two rotations wheat follows alfalfa in a 4-year rotation and beets in a 2-year rotation. The maximum yield in 1932 was 35.0 bushels per acre in a 4-year rotation where wheat followed alfalfa, and the minimum was 15.5 bushels per acre in plot no. 5–a, continuously cropped, which has returned an average yield for 19 years of 14.0 bushels per acre. For 21 years wheat following beets in a 2-year rotation has averaged 23.3 bushels per acre. Wheat following alfalfa in a 4-year rotation returned 25.1 bushels per acre for the same period.

Winter wheat has been grown in 2 rotations, 1 continuously cropped and 1 in a 6-year rotation following corn. Neither method has proved satisfactory. The average yield for 18 years from the continuously cropped plot has been 13.4 bushels per acre, and from the one following corn it has averaged 13.3 bushels per acre for the same period.

Under these conditions neither spring nor winter wheat fit advantageously into the planting program of most irrigated farms in the Belle Fourche area either as a cash crop or feed crop. Over a series of years oats, barley, and corn yield more than wheat.

FLAX

Table 11 gives the annual yields of flax for the years 1930–32, together with the average yields by 6-year periods from 1912 to 1929. Flax is grown in 3 rotations—1 continuously cropped, 1 in a 6-year rotation following corn harvested with hogs, and the other in a 6-year rotation following sugar beets.

The average yield for the continuous flax plot for 21 years was 9.7 bushels per acre. The average yield in rotation 65, flax following

corn, for the same period was 15.0 bushels per acre, and in rotation 66, flax following sugar beets, the average yield was 14.6 bushels. That flax impairs the productivity of the land more rapidly than wheat or oats is not substantiated by these results, as the yields of flax in continuous cropping have been maintained as well or better than the continuously cropped grain plots. Flax following corn or sugar beets has done equally well as far as yields are concerned. Even if the other factors were favorable, flax under irrigation is not a crop to be recommended, because of the difficulty in controlling weed growth. To hold the weeds in check as much as possible, seeding has been delayed until about May 20, in order to sprout the weed seeds and as far as possible eradicate them before the flax is planted.

TABLE 11.—*Annual acre yields of flax for each year 1930–32, together with average yields by 6-year periods 1912–29*

Rotation no.	Crop sequence	1930	1931	1932	6-year average		
					1912–17	1918–23	1924–29
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
9	Flax, continuous	10.1	1.0	7.2	14.3	7.9	9.1
65	Flax, oats, alfalfa, 3-year (hogged), corn (hogged)	15.2	6.8	13.6	16.2	17.4	12.9
66	Flax, barley, corn, winter wheat, red clover, sugar beets	12.5	6.8	13.0	15.5	15.4	14.8
	Annual mean	12.6	4.9	11.3	15.3	13.6	12.3
	Maximum	15.2	6.8	13.6	.....	.....	.....
	Average	5.1	5.8	6.4	.....	.....	.....

SUMMARY OF OBSERVATIONS ON THE ROTATION EXPERIMENTS

As a rule, crops following alfalfa show increases in yields as compared with rotations not including alfalfa or sweetclover, but those increases are much higher in rotations where the alfalfa is pastured with sheep or hogs. The applications of manure have influenced favorably the yields of sugar beets, potatoes, and alfalfa, and increased slightly the yield of grain. Sugar beets following a cultivated crop have given fairly uniform good results, and sugar beets following a grain crop without manure, or following red clover, or immediately after alfalfa have given low yields. Potatoes in rotations which include manure or alfalfa or both have given better yields than without these treatments. The same is true of corn. Harvesting certain field crops by pasturing with livestock has resulted in higher returns per acre than harvesting in the usual way and has given a marked increase in subsequent crop yields.

Satisfactory stands of alfalfa have been obtained by using grain as a nurse crop except in years when grasshoppers are abundant, otherwise seeding alfalfa without a nurse crop has produced the most satisfactory stands. The best results are obtained by fall-plowing the land. This practice is particularly desirable in connection with the preparation of the land for small grains and sugar beets.

The outstanding advantages of a systematic rotation are: (1) Increase in crop yields; (2) the reduction in risks (including climatic conditions, plant diseases, insect pests, and price fluctuations); and (3) better distribution of labor and hence more economical production.

The following cropping systems, based upon the observations of 21 years, are recommended in the irrigated rotations. On the lighter soils of the project where the land is uniform, both as to quality of soil and ease of irrigation, the entire farm may be divided into seven fields as nearly equal in size as practicable. Four of these fields should be in alfalfa each year, and the other three planted to such crops as corn, potatoes, sugar beets, or grain. Under such a system, one field of alfalfa would be plowed up each year and another planted to grain and alfalfa to replace the one plowed.

On the heavy gumbo soils of low productivity, where much of the land is too steep to irrigate satisfactorily when planted to a cultivated crop, the most logical procedure is to plant such land to alfalfa and continue it in this crop as long as the stand remains fairly good. In the locations where the land, though heavy, is of better quality and of such slope that cultivated crops may be irrigated without difficulty, a 3- or 4-year rotation may be used as follows: First year, grain seeded to sweetclover; second year, pastured or harvested for hay if stock is not available; third and fourth years, such crops as corn, potatoes, or sugar beets. For maximum yields, manure should be applied at least once during the cycle of the rotation. It is highly desirable that the rotation scheme be so planned that sufficient feed is produced for the maintenance of the farm livestock.

MIXED GRASS PASTURES

Mixed grass pastures planted in 1916 and 1917 are still in good condition and are recommended in cases where a permanent pasture is desired. For a permanent grass pasture, the following mixture has been found to give satisfactory results: Bromegrass, Kentucky bluegrass, orchard grass, meadow fescue, and western wheatgrass, 5 pounds each, 2 pounds of white clover, 1 pound of alfalfa, and 5 pounds of sweetclover, making a total of 33 pounds per acre. The mixture may be planted with a grain drill or sown broadcast and lightly harrowed. In either case, care must be taken not to cover the seed too deeply.

For convenience, a permanent pasture of from 5 to 10 acres should be established, depending on the size of the farm and the number of livestock. A desirable land preparation for establishing a permanent grass pasture is good clean corn or beet ground, disked, leveled, and harrowed before planting. The planting may be done in the spring with a nurse crop of grain. The nurse crop may be kept clipped during the summer, rather than harvested for grain. If clipped, a much better growth of the grass will occur and the pasture will be more productive the following year.

To obtain a maximum carrying capacity on grass pasture, the field should be given an application of manure every fall or winter and harrowed with a spring-tooth harrow in the spring. The grasses used in the mixture are not deep-rooted, and frequent irrigations should be applied to keep them in a vigorous growing condition throughout the summer.

PASTURING SWEETCLOVER WITH DAIRY COWS

Rotation 37 covers a 3-year period, corn, barley seeded to sweetclover, and sweetclover pastured with dairy cows. When the cows were turned into the sweetclover they did not take to it readily. Although the quantity of milk varied but little when changing to sweetclover from the grass pastures, the cows lost in weight. During the 11 years that sweetclover has been pastured, there has been only one case of bloat.

Pasturing is divided into two periods, the spring and summer period, from about May 15 to August 15, when the second-year sweetclover is pastured, and the fall period, from about August 15 to October 1, when the spring-seeded sweetclover seeded with barley as a nurse crop is pastured. Like all other irrigated pastures, the sweetclover field should be divided into two lots, so that the stock may be kept off the land during irrigation. By this method a much better growth is obtained than when the whole area is pastured continuously. Handled in this manner, it appears from the results of the past 7 years that an acre of sweetclover should furnish pasture for two cows from about May 15 to October 1.

While pasturing dairy cows on sweetclover it is necessary to feed some grain, which was done at the rate of 1 pound per 4 pounds of milk produced. From the results obtained during the 7-year period, it appears that sweetclover may be included in the list of desirable crops on the heavy gumbo soils of the Belle Fourche project, not only for the actual cash returns per acre for pasture but for the beneficial effects on subsequent crop yields.

PASTURING ALFALFA WITH HOGS

In connection with two of the irrigated rotation experiments, the third year of alfalfa is pastured with hogs. One is rotation 65 and consists of 3 years alfalfa followed by corn, flax, and oats. The other is rotation 69 and consists of 3 years of alfalfa, 2 crops of corn, and 1 of oats. The third-year alfalfa and the corn in each rotation are pastured with hogs. While on alfalfa pasture, the hogs are fed 2 pounds of corn daily for each 100 pounds live weight. Each of the two plots of alfalfa is divided into two lots and pastured alternately, the hogs being changed every 2 weeks. This arrangement results in a more uniform growth of the alfalfa and greater convenience in irrigating. The pasture season is divided into two periods—the spring period from early May to July, when fall pigs are used, and the summer period from July to September, when spring pigs are utilized. Changing from fall to spring pigs about July 1 cannot be recommended as a farm practice.

When the experiment was begun, the object was to obtain the largest quantity of pork to the acre of alfalfa, while the practical problem is to obtain the cheapest gains for the grain fed by utilizing alfalfa pasture as a supplementary feed. The results for the 18- and 20-year periods are as follows: The total average live weight per acre for the two rotations is 2,253 pounds, or at the rate of 20 fall pigs for the spring period and 30 pigs for the summer period. The total gain per acre has been 1,862 pounds of pork, requiring 5,331 pounds of corn, or at the rate of 2.87 pounds of corn for 1 pound of pork. The results of pasturing alfalfa in rotation 65 for 20 years and in rotation 69 for 18 years are shown in table 12.

TABLE 12.—*Results of pasturing alfalfa with hogs in rotations 65 and 69, 1913–32*

Year	Rotation no.	Length of test	Weight, acre basis			Grain fed per pound of gain
			Live weight	Grain fed	Gain	
		Days	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1913	65	94	1,508	4,292	1,068	4.01
1914	65	121	1,815	5,104	1,830	2.79
1915	65	132	2,092	4,787	2,024	2.36
	69	132	2,068	4,976	2,108	2.36
1916	65	119	2,286	5,200	1,962	2.70
	69	119	2,238	5,128	2,006	2.56
1917	65	119	1,956	4,594	1,742	2.64
	69	119	1,956	4,464	1,740	2.56
1918	65	121	1,934	4,880	1,942	2.51
	69	121	1,970	4,880	2,138	2.28
1919	65	109	2,052	4,444	1,714	2.60
	69	109	2,052	4,444	1,688	2.63
1920	65	122	2,124	5,228	2,024	2.58
	69	122	2,124	5,228	2,032	2.57
1921	65	118	1,945	4,776	1,942	2.46
	69	118	1,964	4,776	2,004	2.38
1922	65	114	2,156	4,908	1,856	2.60
	69	114	2,168	4,908	1,932	2.54
1923	65	125	2,290	5,928	2,052	2.85
	69	125	2,344	5,928	2,260	2.62
1924	65	121	2,823	6,712	1,862	3.54
	69	121	2,816	6,712	1,866	3.53
1925	65	137	2,301	7,412	2,500	2.96
	69	137	2,295	7,636	2,100	3.65
1926	65	124	2,371	6,552	2,185	2.54
	69	124	2,242	5,661	1,664	3.40
1927	65	108	2,528	5,316	1,664	3.19
	69	108	2,444	5,464	1,929	2.85
1928	65	122	2,462	5,820	1,721	3.38
	69	122	2,551	5,980	2,076	2.88
1929	65	102	2,560	4,520	1,468	3.08
	69	102	2,600	4,492	1,552	2.89
1930	65	127	2,338	5,856	1,904	3.08
	69	127	2,318	5,661	1,824	3.11
1931	65	122	2,204	5,192	1,632	3.18
	69	122	2,051	4,964	1,424	3.49
1932	65	106	2,563	5,372	1,716	3.13
	69	106	2,513	5,316	1,500	3.54
Averages:						
Rotation 65 (20 years)		118	2,234	5,205	1,844	2.91
Rotation 69 (18 years)		119	2,273	5,368	1,830	2.83

PASTURING CORN WITH HOGS

The results of harvesting corn with hogs for the 18- and 21-year periods are as follows: The average length of the test was 25 days; average initial weight, 91 pounds; average daily gain, 1.68 pounds, requiring 4.2 pounds of corn for 1 pound of gain. The average yield of corn per acre for the period was 50.6 bushels per acre which produced 694 pounds of pork. Table 13 gives the results of hogging corn for 21 years in rotation 65 and for 18 years in rotation 69.

