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CROP ROTATION AND TILLAGE EXPERIMENTS AT THE NORTH PLATTE (NEBR.)
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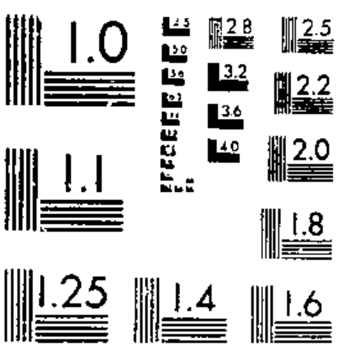

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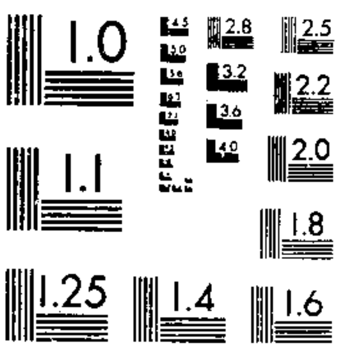

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Crop Rotation and Tillage Experiments at the North Platte (Nebr.) Substation 1907–34[1]

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United States Department of Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering, in cooperation with the Nebraska Agricultural Experiment Station

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INTRODUCTION

The Nebraska Agricultural Experiment Substation, designated in this bulletin as the North Platte Substation, is one of a group of sta-

[1] Submitted for publication August 30, 1941. Suspended by wartime restrictions and resubmitted October 6, 1949.

[2] The following men had immediate charge of the experimental work reported in this bulletin: W. W. Burr, 1906–12; W. M. Osborn, 1913–14; and L. L. Zook, 1915–34. H. E. Weakly assisted with the experimental work from 1923 to 1934. W. P. Snyder was station superintendent from 1904 to 1934.

tions at which the Division of Dry Land Agriculture[3] cooperated in studies of tillage practices and methods of crop production on the Great Plains. It is 3 miles south of North Platte, Lincoln County, Nebr., about 75 miles north of the southern boundary of the State, and 60 and 160 miles east, respectively, of the Nebraska-Colorado and Nebraska-Wyoming State lines. The results obtained are applicable to a large area of hard lands in central and western Nebraska and in smaller degree to northwestern Kansas, northeastern Colorado, and southwestern Wyoming.

The station was established in 1904; the cooperative dry-land investigations were begun in 1906. The fields used are on tableland near the south rim of the Platte Valley at an elevation of approximately 3,000 feet. This bulletin reports results obtained for the 28-year period 1907–34. The original location was abandoned in 1934 to provide a right-of-way for an irrigation and power project. After revision and enlargement, the work has been continued nearby since 1936.

AGRICULTURAL DEVELOPMENT

A valuable natural resource of the Central States as well as of all the Great Plains area was its native grass cover. For centuries before the coming of white men, decaying grass residues had slowly built up organic matter in the surface soils. The sod cover was an effective protection against wind and water erosion. Grass supported large herds of buffalo, deer, and antelope, which in turn supplied nomadic Indians with food and wearing apparel. The first white settlers changed the buffalo ranges into cattle ranges, with little or no disturbance to native vegetation. Immigration into the territory increased, following the passage after the Civil War of laws allowing land acquisition by settlement. Level lands were broken out for production of cultivated crops, and by the end of the nineteenth century little of the original grass cover remained except in rough or sandy areas. Cattle raising was pushed back into such areas, where it has remained as a comparatively stable and profitable business.

Chief among the hazards hindering the development of a stabilized agriculture in the Great Plains is the limited amount and highly variable distribution of its rainfall. The average rainfall is not sufficient to permit the better soils to reach their full capacity to produce. Occasional years or series of years of above-average rainfall have produced abundant crops, stimulated the inflow of new settlers, and encouraged undue inflation of land values. Periods of very low rainfall with low yields or complete crop failure have reversed these trends, so that the development of established farming practices has been slow and irregular.

Farming systems that have contributed most to a permanent development of the area and in the long run have proved most profitable include crop diversification and rotation, the production of some feed crops, and the use of part or all of the crops produced for feeding to livestock. Such systems can be most effectively organized where grasslands are included in the farm unit. On this account, level farm lands

[3] Now a part of the Division of Soil Management and Irrigation

adjacent to broken or hilly areas are more fortunately located than those in the large level areas where most of the grass has been broken out. The reestablishment of grass on some of the large level areas in order to maintain a balanced farming system is now desired by many farmers. Other areas on steep slopes or poor soils that were unwisely broken out in the first place in many cases should be returned to grass.

The leading crops of the central Great Plains are winter wheat and corn, with smaller acreages of spring grains and sorghums. The most noteworthy changes in recent years have been the increase in sorghums as a replacement for corn, the increase in barley over other spring grains, and the increase in fallowing as a preparation for winter wheat.

Definite long-time crop rotations are difficult to maintain because of the frequency of crop failures and the necessity of using emergency substitutes. Common practices and crop sequences are: Seeding winter wheat in standing cornstalks; seeding spring grains on disked cornland; growing winter wheat after fallow, followed by corn; and frequently continuing one crop on the same ground for several years.

SOIL CHARACTERISTICS

The tableland soil on which the station's dry-land fields are located is classified as Holdrege very fine sandy loam by the United States Department of Agriculture Soil Survey Report of Lincoln County, Nebr. (No. 35, ser. 1926). This soil is derived directly from the loess formation. The color is dark grayish brown in the upper layers, shading into the light gray of the parent material at depths of 3 to 6 feet. The most characteristic feature is the vertical columnar structure distinct in the upper subsoil and fading out at depths of 18 to 24 inches. The zone of maximum compaction, which is 10 to 15 inches thick, lies between depths of 18 to 40 inches and has been developed by the concentration of fine materials washed down from above. The upper layers have been leached of carbonates, and a concentration of these is found at depths of 3 to 4 feet where lime appears in numerous seams, streaks, blotches, and fine winding threads. Farther down, the floury, light-gray parent material is uniform and of great thickness. The depth to water-bearing gravels on the station uplands is 225 to 250 feet.

The United States Department of Agriculture Bureau of Soils in 1909 made physical analyses of samples from the station fields, at depths of 1 to 18 inches and 19 to 36 inches. In the upper section, the content of coarse to fine sand was 3 percent; very fine sand, 50 percent; silt, 41 percent; and clay, 6 percent. In the lower section the content of medium to fine sand was 3 percent; very fine sand, 61 percent; silt, 31 percent; and clay, 5 percent.

Holdrege very fine sandy loam virgin soils are well supplied with organic matter and are productive when moisture is adequate. The high sand content makes them easily tilled and facilitates the absorption of water.

There was some variation in soil type among the three experimental fields from which the results reported in this bulletin were obtained.

These fields were at varying distances from a depression in which the soil was the heavy basin phase of Holdrege. The soil of field 49, nearest to this basin, approached this phase on its lowest side. The soil of field 41, which was farthest from the basin, was generally lighter, and on the highest ground the soil approached the Colby series. Field 42 was intermediate. Volume weights of cultivated soils in the upper foot section ranged from 70 to 77 pounds to the cubic foot. The heaviest soils were reached at depths of about 4 feet and ranged from 85 to 92 pounds to the cubic foot. The average weight for the upper 6-foot section was about 85 pounds to the cubic foot. The average hygroscopic coefficient was about 8.5 percent, and the average moisture

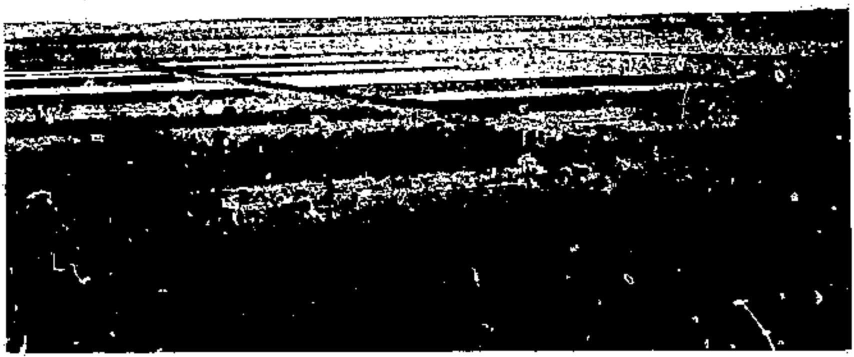

FIGURE 1.—Field 49, looking east, showing slope to east and north and generally level tableland of the surrounding country. North Platte Substation, July 1916.

equivalent about 21 percent. After prolonged drought moisture in cropped soils frequently was less than the hygroscopic coefficient. The average quantity of water that could be stored for use of crops in these soils was approximately 1.5 inches per foot, or about 8 inches in the upper 6-foot section.

Figure 1 shows the slope of the land to the east and north in field 49 and the generally level tableland of the surrounding country.

CLIMATIC CONDITIONS

Climatic factors are the dominant influences in crop production in the Great Plains region. On soils capable of high production, average yields are limited by an inadequate moisture supply. High variability in the nature, distribution, and amount of precipitation, in temperatures, and in wind movement creates conditions at times very favorable, at other times disastrous, and normally more or less hazardous.

Climatic records covering 50 to 75 years are available from a number of stations. The United States Weather Bureau station at North Platte has been in operation since 1874. At the North Platte Substation, observations were begun in 1907 and have been continuous since that time. The observation station on tableland near the crop rotation fields was maintained only for the 6-month period April 1 to September 30 each year. The records here presented are from this station for those months, supplemented by rainfall records from the North Platte Station maintained by the Weather Bureau, and by temperature and wind velocity records from a station near the substation buildings, for the time from October 1 to March 31. The monthly, seasonal, and annual mean temperatures are shown in table 1.

Temperature extremes, sudden changes, and seasonal means exert pronounced influences on crop production. The longest periods of departure in one direction as shown in the table were the 6 years below normal annual mean temperature from 1915 to 1920 and the 5 years above seasonal mean temperature, 1930 to 1934.