TABLE 13.—*Results of harvesting corn with hogs in rotations 65 and 69, 1912–32*

Year	Rotation no.	Length of test	Weight, acre basis		Corn		Average per pig	
			Total initial	Gain	Estimated acre yield	Fed per pound of gain	Initial weight	Daily gain
		Days	*Pounds*	*Pounds*	*Bushels*	*Pounds*	*Pounds*	*Pounds*
1912	65	20	680	340	28.7	4.7	86	1.63
1913		11	1,632	560	34.0	3.4	51	1.59
1914		20	1,708	552	34.8	3.3	106	1.81
1915	65	15	1,620	548	40.6	4.2	81	1.85
	69	10	1,780	451	34.0	4.2	89	1.87
1916	65	24	1,252	518	59.1	5.9	104	1.80
	69	26	1,268	450	47.7	5.8	105	1.53
1917	65	30	1,280	682	67.4	5.5	108	1.60
	69	37	1,206	537	55.4	5.7	109	1.39
1918	65	33	1,530	758	55.8	4.1	95	1.43
	69	35	1,190	667	56.7	4.7	99	1.58
1919	65	32	1,342	642	40.9	3.5	67	1.00
	69	32	998	554	40.0	4.0	62	1.08
1920	65	19	1,466	682	42.8	3.5	74	1.70
	69	28	1,025	703	43.0	3.5	73	1.89
1921	65	32	1,240	1,034	63.7	3.4	77	2.02
	69	26	1,087	866	52.7	3.6	77	2.38
1922	65	37	1,480	962	68.1	3.9	74	1.30
	69	37	1,323	1,035	68.9	3.7	74	1.50
1923	65	24	1,402	854	64.7	4.2	74	1.78
	69	24	1,423	728	53.2	4.2	70	1.69
1924	65	16	1,424	428	32.0	4.2	89	1.67
	69	16	1,750	512	37.0	4.0	87	1.60
1925	65	30	1,812	1,080	69.9	3.6	91	1.80
	69	30	1,814	978	68.2	3.9	101	1.81
1926	65	24	1,580	884	50.3	3.6	79	1.84
	69	24	1,509	708	58.8	4.7	87	1.70
1927	65	18	1,936	404	46.4	6.4	121	1.40
	69	15	1,800	384	38.6	5.6	128	1.73
1928	65	27	1,036	960	58.7	3.4	97	1.78
	69	24	1,042	742	60.7	4.6	110	1.72
1929	65	23	1,616	852	50.9	3.3	81	1.85
	69	25	1,608	774	52.6	3.8	89	1.72
1930	65	24	1,676	536	45.9	4.8	140	1.86
	69	24	1,910	718	61.8	4.8	137	2.13
1931	65	22	1,948	720	45.3	3.5	97	1.64
	69	25	1,850	560	38.3	3.8	103	1.56
1932	65	24	2,028	920	52.1	3.2	84	1.60
	69	24	1,736	704	40.3	3.5	87	1.65
Average:								
Rotation 65 (21 years)		24	1,550	712	50.3	4.1	89	1.67
Rotation 69 (18 years)		20	1,518	676	51.0	4.3	94	1.70

PASTURING ALFALFA, CORN, AND BEET TOPS WITH SHEEP

Rotation 71 covers a 6-year period, 3 years of alfalfa and 1 year each of corn, beets, and oats. The third year of alfalfa is pastured with ewes and lambs, and the corn is harvested with lambs. From 1916 to 1923, inclusive, the ewes were removed about the latter part of July and the lambs pastured for the remainder of the season. From 1924 to 1932, inclusive, the lambs were taken off the alfalfa and sold about the first week in August, when they had reached a weight of about 85 pounds, which is considered a good marketing weight. The ewes were retained on the alfalfa pasture until the early part of October. On alfalfa yielding 4 tons per acre, the carrying capacity per acre would be at the rate of about 8 ewes from May 20 to October 1 and 12 lambs from May 20 to about August 1. If this alfalfa was fed as hay, it would be equal to about 4.5 pounds per head a day.

The results of pasturing alfalfa on an acre basis from 1916 to 1932 are given in table 14.

TABLE 14.—*Results of pasturing ewes and lambs on alfalfa, 1916–32*

Year	Number of—		Average initial weight for—		Pasturing period for—		Average gain of lambs	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Daily per lamb	Per acre
			Pounds	*Pounds*	*Days*	*Days*	*Pound*	*Pounds*
1916	12	12			87	87	0.23	240
1917	8	16	128	35	80	80	.30	380
1918	8	12	140	33	82	112	.30	405
1919	8	12	120	30	74	74	.57	512
1920	8	12	127	48	59	103	.45	560
1921	8	12	153	49	46	106	.41	528
1922	8	12	136	41	56	103	.30	372
1923	8	12	137	48	70	105	.30	300
1924	8	12	114	52	120	56	.49	328
1925	8	12	146	40	143	78	.51	480
1926	8	12	122	41	141	96	.50	572
1927	8	12	165	57	90	74	.33	292
1928	8	12	123	63	110	75	.33	300
1929	8	12	156	62	91	67	.47	380
1930	8	12	161	44	49	49	.39	232
1931	8	12	153	51	63	63	.27	208
1932	8	12	180	35	111	77	.63	584
Maximum			180	63	141	112	.63	584
Minimum			114	30	46	49	.23	208
Average			141	15	88	82	.40	398

The average daily gain for this period was 0.4 pound per lamb, and the average total gain per acre was 398 pounds. When pasturing sheep on alfalfa, certain losses from bloat may occur. Farmers on the project who pasture sheep in large numbers have sustained losses, but they have not been considered heavier than those which occur on the range from other causes. It is much safer to pasture lightly than too closely, and more satisfactory gains are obtained. The pastures should be divided into two equal parts, and the sheep changed from one to the other about every 2 or 3 weeks. This will permit the land to be irrigated during the vacant period.

The corn plot in rotation 71 was pastured with lambs, and as soon as the beets were harvested they also had access to the beet tops. Since 1924 alfalfa hay in racks has been substituted for the alfalfa pasture. The lambs are generally turned in on the corn early in September, and for the first 2 weeks they feed on the leaves and husks of the corn before they go into the grain. No digestive disorders have been noted which could be attributed to overfeeding of corn. Table 15 shows the results of the experiment with lambs from 1916–32.

The average total gain per acre was 663 pounds, supplemented with 1 acre of beet tops and alfalfa hay fed in racks. In 1930, which represented an average year, it required 1 acre of corn yielding 63.7 bushels, 1 acre of beet tops, and 7,640 pounds of alfalfa hay to make a gain of 832 pounds. It required 4.3 pounds of corn and 9.2 pounds of alfalfa to make 1 pound of gain. The average daily gain for a period of 72 days was 0.34 pound.

TABLE 15.—*Results of harvesting corn with lambs, 1916–32*

Year	Lambs			Corn		Average gain of lambs—	
	Number per acre	Pasturing period	Average initial weight	Acre yield	Fed per pound of gain	Per acre	Daily per lamb
		Days	*Pounds*	*Bushels*	*Pounds*	*Pounds*	*Pound*
1916	40	62	65	52.0	4.9	600	0.24
1917	48	42	72	57.0	4.4	724	.36
1918	32	60	72	55.0	5.1	600	.31
1919	32	42	71	30.0	5.4	496	.37
1920	28	43	65	42.0	5.3	440	.37
1921	24	63	91	53.0	5.6	528	.35
1922	40	73	47	60.0	6.3	536	.18
1923	40	56	64	59.0	6.5	504	.22
1924	32	49	64	38.0	4.4	488	.31
1925	52	33	81	45.1	2.9	876	.51
1926	40	56	60	49.7	3.9	720	.32
1927	56	26	62	45.7	5.7	448	.31
1928	60	41	61	52.6	2.3	1,252	.51
1929	68	34	66	50.9	7.2	396	.17
1930	72	34	72	63.7	4.3	832	.34
1931	52	38	64	37.3	2.5	824	.42
1932	52	67	70	43.3	2.4	1,008	.30
Maximum	72	73	91	63.7	7.2	1,252	.51
Minimum	24	26	47	30.0	2.3	396	.17
Average	45	46	67	49.1	4.5	663	.33

PASTURING SWEETCLOVER WITH SHEEP

In 1928, two 4-year rotations, including sweetclover, were added to the present series, in which sweetclover is pastured in the fall of the first year and all of the second year. The average results of pasturing these rotations the second year are shown in table 16.

The lambs have been taken out about August 1, when they generally reached marketable weight. The ewes are continued on the second season's growth until the spring-seeded sweetclover has become well established, which is generally the latter part of August. The sweetclover will furnish fall pasture for the ewes for about 40 days. Like all other irrigated pastures, the sweetclover pasture should be divided into two lots, so that the stock may be removed when an irrigation is required. By this alternation a much better growth is obtained than when the whole area is pastured continuously.

TABLE 16.—*Results of pasturing ewes and lambs on sweetclover, 1928–32*

Year	Number of—		Average initial weight for—		Pasturing period for—		Average gain of lambs	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Daily per lamb	Per acre
			Pounds	*Pounds*	*Days*	*Days*	*Pound*	*Pounds*
1928	8	12	150	50	105	75	0.297	267
1929	8	12	151	64	85	61	.324	249
1930	8	12	149	42	82	62	.335	249
1931	8	12	144	51	103	78	.267	278
1932	8	12	145	35	87	65	.320	253
Maximum			151	64	105	78	.335	278
Minimum			144	35	82	62	.297	249
Average			148	50	88	69	.316	259

MAXIMUM CROP PRODUCTION

A cropping experiment to obtain information as to the maximum yields which could be obtained from certain crops was inaugurated in 1920. In this experiment it has been the aim to use such cultural methods and crop sequences as have been found to give high yields in the irrigated rotations and in other experiments at the station.

In this experiment 10 crops of local importance with the following crop sequences were used: Rotation no. 1, oats, corn, mangels (half sugar); rotation no. 2, spring wheat, potatoes, sugar beets; rotation no. 3, barley, potatoes, mangels (Mammoth Long Red); rotation no. 4, corn and flax; rotation no. 5, winter wheat and summer fallow; and rotation no. 6, alfalfa plowed and reseeded every 4 years. Manure was applied to all cultivated crops and alfalfa each year at the rate of 18 spreader loads per acre. Where plowing was necessary this was done in the fall. In table 17 are given the yields in the maximum-production experiment for the 12-year period 1920–31.

TABLE 17.—*Yields of crops in maximum-production experiments, 1920–31*

Crop	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	Average
Alfalfa.....tons..	4.50	5.41	5.42	3.75	4.97	6.09	5.64	4.10	4.89	6.20	6.07	4.30	5.03
Barley.....bushels..	31.2	30.0	65.0	51.7	34.5	52.9	56.5	47.3	60.8	42.5	61.8	32.5	47.1
Beets.....tons..	15.0	13.7	22.4	19.5	19.0	21.1	20.9	15.5	20.7	20.6	20.7	13.7	18.5
Corn.....bushels..	52.4	58.4	56.0	56.7	37.2	65.1	62.8	41.1	54.0	46.8	56.5	31.2	50.6
Flax.....do....	7.1	18.2	16.9	8.8	13.6	14.7	19.6	14.3	15.9	.....	12.1	3.2	13.1
Mangels:													
Half sugar...tons..	18.5	30.5	34.9	30.0	44.0	33.4	24.3	25.2	31.0	33.9	43.3	27.4	31.3
Mammoth Long Red.....tons..	20.5	32.9	49.8	33.7	38.3	33.2	17.8	28.3	32.3	31.8	32.9	20.5	31.5
Potatoes....bushels..	98.3	122.5	363.0	264.0	301.6	330.3	298.0	201.3	351.3	254.2	288.6	205.7	250.8
Oats.....do....	40.3	45.3	67.5	60.0	64.1	73.1	74.4	37.4	81.2	88.7	86.2	42.5	63.9
Wheat:													
Spring.....do....	16.3	26.7	31.2	18.2	22.3	32.7	28.7	13.3	38.5	34.5	41.1	17.3	26.7
Winter.....do....	.....	27.3	45.5	20.1	62.0	24.7	57.6	9.9	.....	38.8	69.3	14.5	37.8

The yields in this experiment for the 12-year period have been consistently high and it is believed of a magnitude sufficient to cover production costs at the prevailing local prices for that period.

VARIETY TESTS OF CEREALS

During the period covered by this report, a number of varieties of spring wheat, oats, barley, flax, and corn were tested for the purpose of determining which are best adapted to the local conditions under irrigation.

SPRING WHEAT

In 1926 the wheat was planted on land previously in potatoes, on corn ground in 1927, 1928, and 1929, and on sugar-beet ground in 1930, 1931, and 1932. In all instances the land was disked only, and the wheat was seeded at the rate of 5 pecks per acre with a disk drill in triplicated fiftieth-acre plots. The results are recorded in table 18.

For the 7-year period, Kubanka, a durum variety, yielded 30.8 bushels per acre. Of the bread wheats, Reliance has the highest yield, followed by Ceres and Marquis. In 1928, four new varieties were included—Mindum and Nodak of the durum varieties and Marquillo and Supreme of the bread varieties. For the 5-year period 1928–32, inclusive, Nodak yielded 4.3 bushels more than Kubanka and Mindum 2.0 bushels more. The bread wheats, Marquillo and

Supreme, yielded less than either Reliance, Ceres, or Marquis during this same period. Reward and Hope were added to the test in 1929 and Federation and Champlain in 1930, but none of these new varieties has proved superior in yield to Reliance or Ceres. In 1927 unusually low yields were harvested, which was attributed to unseasonably late seeding on May 26.