TABLE 1.—*Monthly, seasonal, and annual mean temperatures and absolute maximum and minimum temperatures for each month at North Platte Substation for the 28 years, 1907–34*

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	April–Sept.	Annual
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1907	20	32	11	43	52	66	72	72	61	53	37	30	61	49
1908	31	30	40	51	56	65	71	70	69	40	39	29	64	50
1909	25	27	36	43	57	67	72	75	63	51	39	15	63	48
1910	22	26	51	54	54	68	75	69	64	55	38	30	64	51
1911	28	30	44	47	60	76	72	70	66	46	33	23	65	50
1912	11	29	23	48	60	66	71	71	58	52	41	30	62	47
1913	24	21	33	51	59	70	75	79	63	47	43	29	66	50
1914	34	23	38	50	60	72	77	74	66	53	44	18	67	51
1915	20	30	27	54	54	63	69	67	61	55	41	28	61	47
1916	15	29	43	47	58	64	79	73	62	49	36	19	64	48
1917	23	27	33	44	52	67	77	70	63	45	46	24	62	48
1918	15	29	45	43	61	72	74	73	60	54	37	28	64	49
1919	29	21	37	46	58	69	76	73	68	45	28	19	65	48
1920	20	30	38	40	58	68	74	70	65	55	35	27	63	49
1921	30	34	43	49	60	74	77	73	65	55	38	31	66	52
1922	22	21	39	48	60	72	72	77	68	54	39	28	66	50
1923	33	26	31	47	56	67	74	69	63	47	42	30	63	49
1924	21	32	29	49	52	66	72	73	59	57	40	15	62	47
1925	30	36	43	53	58	71	75	73	66	41	38	28	64	50
1926	31	38	37	47	61	67	75	75	60	55	34	27	65	51
1927	26	33	36	50	60	65	72	68	64	56	38	19	63	49
1928	30	42	41	45	61	61	73	72	61	52	37	28	62	49
1929	19	19	40	50	56	67	77	77	58	53	32	31	64	48
1930	11	40	36	51	56	67	77	74	65	51	37	29	66	50
1931	33	29	35	49	57	73	77	72	70	55	37	29	66	51
1932	23	43	31	52	63	69	77	75	63	48	40	21	67	50
1933	33	25	40	49	57	76	78	71	68	54	42	33	67	52
1934	31	43	39	52	69	75	81	75	57	57	42	28	69	54
Average means	25	29	38	48	58	69	75	73	63	52	38	26	64	50
Maximum	70	71	86	94	102	109	109	108	105	94	83	72	------	------
Minimum	−28	−21	−13	10	22	38	41	40	20	4	−25	−30	------	------

December and January were generally the coldest months and July was the warmest. The absolute minimum and maximum temperatures recorded during the 28-year period were −30° and 109° F. No winter passed during this period without subzero temperatures. The average number of days of such temperatures was 18; the lowest number in any year was 4, and the highest, 39. Previous to 1907, temperatures of −35° were recorded for both January and February at the North

Platte Weather Bureau station. Temperatures of 100° or above were recorded in 18 of the 28 years, and at some time in each of the months May, June, July, August, and September. The average number per year was 4, and the greatest number was 32, of which 17 were consecutive, in 1934.

The frost-free period determines the growing season of tender crops. The dates of last spring and first fall occurence of 32° F. or lower temperatures and the number of days intervening are shown in table 2. The spring dates are from the tableland station. The fall dates before October 1 are from the tableland station; those for October 1 or later from the benchland station near the substation buildings. The tableland station was near the table's edge where, on account of the draining off of cool air to lower levels, the temperatures were several degrees higher on still nights than in the valley or farther back on the table. As a result, the frost-free periods average somewhat longer than for the general locality. The average length of season was 151 days. There was a tendency for the shorter seasons to have somewhat lower and the longer seasons somewhat higher mean temperatures for the April–September season, although there were numerous exceptions to this.

TABLE 2.—*Frost-free periods at the North Platte Substation for the 28 years 1907–34*

Year	Killing frost				Frost-free period
	Last in spring		First in fall [1]		
	Date	Temperature	Date	Temperature	
		°F.		°F.	Days
1907	May 26	32	Oct. 11	31	138
1908	May 5	32	Sept. 26	26	144
1909	May 8	30	Oct. 10	32	155
1910	May 2	28	Oct. 20	23	171
1911	May 2	32	Oct. 16	32	167
1912	Apr. 21	29	Sept. 24	28	156
1913	May 2	32	Sept. 24	27	145
1914	Apr. 28	31	Oct. 11	29	166
1915	May 20	31	Oct. 4	31	137
1916	May 2	29	Sept. 27	32	148
1917	May 7	30	Oct. 7	24	153
1918	May 9	30	Sept. 19	30	133
1919	Apr. 26	30	Oct. 4	29	161
1920	Apr. 29	29	Sept. 28	29	152
1921	Apr. 28	30	Oct. 3	29	158
1922	Apr. 19	26	Oct. 7	30	171
1923	May 15	31	Oct. 12	29	150
1924	May 23	30	Sept. 28	32	128
1925	May 4	32	Oct. 5	30	154
1926	May 13	32	Sept. 23	26	133
1927	May 8	32	Sept. 19	31	134
1928	Apr. 26	26	Sept. 26	31	153
1929	May 15	30	Oct. 11	28	149
1930	May 18	32	Oct. 15	26	150
1931	May 21	31	Sept. 25	31	127
1932	Apr. 30	31	Oct. 5	29	158
1933	Apr. 14	21	Oct. 7	31	176
1934	Apr. 26	32	Sept. 25	24	152
Average	May 5		Oct. 3		151

[1] Temperatures in October are from records at the station on bench near substation buildings.

Wind movement was measured by 4-cup anemometers placed 2 feet above the ground. Table 3 shows monthly, seasonal, and average velocities for the 27 years 1908–34, and averages for all months and annual averages for the 20 years 1915–34. Wind movement is an important factor in crop production. High winds create an ever-present menace from soil blowing whenever the surface is dry and not protected by a vegetative cover. Damage most frequently occurs in the spring, when the velocities are greatest and the crops not yet established. In other seasons, special tillage precautions are necessary to control soil blowing on areas that are kept free of vegetation to increase moisture storage. Wind movement increases evaporation and transpiration and thus directly affects both the storage and use of moisture. At this substation, seasonal average velocities ranged from 6.1 miles in 1920 to 9.0 miles in 1911. The highest velocities attained for 24-hour periods were 34.3 miles per hour on March 14, 1913, and 27.1 miles per hour on April 18, 1933. Records below 5 and above 20 miles per hour were relatively few.

TABLE 3.—*Monthly, seasonal, annual, and average wind velocity (miles per hour) at the North Platte Substation for the 27 years 1908–34*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr.–Sept. mean	Annual mean
1908				9.4	9.1	8.1	6.1	7.1	8.7				8.1	------
1909				8.5	9.4	6.2	6.0	6.8	6.7				7.4	------
1910				10.5	8.3	10.6	6.9	6.8	7.6				8.4	------
1911				10.1	10.5	10.1	7.8	7.8	7.6				9.0	------
1912				9.5	9.5	8.0	7.0	5.8	7.0				7.8	------
1913				10.7	8.3	8.6	7.4	7.3	7.4				8.3	------
1914				8.3	8.9	7.6	6.5	6.7	8.0				7.7	------
1915	5.8	6.4	6.8	8.4	7.4	7.1	5.5	4.1	6.5	5.6	5.6	4.1	6.5	6.1
1916	5.2	4.5	7.3	7.5	8.4	7.0	8.7	6.0	6.3	6.3	4.7	4.0	7.5	6.5
1917	5.0	5.8	7.0	9.2	8.8	7.5	6.0	5.7	6.0	6.5	4.5	5.5	7.3	6.5
1918	5.8	6.4	6.4	10.1	9.5	6.7	6.2	5.6	5.8	4.8	4.9	5.6	7.3	6.5
1919	3.7	6.5	6.0	8.7	7.6	7.0	6.2	4.7	5.2	4.3	4.8	4.1	6.7	5.8
1920	4.6	4.8	7.3	8.7	8.1	5.8	3.7	5.0	5.1	5.4	3.7	4.8	6.1	5.0
1921	4.8	5.2	6.9	10.1	10.2	6.7	7.2	3.2	4.3	4.1	3.3	3.5	6.9	5.8
1922	4.5	3.9	5.0	8.6	8.1	6.8	5.5	5.2	5.7	2.9	5.6	4.3	6.7	5.5
1923	5.2	5.0	8.1	6.6	8.2	8.5	4.9	4.3	5.4	3.7	3.0	4.4	6.3	5.6
1924	4.2	5.2	4.4	9.1	8.5	6.6	6.8	6.2	7.0	5.6	3.9	5.3	7.4	6.1
1925	4.7	5.2	7.2	9.0	8.2	7.6	5.5	7.2	5.7	3.8	2.1	5.7	7.2	6.0
1926	5.7	6.3	6.6	6.3	7.8	7.0	6.5	6.7	7.2	4.4	4.3	4.0	6.9	6.1
1927	5.0	4.8	8.6	8.1	10.8	7.3	5.7	4.9	6.0	4.1	3.7	4.1	7.1	6.1
1928	3.6	4.8	5.3	10.3	7.2	5.9	5.1	5.6	5.2	4.5	4.0	3.8	6.6	5.5
1929	5.1	4.4	6.5	8.5	8.0	6.1	7.0	5.5	6.0	4.2	4.1	3.4	7.0	5.8
1930	3.0	3.0	5.1	8.3	9.0	6.3	5.0	4.6	4.8	4.0	4.2	3.5	6.3	5.1
1931	3.5	4.0	6.0	6.7	8.3	6.6	6.2	6.0	6.4	5.7	3.9	3.7	6.7	5.6
1932	4.3	5.4	6.9	10.7	9.4	6.8	7.5	7.0	5.9	5.3	5.8	3.9	7.9	6.6
1933	5.0	6.5	8.4	11.1	9.0	7.6	7.1	6.3	7.1	2.5	3.5	4.4	8.0	6.5
1934	5.0	5.4	6.7	7.6	9.9	8.8	8.1	7.4	8.6	5.5	3.8	3.9	8.3	6.7
Average	4.7	5.2	6.6	8.9	8.8	7.4	6.4	5.9	6.4	4.7	4.2	4.3	7.3	6.0

Evaporation registers the combined effects of humidity, temperature, and wind velocity and is often a good index of the severity of drought conditions. Table 4 shows the monthly and seasonal evaporation, the seasonal precipitation, and the ratios of evaporation to precipitation for the April–September season for the 28 years 1907–34. The records were compiled from daily readings made on a 2- by 6-foot round tank set into the ground about 21 inches and with the water level maintained at approximately the ground level. Evaporation-precipitation ratios show a strong inverse relationship to corn yields. For the 12 years with corn yields below 15 bushels to the acre, the average evaporation-precipitation ratio was nearly 4 to 1. For the 6 years with corn yields above 30 bushels, the average evaporation-precipitation ratio was slightly above 2 to 1.

Precipitation is the most important single factor in crop production throughout the Great Plains. At North Platte, good crops usually were produced with normal precipitation and distribution. The normal distribution is favorable, as the greatest rainfall comes during the season of maximum growth and crop need. The chief hazards are wide departures below normal precipitation, departures from normal distribution, and the large proportion of the total received in small, isolated showers or in larger rains that fall too rapidly to be effective.