TABLE 18.—*Yields of wheat varieties under irrigation, 1926–32*

Variety	Acre yields of wheat							
	1926	1927	1928	1929	1930	1931	1932	Average
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Acme	40.7	16.4	40.6					32.6
Kubanka	38.9	12.2	40.0	34.2	36.9	11.7	42.0	30.8
Mindum			46.7	37.5	34.7	14.7	43.1	35.3
Nodak			49.5	42.8	40.3	17.0	36.0	37.3
Marquis	29.3	5.0	28.9	35.3	30.6	14.4	35.8	25.6
Power	27.8	4.7						16.2
Kota	31.3	7.2	36.1					24.9
Haynes Bluestem	24.8	4.5						14.1
Ceres	32.6	7.5	36.4	41.0	30.3	17.2	39.2	20.3
Quality	25.8	3.6	24.7					18.0
Reliance	34.1	5.3	39.7	42.2	35.0	17.8	42.0	30.9
Ruby		3.9	18.1					11.0
Marquillo			32.8	37.2	27.0	9.7	33.3	28.0
Supreme			33.3	32.2	30.8	12.2	29.5	27.6
Reward				30.6	21.9	12.8	35.3	25.1
Hope				33.1	28.3	12.2	35.8	27.3
Federation					20.2	9.7	28.9	22.6
Champlain					33.3	16.9	39.2	29.8
Thatcher (Minnesota No. 2903)							39.2	

OATS

The oat varieties tested in 1926 were planted on land that was in peas the preceding year, on alfalfa land hog-pastured in 1927, disked corn ground in 1928, 1929, and 1930, disked potato ground in 1931, and disked beet ground in 1932. The oats were seeded at the rate of 10 pecks per acre with a disk drill in triplicated fiftieth-acre plots. The low yields in 1927 were due to the late seeding date of May 26. The results for the last 7 years are shown in table 19.

TABLE 19.—*Yields of oat varieties under irrigation, 1926-32*

Variety	Acre yields of oats							
	1926	1927	1928	1929	1930	1931	1932	Average
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Sixty-Day	84.9	41.1	75.8	70.1	98.9	31.2	84.4	70.8
Swedish Select	91.5	26.0	92.2	91.6	102.1	29.2	101.0	76.2
Canadian	61.2	17.7	91.4	80.4	105.2	30.2	100.5	70.4
Silvermine	87.2	24.5	92.0	89.3	104.7	31.8	104.7	76.4
White Russian	79.1	35.9	93.7	68.7	77.1			70.9
Hull-less [1]	71.6	15.1		47.8	82.8			50.8
Victory	89.6	23.9	93.0	86.0	103.6	27.1	95.8	74.1
Golden Rain	88.6	21.4	89.8	80.6	109.4	33.9	99.9	75.7
Markton	73.0	16.1	97.6	90.6	114.6	35.4	103.6	75.8
Gopher	58.3	33.8	83.6	77.6	101.6	28.6	77.0	65.9
Idamine					116.1	33.3	103.1	84.2
Rainbow					110.9	41.7	103.3	85.3

[1] The yield of Hull-less oats is computed on the basis of 32 pounds to the bushel.

Of the early varieties, the Sixty-Day has given the best yield, 70.8 bushels, which is 4.9 bushels more than Gopher. Of the five midseason varieties, there is very little choice. The Silvermine and Swedish Select show a slight advantage. The White Russian is a late variety, about 10 to 14 days later than the midseason types. It has returned yields less than either the early or midseason varieties and for this reason is not recommended for western South Dakota. The Hull-less gave the lowest average yield of all the varieties and is not recommended except when needed for special feed requirements.

BARLEY AND EMMER

The barley varieties and the White Spring emmer from which yields are compared were planted on disked corn ground in 1926, on alfalfa hog-pastured and fall-plowed in 1927, and on corn ground in 1928–32, inclusive. The barley was seeded at the rate of 8 pecks per acre with a disk drill in triplicated fiftieth-acre plots. The annual and average yields of these cereals are recorded in table 20.

TABLE 20.—*Yields of barley varieties compared with yields of emmer under irrigation, 1926–32*

Variety	Acre yield							
	1926	1927	1928	1929	1930	1931	1932	Average
Barley:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Trebi (C.I. 936)	26.8	30.9	54.9	49.5	81.7	27.1	70.7	48.8
Const (C.I. 600)	25.6	26.9	41.7	33.3	68.7	----	----	39.1
Hannchen (C.I. 531)	28.4	24.0	42.4	46.9	52.9	17.4	68.4	39.9
Chevalier	29.3	41.0	56.4	49.3	57.3	29.8	52.8	43.0
Minsturdi (C.I. 1556)	31.6	27.4	34.4	43.1	49.4	----	----	37.2
Luth (C.I. 603)	25.1	19.8	36.9	41.7	60.4	----	----	36.7
White Smyrna (C.I. 195)	----	30.2	52.1	42.7	73.1	30.9	76.7	51.9
Awnless Horsford (C.I. 507)	----	16.3	27.6	33.3	40.6	----	----	58.4
Hull-less Nepal (C.I. 595)	----	16.0	26.9	35.8	41.7	----	----	26.9
Comfort (C.I. 4578)	----	----	----	----	57.8	7.6	59.7	41.7
Velvet (C.I. 4252)	----	----	----	----	44.2	5.9	47.2	32.4
X-239 Redfield	----	----	----	----	----	9.6	52.8	30.9
X-240 New Era	----	----	----	----	----	13.6	50.4	31.7
X-241 Redfield	----	----	----	----	----	9.4	50.8	30.1
Glabron (C.I. 4577)	----	----	----	----	----	----	53.1	----
Odessa (C.I. 182)	----	----	----	----	----	----	57.6	----
Lion × Manchuria (C.I. 6091)	----	----	----	----	----	----	57.3	----
Emmer (32-pound bushel)	49.3	67.7	76.5	45.1	78.1	32.3	65.6	59.2

The yields of emmer in pounds of grain per acre were less than the better varieties of barley. The Trebi (C.I. 936), a six-rowed variety, produced the highest yield per acre during this period. White Smyrna, Awnless Horsford, and Hull-less Nepal were included in 1927. White Smyrna is a close second in yield for the 6-year period and has proved to be one of the best varieties to grow under dryland conditions. The Awnless Horsford and the Hull-less Nepal produce grain of good quality, but the yields are low in comparison with other varieties. In 1930 Velvet and Comfort, smooth-awned varieties, were included in the test, and for the 3 years the yields have not compared favorably with either Trebi or White Smyrna. A comparison of the yields in pounds per acre of barley and White Spring emmer during the 7-year period 1926–32 is as follows: Trebi barley, 2,342.4 pounds; White Spring emmer, 1,894.4 pounds.

CORN

In 1926, 1928, 1929, 1930, and 1932, 20 varieties of corn were grown under irrigation for the purpose of ascertaining the varieties best adapted to local conditions. They were planted in triplicated plots,

TABLE 21.—*Yields and condition of corn varieties grown under irrigation, 1926–32*

[The excess moisture content at husking time (columns 13–18) is given as a percentage of the air-dry weight of grain after being air-dried for approximately 1 month, when it still contained about 12 percent of moisture]

Variety	Acre yield of grain						Acre yield of stover				
	1926	1928	1929	1930	1932	Average	1926	1929	1930	1932	Average
1	2	3	4	5	6	7	8	9	10	11	12
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Squaw	46.9	54.9	46.6	40.5	45.9	47.0	1.3	1.1	1.2	1.1	1.2
Flint:											
Gehu	39.9	42.9	39.8	41.1	43.2	41.4	1.0	.9	1.0	1.7	1.1
Rainbow	39.2	54.0	42.5	54.2	52.8	48.5	2.2	2.6	2.4	2.4	2.4
Disco White	41.1	54.0	56.1	------	55.5	50.2	1.6	1.5	2.1	2.3	1.9
Stewart	------	39.4	44.0	45.9	52.1	45.5	------	1.3	1.1	1.5	1.3
Yellow dent:											
North Dakota	28.9	48.0	35.7	38.4	37.0	37.6	.9	1.6	1.3	1.4	1.3
Minnesota No. 13	45.6	48.0	43.2	39.8	48.0	44.9	1.3	1.5	1.7	1.8	1.6
Alta	48.2	50.4	46.6	48.7	48.0	49.6	.9	1.5	1.2	1.5	1.3
All Dakota	42.4	52.3	41.1	39.8	------	43.9	1.3	1.0	1.6	------	1.3
Black Hills	48.9	49.7	39.8	------	------	46.1	1.4	1.7	2.2	------	1.8
Burda	43.7	54.0	45.3	40.6	45.3	47.0	1.0	1.2	1.1	1.6	1.2
Bentzel, Vale	48.2	48.9	39.1	45.3	------	45.4	1.5	1.4	1.9	------	1.6
Hugh Folden, Whitewood	45.5	50.0	45.3	48.0	------	47.4	1.3	1.6	1.7	------	1.5
White Cap, Spearfish	------	59.1	50.1	63.1	52.1	56.1	------	1.2	1.7	1.1	1.3
Wisconsin No. 25	------	48.0	39.1	41.1	40.5	42.2	------	1.0	1.2	1.2	1.1
Ola, Soma	------	51.4	45.9	49.4	57.6	51.1	------	1.4	1.7	1.7	1.6
White dent:											
Payne	46.9	56.4	48.0	53.5	54.9	51.9	1.2	1.1	1.9	2.0	1.5
Silver King	41.8	46.3	41.8	41.8	------	42.9	1.0	1.0	1.8	------	1.5
Rustler	------	43.7	46.4	49.4	48.7	47.1	------	1.6	2.4	1.9	2.0
Northwestern dent	45.0	42.0	43.9	39.8	40.5	42.2	1.3	1.7	1.6	1.3	1.5

Variety	Grain conditions at husking time																	
	Excess moisture content						Soft corn						Shelled corn					
	1926	1928	1929	1930	1932	Average	1926	1928	1929	1930	1932	Average	1926	1928	1929	1930	1932	Average
1	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Squaw	4	11	12	2	6	7	0	2	0	6	0	2	75	81	80	82	79	79
Flint:																		
Gehu	2	4	9	0	9	5	0	0	0	7	0	1	79	83	80	82	83	81
Rainbow	26	54	26	28	27	32	14	13	0	3	0	6	79	67	75	71	74	73
Disco White	12	27	19	----	19	19	5	0	0	----	0	3	70	74	76	----	79	75
Stewart	----	15	15	9	9	10	----	4	0	5	0	2	----	81	77	72	70	77
Yellow dent:																		
North Dakota	11	25	12	18	14	16	0	11	0	16	0	5	79	82	80	79	80	80
Minnesota No. 13	8	34	14	31	17	21	1	13	0	10	0	5	78	78	82	79	81	80
Alta	5	17	12	15	14	13	0	8	0	9	0	3	80	81	80	82	81	81
All Dakota	9	25	13	21	----	17	17	4	7	2	----	7	76	82	82	78	----	79
Black Hills	13	26	20	----	----	20	12	12	0	----	----	8	70	79	79	----	----	79
Burda	4	21	11	13	14	13	1	7	0	2	0	2	80	80	80	80	81	80
Bentzel, Vale	12	37	14	18	----	20	8	19	0	16	----	11	79	78	80	79	----	79
Hugh Folden, Whitewood	10	30	14	19	----	18	0	5	5	6	----	4	77	80	80	79	----	79
White Cap, Spearfish	----	12	11	1	11	9	----	1	0	4	0	1	----	82	80	82	82	81
Wisconsin No. 25	----	11	9	13	11	11	0	3	2	2	0	2	----	82	83	82	82	82
Ola, Soma	----	26	10	15	10	15	----	5	0	5	0	2	----	82	80	79	80	80
White dent:																		
Payne	7	18	9	15	15	13	0	3	0	2	0	1	80	82	83	81	81	81
Silver King	14	41	16	18	----	22	23	73	9	14	----	30	79	80	82	81	----	80
Rustler	----	33	13	17	19	26	----	12	0	16	0	7	----	77	80	77	83	79
Northwestern dent	0	10	14	12	11	11	1	0	0	2	0	1	80	82	80	80	78	80

there being two rows in each plot 132 feet long; the hills were spaced to 42 inches in the row and thinned to three stalks. In table 21 the annual and average yields for the 5 years are recorded. The yields are computed from the air-dry weight at 70 pounds per bushel of ear corn. Also the condition of the corn when harvested and the percentage of grain are shown.

At the time of husking, each variety was weighed and samples taken to determine the loss of weight in air-drying. This excess moisture at harvest time is given as the percentage of air-dry weight of corn after drying from 3 to 4 weeks, when it still contained about 12 percent of moisture. The loss is shown in columns 13 to 18 in the table. The percentage of mature corn was determined by segregating the immature ears and weighing the resulting mature ears. The percentage of shelled corn was determined by weighing the air-dry corn before and after shelling.

Of the flint varieties the Gehu has proved to be the earliest maturing of those included in the test. This variety yields well and may be advantageously utilized for early pasturing. Of the dent varieties, Payne White Dent, Spearfish White Cap, and Alta are the outstanding varieties. In years favorable to corn production, Alta and Spearfish White Cap outyield Payne White Dent, although this latter variety has proved to be the most satisfactory during years unfavorable for corn production.

VARIETY TESTS OF FLAX

The flax varieties which have been tested were seeded on disked corn ground in 1926, fall-plowed wheat ground in 1927, disked corn ground in 1928, fall-plowed sweetclover pasture in 1929, disked corn ground in 1930, disked sugar-beet ground in 1931, and fall-plowed sweetclover pasture in 1932.

The flax was seeded with a disk drill at the rate of 40 pounds per acre in triplicated fiftieth-acre plots. In 1928 two wilt-resistant varieties, Red Wing (C.I. 320) and Bison (C.I. 389), were included in the test. For the 5-year period 1928–32, Bison has given the highest average yield. In 1931 Buda was added to the test, but so far has shown no particular merit. The annual and average yields of flax from 1926 to 1932 are recorded in table 22.