TABLE 4.—*Monthly and seasonal evaporation, seasonal precipitation, and evaporation-precipitation ratios for the period April to September, at the North Platte Substation for the 28 years 1907–34*

Year	Evaporation							Precipitation	Ratio: Evaporation to precipitation
	April	May	June	July	Aug.	Sept.	Total		
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	
1907	6.45	6.23	7.70	7.56	7.70	5.60	41.33	14.45	2.86
1908	6.00	6.99	6.26	7.51	6.93	8.24	41.93	16.57	2.53
1909	4.63	7.35	9.12	7.85	8.34	6.13	46.42	16.30	2.48
1910	7.49	5.98	9.90	9.75	7.60	5.58	46.57	9.79	4.76
1911	5.70	7.21	12.40	9.86	8.09	6.35	49.70	11.69	4.25
1912	4.84	7.54	7.59	8.97	7.46	5.29	41.69	11.59	3.60
1913	6.66	6.63	9.22	10.39	11.58	7.01	51.47	12.37	4.16
1914	5.64	6.32	8.98	10.15	9.58	6.77	47.44	12.78	3.71
1915	6.11	5.89	6.04	6.61	5.98	4.87	35.50	28.80	1.23
1916	4.55	7.02	6.96	11.03	7.76	6.28	43.60	12.01	3.63
1917	4.39	4.59	8.26	10.40	7.68	4.88	40.59	14.16	2.87
1918	4.30	7.37	8.39	8.88	8.05	4.86	41.85	11.76	3.56
1919	4.02	6.07	6.98	9.95	7.38	5.73	40.13	20.08	2.00
1920	3.32	4.56	6.48	8.63	7.51	5.88	36.38	17.64	2.06
1921	4.57	6.64	7.19	10.87	8.02	5.50	42.79	12.92	3.31
1922	4.64	6.68	8.34	7.03	8.06	6.31	40.96	15.94	2.57
1923	4.67	5.73	6.49	6.86	5.49	4.97	34.21	23.54	1.45
1924	5.67	5.95	6.28	8.12	7.94	4.75	38.71	10.89	3.55
1925	5.35	6.26	7.06	9.50	7.58	5.17	41.52	12.48	3.33
1926	5.31	7.46	7.45	8.80	8.59	4.62	42.23	11.68	3.62
1927	4.20	7.22	6.19	7.97	5.35	5.55	36.48	18.42	1.98
1928	6.14	6.30	4.80	6.73	7.56	6.15	37.68	16.08	2.34
1929	4.59	5.58	6.63	8.68	8.33	4.38	38.19	14.50	2.63
1930	4.38	5.69	6.18	8.33	5.98	4.81	35.37	18.62	1.90
1931	4.28	6.80	8.20	10.27	8.71	7.65	45.91	7.58	6.06
1932	5.45	7.71	6.99	9.11	8.21	6.27	43.74	16.07	2.72
1933	6.00	5.97	9.56	10.67	5.93	6.59	44.72	15.59	2.87
1934	6.33	9.60	10.59	13.30	9.64	5.88	55.34	11.99	4.62
Average	5.20	6.56	7.64	9.07	7.75	5.80	42.02	14.87	2.83

Monthly, seasonal, and annual precipitation and averages for the 28-year period 1907–34 are shown in table 5. The annual average precipitation of 18.89 inches was 0.4 inch greater than the normal calculated from the longer record of the Weather Bureau at North Platte. Annual totals ranged from 11.18 inches in 1910 to 34.85 inches, in 1915. The longest periods of subnormal precipitation were the 5 years 1910–14 and the 4 years 1931–34. Above normal precipitation did not occur in more than 2 consecutive years. The average seasonal precipitation of 14.87 inches was nearly 80 percent of the annual average. The greatest amount of rain received in any 24-hour period was 3.90 inches on June 8, 1919. The longest period during the April–September season without measurable rain was 34 days in July and

August 1928. The longest period with no rain of 0.5 inch or more in 24 hours was 82 days from May 10 to July 30, 1933.

The effectiveness of rainfall is determined to a large extent by the amount received at one time and its rapidity of fall. Small, isolated showers may give passing relief, but rains of less than one-half inch, unless supplemented by other rains at short intervals, are of little value for sustaining plant growth or for soil-moisture storage.

TABLE 5.—*Monthly, seasonal, and annual precipitation at the North Platte Substation for the 28 years 1907–34*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr.–Sept.	Annual
	Inch	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1907	0.39	0.51	0.10	0.23	2.01	2.53	4.84	1.80	2.44	0.64	0.31	0.80	14.45	17.20
1908	.16	.78	.20	.45	4.59	6.01	3.44	1.88	.20	3.41	.50	.20	16.57	21.91
1909	.29	1.61	.08	.55	3.09	4.99	5.48	1.73	.46	.22	2.24	1.37	16.30	23.01
1910	.34	.02	.19	.62	1.76	3.11	.12	3.21	.07	.01	.11	.72	9.79	11.18
1911	.28	.39	.20	2.34	1.34	.50	3.61	2.64	1.28	3.45	.04	.65	11.69	16.70
1912	.74	.81	3.08	3.02	1.72	.70	2.78	1.33	2.04	1.44	.01	.18	11.69	17.85
1913	.16	.94	1.68	2.09	2.44	2.81	2.76	1.28	.99	.14	.14	3.09	12.37	18.52
1914	.18	.96	.41	1.46	1.66	4.59	1.37	3.54	.16	1.30	(1)	.87	12.78	16.69
1915	.51	1.11	2.23	6.77	5.80	4.76	6.10	3.19	2.09	1.16	.22	.82	28.80	34.85
1916	.85	.51	.20	.70	2.23	4.40	.40	2.88	1.40	.50	.47	.42	12.01	15.26
1917	.74	.35	1.48	1.45	4.02	2.00	.78	3.46	2.45	.32	.71	.27	14.10	18.03
1918	.54	.28	.32	2.32	3.25	1.82	1.03	1.98	.48	1.43	.29	1.31	11.70	15.03
1919	.03	1.50	.44	1.77	2.72	7.33	5.33	1.12	1.81	1.30	2.83	.32	20.08	26.56
1920	.07	.72	.38	4.24	3.49	1.93	3.31	4.62	.15	1.20	.04	.60	17.64	20.74
1921	.58	.30	.42	1.17	2.43	1.14	3.12	3.50	1.56	.02	.04	.14	12.92	15.48
1922	.66	.05	.47	2.88	1.10	1.17	4.69	2.35	.66	.14	2.35	.01	15.94	19.62
1923	.11	.14	.38	2.02	6.17	4.03	5.52	3.80	1.40	1.77	.45	.30	23.54	26.78
1924	.08	.36	1.93	.30	2.48	2.35	1.81	1.85	2.04	.05	.08	1.81	10.89	16.10
1925	.07	.51	.22	2.07	2.30	3.00	1.36	2.46	1.20	.76	.37	.64	12.48	15.05
1926	.22	.12	.54	.37	1.29	3.51	2.11	3.20	1.20	.83	.33	.28	11.68	14.00
1927	.10	.48	1.20	3.74	2.33	4.80	.51	3.53	3.42	.20	.26	.38	18.42	21.16
1928	.13	.17	1.40	(1)	4.21	4.72	6.40	(1)	.75	2.61	.99	.08	16.08	21.46
1929	.23	.44	.28	4.33	2.36	.73	1.12	3.42	2.54	1.62	.48	.01	14.50	17.50
1930	.51	.24	.29	3.61	6.28	4.62	.78	2.22	1.11	4.15	1.03	.17	18.62	25.91
1931	.03	.76	1.81	1.27	.21	4.10	.79	.80	.41	.34	.59	.15	7.58	11.26
1932	.41	.30	.54	2.21	1.78	4.81	5.21	1.67	.33	1.03	(1)	.27	16.07	18.71
1933	.16	.15	.62	5.73	2.85	.61	1.24	2.93	2.23	(1)	.17	1.06	16.59	17.75
1934	.05	.52	.36	.41	.67	2.12	1.03	3.99	3.77	.30	.17	.42	11.09	13.81
Average	.31	.55	.80	2.08	2.87	3.21	2.79	2.51	1.41	1.16	.58	.62	14.87	18.89

[1] Trace.

In table 6, seasonal rainfall as recorded at the tableland station for the April–September season is classified according to the number of days of rains of given amounts and the total quantity contributed by each class. Days with recorded rainfall for the 183-day period ranged from 32 in 1931 to 68 in 1915. The average number was 47, or 1 day in every 4. Days with 1 inch or more of rainfall ranged from 0 to 10, averaged 3, and contributed 33 percent of the total rainfall. Days with rainfall from 0.50 to 0.99 inch ranged from 0 to 12, averaged 7, and contributed 31 percent of the total. Days with rain from 0.25 to 0.49 inch ranged from 3 to 15, averaged 9, and contributed 20 percent of the rainfall. The high number of rainfall days came in the class with less than 0.25 inch in amount. The number ranged from 19 to 41, averaged 28, and contributed only 16 percent of the rainfall. Where one-third of the normal rainfall comes in rains too light for effectiveness—that is, in amounts less than 0.50 inch—and a portion of heavier rains is lost by runoff, it is apparent that the total must be larger than the actual crop needs if satisfactory yields are to be obtained.

TABLE 6.—*Number of days and total amounts of rainfall from each of four classes, and totals for the April–September season at the North Platte Substation for the 28 years 1907–34*

Year	0.01 to 0.24 inch		0.25 to 0.49 inch		0.50 to 0.99 inch		1.00 inch or more		Seasonal total	
	Days	Total	Days	Total	Days	Total	Days	Total	Days	Rainfall
	Number	*Inches*	*Number*	*Inches*	*Number*	*Inches*	*Number*	*Inches*	*Number*	*Inches*
1907	29	2.98	10	3.37	5	2.96	4	5.14	48	14.45
1908	31	3.08	12	4.18	5	3.22	4	6.09	52	16.57
1909	30	2.88	7	2.45	7	4.77	3	6.20	47	16.30
1910	32	2.56	3	1.01	6	4.73	1	1.49	42	9.79
1911	30	2.42	8	2.76	6	4.41	2	2.10	46	11.69
1912	30	2.36	7	2.55	7	4.93	1	1.75	45	11.59
1913	26	1.74	9	3.25	11	7.38	0	0	46	12.37
1914	25	2.00	11	4.13	7	5.44	1	1.21	44	12.78
1915	36	3.38	10	3.29	12	7.98	10	14.15	68	28.80
1916	28	2.19	4	1.53	8	5.02	3	3.27	43	12.01
1917	31	3.60	6	2.20	10	6.50	1	1.80	48	14.10
1918	19	1.72	11	4.17	9	5.87	0	0	39	11.76
1919	20	1.79	10	3.75	7	5.32	5	9.22	42	20.08
1920	30	2.71	12	4.06	6	4.05	4	6.82	52	17.64
1921	26	2.49	7	2.47	5	3.58	3	4.38	41	12.92
1922	19	1.66	9	3.13	8	5.06	4	6.09	40	15.94
1923	27	1.51	15	5.63	8	5.89	7	10.51	57	23.54
1924	41	2.72	6	2.13	4	2.53	3	3.51	54	10.89
1925	29	1.80	6	1.98	8	4.95	3	3.75	46	12.48
1926	36	2.65	12	3.05	4	2.46	2	2.02	54	11.68
1927	35	2.33	11	3.93	8	4.70	4	7.46	58	18.42
1928	24	1.73	13	4.72	8	5.32	3	4.31	48	16.08
1929	28	2.88	6	2.04	4	2.70	4	6.88	42	14.50
1930	25	2.73	9	3.31	7	4.61	6	7.97	47	18.62
1931	23	1.86	7	2.45	0	0	2	3.27	32	7.58
1932	22	1.97	7	2.58	8	5.75	4	5.77	41	16.07
1933	27	2.57	8	3.20	6	3.92	3	5.90	43	15.59
1934	27	2.34	6	1.95	4	3.00	3	4.70	40	11.99
Average	28	2.38	9	3.07	7	4.54	3	4.88	47	14.87

GENERAL CHARACTER OF THE SEASONS

The relationships of the various climatic elements are highly variable. At times factors other than climate, such as weed competition, insect pests, and plant diseases, are important in determining crop growth and yield. The combination of conditions is never the same in any 2 years. On this account, a brief review of the important factors operating each year and their reactions upon crop production is presented.

1907.—The season opened early, with favorable tillage and seeding conditions in March. April and May were cold and dry. Early growth of spring grains was slow. Weeds became established and furnished strong competition. Rainfall was nearly normal in amount but somewhat erratic in distribution. Crops suffered from lack of moisture during several short intervals but were not seriously injured. Crop yields were somewhat above the average of later years.

1908.—The season was very favorable for crop production. Limited moisture in early spring prevented excessive vegetative growth. Later, timely rains made good filling possible. Seasonal and annual rainfalls were above normal, with favorable distribution, and there were numerous rains in adequate amounts for effective storage and use. This was the only year with both seasonal and annual average temperatures exactly normal. Yields of all crops were good. The average yield of 26.6 bushels of spring wheat was not again reached in the history of the station. The yields of oats were the highest of any year except 1915. Freezing temperature came 7 days early in the fall, but crops were well-matured.

1909.—Early spring conditions were unfavorable for the germination and growth of grains. Poor stands were obtained, and the set-back was so great that crops did not respond to later rains as in the previous season. Precipitation was above normal. Both spring and fall frost dates were late, and the frost-free season was 4 days longer than normal. Small-grain yields were slightly below and corn yields above average.

1910.—This season was one of the driest of record. Annual precipitation was the lowest and seasonal rainfall the second lowest of the 28-year period. The mean wind velocity for June was the highest of record. The seasonal evaporation-precipitation ratio was the highest of any year except 1931. The frost-free season was the second longest of record. Yields were fair on fallowed land and low on cropped land and probably would have been complete failures except for the favorable moisture carry-over from the previous year.

1911.—This season was the first of those of total crop failures. It was long, temperatures were high, winds were persistent, and rainfall was deficient. June mean temperature was one of the highest of record for the month, and evaporation of 12.49 inches was the highest for any month of record except July 1934. Two additional abnormal conditions contributed to the crop disaster. These were (1) the very dry year preceding, during which there was very little accumulation of moisture even in fallow; and (2) a very heavy infestation of grasshoppers. The only crop harvested was corn, of which the stover yield averaged less than half a ton and the grain yield less than 1 bushel to the acre.

1912.—Spring work and seeding were delayed by late snows and low temperatures. Germination was rapid and early growth good. High temperatures and strong winds the latter part of May created droughty conditions. June rainfall of 0.50 inch was the low record made for that month during the 28 years. Grain crops were saved from complete failure by moderate June temperatures and a 9-day period (June 5–13) with cloudy, threatening weather. Winter wheat survived the winter well. Fallows had not accumulated much moisture during the previous dry year, and the yield of winter wheat after fallow was only 4 bushels above that after corn. Early growth of corn was curtailed by dry weather, but the plants were not injured beyond recovery as in the previous year. They responded to normal July and early August rainfall, and despite a later dry period produced above-normal yields of grain. This was one of the few years when a favorable combination of factors brought about an above-normal corn yield despite a heavy deficiency in summer rainfall. Potato and sorgo yields were also slightly above normal.

1913.—An unusual weather feature of 1913 was the blizzard of March 13–14. Precipitation in the form of snow was 1.47 inches, the minimum temperatures reached 0° F., and the average wind velocities for the 2 days were 25.5 and 34.3 miles per hour. Livestock losses were heavy in the range territory. Another unusual feature was the 3.09-inch precipitation in December. This raised the annual precipitation to practically normal, after 7 successive months of deficiency. Rainfall was deficient for most of the summer months; and conditions were aggravated by violent temperature changes, seasons of hot wind, and one rather heavy hail. Evaporation for June was the fourth highest of record, and for the season it was the highest previous to 1934. Oats were killed by a late freeze while emerging and had to be reseeded. Weed competition was heavy, and grasshoppers finished the crop. Winter wheat came through the winter with good stands, and made fair yields when seeded after corn and fallow and poor yields when seeded after small grain. Corn was damaged by grasshoppers and hail, as well as drought. It failed to produce grain, and the stover yields were approximately three-fourths ton per acre.

1914.—This was the fifth successive year of poor crop conditions. All months of the growing season except June and August were below normal in rainfall. Dry soil at winter wheat seeding time resulted in poor stands. Soil blowing damaged the crop severely in early spring, and weed competition was severe. The response to fallow was poor, and the average yield of winter wheat was lower than for the previous 2 years. Spring grains made poor yields. Corn was damaged by grasshoppers as well as dry weather, and the grain yield was below 5 bushels to the acre. Sorgo was the only crop approaching normal yield.

1915.—Several climatic records that still stand were established. The seasonal precipitation and the annual precipitation were, respectively, 194 and 184 percent of normal. All months of the April–September season were above normal in precipitation and, except for temperature in April and wind in September, were deficient in mean temperature and wind velocity. Evaporation was the third lowest of record and 6.52 inches below the 28-year average. Seasonal evaporation was only 1.23 times the precipitation, the lowest ratio of record. April precipitation exceeded evaporation. Heavy snow fell on May 18 and 19. Soil moisture continued to accumulate during the growing season. The maximum temperature was 101° F. on May 13, and the next highest maximum was 91° on July 17. Crop yields were so greatly out of line with usual trends that a number of years were required to correct the effect on continuing averages. The rank growth of winter wheat on fallow and green-manure preparations was flattened by the May snow, badly lodged for the rest of the season, and damaged by scab and rust. Preparations that normally produced low yields were at the top, and the preparations normally high were at the bottom. Spring grains made excellent yields. On some plots, the yield was more than double the total of the previous 5 years. Seeding and harvest were unseasonably late. Temperatures were too low for the best development of corn. Considerable damage was done by hail on August 10. Yields were above normal but of poor quality on account of poor maturity.

1916.—After the excesses of 1915, seasonal and annual precipitation dropped back below normal. Because of excellent moisture conditions at seeding time, winter wheat survived the winter with perfect stands. Aided by the large moisture reserves and a high June rainfall, all small grains made good growth. Yields were good and of high quality. Conditions for corn were much less favorable. Early growth was rapid and succulent. A summer period of 58 days (June

13 to August 1) with no rain above 0.5 inch and with 31 days of 90° F. or higher maximum temperature left corn with little chance of recovery. July evaporation of 11.03 inches and a mean temperature of 79° were the highest records ever recorded up to 1916 for that month.

1917.—Precipitation, both seasonal and annual, was only slightly below normal. Abnormal distribution of precipitation was the chief factor adversely affecting crop production. May, August, and September had excessive rainfall, but the other months of the growing season had a deficiency. A 74-day midsummer drought from June 5 to August 17, during which no daily rain reached 0.5 inch, greatly reduced the yields of spring-seeded crops. Dry soil at seeding time, a long season of low winter temperatures, and dry weather and high winds in early spring resulted in poor stands and no survival of winter wheat. Corn was seriously set back by the long season of drought but made some recovery with the August rains. Stover yields were somewhat above normal, but the grain yield was low, immature, and of poor quality.

1918.—This year was the last of a 9-year series, all except 1915, with subnormal seasonal and annual precipitation. There were no drought periods so extended as those of the previous 2 years, but the rainfall of each month of the growing season, except April and May, was below normal. Winter survival of fall-seeded wheat was poor. All grain crops were severely injured by lack of moisture and high temperatures in June. The response of spring grains to fallow was good, and of winter wheat fair. Small-grain yields were generally poor. As in 1912, corn was retarded by unfavorable growing conditions in June, but this was to its later advantage. The medium-sized stalks were able to use a limited moisture supply for grain production, and above-normal yields of good quality grain were produced on less than normal precipitation.

1919.—This season marked a turning point from the long period of generally severe conditions, low yields, and crop failures. It ushered in a 6-year period extending to 1924 of generally favorable conditions, with no complete failure of any crop and with above-normal yields of one or more crops each year. Seasonal and annual precipitation were above normal but rather poorly distributed. The June rainfall of 7.33 inches was the high record for that month during the years covered. The record for a single day, 3.90 inches on June 8, was also the high record for the 28 years. Winter wheat survived with full stands. All small grains made excessive straw growth, rust injury was severe, and some lodging occurred. The heavy straw growth exhausted moisture rapidly, and despite the excess early moisture, incomplete filling resulted from a short period of dry weather near the end of the season. Corn fired some during the latter part of the 41-day dry period from August 2 to September 11, inclusive. However, deep penetration of moisture from early rains and moderate temperatures permitted the crop to carry through with very minor injury, and the average yield of 34.1 bushels was the highest ever obtained up to that time. The crop was fully matured and of excellent quality.

1920.—The season was unusually favorable, with a fair excess of seasonal and annual precipitation, medium-low temperature, low evaporation, and low wind movement. Rainfall distribution was somewhat erratic. There were deficiencies for June and September and excesses for the other months of the growing season. April was unseasonably cold. Small grains started slowly and tillered sparsely, and weed competition was severe. There were indications of moisture exhaustion under small grains late in June, but timely rains early in July delayed harvest and completed filling of heads. There was some rust injury, particularly to spring wheat. There was but little favorable response of winter wheat to fallow. The average yields of all grain crops were above normal. Conditions were most favorable for corn. Early growth was curtailed by limited moisture and moderate temperatures in June. The excess rainfall of August furnished adequate moisture for later growth, and good curing weather developed a high-quality crop. The average yield of 38.2 bushels established a new high record. Heavy frost damage to corn occurred in many nearby sections on August 13, but the minimum temperature reached on the station was 38°. Previous to 1920, only three crops of bromegrass and alfalfa had been harvested in 13 years. This year was the beginning of a 6-year period without failure of these crops.

1921.—Precipitation, both seasonal and annual, was subnormal, and distribution was distorted. For the first 3 months of the growing season it was below, and for the last 3 months above normal. There was a good carry-over of moisture from 1920, especially where late summer weeds were controlled. Moderate temperatures permitted effective use of the moisture available. Early growth was slow and tillering sparse, so that small grains filled well on a limited moisture supply. The yield of winter wheat was above normal. Grasshopper damage on oats was spotted and was estimated at 40 percent on the worst areas. The average yield of oats was somewhat below normal. The response of winter wheat and barley to fallow was very good and of oats slight. Corn yields were about normal, and the quality was good.

1922.—Precipitation was above normal for both the season and the year. Monthly totals for April, May, and July were above normal, for August nearly normal, and for June and September below normal. May rainfall was the highest since 1915, but was of low efficiency because of the rapid fall and high runoff of two heavy rains. Winter wheat survived with imperfect stands. This proved beneficial, as full stands would have suffered more severely during the June drought. The average yield was the lowest since 1918. Spring grains were severely damaged by the June drought, and their yields were only about half of normal. Small-grain crops responded well to fallow. Climatic factors were more favorable for corn than for small grains. Most of the plots were washed out by the heavy May rains and were replanted June 2 and 3. The set-back was slight. Midsummer moisture and temperatures were favorable. The crop matured well, and the yields were about 50 percent above normal.