TABLE 22.—*Yields of flax varieties under irrigation, 1926–32*

Variety	Acre yield							
	1926	1927	1928	1929	1930	1931	1932	Average
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Dumont	17.6	20.0						18.8
Primost	16.1	15.6	23.2	10.1	9.6	6.2	12.9	13.4
N.D.R. No. 52 (C.I. 8)	17.2	20.3						18.7
N.D.R. No. 114 (C.I. 13)	15.3	16.7						16.0
Winona	18.2	16.1	22.3	9.1	8.7			14.9
Rio (Argentine)	17.0	23.3	22.3	14.4	11.2	5.7	15.1	16.3
Linota	14.1	21.4	24.4	11.0	9.4	6.5	13.1	14.3
Redwing			22.0	12.8	9.0	6.5	11.8	12.5
Bison			25.3	15.3	10.2	7.7	13.2	14.3
Buda						5.1	12.1	8.6

VARIETY TESTS OF BEANS

On the heavier soil types characteristic of the Belle Fourche area it is doubtful if the production of beans will be able to compete successfully with certain other more promising farm crops. However, the possibility that the farmer might grow small areas of beans for home consumption justified the inclusion of some of the more promising varieties for the purpose of ascertaining the relative yields. Twelve varieties have been under observation for 3 years, and the yields are given in table 23.

In 1926 the beans were grown on disked potato ground, in 1931 on flax ground, and in 1932 on pastured sweetclover ground fall-plowed. They were planted in triplicated fiftieth-acre plots.

The yields of the stringless varieties have not proved satisfactory, and their production as a commercial crop does not appear to be warranted on the heavy gumbo soils similar to those existing where this test was conducted. The Great Northern field bean has given fairly satisfactory results, as has the Ito San variety of soybean.

TABLE 23.—*Yields of bean varieties under irrigation, 1926, 1931, and 1932*

Variety	Acre yield				Variety	Acre yield			
	1926	1931	1932	Average		1926	1931	1932	Average
	Bu.	*Bu.*	*Bu.*	*Bu.*		*Bu.*	*Bu.*	*Bu.*	*Bu.*
Black Valentine	5.0	7.9	8.9	7.3	Bountiful		6.7	9.1	7.9
Currier Rust Proof		4.9	3.6	4.2	Stringless Refugee		3.6	3.9	3.7
Giant Stringless Green Pod	16.7	3.8	6.1	8.9	Burpee Stringless Green Pod		8.6	8.1	8.3
Tennessee Green Pod		4.9	5.5	5.2	Great Northern	25.8		19.7	22.7
Early Improved Red Valentine		6.5	10.8	8.6	Manchu soybeans			16.1	
Improved Golden Wax	11.7	6.2	6.7	8.2	Ito San soybeans	21.5		12.0	16.7

VARIETY TESTS OF POTATOES

Potatoes are a crop of some importance in the Belle Fourche area and may well be included in the cropping system, particularly on the lighter soils of the project. A varietal test of potatoes has been conducted for the purpose of securing information relative to the varieties best adapted to the locality.

In 1926, 1927, and 1929 the potatoes were grown on irrigated land that had been in sweetclover, pastured with sheep and fall-plowed. In 1928 the preceding crop was grain, manured at the rate of 12 tons per acre and fall-plowed. It was grown in triplicated plots of two rows each, the rows being 42 inches apart and 132 feet long. The acre yields and percentages of marketable tubers grown during this period are given in table 24.

The highest yields of all varieties were harvested in 1928, when the potatoes followed grain manured. The highest per acre yield was from the Bliss Triumph of 234.8 bushels, of which 90 percent were marketable, followed by Irish Cobbler, 228 bushels, 89 percent marketable, and Early Ohio, 204.8 bushels, 90 percent marketable. One of the main factors influencing yields is the planting of seed potatoes which are free from disease. This is indicated in table 24. Bliss

Triumph was grown from local seed, with a yield of 162.6 bushels per acre, as compared to 210.1 bushels from certified seed, a difference of 47.5 bushels in favor of the certified seed.

TABLE 24.—*Yields per acre of potato varieties under irrigation, 1926–29*

Variety	1926		1927		1928		1929		Average	
	Total	Marketable	Total	Marketable	Total	Marketable	Total	Marketable	Total	Marketable
	Bu.	*Pct.* *Bu.*	*Bu.*	*Pct.* *Bu.*	*Bu.*	*Pct.* *Bu.*	*Bu.*	*Pct.* *Bu.*	*Bu.*	*Pct.* *Bu.*
Bliss Triumph:										
Certified seed	144.0	92 132.5	269.7	79 216.8	260.3	97 252.5	245.2	93 218.7	234.8	90 210.1
Immature seed	236.7	87 205.9	233.1	83 193.5	261.1	95 248.0	228.8	94 215.1	238.9	90 215.6
Farm seed	183.5	85 156.0	210.4	78 163.8	245.1	95 232.8	161.0	94 97.8	185.7	88 162.6
Irish Cobbler	184.2	90 165.8	272.5	81 220.7	237.3	91 215.9	216.7	96 230.0	228.2	89 203.1
Irish Cobbler (certified seed)			230.1	83 191.0	225.1	94 211.6	221.6	95 216.5	225.6	91 204.4
Greeley Pearl	158.8	90 142.9	157.6	83 130.8	217.6	95 206.7	114.8	88 101.0	162.2	89 145.3
Rural New Yorker	180.5	90 162.4	206.4	79 163.1	242.4	92 223.0	133.6	93 124.2	190.7	88 168.2
Green Mountain	143.0	73 104.4	143.7	50 71.8	166.7	70 116.7	160.4	92 147.6	153.4	73 113.9
Idaho Russet	189.2	92 174.1	205.9	61 131.8	.....	.....	154.4	72 111.2	183.2	76 139.0
Early Ohio (certified seed)	.....	.....	216.3	84 181.7	194.4	94 182.7	203.6	92 187.3	204.8	90 183.9

SILAGE TESTS

Tests of silage crops have been conducted since 1917. The varieties were grown in triplicated plots of four rows each, 132 feet long and 42 inches apart. The annual yields from 1926 to 1929 are recorded in table 25. The silage corn has been planted at the same time as the corn grown for the grain, usually about May 15. The corn is generally harvested between September 1 and 15, and at that time the grain of the earlier varieties usually is well dented. At the time of harvesting, samples were taken of each variety for dry-weight determinations. These results are also given in table 25.

TABLE 25.—*Yield and dry-matter content of silage crops grown under irrigation, 1926–29*

Variety	Acre yield					Comparison of total yield and air-dry matter									
	1926	1927	1928	1929	Average	1926		1927		1928		1929		Average	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
Corn:															
Sweet Fodder	7.99	8.36	6.16	10.59	8.27	18	1.44	27	2.26	23	1.42	28	3.07	24	2.05
Payne White Dent	6.26	8.08	7.57	9.63	7.88	30	1.88	27	2.18	35	2.65	39	3.76	33	2.62
Red Cob	10.35	11.04	8.68	13.40	10.87	25	2.59	26	3.20	28	2.43	27	3.62	27	2.96
Early Murdock	8.88	9.92	8.63		9.14	27	2.40	26	2.58	31	2.66			28	2.55
Minnesota Amber sorgo	10.35	11.56	9.61	14.16	11.28	23	2.38	27	3.12	31	2.80	28	3.96	27	3.07

During the 4 years, Minnesota No. 13 sorgo has given the best yield per acre. In no year has the Early Murdock, Red Cob, or Sweet Fodder had mature corn. The same variety of corn that is generally grown for grain should be used for silage. In previous tests, Dakota Amber sorgo has been included, and the yield per acre has been found to be about the same as corn, but cane silage is not relished so much by livestock, and the same is true of Mammoth Russian sunflower. Where corn can be grown successfully it is to be preferred.

WINDBREAK PLANTINGS

ON DRY LAND

Tests of various species of trees for shade and windbreaks have been conducted in cooperation with the Division of Dry Land Agriculture and the Forest Service. In 1909 the following species were planted with the exception of the hackberries and the Austrian pines, which were planted the following spring:

Common name	Scientific name
Ash, green	*Fraxinus lanceolata.*
Cedar, red	*Juniperus virginiana.*
Elm, American	*Ulmus americana.*
Hackberry	*Celtis* sp.
Honeylocust	*Gleditsia triacanthos.*
Locust, black	*Robinia pseudoacacia.*
Pea-tree, Siberian	*Caragana arborescens.*
Pine, Austrian	*Pinus nigra.*
Pine, Scotch	*Pinus sylvestris.*
Poplar, northwest	*Populus* sp.
Russian-olive	*Elaeagnus angustifolia.*
Spruce, Black Hills	*Picea glauca albertiana.*
Willow, Russian golden	Horticultural variety of *Salix vitellina.*
Willow, white	*Salix alba.*

The land was broken in June 1908 from native sod and was thoroughly replowed in the early fall, in order to kill out all native vegetation. The spring and summer of 1909 was very favorable to plant growth, and good stands were obtained from all varieties. All survived the winter of 1909–10 without serious injury, except the black locust and the Scotch pine. The Austrian pine planted in 1910 was a total failure, and only about half a stand of hackberry resulted from planting made that year.

During the winter of 1912–13 the cottonwood, black locust, and white and golden willows were killed to the ground. This appeared due to their having been weakened by drought and thus made more subject to injury by low winter temperatures. However, with the exception of black locust, these species came through successfully when irrigated. For the first 6 years, the green ash had the appearance of the most promising tree for dry-land conditions, but in 1917 the trees were badly infested with borers, and nearly all died during the summer of 1918.

The trees planted in 1909 were spaced in rows 6 feet apart and 4 feet apart in the row. Cultivation was possible only for the first 3 to 4 years. Weeds and native grasses soon infested the plantings and the trees gradually died, until in 1930 only four species survived. These were the honeylocust, Russian-olive, Siberian pea-tree, and the red cedar. During the past 10 years even these species have made little growth (fig. 4).

In 1923 another planting was made. The land was summer-fallowed the year before planting. Three of the surviving varieties of the first planting were used, which included honeylocust, Russian-olive, and American elm. The rows were 16 feet apart and the plants spaced 6 feet apart in the row. The first season was very favorable to growth, and good stands were secured. These trees have been given clean cultivation to date and made excellent growth, except the

American elm. This species (fig. 5), even with the wider spacing, does not appear to be adapted to dry-land conditions in western South Dakota.

The results, thus far, indicate that where the trees are not irrigated a spacing of about 24 feet between rows and 6 feet between the trees in the row is advisable. With the wider spacing, very little hand

FIGURE 4.—Russian-olive and Siberian pea-tree at the left, hackberry and American elm in the center, and honeylocust at the right. Trees planted in 1909–10 on dry land, spacing 6 by 4 feet. (Photographed Aug. 15, 1931.)

FIGURE 5.—Honeylocust at the left, American elm in the center, and Russian-olive at the right. Trees planted in 1923. Spacing rows 16 feet apart and 6 feet apart in the row, indicating the desirability of wider spacing and clean cultivation when the planting is not irrigated. (Photographed Aug. 15, 1931.)

work is necessary after the trees are established, as weed growth can be controlled by cultivation.

The land where trees are to be planted should be free from weeds and native vegetation previous to planting. This may be done by using a cultivated crop, but preferably by summer-fallowing. Of the surviving species tested, honeylocust, Russian-olive, red cedar, and Siberian pea-tree are the most desirable.

ON IRRIGATED LAND

About 7 acres are used for testing trees under irrigation for windbreak purposes. Plantings were begun in 1912. Table 26 records the species of trees, date of planting, and height in 1930.

TABLE 26.—*Results of tree plantings under irrigation*

Species	Date planted	Total height, 1930	Species	Date planted	Total height, 1930
	Year	*Feet*		*Year*	*Feet*
Russian-olive, *Elaeagnus angustifolia*	1913	16	Chinese elm, *Ulmus pumila*	1912	35
Pea-tree, Siberian, *Caragana arborescens*	1913	10	White willow, *Salix alba*	1912	28
American elm, *Ulmus americana*	1912	25	Jack pine, *Pinus banksiana*	1914	20
Honeylocust, *Gleditsia triacanthos*	1914	18	Bull pine, *Pinus scopulorum*	1914	16
Northwest poplar, *Populus* sp.	1914	35	Black Hills spruce, *Picea glauca albertiana*	1916	12
Green ash, *Fraxinus lanceolata*	1912	20	Russian golden willow, *Salix vitellina aurea*	1914	30
Boxelder, *Acer negundo*	1914	20			

Before planting trees under irrigation, it is advisable to destroy weeds and native vegetation. This may be done by growing a cul-

FIGURE 6.—A view of a part of the grounds of the Belle Fourche station, shortly after the station was established and before the windbreak plantings were made. (Photographed in December 1910. Compare with fig. 7.)

tivated crop, but summer-fallowing the season prior to planting is preferable. To insure plenty of moisture for the spring planting, the land should be irrigated the previous fall. The young trees should be irrigated immediately after planting.

In the first planting the plan was so outlined that the spacing between rows was 8 feet with the trees spaced 4 feet apart in the row. This spacing is too close, even under irrigation. Rows 12 feet apart with trees 6 feet apart in the row are more convenient for cultivation and have been found to result in a better tree growth.

Trees not more than 2 years old are recommended, as they cost less and are much more easily established than older trees. The land should

be kept free from weeds by frequent cultivation and should be irrigated frequently during the summer. A late-fall irrigation is desirable, as it has been found that the trees will withstand the low winter temperatures with less injury than will be the case if the soil is permitted to become too dry. During the first 4 or 5 years after planting, the trees should be kept free from weeds by cultivation. After the trees become well established, a mulch of straw helps to keep the weeds down and aids in preventing soil erosion. Mulching is particularly desirable if the windbreak is located on sloping land.