1923.—This season was the nearest to that of 1915 in high precipitation and low evaporation-precipitation ratio. Evaporation of 34.21 inches was the lowest of record. Precipitation for the 6 summer months was 8.67 inches above normal. There were only 8 days with 90° F. or higher temperatures, the highest being 94°. All grain crops except winter wheat made high yields. Because of lack of moisture at seeding time, winter wheat failed to survive on corn ground and late tillage after small grains. On fallowed land the spring growth was excessive, and the loss was heavy from lodging, rust, and poor filling. Contrasts were striking between results from early and late plowing. Conditions were very favorable for corn, and the average yield of 50.4 bushels to the acre was the highest obtained in the 28 years.

1924.—The outstanding feature for this year was the good to excellent yields of all crops on a very limited moisture supply. The April–September season was the third driest of record, the precipitation for each month except September being below normal. There was an unusually high carry-over of moisture from the previous year. Low temperatures, moderate wind velocities, low evaporation, and favorable distribution also contributed to the effectiveness of the season's rainfall. There were an unusual number of light rains on successive days, with little runoff and high absorption. Survival of winter wheat was perfect. Low spring temperatures delayed the growth of all small grains, and water requirements of the plants were low. The yields of spring grain were almost as high as those of 1923; the yields of winter wheat, the highest since 1915. The effects of early tillage the previous fall were much greater than for any other year, the yields on early-tilled plots being practically equal to those on fallowed land. In many cases, the yields on early-plowed plots were three times those from adjacent late-plowed plots. Corn suffered from lack of moisture during much of the growing season, but severe burning was prevented by low temperatures. The quality was good, and the yields were almost normal.

1925.—Precipitation, both seasonal and annual, was again deficient. The seasonal deficiency was less than that of the previous year, but this year was at a disadvantage in starting with less moisture storage and in having higher summer temperatures and less favorable rainfall distribution. Winter wheat stands and survival were good, and spring-seeded crops started well. There were frequent periods of high wind. Grain crops were severely injured by soil blowing and then by lack of moisture. Corn was burned by hot summer winds. Yields were generally good on fallowed land. On cropped land all crops except sorgo and potatoes were almost complete failures.

1926.—Seasonal precipitation was the fifth and the annual the fourth lowest in the 28 years. The precipitation was slightly above normal in June and August, but for the other months of the growing season it was below normal. Severe damage resulted from high winds and soil blowing early in the spring. Although mean velocities were not high, intermittent high winds were unusually destructive. There were also intermittent periods of high temperatures. Dry soils at seeding time were responsible for poor stands of winter wheat. Spring grains likewise started poorly and were mostly destroyed early in the season. Crops were harvested only on fallowed land, where medium yields were obtained. Corn suffered severely from insufficient moisture and high temperatures in July, and it was not much revived by August rains. Grain yields averaged only 2 bushels to the acre, and stover was light and of poor quality. The only crop producing a normal or better yield was potatoes. The yield of 237.3 bushels on fallowed land was the record yield made to this date.

1927.—The season was generally good. Precipitation for both the season and the year was well above average. Rainfall was high for 4 of the summer months. Two dry periods, one in May and the other in July, threatened crop injury, but these periods were relieved before serious damage was done. Stands of winter wheat after corn and on late plowing after small grains were poor, but on early-plowed land and on fallowed land they were good. No reseeding was done. The response to early tillage and to fallow was unusually good. The average yield of winter wheat was above normal, but the range in yield between tillage methods was much wider than usual. Conditions were favorable for spring grains. Response to early tillage and to fallow were good but not so pronounced as for winter wheat, where differences in stand constituted a contributing factor. The average yield of spring wheat was closer than usual to that of winter wheat. Conditions were unusually favorable for corn. Low temperatures during the dry period in July prevented drought injury. Ears were well-matured, but leaves and stalks were still green when frosted on September 19. The corn yield was the second highest in the station's history. The cool temperatures and the short season were less favorable for milo, and its yield was farther below that of corn than for any season during which crops were compared. The 5.6 tons to the acre of Amber sorgo was the high record yield for this crop. Moisture storage in fallowed land was 41.3 percent of the rainfall for the fallow period. This was the highest percentage of rainfall stored during any fallow season.

1928.—Precipitation, both seasonal and annual, was above normal in fair amounts. An unusual climatic feature was the establishment of new low rainfall records for 2 months of the growing season. April and August were without measurable rainfall at the tableland station, and 0.04- and 0.11-inch rainfalls were low records for these months at the Weather Bureau station. Rainfall for May and June was well above normal; that for July was the highest of record. The combination of other climatic factors was favorable for crop production. Winter wheat survived with complete stands on all preparations. Spring grains were sown early, and good stands were obtained. All grains were checked by a moisture shortage in April. Response was good to abundant rains in May, June, and July. The growth of straw was heavy, and there was some lodging on land that had been fallowed. Above-normal yields were obtained on all crop sequences and preparations, and the yields on fallowed land were outstanding. The yields of 60.8 bushels of winter wheat and 88.9 bushels of oats to the acre on clean fallowed land this year were record highs for these crops during the investigations. Moderately low temperatures prevented excessive stalk growth of corn during June and July. Yields were somewhat reduced by the dry weather of August and September. These conditions contributed to good maturity and high quality, and yields were well above average. Bromegrass, alfalfa, and potatoes gave record yields. The average of 255.4 bushels of potatoes was 2.7 times the long-time average.

1929.—Seasonal and annual precipitation totals were subnormal by insignificant amounts. In comparison with the normal, the precipitation was high in April, somewhat low in May, very low in June, low in July, and high in August and September. Good stands of winter and spring grains were obtained, but crops were severely punished by high winds and soil blowing before adequate rains came late in April. The response of all grains to fallow was very good, and the yields on this type of preparation were double or more those on cropped land. Corn suffered severely from drought in June and July. The crop was saved from complete failure by moderate temperatures and generous rains in August, but the average yield was low. Milo fared somewhat better and outyielded corn by about 5 bushels to the acre.

1930.—This was the last year of the series during which the seasonal and annual precipitation was about normal or substantially above. Seasonal rainfall was erratic in distribution. Rainfall in May was the highest of record for that month, and in April and June it was well above normal. July was very dry, and August and September were below normal. There was no rain of 0.5 inch in amount for the 64-day period, June 25 to August 27, inclusive. Evaporation in May was less than the precipitation, and evaporation for the season was the second lowest of record. January was the coldest month of record, and the penetration of frost into the soil was unusually deep. Midsummer temperatures were moderately high, but accompanying wind movement was low so that evaporation was not excessive. Yields of all crops were excellent. Winter wheat survived the winter with full stands, regardless of low winter temperatures. The average yield of 42.3 bushels to the acre was the highest of record. Differences due to tillage and previous cropping were smaller than usual. Only 1 of 74 plots produced less than 30 bushels to the acre. Straw yields were the highest on record. The yields of grain on fallowed and green-manured plots were reduced, and harvest was made difficult by lodging. The yields of all spring-sown small grains were close to the high records. Although the growth of small grain was very rank, the May and June rainfall was sufficiently high so that, as in 1915, there was more moisture in the soil at the end than at the beginning of the growing season. During August, when the moisture requirements of corn were high and the supply had to be drawn from the lower depths of the root zone, some wilting of plants occurred. With normal moisture during this season, high record yields of corn probably would have been obtained. The average yield was about 150 percent of normal. Conditions were more favorable for milo. Its yield of 46.9 bushels to the acre exceeded that of corn by 17 bushels and was the second highest yield for that crop.

1931.—This was the first of a series of years of adverse climatic conditions and severe reduction of crop yields. Seasonal precipitation of 7.58 inches was the lowest of record, and the annual precipitation was second only to 1910. June was the only summer month with above-normal precipitation, and two heavy rains in that month fell rapidly and were of low efficiency because of runoff. Temperatures were high, and evaporation 6.06 times the precipitation was the highest evaporation-precipitation ratio of record. Days without measurable rain during the April-September season also made a new high record. Rain was recorded on only 32 of the 183 days, making approximately a 1 to 6 ratio in comparison with the normal of 1 to 4. Despite extremely unfavorable climatic conditions, all crops except corn and potatoes made about normal or higher yields. Grain crops were favored by a high moisture storage at the beginning of the season and by the high June rainfall. The response to fallow was excellent. In most cases, the yields on fallowed land were more than double those on cropped land. Corn suffered severely as a result of scant rainfall and high temperatures in July and August. The yields were about two-thirds normal. Without the favorable subsoil moisture storage of 1930, the crop doubtless would have been a total failure. The conditions were much more favorable for sorghums than for corn. The yield of milo was the third highest of record and nearly 2.5 times that of corn.

1932.—Precipitation was close to normal, but various adverse factors reduced crop yields to low levels or failure. The rainfall of April, June, and July was above normal, and for other months it was not so greatly reduced as in some other years. Temperatures, wind velocities, and evaporation were moderately high. Soils were too dry in the fall for the germination of winter wheat. Even on fallowed land with a fair supply of moisture at lower depths, it was too dry in the seeding area for germination. Winter wheat was practically a complete failure. There was moisture to germinate spring grains, but the crops were damaged early by high winds and scant moisture except on fallowed land. Hail on June 11 damaged spring grains an estimated 15 percent. Yields on cropped land were less than half of normal, but on fallowed land they were very good. Corn was developing well until almost completely wiped out by hail on August 5.

1933.—As in 1932, precipitation was about normal. Rainfall was high in April, second only to that of 1915, normal in May, very low in June and July, and slightly above normal in August and September. The soil was dry the previous fall. Winter wheat on cropped land germinated poorly, and about 50 percent of it was abandoned. Yields on fallowed land were only fair. Spring grains were punished by April winds, the mean of which was the highest of record. The response to improved moisture conditions later was not favorable. Straw growth was scarcely tall enough to be cut with a binder. The gains from fallowed land above other methods of preparation were less than usual for years of reduced yields. Corn was delayed by dry weather in June and July but made a fair response to better moisture conditions in August and September. Corn and milo were about equal in yield and somewhat above normal.

1934.—The closing year of these investigations set various new adverse climatic records and added another season of practically total crop failure. The precipitation for both the growing season and the year was low enough to account for crop failure. Added to this were all-time high temperature and evaporation records and wind velocities nearly equal to previous high records. There were 32 days with maximum temperatures of 100° F. or more. Of these, 17 were consecutive, July 8 to 24. During this period, an absolute temperature of 109° was reached three times, and records of 105° or more were made on 10 days. Seasonal evaporation of 55.34 inches was 13.32 inches above the long-time average and 3.87 inches above the previous high record, made in 1913. Daily evaporation records above 0.5 inch were made on 40 days and above 0.7 inch on 2 days. Under the extremely adverse climatic conditions, crops had little chance of survival. A few plots of grain on fallowed land were harvested. The yields averaged about half the usual yields on cropped land.

Corn produced no grain, and the stover yield of 352 pounds to the acre was the lowest of record. Drilled Amber sorgo produced approximately 1 ton to the acre, and milo produced no grain.

EXPERIMENTAL METHODS AND CONDITIONS

The different investigations of rotations and methods of tillage at this station were located in three fields. These, in order of their establishment, were designated as fields 41, 49, and 42. Diagrams of these fields are shown as figures 2, 3, and 4. Annual movement of crops within rotations was to the next highest lettered plot, and from plot A back to the lowest lettered plot.

In field 41, there were 92 plots of which 78 were used in 23 crop rotations varying in length from 2 to 6 years. The remaining 16 plots were used for continuous cropping and alternate fallow, cropping with 4 different crops.

In field 49, there were originally 90 plots of which 83 were used for 27 crop rotations varying in length from 2 to 5 years, and 7 plots were used for continuous or alternate fallow cropping with winter wheat. A later extension of field 49 contained 36 plots, divided into 12 crop rotations.

Field 42 was designed to obtain more accurate data in comparisons between a few tillage practices and cropping systems. It contained 108 plots, in 6 series of 18 plots each. Continuous cropping, 2-year rotations, and 3-year rotations only were used. For continuous cropping, corn, oats, and winter wheat were each grown under 2 methods of tillage, each method being replicated 4 times. Each of these grain crops was grown in 2-year rotations with corn and winter wheat in alternation with fallow. Each of the four 2-year combinations was used on 2 methods of tillage, and each method was replicated 4 times. In 3-year rotations, corn and winter wheat were each used in 2 crops of the other, and 2 crops of winter wheat were grown after fallow. Each of the three 3-year rotations was replicated 4 times.

Records from field 41 cover the 28 years beginning with 1907; from field 49, the 23 years beginning with 1912 on the original fields, and 14 years beginning with 1921 on the extension; and from field 42, the 12 years beginning with 1923. The work on all three fields was terminated with the crop of 1934. Altogether a total of 6,446 plot-year records were obtained.

The plots were 132 feet long by 33 feet wide. They were separated along the side by 3.5-foot alleys, and along the ends by 16.5-foot roadways in fields 41 and 42 and by 20-foot roadways in field 49. The plot lengths were in an east-west direction in fields 41 and 42, and in a north-south direction in field 49. The alleys were clean-cultivated. No fixed tillage practice was followed on the roadways. In some years they were clean-cultivated, in some years seeded in the spring with winter rye, and in other years summer-seeded with Sudan grass. Cropping the roadways aids in controlling soil erosion by washing and blowing, but it increases the labor of handling tillage implements when two or more plots in line receive the same treatment.

The methods of cultural treatments under trial were disking, spring plowing, and fall plowing for corn and spring grains; disking, early plowing, and late fall plowing for winter wheat and rye; disking and

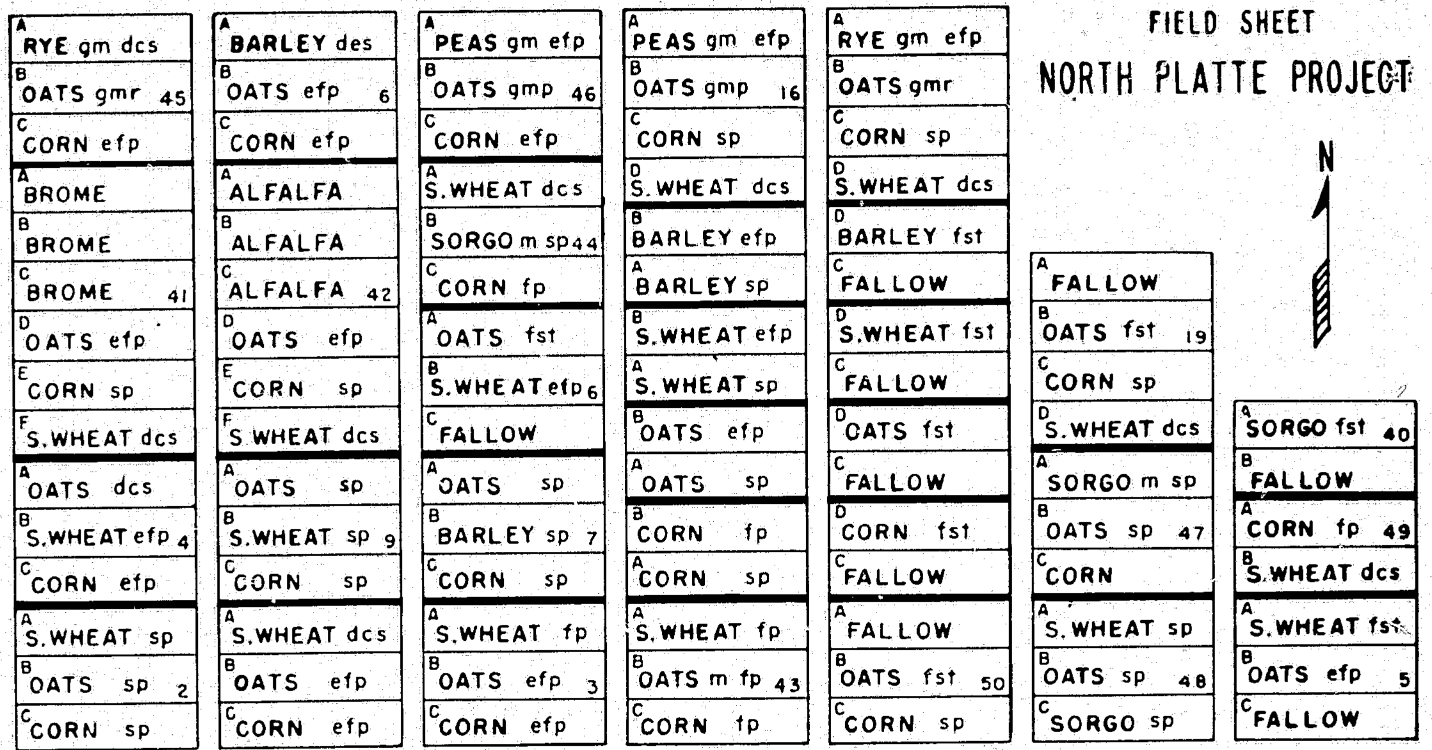

FIGURE 2.—Diagram of field 41: dcs = disked corn stubble; efp = early fall plowing; fp = fall plowing; fst = following summer tillage; gmp = green manure peas; gmr = green manure rye; m = barnyard manure; sp = spring plowing.

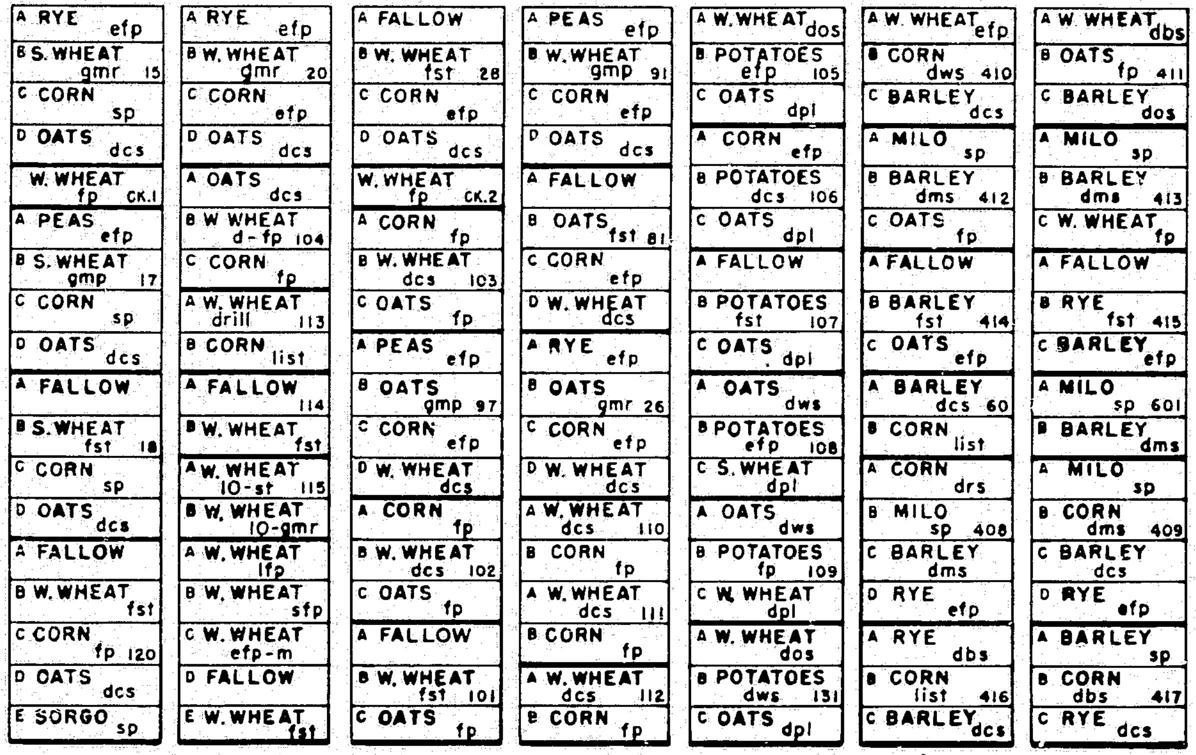

FIGURE 3.—Diagram of field 49: dbs = disked barley stubble; dcs = disked corn stubble; dos = disked oats stubble; dpl. = disked potato land; drs = disked rye stubble: dws = disked wheat stubble; efp = early fall plowing; fp = fall plowing; fst = following summer tillage; gmp = green manure peas; gmr = green manure rye; m = barnyard manure; sp = spring plowing.