From observations to date, Russian-olive, honeylocust, American elm, cottonwood, Black Hills spruce, bull pine, and Siberian pea-tree seem to be well adapted for windbreak purposes under irrigation in western South Dakota. These tests further indicate that Black Hills spruce and bull pine should be more extensively utilized. For the first few years the evergreens make a rather slow growth, and for this reason it is desirable that they be planted between rows of species

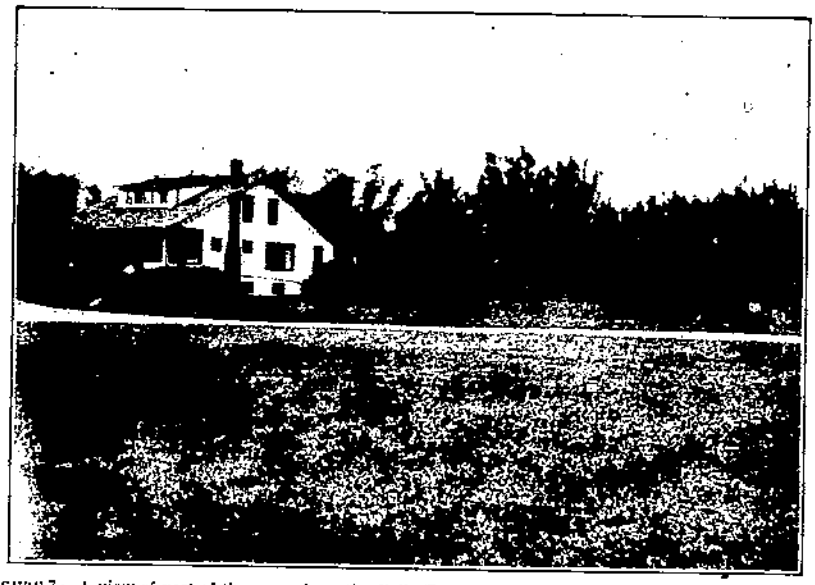

FIGURE 7.—A view of part of the grounds at the Belle Fourche station, indicating the attractiveness of a lawn and the effective windbreak in the background. (Photographed July 15, 1931.)

that grow more rapidly, these rows to be removed when the evergreens have reached sufficient size. For windbreak purposes, evergreens are much more effective than deciduous trees. The white and golden willows have proved satisfactory and grow rapidly when planted where the soil moisture is abundant, as is the case adjacent to an irrigation ditch. The Chinese elm makes a very rapid growth and has proved to be relatively free from disease, but has not been found hardy in this locality. Some years injury is confined to tip-killing, but during more severe winters it may be killed to the ground. For this reason it is not recommended where permanent plantings are desired.

The location of farm buildings, the windbreak plantings, the selection and arrangement of the ornamental plantings, and the size and location of the lawn are all worthy of consideration. The attractive-

ness of the farmstead is a source of continual satisfaction to occupants, and it enhances the value of the property (figs. 6 and 7). On an 80-acre farm, the size of the farmstead would probably have to be limited to 5 or 6 acres, but on a larger farm this may be increased to 10 acres. The most important consideration is the location. Whenever possible the farmstead should be located near the public highway and at the same time have the fields readily accessible.

In the Belle Fourche area the prevailing winter winds are from the north and west; consequently, the main windbreaks should be located on these two sides. The house should be next to the main entrance, with appropriate lawn and ornamental plantings, and should be separated from the barns and yards by screen plantings. The barns and yards should not be too close to the living quarters. A minimum distance is 200 feet, but this may be increased advantageously if space permits. Where possible, the barns and yards should have a southern exposure. The arrangement of the lawn and ornamental plantings may be simple and yet attractive. The plantings should be in groups, leaving the lawn open, which permits it to be properly cared for with minimum effort (fig. 7).

The ornamental shrubs chiefly featured in the station-grounds planting program are as follows:

Boxelder	*Acer negundo.*
Cranberry, highbush	*Viburnum* sp.
Dogwood	*Cornus* sp.
Elder, cutleaf American	Horticultural variety of *Sambucus canadensis.*
Elder, golden American	Do.
Honeysuckle, Tatarian	*Lonicera tatarica.*
Lilac, common white	Horticultural variety of *Syringa vulgaris.*
Mockorange	*Philadelphus* sp.
Snowball, common	Horticultural variety of *Viburnum opulus.*
Spirea, Vanhoutte	A hybrid *Spiraea.*
Yellowberry currant	Horticultural variety of *Ribes aureum.*

FARM ORCHARDS

The commercial production of the larger fruits, such as apples, is not a promising farm enterprise on the Belle Fourche project, particularly on the heavier soils. However, the advantages of the home orchard, both under dry-land and irrigated conditions, for supplying fruit for home consumption should not be ignored.

Under dry-land conditions in 1913 the following varieties of apples were planted: Wealthy, Oldenburg (Duchess of Oldenburg), Jewell (Jewell Winter), Hibernal, and Malinda. The crab apples included consisted of the following: Florence, Virginia, Transcendent, and Minnesota. The trees were spaced 33 by 33 feet apart and have been given continuous clean cultivation. These trees began to bear in 1920, and have produced some fruit every year except when unusually late spring frosts have occurred. The trees have been maintained in a healthy growing condition in spite of the fact that they have been dependent solely upon rainfall.

In 1916 the following varieties of apples were planted in the irrigated orchard: Wealthy, Hibernal, Longfield, Patten, Yellow Transparent, Jewell, Oldenburg, and Ben Davis. At the same time there were included crab apples as follows: Virginia, Minnesota, Florence, Whitney, and Transcendent. Stock 1 year old was used and is

recommended. All varieties except the Ben Davis, which was winterkilled the first winter, have been maintained in a satisfactory growing condition.

The trees were planted 20 by 24 feet, but this has been found to be too close, and a spacing of from 35 to 40 feet is recommended, particularly on the lighter soils. For the first 6 years the orchard was given clean cultivation, but this proved to be unduly expensive. In 1922 the orchard was seeded to red clover with the exception of a space about 10 feet around each tree, which was kept fallow, and later mulched with straw manure. Red clover has proved to be an excellent cover crop, and some returns have been realized from the crop, particularly when the trees were small. Every other year the second-

FIGURE 8.—Irrigated orchard at the Belle Fourche station, showing a cover crop of red clover. Trees planted in 1916. (Photographed Aug. 15, 1931.)

cutting clover has been allowed to go to seed. This method has maintained a good stand of clover since it was first planted in 1922 (fig. 8).

From 1916 to 1920 seven varieties of plums were included in the orchard plantings, both under dry-land and irrigated conditions. Those planted included the Wolf, Wyant, Desoto, Compass, Sapa, Waneto, and Hanska. The planting, which was not irrigated, survived only about 10 years. Those grown in conjunction with the irrigated orchard have survived and have proved to be fairly satisfactory as a fruit crop.

No special precautions or treatments are required for the proper maintenance and care of the home orchard other than those stated. The usual spraying for insect control is desirable. To obtain the best results, the trees should be pruned annually. It is desirable to head the trees low, in order to avoid injury from severe windstorms, which occur frequently.

HOME GARDENS

A substantial reduction may be made in the total costs in farm enterprises by having a well-planned garden (fig. 9). The necessary cash outlay is small, quite out of proportion to the saving that results, and there is the satisfaction of having fresh vegetables at hand during the summer months and a supply stored in the cellar to draw upon during the winter.

Good soils should be selected, having a slight slope to facilitate irrigation; and it is desirable to have the tract protected by a windbreak. The land should be heavily fertilized with well-rotted barnyard manure disked in, followed by fall-plowing. As soon as the ground can be worked in the spring it should be disked, leveled, and

FIGURE 9.—Vegetable garden at the Belle Fourche station. (Photographed Aug. 15, 1931.)

harrowed until a good seed bed is obtained. The size of the farm garden may range from one-half to 1½ acres, depending upon the size of the family. Since cucumbers may be regarded as a cash crop, one-quarter to 1 acre of this crop often may be advantageously utilized as a supplementary cash income for the family during the summer months.

It is advisable to have the tract arranged and the rows so spaced that hand labor is reduced to the minimum. To keep the crop in good growing condition, continuous and clean cultivation should be practiced. Light furrow irrigation at frequent intervals is advisable. Early-ripening varieties adapted to the locality should be used, and in many instances the harvest season may be prolonged by successive plantings. The hardier varieties should be planted as soon as the ground can be worked.

A wide range of vegetables adapted to the northern latitudes do well on the project. The following varieties are among those which have given satisfactory results:

Cabbage: Early Jersey Wakefield, Copenhagen Market, Premium Flat Dutch.
Cauliflower: Dwarf Erfurt and Early Snowball.
Beets: Crosby Egyptian Early, Detroit Dark Red, and Blood Turnip.
Radish: French Breakfast, Icicle, and Scarlet Globe.
Lettuce: Prize-head and Grand Rapids.
Onions: Yellow Globe Danvers, Red Globe, and White Globe.
Parsnips: Hollow Crown.
Carrots: Oxheart, Danvers Half Long, and Chantenay.
Peas: Alaska, Thomas Laxton, and Stratagem.
Beans: Great Northern, Giant Stringless, Red Valentine, Kidney Wax, and Black Valentine.
Tomatoes: Earliana, John Baer, Bonny Best, Bison, and Yellow Pear.
Turnips: Purpletop and Early Snowball.
Rutabaga: Purple Top.
Cucumbers: White Spine, Improved Long Green, and Tom Watson.
Muskmelon: Emerald Gem, Osage, and Rocky-Ford.
Squash: Table Queen, Crook Neck, Green, and Golden Hubbard.
Pumpkin: Small Sugar.
Celery: Golden Self-Blanching.
Eggplant: Black Beauty.
Sweet corn: Golden Bantam and Evergreen.
Potatoes: Bliss Triumph, Irish Cobbler, and Early Ohio.
Rhubarb: Victoria.
Asparagus: Washington.
Small fruits:
Strawberries: Dunlap and Champion Everbearing.
Currants: Perfection and White Grape.
Gooseberries: Carrie, Smith, and Downing.

FEEDING EXPERIMENTS WITH HOGS[2]

The crop-utilization experiments with hogs for the past 5 years include pasturing tests on alfalfa and methods of production for fat market hogs. For this purpose purebred Duroc-Jersey gilts were used. After the pigs were weaned the dams were put on self-feeders and fattened for market. Each spring and fall a new set of gilts was selected for breeding purposes from the self-fed lots, from which the next crop of pigs was raised. During the winter gestation period the gilts were fed ground grain at the rate of 5 to 6 pounds, together with 6 pounds of half-sugar mangels per head and alfalfa in self-fed racks. During the summer the gilts were fed 5 to 6 pounds of ground feed and had access to alfalfa pasture. When the pigs were about 3 weeks old the dams and their litters were self-fed ground feed. In the spring they were turned into good alfalfa pasture and in the fall had access to third-cutting alfalfa in racks. In 1926 and 1927 the ground feed consisted of 2 parts by weight of ground barley and 1 part by weight of ground oats. In 1928 the feed was ground barley for the spring pigs and ground wheat 2 parts by weight and 1 part ground barley for the fall pigs; in 1929, ground barley 1 part by weight and ground wheat 2 parts. In 1930 the feed used was ground wheat and ground barley, equal parts by weight. Table 27 shows the feed requirements for spring pigs during the gestation and suckling periods, 1926–30.

[2] The crop-utilization investigations with hogs, sheep, and lambs are conducted in cooperation with the Bureau of Animal Industry of this Department and the South Dakota Agricultural Experiment Station.

TABLE 27.—*Feed requirements of spring pigs during the gestation and suckling periods, 1926–30*

Year	Weight of feed per pig				Weight of feed per 100 pounds of gain				Average of weaned pigs	
	Grain	Tankage	Half-sugar mangels	Alfalfa	Grain	Tankage	Half-sugar mangels	Alfalfa	Per sow	Weight
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Number*	*Pounds*
1926	184	.....	115	55	548	.....	342	164	6.1	34
1927	255	32	209	.....	628	79	515	.....	5.8	41
1928	165	2	111	28	338	5	250	66	11.0	43
1929	232	.....	89	37	492	.....	126	78	7.0	47
1930	286	13	160	32	640	29	358	73	6.2	45
Average	224	10	131	38	529	38	319	95	7.2	42

The average grain requirement per weaned pig may seem somewhat high, but this is due in part to the fact that all grain consumed by the sows and boar during the gestation and suckling period has been charged to the pigs, without allowing for the gains made by the mature animals. This average gain, per sow, for the 5-year period was 69 pounds for the fall pigs and 65 pounds for the spring pigs.

Table 28 shows the feed requirements for the fall pigs during the gestation and suckling period, 1925–30.

TABLE 28.—*Feed requirements of fall pigs during the gestation and suckling periods, 1925–30*

Year	Weight of feed per pig				Weight of feed per 100 pounds of gain				Average of weaned pigs	
	Grain	Tankage	Half-sugar mangels	Alfalfa pasture	Grain	Tankage	Half-sugar mangels	Alfalfa pasture	Per sow	Weight
	Pounds	*Pounds*	*Pounds*	*Days*	*Pounds*	*Pounds*	*Pounds*	*Days*	*Number*	*Pounds*
1925	191	.....	53	100	572	.....	158	100	6.5	33
1926	217	.....	128	136	628	.....	371	136	7.2	35
1927	188	.....	54	118	646	.....	188	118	6.8	29
1928	135	.....	70	123	518	.....	197	123	11.5	36
1929	237	9	15	109	584	22	36	109	7.4	41
1930	261	.....	47	115	792	.....	143	115	6.8	33
Average	213	.....	61	118	623	.....	182	118	7.7	34

The feed requirement per weaned pig is practically the same as in table 27. The difference in feed requirement per 100 pounds is due in part to the 8-pound difference in weight at the time of weaning. The spring pigs were farrowed from March 20 and through April, and the fall pigs from September 15 to October 15. Both spring and fall pigs were weaned when about 10 weeks old.