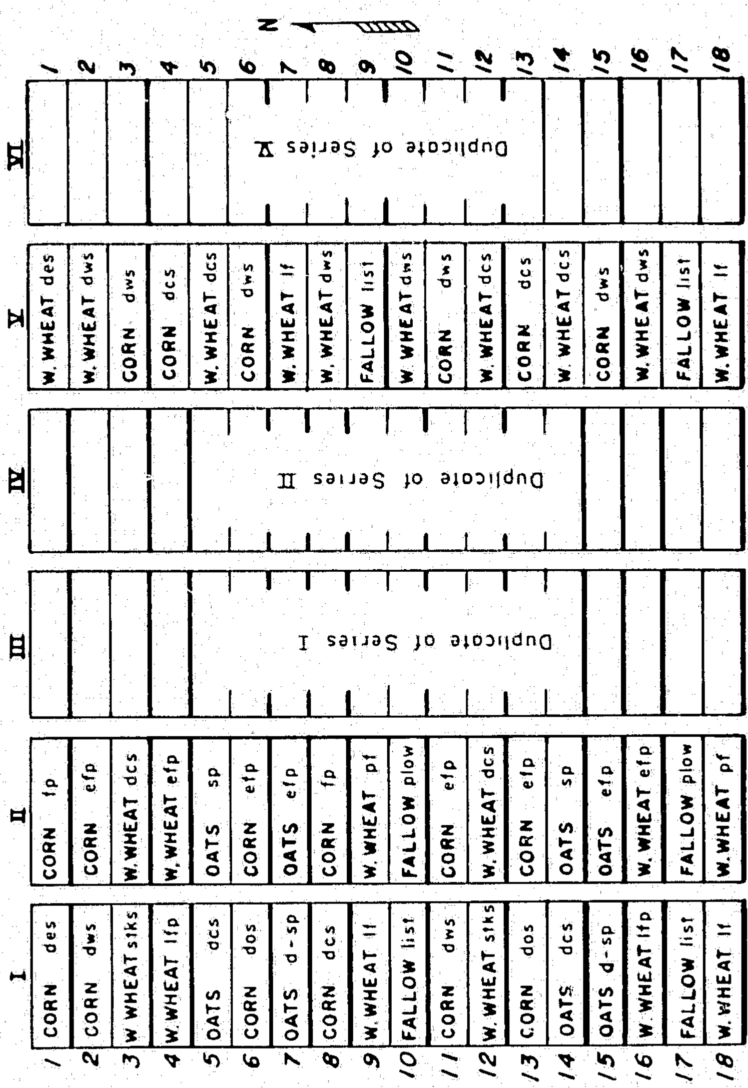

FIGURE 4.—Diagram of field 42: dcs = disked corn stubble; dos = disked oats stubble; dsp = alternate disk and spring plowing; dws = disked wheat stubble; efp = early fall plowing; lf = listed fallow; lfp = late fall plowing; pf = plowed fallow; sp = spring plowing; stks = seeded in standing stalks.

spring plowing for sorgo and milo; disking and fall plowing for potatoes; summer fallowing for all crops; and green manuring for winter wheat and oats.

All plowing was done with a two-way moldboard plow. All disking was doubled by lapping the disk half way to keep the surface level. Disking and spring plowing for small grains were begun as soon as the ground was free of frost and in proper condition for tillage. These operations were usually completed so that seeding was done in March or early April.

Spring plowing for corn and later crops was done after small-grain seeding was complete. Early fall plowing after small grain was done as soon as possible after harvest and threshing, usually between July 15 and August 10. Some later tillage was usually necessary on early-plowed land to kill weeds and volunteer grain. Late fall plowing for fall-seeded grains was done from September 15 to 20, which was shortly before seeding time. Nearly all plowed land was firmed by going over it immediately after plowing with a Campbell-type subsurface packer. Land left loose by double disking was also packed in years when the moisture content was low.

Summer fallow, except for special treatments, was disked in the fall if necessary to destroy the weeds and volunteer grain; disked again in the spring to control early weed growth; and plowed between June 15 and July 15. Cultivation after plowing was done only to the extent required to destroy late weeds, with a spike-tooth or spring-tooth harrow, duckfoot cultivator, or rod weeder. Use of a disk was avoided, as it pulverizes the soil excessively and leaves it in condition to blow.

After plowing under winter rye and field peas for green manure, treatment was the same as for the summer-tilled land. The green-manured land accumulated less moisture than that clean-fallowed for the full season. Barnyard manure was used on a few plots.

Table 7 shows the results of these cultural-treatment experiments. The varieties grown were those that were considered best adapted to the locality. The same variety was seeded on all plots of each crop in any given year, but changes to other varieties were made from time to time as better varieties were indicated by results from varietal tests at the station.

Table 7.—*Crops, varieties, seeding rate, number of plots seeded annually, and average date of seeding in crop rotation and tillage experiments at North Platte Substation*

Crop	Variety	Seed used per acre	Plots seeded annually	Average date of seeding
			Number	
Corn	Substation White	(1)	22-82	May 12.
Spring wheat	Kubanka; Ceres	4 pecks	19-23	March 28.
Oats	Kherson; Nebraska 21	6 pecks	23-62	April 1.
Barley	Common 6-row; Smyrna; McClymont; Comfort	8 pecks	5-17	April 2.
Winter wheat	Turkey	4 pecks	25-72	Sept. 21.
Winter rye	Common; Rosen	4 pecks	2-5	Sept. 20.
Potatoes	Early Ohio; Irish Cobbler	10 bushels	6	April 20.
Sorgo	Amber	4 pecks	4-5	June 5.
Milo	Dwarf Yellow	6 pounds	6	June 2.
Peas	Colorado Field	150 pounds	2-5	April 14.
Bromegrass	Smooth	20 pounds	1	April 9.
Alfalfa	Common	15 pounds	1	April 16.

[1] Corn planted at average spacing of 12 inches, later thinned to 24 inches between plots in row.

SCHEDULE OF CROPPING SYSTEMS

The following is a list of the rotations and continuous cropping methods used in each field, showing the crops and tillage practices used in each system. In fields 41 and 49 the rotations are designated by numbers and the plots within rotations by letters. In field 42, the designations are Roman numerals for series of plots and consecutive Arabic numbers for plots within series. In this field, each cultural method was replicated four times.

Numerical List of Crop Rotations in Field 41

Rotation 1:
- Wheat on disked corn ground.
- Oats on early fall plowing.
- Corn on early fall plowing.

Rotation 2:
- Wheat on spring plowing.
- Oats on spring plowing.
- Corn on spring plowing.

Rotation 3:
- Wheat on fall plowing.
- Oats on early fall plowing.
- Corn on early fall plowing.

Rotation 4:
- Oats on disked corn ground.
- Wheat on early fall plowing.
- Corn on early fall plowing.

Rotation 5:
- Wheat on summer fallow.
- Oats on early fall plowing.
- Summer fallow.

Rotation 6:
- Barley on disked corn ground.
- Oats on early fall plowing.
- Corn on early fall plowing.

Rotation 7:
- Oats on spring plowing.
- Barley on spring plowing.
- Corn on spring plowing.

Rotation 8:
- Oats on summer fallow.
- Wheat on early fall plowing.
- Summer fallow.

Rotation 9:
- Oats on spring plowing.
- Wheat on spring plowing.
- Corn on spring plowing.

Rotation 14:
- Winter rye on fall plowing, turned under.
- Oats on rye turned under.
- Corn on spring plowing.
- Wheat on disked corn ground.

Rotation 16:
- Peas on fall plowing, turned under.
- Oats on peas turned under.
- Corn on spring plowing.
- Wheat on disked corn ground.

Rotation 19:
- Summer fallow.
- Oats on summer fallow.
- Corn on spring plowing.
- Wheat on disked corn ground.

Rotation 40:
- Summer fallow.
- Sorghum on summer fallow.

Rotation 41:
- Bromegrass.
- Bromegrass.
- Bromegrass, broken up in fall.
- Oats on sod broken previous fall.
- Corn on spring plowing.
- Wheat on disked corn ground.

Rotation 42:
- Alfalfa on fall-plowed land.
- Alfalfa.
- Alfalfa.
- Oats on alfalfa sod plowed previous fall.
- Corn on spring plowing.
- Wheat on disked corn ground.

Rotation 43:
- Wheat on fall plowing.
- Oats on land manured and fall-plowed.
- Corn on fall plowing.

Rotation 44:
- Wheat on disked corn ground.
- Sorgo on land manured and spring-plowed.
- Corn on fall plowing.

Rotation 45:
- Winter rye on disked corn ground, turned under.
- Oats on rye turned under.
- Corn on early fall plowing.

Rotation 46:
- Peas on fall plowing, turned under.
- Oats on peas turned under.
- Corn on early fall plowing.

Rotation 47:
- Sorgo on land manured and spring-plowed.
- Oats on spring plowing.
- Corn on early fall plowing.

Rotation 48:
- Wheat on spring plowing.
- Oats on spring plowing.
- Sorgo on spring plowing.

Rotation 49:
- Corn on fall plowing.
- Wheat on disked corn ground.

Rotation 50:
- Summer fallow.
- Oats on summer fallow.
- Corn on spring plowing.

Continuous and Alternately Cropped Plots in Field 41

Plot	Crop
A	Spring wheat on spring plowing.
B	Spring wheat on early fall plowing.
C or D	Spring wheat alternating with fallow.
A	Oats on spring plowing.
B	Oats on early fall plowing.
C or D	Oats alternating with fallow.
A	Barley on spring plowing.
B	Barley on early fall plowing.
C or D	Barley alternating with fallow.
A	Corn on spring plowing.
B	Corn on fall plowing.
C or D	Corn alternating with fallow.

Numerical List of Crop Rotations in Field 49

Rotation 15:
- Winter rye on fall plowing, turned under.
- Spring wheat on rye turned under.
- Corn on spring plowing.
- Oats on disked corn ground.

Rotation 17:
- Peas on fall plowing, turned under.
- Spring wheat on peas turned under.
- Corn on spring plowing.
- Oats on disked corn ground.

Rotation 18:
- Summer fallow.
- Spring wheat on summer fallow.
- Corn on spring plowing.
- Oats on disked corn ground.

Rotation 20:
- Winter rye on early fall plowing, turned under.
- Winter wheat on rye turned under.
- Corn on early fall plowing.
- Oats on disked corn ground.

Rotation 26:
- Winter rye on early fall plowing, turned under.
- Oats on rye turned under.
- Corn on early fall plowing.
- Winter wheat on disked corn ground.

Rotation 28:
- Summer fallow.
- Winter wheat on summer fallow.
- Corn on early fall plowing.
- Oats on disked corn ground.

Rotation 60:
- Barley on disked corn ground.
- Corn listed in barley stubble.

Rotation 81:
- Summer fallow.
- Oats on summer fallow.
- Corn on early fall plowing.
- Winter wheat on disked corn ground.

Rotation 91:
- Peas on early fall plowing, turned under.
- Winter wheat on peas turned under.
- Corn on early fall plowing.
- Oats on disked corn ground.

Rotation 97:
- Peas on early fall plowing, turned under.
- Oats on peas turned under.
- Corn on early fall plowing.
- Winter wheat on disked corn ground.

Rotation 101:
- Summer fallow.
- Winter wheat on summer fallow.
- Oats on fall plowing.

Rotation 102:
- Corn on fall plowing.
- Winter wheat on disked corn ground.
- Oats on fall plowing.

Rotation 103:
- Corn on fall plowing.
- Winter wheat on disked corn ground, top-dressed with manure.
- Oats on fall plowing.

Rotation 104:
- Oats on disked corn ground.
- Winter wheat on early disking, late plowing.
- Corn on fall plowing.

Rotation 105:
- Winter wheat on disked oats stubble.
- Potatoes on early fall plowing.
- Oats on disked potato land.

Rotation 106:
- Corn on early fall plowing.
- Potatoes on disked corn ground.
- Oats on disked potato land.

Rotation 107:
- Summer fallow.
- Potatoes on summer fallow.
- Oats on disked potato land.

Numerical List of Crop Rotations in Field 49—Continued

Rotation 108:
- Oats on disked wheat stubble.
- Potatoes on early fall plowing.
- Spring wheat on disked potato land.

Rotation 109:
- Oats on disked wheat stubble.
- Potatoes on early fall plowing.
- Winter wheat on disked potato land.