FEEDING EXPERIMENTS WITH FALL PIGS

The feed requirements of fall pigs from the time of weaning until they reached marketable weight are given in table 29.

After weaning, the fall pigs were divided into two lots in this feeding test. Each year the pigs in lot 1 have been fed a limited ration and in lot 2 have been self-fed. The limited-ration group was

fed 1½ pounds of shelled corn from the time they were weaned until turned on alfalfa pasture about May 20, after which they were fed a 2-percent ration of shelled corn; that is, 2 pounds per 100 pounds of live weight. This 2-percent ration was fed until about July 10, after which they were self-fed corn on good alfalfa pasture until they were fat and had reached a marketable weight. The pigs in lot 2 were self-fed with corn from the time of weaning until ready for the market. Both lots were fed third-cutting alfalfa in racks during the winter months.

TABLE 29.—*Feed requirements of fall pigs during the wintering period 1925–29*

Year	Average per pig							
	Weight				Gain			
	Initial		Final		Total		Daily	
	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1925	33	33	216	212	183	179	0.71	0.98
1926	35	35	200	205	165	170	.67	1.09
1927	18	33	240	221	222	188	.88	1.05
1928	36	36	234	241	198	205	.88	1.15
1929	38	42	212	206	174	164	.64	.97
Average	32	36	220	217	188	181	.76	1.04

Year	Grain requirements per 100 pounds of gain							
	Winter period				Gestation, suckling, and winter periods [1]			
	Lot 1		Lot 2		Lot 1		Lot 2	
	Corn	Alfalfa	Corn	Alfalfa	Grain	Alfalfa	Grain	Alfalfa
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1925	340	189	473	146	376	163	490	127
1926	338	204	310	216	387	243	370	179
1927	327	70	372	98	380	77	400	91
1928	300	170	357	105	333	144	380	106
1929	398	102	471	123	437	133	490	98
Average	340	179	398	156	383	152	426	132

[1] The figure for grain requirement per 100 pounds of gain for the gestation, suckling, and winter periods combined is derived as follows:
Let a=the grain requirement per pig for the gestation and suckling period (table 28).
Let b=the grain requirement per pound of gain during the pasture period (table 20).
Let c=the total gain per pig during the winter period (table 29).
Let d=the final weight per pig at the end of the winter period (table 29).
Whence $\frac{a+(b\times c)}{d}$=grain requirement for the whole period.

The 5-year average feed requirement, as shown in table 29, for the limited ration fall pigs is 340 pounds shelled corn, 179 pounds alfalfa hay, and 75 days alfalfa pasture. The average number of days required from time of weaning to marketable weight has been 248. During the 5-year period the average selling price was $9.25 per 100 pounds at Newell. The total average feed requirement for the lots self-fed is 398 pounds of shelled corn and 156 pounds of alfalfa hay.

The feeding period from weaning to marketable weight has been 170 days. The average selling price for the lots self-fed for 5 years, 1925–29, inclusive, was $9.65 per 100 pounds live weight.

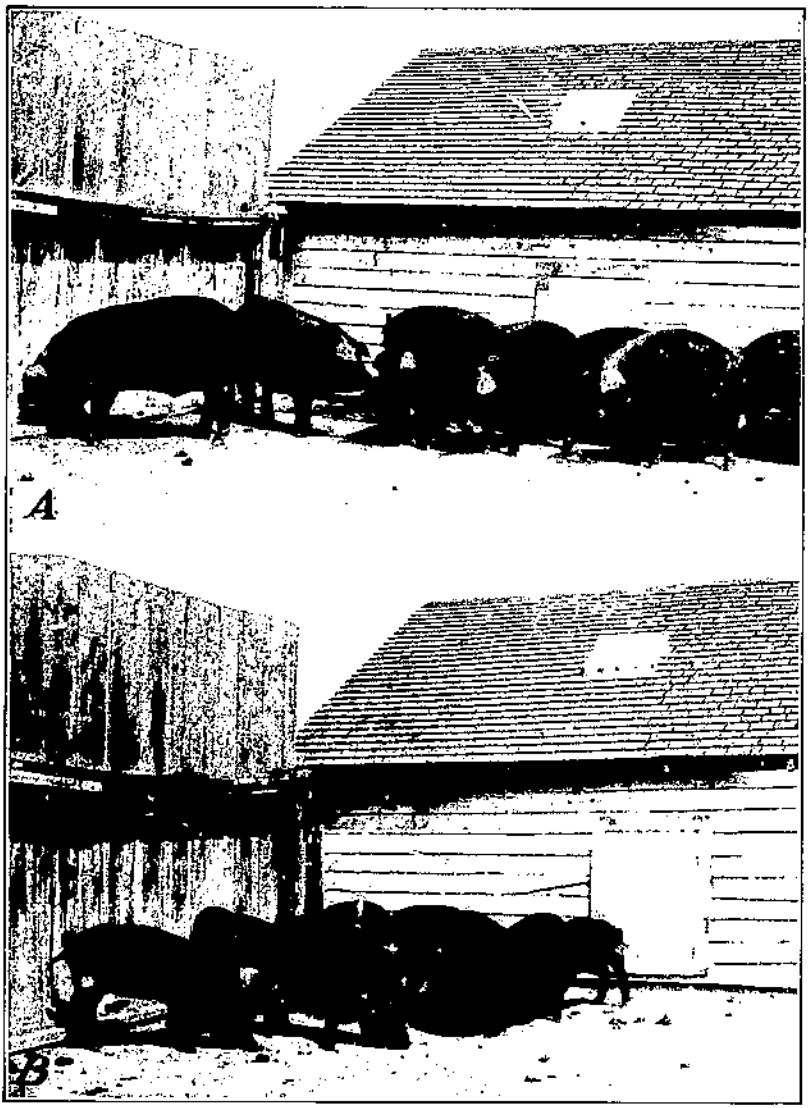

FIGURE 10.—*A*, Self-fed fall pigs on shelled corn and 60-percent tankage and alfalfa hay. Average weight on December 1, 1930, was 32.6 pounds; April 23, 1931, 221.2 pounds. *B*, Limited-ration fall pigs fed 1½ pounds of shelled corn each per day and alfalfa hay. Initial average weight on December 1, 1930, was 21.3 pounds. Average weight April 23, 1931, was 77.6 pounds.

Comparing the two methods of finishing hogs for market, the limited-ration method of feeding required 58 pounds less corn, 23 pounds more alfalfa, and approximately 50 more pasturing days per 100 pounds of gain, and 78 days longer feeding period than the self-fed lots (fig. 10, *A*). The average selling price for the self-fed lots

for the 5-year period was 40 cents per 100 pounds higher than for the limited-ration lots (fig. 10, *B*). The 78-day longer feeding period, 50 days alfalfa pasture, and 40 cents per hundredweight lower selling price more than offset the 58 pounds of shelled corn required to make 100 pounds of gain.

FERTILIZING EXPERIMENTS WITH SUGAR BEETS[3]

Within the past few years there has been an increasing interest in the possibilities of stimulating the yields of sugar beets by the use of commercial fertilizers. The beneficial effects on the yields of beets resulting from the applications of stable manure and the inclusion of leguminous crops in a rotation have been well recognized. However,

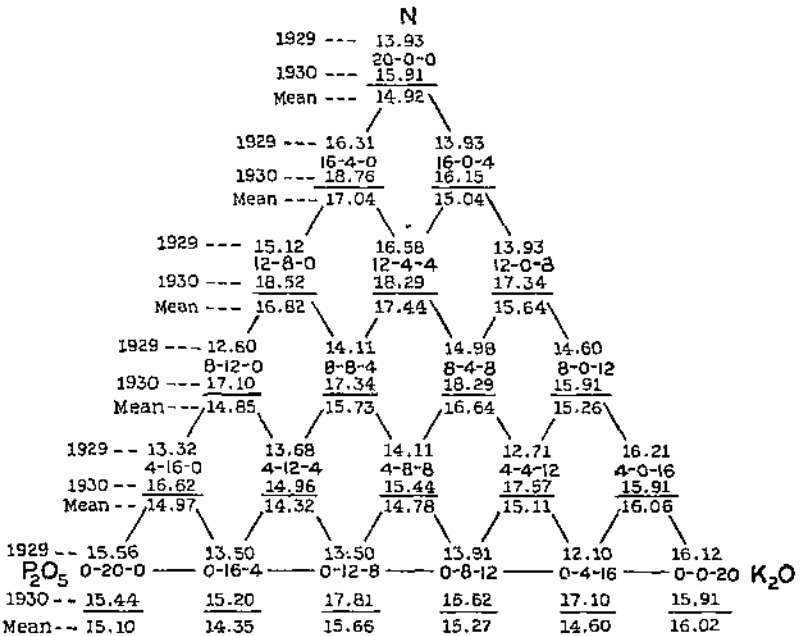

FIGURE 11.—Commercial fertilizer mixtures applied and resulting sugar-beet yields (tons per acre) at the Belle Fourche station, 1929-30. Figures following the years represent yields.

stable manure is not always advisable; and if a legume is used to improve the productivity of the soil, one or more years must elapse before the land can again be used for more intensive cash crops such as sugar beets. This condition, together with the somewhat successful use of commercial fertilizer on sugar beets in certain other irrigated sections, led to the introduction of fertilizer investigations at the station in order to ascertain to what extent the yields of sugar beets would be influenced by the application of different formulas.

For the years 1929 and 1930 the complete Schreiner triangle, consisting of 21 different fertilizer applications, was used. The basis of interpretation of this type of experiment is an equilateral triangle in which the apex points represent the single elements with nitrogen (N)

[3] Prepared by L. A. Hurst, biochemist, Division of Soil Fertility, Soil Investigations, Bureau of Chemistry and Soils.

at the top, phosphoric acid (P_2O_5) at the left, and potash (K_2O) at the right. Each side of the triangle is divided into five points, representing mixtures of two elements, and where the connecting lines intersect each other in the interior of the triangle complete mixtures of varying ratios are represented.

The results of the fertilizer-ratio studies of 1929 and 1930 are shown by the triangle diagram designated as figure 11, with the fertilizer mixture and the yield of beets per acre. The figure immediately above each mixture represents the 1929 beet yields in tons per acre, while that below indicates the results obtained in 1930. The average yield in 1929 of 10 untreated check plots was 12.22 tons per acre; in 1930, 15.06 tons.

It will be noted that proceeding from the top to the bottom each line represents mixtures with 4 percent less nitrogen, with a corresponding increase in either phosphoric acid or potash or both. The same is true beginning with phosphoric acid at the lower left-hand corner or potash at the lower right-hand corner.

The foregoing results indicate that practically all fertilizer mixtures produced some increase over the unfertilized check plots and that mixtures carrying 12 to 16 percent of nitrogen produced the highest yields. The land on which these experiments were conducted was broken from native sod in 1911 and cropped to small grains, including corn, without the application of barnyard manure or seeding to alfalfa. Perhaps the apparent response to nitrogen is due to this practice, since no nitrogen was added prior to planting to beets.

The 1931 experiment had to be abandoned, owing to adverse weather conditions. The 1932 experiment contained only six mixtures, as follows: 0–20–0, 4–16–0, 8–4–8, 12–8–0, 4–12–4, and a 2–16–2 mixture. The experiment was replicated four times. The following yields were obtained:

	Tons per acre
Unfertilized check	12.29
0–20–0	13.17
8–4–8	12.74
12–8–0	13.21
2–16–2	13.32
4–16–0	12.97
4–12–4	13.28

The result for 1932 indicates that the yields of sugar beets may have been stimulated slightly but not appreciably as a result of applications of commercial fertilizers.

EXPERIMENTS WITH CROPS ON DRY LAND [4]

The experimental work on dry land at the Belle Fourche Field Station consists chiefly of crop-rotation and tillage-method investigations in which the common field crops are grown in various sequences or combinations on a number of different cultural treatments. With the exception of a few rotations started in 1922 and 1930, these experiments have been continuous since 1908, and an unbroken record of results for 24 years, exclusive of the first year when all crops were on uniformly prepared land, is available.

[4] The experiments on dry land are conducted by the Division of Dry Land Agriculture, Bureau of Plant Industry, in cooperation with the Division of Western Irrigation Agriculture, Bureau of Plant Industry, United States Department of Agriculture. The Division of Genetics and Biophysics, Bureau of Plant Industry, cooperated in obtaining soil-moisture and climatic data.

The data obtained afford reliable information concerning the adaptation of the common field crops to the nonirrigated lands of the section, the value of the various cultural treatments, and the effects of the various crops upon following crops. The results also point out the fundamental features of farming systems most apt to be stable and successful on the dry lands.

INFLUENCE OF CLIMATIC CONDITIONS

Production of crops on dry land is dependent to a large extent upon climatic conditions. Temperature, wind velocity, humidity, and evaporation all have considerable influence upon crop growth, but precipitation is the most important and chief limiting factor. An equitable distribution as well as an adequate amount of precipitation during the growing season is essential to the unretarded development of crops, but there are very few seasons in which conditions are ideal. Periods of drought occur even in most of the wettest years, and crop yields frequently do not correspond to the total annual or seasonal precipitation. Unfavorable distribution may cause crop production to be relatively low in a year of high total precipitation, and good distribution of rainfall in a moderately dry year may result in fairly large yields of crops. As a rule, however, crop yields are above average in years of high precipitation and below average in the drier years. The total annual or seasonal precipitation, therefore, serves as a rough index of the favorableness of the season.

The total precipitation for each calendar year and each growing season, April to September, inclusive, from 1909 to 1932 is given in table 30. The first half of the 24-year period in which the experiments were conducted was somewhat drier than the second half of the period. The average seasonal and annual precipitation from 1909 to 1920 was 1.64 inches and 1.90 inches less, respectively, than from 1921 to 1932. Both precipitation and crop yields were below normal in 7 years of the earlier period. The seasonal precipitation was above normal in the other 5 years, but its distribution during 2 of them was so unfavorable that the yields of most crops were below the average. There were only 5 years from 1921 to 1932 in which the seasonal precipitation was below normal, and in 3 of these years the distribution of the precipitation was sufficiently favorable for the majority of the crops to produce average yields or better. The precipitation for the other 7 years of this period was above normal, and in none of them was the distribution extremely adverse to crop growth, although summer droughts in 2 of the years, 1927 and 1932, materially reduced crop yields.

The better moisture conditions of comparatively recent years have had a pronounced effect upon crop returns, as shown by the average yields for the two 12-year periods given in table 30. The average production of potatoes, flax, corn, and all small grains from 1921 to 1932 was from 25 to 63 percent greater than from 1909 to 1920. Conditions during the earlier period were more erratic than from 1921 to 1932. Returns from crops were relatively high in 1909 and 1920, and extremely high yields were produced in 1915. All crops were an absolute failure in 1911 and essentially total failures in 1910 and 1919. In 1912 small grains were again a failure, but good yields of corn, sorgo, and potatoes were obtained. Since 1921 there has been only 1 year, 1931, which may be termed a failure, but the yields of 1921

TABLE 30.—*Annual and average acre yields of crops grown in the dry-land rotations, and the seasonal and annual precipitation at the Belle Fourche Field Station, S.Dak., 1909-32*

Year	Winter rye	Winter wheat	Spring wheat	Oats	Barley	Flax	Corn, grain	Corn, stover	Sorgo, fodder	Potatoes	Bromegrass [1]	Alfalfa [1]	Sweetclover [1]	Precipitation	
														Seasonal (Apr.–Sept.)	Annual
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Pounds*	*Pounds*	*Bushels*	*Pounds*	*Pounds*	*Pounds*	*Inches*	*Inches*
1909		28.9	28.7	60.9	31.7	8.0	19.3	3,305	5,920	52.0	3,940	1,910		14.37	17.73
1910		1.8	2.6	6.8	3.0	.0	.6	2,839	3,360	54.1	380	0		9.71	12.55
1911		.0	.0	.0	.0	.0	.0	0	0	.0	0	0		4.70	6.64
1912		.0	.0	8.2	.7	.0	21.9	2,623	4,100	137.4	280	300		14.36	16.09
1913		21.3	10.8	23.9	10.1	.0	8.6	986	3,400	52.4	2,780	1,850		8.32	12.53
1914		18.2	10.1	26.3	9.5	.0	.5	1,115	1,725	27.7	2,380	1,310		8.21	11.70
1915		36.2	57.6	125.6	72.2	25.4	41.5	2,785	6,470	120.9	2,400	5,475		17.08	21.02
1916		12.7	17.3	33.3	31.0	3.4	32.5	2,198	9,500	149.1	2,375	1,250		10.23	13.40
1917		3.8	7.4	17.1	22.9	3.1	20.4	1,969	3,300	72.5	2,850	2,430		10.01	13.32
1918		27.1	11.9	23.3	14.6	7.9	30.0	2,977	7,760	88.0	1,675	1,225		14.65	18.31
1919		2.0	.9	2.3	1.3	.0	.3	235	0	.0	1,050	550		8.44	14.25
1920		1.6	29.9	63.8	60.9	22.1	37.4	2,008	5,900	60.8	0	6,150		20.56	25.89
1921		5.4	7.3	11.6	12.8	.0	9.0	1,435	2,450	27.1	0	0		9.06	11.09
1922		30.8	32.2	66.0	44.8	17.1	42.3	3,069	5,970	86.2	2,150	4,000		17.42	23.16
1923	28.5	21.3	28.0	57.5	47.9	12.0	52.4	3,379	7,820	225.0	2,050	4,150		22.78	27.37
1924	26.7	30.5	21.5	44.1	28.3	3.0	17.7	1,122	3,510	106.5	2,350	1,775	2,050	6.70	13.80
1925	21.6	23.6	19.8	52.2	32.3	3.0	9.0	1,710	4,640	60.2	1,250	850	4,100	7.98	10.76
1926	24.9	32.4	31.3	59.7	44.1	3.0	33.4	1,852	6,350	119.1	1,100	2,275	2,250	13.42	17.16
1927	12.2	11.4	21.6	39.1	13.2	13.4	30.3	2,786	7,260	53.9	2,345	4,095	3,160	21.25	24.46
1928	19.8	25.8	32.9	66.0	49.3	13.6	32.3	1,445	4,694	99.9	550	1,805	4,420	13.52	15.95
1929	28.0	33.6	28.3	57.0	36.3	10.0	28.4	1,624	5,016	99.3	2,845	4,240	3,830	16.92	22.35
1930	21.8	19.9	15.4	40.9	32.2	6.9	8.4	2,084	5,500	76.5	1,270	680	2,160	8.86	12.11
1931	3.0	3.6	.5	.5	2.3	.1	.3	447	300	.0	340	0	270	5.69	8.80
1932	20.0	[2] 12.0	17.7	40.1	40.6	5.2	9.5	1,702	3,870	63.9	325	280	200	16.71	19.24
Average, 1909-32		16.8	18.1	38.6	26.8	6.6	20.4	1,901	4,539	76.4	1,501	1,942		12.54	16.24
Average, 1923-32	20.6	21.4	21.7	45.7	32.7	7.0	22.2	1,815	4,917	90.4	[3] 1,375	[3] 1,778	[3] 2,493	13.38	17.20
Averages (12-year periods):															
1909-20		12.8	14.8	32.6	21.5	5.8	18.0	1,920	4,280	67.9	1,621	1,871		11.72	15.29
1921-32		20.9	21.4	44.6	32.0	7.3	22.8	1,885	4,798	84.8	1,381	2,013		13.36	17.19

[1] Yields of bromegrass, alfalfa, and sweetclover obtained from 2- or 3-year-old meadows.
[2] Winter wheat winter-killed on 8 of 9 plots in 1932, and the yields of spring wheat reseeded on 8 plots are included in the average yield for winter wheat for 1932.
[3] Average yields for 9 years, 1924-32.

were quite low. During the 9-year period, 1922–30, good yields of practically all crops were produced every year. Although there has been only 1 year of crop failure since 1919, it is evident that dry, unproductive seasons may occur at any time, and the results of the past 24 years show that any permanent farming system must be based upon the probable occurrence of a series of dry years with the possibility of the production of grain being a complete failure for 2 or more consecutive years.

ADAPTATION OF CROPS

The average yields of the 12 different crops grown in the dry-land rotations are given in table 30. The yields of the various crops are not strictly comparable, owing to variations in crop sequence and

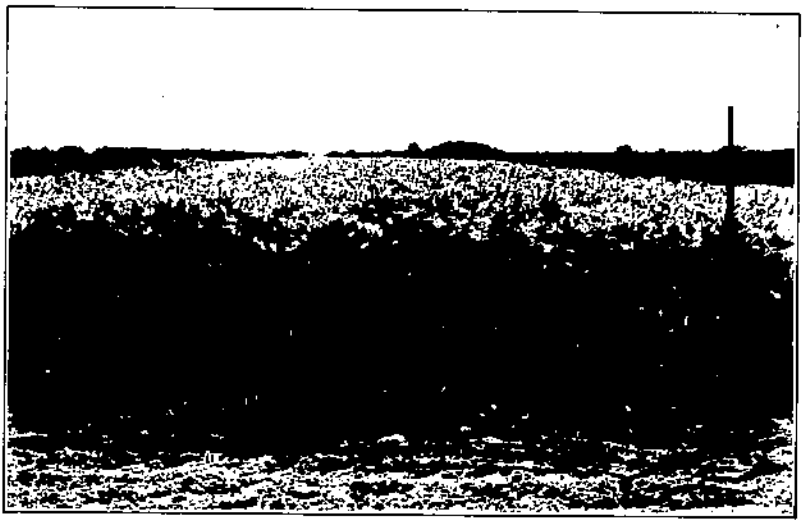

FIGURE 12.—Dry-land spring wheat on land summer-followed the previous year. (Photographed July 27, 1932.)

cultural methods, but the treatments are sufficiently similar to afford a reliable indication of the adaptability of the different crops. Flax, barley, and winter wheat are shown to some disadvantage, because they are grown under a greater proportion of poor methods than other crops.

There are no extremely wide variations between the 24-year average yields of the cereal crops grown in the experiments. Barley has produced the most pounds of grain per acre and may be considered the best small-grain feed crop, but so far as yield is concerned there is not a great deal of difference between oats and barley. Winter wheat has proved to be about as well adapted to this locality as spring wheat, the average yield of winter wheat being only 1.3 bushels per acre less than that of spring wheat. Winter wheat has never been totally winter-killed except in 1932 when the crop was destroyed on most of the plots, but winter wheat frequently is so seriously injured by soil blowing and dry weather that recovery and resumption of growth in the spring are very slow. Good yields of winter wheat have been obtained in a number of years, such as 1913, 1914, and

1918, when the yields of spring wheat were unusually low. The substitution of winter wheat for a portion of the spring wheat would assure greater stability in crop returns in the limited area of western South Dakota adapted to winter wheat. Under normal market conditions spring wheat (fig. 12) and winter wheat are the best dry-land cash crops.

The average yield of winter rye from 1923 to 1932, inclusive, was 0.8 bushel per acre less than that of winter wheat. Winter rye is the more winter hardy of the two crops and survives the winter with very little injury, but it has seldom yielded materially more than winter wheat, and there is no advantage derived from growing winter rye for grain, except in the areas where winter wheat cannot be grown successfully.

Flax has been grown on bromegrass sod since 1909. Extremely low yields were produced in 5 years, and the crop was a total failure in 8 years. Flax has proved to be unadapted to the dry lands when grown on newly broken bromegrass sod. The results obtained on other cultural treatments started in 1930 are too meager to present for discussion.

Corn, sorgo, and potatoes have been the cultivated crops included in the rotations. Corn fits into the dryland farming system better than any other crop. The average yield of grain is somewhat less than that of oats and barley, but the value of corn stover tends to minimize the difference in the yields of grain. The grain production from corn has not been so reliable as from small grain, but good yields of ear corn were obtained in some of the years, such as 1912, 1916, 1917, and 1918, when low returns were produced by small grain. The growing of corn in connection with small grain assures more consistent crop returns. There has been only 1 year, 1911, in which no corn stover was produced, but the yields of stover in 1919 and 1931 were so light that they may be classed as failures. Sorgo has proved to be one of the most dependable crops. It was a total failure in 2 years, 1911 and 1919, but good yields were obtained in all other years except 1931. The average yield of sorgo for the 24-year period was 4,539 pounds of field-cured fodder per acre, as compared with 1,004 pounds per acre for corn stover. Where roughage for livestock is required a portion of the acreage reserved for corn may be profitably planted to sorgo. The yields of potatoes have hardly been large enough in most seasons to justify their growth for market. Potatoes may have a place in the cropping system if grown for seed, particularly as the yield of small grain after potatoes is nearly as great as after summer-fallow. All intertilled crops have a beneficial effect upon the following crop of small grain, providing the intertilled crops have been kept clean. Cultivated crops fill an important place in the cropping system as a means of controlling weeds.

Alfalfa, sweetclover, red clover, and bromegrass have been the hay crops grown in the rotation experiments. Alfalfa and sweetclover have proved to be the best adapted to dry-land conditions. The 24-year average yield of alfalfa was 1,942 pounds of hay per acre. Some winter-killing of alfalfa occasionally takes place, but rarely has the damage in this respect been very extensive, and alfalfa meadows should be permitted to remain in alfalfa as long as good yields are produced. During the 9 years in which sweetclover has been grown it has outyielded alfalfa by a margin of 715 pounds of hay per acre.

but the sweetclover hay has been much coarser than alfalfa hay. In most of the years of relatively low production for alfalfa, such as 1925, 1928, and 1930, good yields of sweetclover were obtained. Thus the growing of sweetclover in conjunction with alfalfa assures a more dependable yield of hay. When seeded without a nurse crop, an average yield of 1,488 pounds of sweetclover hay per acre has been produced the first season, and there have been only 2 years out of 10 in which no hay was harvested the first season. Red clover has not been productive and dependable enough on dry land to justify its growth. Bromegrass has produced more hay than alfalfa in many of the drier years, but the average yield of bromegrass was 441 pounds per acre less than that of alfalfa. Bromegrass has a tendency to become sod-bound after a few years, causing a great reduction in yield, and it is inferior to either alfalfa or sweetclover as a hay crop for nonirrigated land. Bromegrass and alfalfa have proved to be unsuited for use in rotations, but sweetclover is well adapted to rotation purposes.

Alfalfa, sweetclover, and red clover have been seeded on fall-plowed land without a nurse crop, and satisfactory stands have generally been obtained. Bromegrass has been seeded with wheat as a nurse crop, but frequently stands of grass were not obtained, and reseeding the following year without a nurse crop was necessary. The obtaining of acceptable stands of any of the hay crops when seeded on dry land with a nurse crop is very uncertain, and seeding with a nurse crop cannot be recommended except when there is an abundance of moisture in the soil.

Good average yields of most of the grain, fodder, and hay crops have been obtained, but years of total failure or near failure occur frequently enough to make dry-land farming unsuccessful unless proper farming systems are adopted and reserves are accumulated to withstand the unfavorable years. Feed crops of small grains and intertilled crops have been the most productive and dependable. Where the grain and stover can be used on the farm, corn has proved to have the most valuable place in the cropping system. Since the best-adapted crops may be most profitably disposed of by feeding to livestock on the farm, the raising or feeding of livestock are important features of dry-land farming systems in this section.

CULTURAL METHODS

As precipitation is such an important limiting factor in the production of crops on dry land, the various cultural treatments influence yields chiefly through their effect on the water supply. Those methods that tend to conserve moisture through the control of weed growth or through the storage of a reserve supply of moisture in the soil are the most productive. The various cultural treatments that do not distinctly serve either of these two purposes have very little difference in effect upon the crop yields. The response of each crop to the important cultural treatments is indicated by the average yields given in table 31.

The yields of all crops on the heavy gumbo soil are greater on fall plowing than on spring plowing, and under farm conditions the advantage of fall plowing for small grain should be more pronounced, as plowing large fields in the spring would probably delay seeding

sufficiently to cause some reduction in yield. Plant growth early in the spring frequently is much more rapid and vigorous on fall plowing than on spring plowing, but dry weather later in the season usually tends to equalize the yields. The returns from sorgo have been distinctly greater on fall plowing than on spring plowing, owing to the fact that good stands of this crop have been obtained on spring plowing only when soil and climatic conditions were unusually favorable. Fall plowing is decidedly better than spring plowing for sorgo and other shallow-seeded crops.

TABLE 31.—*Average yields per acre of leading dry-land crops on different cultural treatments for 24 years, 1909–32, and for 10 years, 1923–32*[2]

Years averaged and crop	Spring-plowed	Fall-plowed	Subsoiled	Fall-listed	Spring-listed	Disked or stubbled in—				Fallow		Green manure		
						After corn	After sorgo	After potatoes	After winter wheat	Manured	Unmanured	Winter rye	Peas	Sweetclover
1909–32:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Winter wheat [1]	....	14.6	[2] 14.3	13.0	....	....	....	....	....	....	23.1	....	....	....
Spring wheat	14.1	16.3	15.1	15.8	....	18.2	15.2	20.8	....	22.5	12.6	20.4	18.8	17.0
Oats	33.3	33.8	33.8	35.4	....	37.8	40.3	45.9	....	48.2	50.9	43.2	43.2	37.8
Barley	24.3	25.4	24.4	22.6	....	20.4	....	....	....	....	37.0	....	....	....
Corn	19.7	20.9	20.7	....	20.3	....	....	....	....	....	27.9	....	....	....
1923–32:														
Winter wheat [1]	....	18.3	....	....	....	25.1	22.4	....	....	....	28.1	....	....	....
Winter rye	....	....	....	....	....	21.6	22.1	....	18.6	....	....	....	....	....
	Lb.	*Lb.*												
Sorgo	4,209	5,349	....	....	....	....	....	....	....	....	....	....	....	....

[1] Winter wheat completely winter-killed in 1932 on all treatments except fallow. The yields of spring wheat reseeded on the various plots on which total winter-killing occurred are included in the average yields for winter wheat.

[2] Average yield for 23 years, 1909–31.

The depth of plowing has not had a great influence upon the production of crops. Plowing 7 or 8 inches deep has resulted in somewhat larger yields of most crops than plowing 4 inches deep, but subsoiling to a depth of 16 inches has had no apparent effect. Plowing deeper than 7 inches is not justified.

Fall-listing has had practically the same influence upon small grain as plowing, but the weed growth has been a little heavier on listed ground. Corn planted with a lister has yielded approximately the same as that surface-planted on plowed land. Listed corn has been more backward early in the spring than surface-planted corn, but there has not been much difference in the time of maturity. Listing is the cheapest and consequently the most profitable method for corn, but special cultivating machinery is required to secure the best results.

Winter rye stubbled in after winter wheat has yielded an average of only 2.4 bushels per acre less than winter rye on corn ground.

Small grains disked [5] or stubbled in on corn ground outyielded grain on all other cultural treatments except summer-fallow, green manure, and unplowed sorgo or potato ground by a substantial margin. The average yields of spring-sown small grain on disked corn ground were from 74 to 81 percent as great as the yields on

[5] Corn and sorgo stubble ground has been prepared for seeding spring grain by disking (12 years), spring-tooth harrowing (5 years), and duck-footing (7 years), but for convenience the treatment is referred to in the dry-land section of this report as disking or disked. Corn and sorgo stubble ground has received no treatment in preparation for seeding fall grain.

summer-fallow. Seeding in standing cornstalks has been the most productive method, except summer-fallow, for winter wheat. During the 10 years 1923–32 the average yield of winter wheat seeded in standing cornstalks was 2.3 bushels per acre greater than when seeded on corn stubble and only 1.9 bushels per acre less than when seeded on fallow. The cornstalks apparently afford considerable protection against the agencies causing winter injury. The low cost of production of grain on unplowed land after corn or other intertilled crops makes this the most profitable of all cultural methods. It is essential, however, that the intertilled crops be kept clean, if favorable returns from the following crop of grain are to be obtained.

Plowing clean corn ground is not advisable. The yields of small grain on plowed corn ground have averaged 1.3 to 3 bushels per acre less than where the corn ground was merely disked.

Turning under winter rye, field peas, and sweetclover for green manure has not had so favorable an effect as summer-fallow upon succeeding crops. The low returns and the expense involved make green manuring prohibitive under present conditions.

The application of barnyard manure has had no consistent beneficial effect. The average yields of spring wheat and oats on fallow land that was manured before plowing are 0.2 bushel and 2.7 bushels per acre less, respectively, than on unmanured fallow land.

The highest yields of all crops has been obtained on summer-fallowed land. The average yields are about 50 percent greater on fallowed than on plowed land, except in the case of corn. The yield of corn on summer-fallowed land was only 33 percent greater than on fall-plowed land that had borne a crop.

The annual yields of spring wheat, oats, and barley on fall plowed, disked corn ground, and summer-fallow given in table 32 show that summer-fallow is of much greater value than the average yields indicate. Since 1909 there have been only two years, 1911 and 1912, in which small-grain crops were complete failures on fallow, but the yields on fallow were quite low in 1919 and 1931. In the years of partial failure of crops on plowed land, good yields have generally been produced on fallow, the returns on fallow in most such instances being 100 percent or more greater than on plowed land. Likewise, in some of the less productive years, as 1918 and 1921, the yields on fallow have been approximately 200 percent or more greater than on disked corn ground. In the more favorable seasons there has not been a great deal of difference between the yields on fallow and those on fall plowing following a crop.

Summer-fallow is unquestionably the cultural method that affords the greatest assurance of crop production in dry years, and it has an essential place in any desirable cropping system. Fallow has proved to be one of the most effective and practical methods for controlling weeds, and it permits a more even distribution of farm work.

The principal disadvantage of summer-fallow is the high cost of production per acre, as only one crop is grown in 2 years, but the highest yields obtained on fallow offset this to a large extent. The comparatively low price of land in western South Dakota, modern power machinery, large acreages, and improved, cheaper methods of summer-fallowing have materially reduced the cost of production, and summer-fallowing may be considered more profitable than cropping every year under average conditions. A factor which may limit the success of

summer-fallowing is soil blowing, and all practical precautions to retard soil drifting are desirable.

TABLE 32.—*Annual and average yields of spring wheat, oats, and barley grown on dry land under three of the most important cultural treatments, 1909–32*

Year	Spring wheat			Oats			Barley		
	Fall-plowed	Summer-fallowed	Disked corn	Fall-plowed	Summer-fallowed	Disked corn	Fall-plowed	Summer-fallowed	Disked corn
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1909	27.5	32.3	29.8	56.7	77.9	58.9	25.0	37.3	43.8
1910	0	5.0	3.8	0	17.3	7.6	4.8	7.0	5.0
1911	0	0	0	0	0	0	0	0	0
1912	0	0	0	6.1	7.3	10.9	0	0	0
1913	8.7	16.4	10.3	17.6	36.0	25.6	8.9	13.4	8.9
1914	5.8	15.2	10.0	16.3	49.8	30.0	7.1	21.7	12.2
1915	56.7	58.9	58.5	123.0	127.0	129.5	71.5	74.3	65.7
1916	11.7	16.7	10.1	16.5	48.8	37.8	33.6	42.7	30.8
1917	5.7	11.8	7.0	15.5	27.7	14.6	23.3	28.1	27.5
1918	6.6	32.2	5.5	14.9	51.6	16.8	11.6	36.0	12.3
1919	0	4.6	0	0	12.0	0	0	8.8	0
1920	29.4	31.4	31.3	61.7	61.6	61.9	50.8	64.4	62.7
1921	1.3	26.6	1.0	.6	40.4	4.0	0	33.5	6.0
1922	33.2	32.6	33.5	67.4	76.0	64.2	42.5	50.4	51.3
1923	28.6	31.0	30.9	61.7	69.3	59.6	49.6	57.7	50.0
1924	23.5	22.6	23.4	47.7	55.4	38.8	31.7	43.3	38.3
1925	18.7	24.4	22.1	43.2	67.2	62.9	29.6	49.6	31.5
1926	20.6	44.3	28.2	52.1	82.6	57.3	37.1	77.9	50.2
1927	19.5	23.8	22.8	31.2	51.8	37.0	3.1	16.5	30.2
1928	25.2	43.9	32.1	51.9	97.7	56.6	62.7	63.1	35.6
1929	28.1	26.8	30.3	50.1	61.9	53.5	32.7	54.8	40.2
1930	12.7	19.0	16.2	30.3	53.5	41.4	30.2	46.7	42.3
1931	0	1.0	0	0	2.0	0	1.6	10.8	1.7
1932	18.2	19.5	17.3	44.0	44.3	37.8	43.3	43.3	45.8
Average	16.3	22.6	18.2	33.8	50.9	37.8	25.1	37.0	29.4

Summer-fallowing may be practiced to good advantage on a substantial portion of the dry land under cultivation. It is apparent that as much corn and other intertilled crops should be grown as can be utilized or disposed of advantageously, but on many of the dry-land farms more land than is required for intertilled crops should be clean cultivated to control weeds, and summer-fallow is admirably suited for handling this acreage.

CROP SEQUENCE

There has been little difference in the effect of the various spring-sown small grains upon succeeding crops. The yields after spring wheat have not been quite so great as after barley, oats, or flax. Winter rye stubbled-in after winter wheat has as a rule been distinctly superior in every respect to winter rye stubbled-in after spring wheat, but as winter rye after spring wheat has been turned under for green manure, actual yield comparisons cannot be made.

Land seeded to the same crop every year since 1908 has shown only a small decline in productiveness. No deficiency in the supply of plant-food substances in the soil of continuously cropped land is indicated, but the decrease in productiveness may be attributed to an increase in weed growth and to certain soil-borne diseases, such as foot rot. Corn, wheat, oats, and barley have yielded nearly as much on continuously cropped land as after small grain in rotations, but the production of small grain grown after small grain in a rotation or on continuously cropped land has not been very dependable. The

uncertainty of producing a crop and the rapid increase of weed growth make extremely hazardous the cropping of the land to small grain more than 2 years in succession.

Higher average yields have been obtained after most of the intertilled crops than after small grain, except when the intertilled crop land has been plowed. The yields of spring wheat on plowed corn ground have been slightly less than the yields obtained after small grain. The relative effects of corn, sorgo, and potatoes upon the yields of following crops, when the land has not been plowed, are shown in table 31. In general, there is little difference between the effects of corn and sorgo, the advantage being in favor of corn with spring wheat and winter wheat and in favor of sorgo with oats and winter rye. The yields of spring wheat and oats after potatoes are distinctly greater than after corn or sorgo, and are nearly equal to those on fallow.

Winter rye, field peas, and sweetclover turned under for green manure have not differed materially in their effect upon following crops, except insofar as they may have influenced the quantity of water stored in the soil. As shown in table 31, the average yields of wheat and oats after rye turned under are essentially the same as after field peas. The yields after sweetclover are lower than after the other two green-manure crops, but this may be attributed to the fact that in many of the years sweetclover was plowed under later in the season, causing a greater reduction in the moisture content of the soil.

The inclusion of hay crops in rotations has had very little effect upon the yields of other crops. The average yield of oats on fall-plowed alfalfa sod was about 2 bushels per acre less than after small grain in rotations in which no sod crop was grown. Bromegrass has had a slightly more favorable effect on following crops than alfalfa. The average yields of oats on sod and of corn following the oats were 2.8 bushels and 2.6 bushels per acre greater, respectively, after bromegrass than after alfalfa.

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