Rotation 110:
- Winter wheat on disked cornland.
- Corn on fall plowing.

Rotation 111:
- Winter wheat on disked cornland.
- Corn, ½ stand, on fall plowing.

Rotation 112:
- Winter wheat on disked cornland.
- Corn on fall plowing.

Rotation 113:
- Winter wheat drilled in corn stubble.
- Corn listed in wheat stubble.

Rotation 114:
- Summer fallow (weedy).
- Winter wheat on weedy summer fallow.

Rotation 115:
- Winter wheat, continuous on early fall plowing, after 10 years fallow.
- Winter wheat, continuous on early fall plowing, after 10 crops rye plowed under.

Rotation 120:
- Summer fallow.
- Winter wheat on summer fallow.
- Corn on fall plowing.
- Oats on disked corn ground.
- Sorgo on spring plowing.

Rotation 131:
- Winter wheat on disked oats stubble.
- Potatoes on disked wheat stubble.
- Oats on disked potato land.

Rotation 408:
- Corn listed on disked rye stubble.
- Milo on spring plowing.

Rotation 408—Continued
- Barley on disked milo stubble.
- Rye on early fall plowing.

Rotation 409:
- Milo on spring plowing.
- Corn listed on disked milo stubble.
- Barley on disked corn ground.
- Rye on early fall plowing.

Rotation 410:
- Winter wheat on early fall plowing.
- Corn listed on disked wheat stubble.
- Barley on disked corn ground.

Rotation 411:
- Winter wheat on disked barley stubble.
- Oats on fall plowing.
- Barley on disked oats stubble.

Rotation 412:
- Milo on spring plowing.
- Barley on disked milo ground.
- Oats on fall plowing.

Rotation 413:
- Milo on spring plowing.
- Barley on disked milo ground.
- Winter wheat on late fall plowing.

Rotation 414:
- Summer fallow.
- Barley on summer fallow.
- Oats on early fall plowing.

Rotation 415:
- Summer fallow.
- Winter rye on summer fallow.
- Barley on early fall plowing.

Rotation 416:
- Winter rye on disked barley stubble.
- Corn listed in rye stubble.
- Barley on disked corn ground.

Rotation 417:
- Barley on spring plowing.
- Corn listed on disked barley stubble.
- Winter rye on disked corn ground.

Rotation 601:
- Milo on spring plowing.
- Barley on disked milo ground.

Continuous and Alternately Cropped Plots in Field 49

Plot	*Crop*
A	Winter wheat on late fall plowing.
B	Winter wheat on early fall plowing.
C	Winter wheat on early fall plowing, top-dressed with manure.
D and E	Winter wheat alternating with fallow.
Check No. 1	Winter wheat on late fall plowing.
Check No. 2	Winter wheat on late fall plowing.

Outline of Continuous and Rotation Cropping in Field 42

Corn, continuous:
- Spring-disked and lister-planted—series I and III, plots 1 and 8.
- Fall-plowed and lister-planted—series II and IV, plots 1 and 8.

Winter wheat, continuous:
- Late fall-plowed—series I and III, plots 4 and 16.
- Early fall-plowed—series II and IV, plots 4 and 16.

Oats, continuous:
- Alternately disked and spring-plowed—series I and III, plots 7 and 15.
- Early fall-plowed—series II and IV, plots 7 and 15.

2-year rotations:
- Corn, spring-disked and lister-planted—series I and III, plots 2 and 11.
- Winter wheat, drilled in standing stalks—series I and II, plots 3 and 12.

- Corn, early fall plowed—series II and IV, plots 2 and 11.
- Winter wheat, disked corn stubble—series II and IV, plots 3 and 12.

- Fallow, listed—series I and III, plots 10 and 17.
- Winter wheat, listed fallow—series I and III, plots 9 and 18.

- Fallow, plowed—series II and IV, plots 10 and 17.
- Winter wheat, plowed fallow—series II and IV, plots 9 and 18.

- Corn, spring-disked and lister-planted—series I and III, plots 6 and 13.
- Oats, disked corn stubble—series I and III, plots 5 and 14.

- Corn, early fall-plowed—series II and IV, plots 6 and 13.
- Oats, spring-plowed—series II and IV, plots 5 and 14.

3-year rotations:
- Corn, disked and lister-planted—series V and VI, plots 3 and 11.
- Winter wheat, disked corn stubble—series V and VI, plots 1 and 12.
- Winter wheat, disked wheat stubble—series V and VI, plots 2 and 10.

- Corn, disked and lister-planted—series V and VI, plots 6 and 15.
- Corn, disked and lister-planted—series V and VI, plots 4 and 13.
- Winter wheat, disked corn stubble—series V and VI, plots 5 and 14.

- Fallow, listed—series V and VI, plots 9 and 17.
- Winter wheat, listed fallow—series V and VI, plots 7 and 18.
- Winter wheat, disked wheat stubble—series V and VI, plots 8 and 16.

AVERAGE YIELDS OF ALL CROPS

The average yields of all crops for the years they were grown during the 28 years 1907–34 are shown in table 8. The average yields include all plots of a grain crop on all methods of tillage in use each year. The numbers of plots are not the same for all years, and the relative numbers of good and poor methods are not the same for all crops, but the differences due to these factors are not great and do not materially change the results. The average yields serve as indices of crop production for single seasons and for the period the crops were grown. Yields of all crops except barley averaged somewhat higher for the 14 years 1921–34 than for the 14 years 1907–20, notwithstanding the fact that the average precipitation for the earlier period was 1.4 inches greater than for the later period.

For the 14 years 1921–34, the average grain yields of the various crops in pounds per acre were—milo, 1,321; corn, 1,215; winter wheat, 1,080; barley, 955; oats, 979; rye, 885; and spring wheat, 828. The slight increase of milo over corn is not sufficient to offset the lower feeding value of milo. The difference in yield between barley and oats is not sufficient for this period to determine the choice of the crop.

CROP YIELDS FROM TILLAGE AND CROP SEQUENCE PRACTICES

In the following pages each crop under trial in the rotation and tillage experiments is discussed separately in relation to tillage methods and crop sequences.

TABLE 8.—*Annual and average acre yields of crops grown in three experimental fields at the North Platte Substation for the 28 years 1907–34*

Year	Corn		Barley	Oats	Spring wheat	Winter wheat	Winter rye	Milo	Sorgo	Bromegrass	Alfalfa	Potatoes
	Grain	Stover										
	Bu.	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Bu.*
1907	20.2	4,506	37.7	31.4	24.7	------	------	------	10,920	1,270	2,170	------
1908	26.1	3,287	35.5	61.1	26.6	------	------	------	9,423	770	1,405	------
1909	26.4	2,529	19.1	26.0	17.2	------	------	------	10,667	0	0	------
1910	5.3	1,571	15.2	13.3	8.2	------	------	------	(1)	0	160	------
1911	.6	782	0	0	0	------	------	------	0	0	0	------
1912	25.5	2,625	17.5	12.8	6.4	10.7	------	------	9,725	0	0	100.5
1913	0	1,487	7.8	0	3.2	14.4	------	------	982	0	0	23.3
1914	4.7	1,633	9.2	8.7	6.3	7.6	------	------	5,988	0	0	21.4
1915	21.0	2,435	37.2	64.3	26.2	35.6	------	------	9,730	0	0	117.8
1916	9.7	1,886	30.7	42.0	17.9	30.7	------	------	4,626	0	0	60.3
1917	9.0	2,837	16.8	9.7	7.3	0	------	------	4,594	775	1,875	65.4
1918	22.0	1,858	10.2	8.5	6.1	6.7	------	------	3,920	0	0	84.5
1919	34.1	2,649	34.1	39.5	14.3	21.9	------	------	8,820	0	0	108.9
1920	38.2	3,503	24.1	39.9	18.1	28.3	------	------	9,440	1,250	1,625	116.1
1921	20.1	2,486	20.2	22.7	10.6	22.9	20.8	24.5	6,440	175	700	56.5
1922	31.9	2,516	10.5	16.5	6.6	13.1	13.3	30.6	6,980	515	575	122.1
1923	50.4	3,510	33.3	56.6	19.7	9.8	20.5	48.5	10,830	740	2,010	98.1
1924	21.8	2,293	27.8	51.3	17.4	32.4	28.5	18.3	2,680	1,300	3,000	110.9
1925	8.4	2,115	12.3	18.7	9.2	10.6	14.1	11.6	7,460	525	725	102.4
1926	2.0	1,440	1.0	2.7	1.4	4.0	0	1.3	4,990	0	0	124.4
1927	47.3	2,705	33.9	30.4	18.4	19.3	20.4	31.4	11,130	575	1,000	150.0
1928	32.8	3,367	39.5	55.6	21.2	35.6	23.3	29.4	10,240	1,875	3,850	255.4
1929	14.1	2,105	23.6	33.2	17.5	10.9	16.9	19.2	6,320	775	1,050	117.0
1930	20.6	2,684	35.3	59.7	26.4	42.3	25.7	46.9	7,500	1,225	3,525	109.8
1931	14.1	2,109	20.1	33.8	17.3	33.1	21.1	34.8	5,460	805	2,475	78.4
1932	7.5	2,735	6.3	10.8	9.9	.2	4.1	8.6	4,760	0	0	90.8
1933	24.0	2,123	14.9	21.7	13.8	9.7	8.6	25.8	6,480	500	800	52.0
1934	0	352	.2	.9	.9	2.4	4.2	0	2,200	0	0	2.6
Average	19.7	2,365	20.5	28.1	13.4	17.7	15.8	23.6	6,639	460	1,016	94.9

[1] Yield record lost.

WINTER WHEAT

Nebraska has been one of the leading States in winter wheat production since hard red winter wheat became established in the United States. For the 20-year period, 1915–34, the average annual production from an average of 3 million acres harvested was 47 million bushels. In acreage, Nebraska was exceeded by Kansas and Oklahoma, but in average production by Kansas only.

Although winter wheat has been extensively grown in the State for more than 40 years, there has been a decided shift in areas during the past 20 years. The first established winter wheat belt was chiefly south of the Platte River and east of the 100th meridian. In this area winter wheat was introduced and supplanted spring wheat during the last 20 years of the past century. From 1900 to 1910 winter wheat in this section was a stable crop on an acreage not much below that in use at the present time. The peak in acreage was reached during and immediately after World War I, followed by a decline nearly to the previous level. Farther west in the State, the winter wheat acreage had increased with land settlement during the early years of the present century and was greatly stimulated during World War I. In contrast to the reduction in acreage in the older wheat belt following the war, acreages in the west continued to expand, owing principally to the increased use and efficiency of power machinery and the lack of competition from other crops as well adapted to the lower rainfall in this section.

By 1930, the winter wheat acreage of the nine counties of the southwest section plus the three counties on the south side of the Panhandle had reached more than 1 million acres, or nearly one-third that of the entire State. In most of this section it is the predominating crop, exceeding corn and other row crops by a ratio of 3 or more to 1 and spring-sown small grains by a wide margin.

When the North Platte Substation was established in 1904, the adaptability of winter wheat to that part of the State was not yet determined and it was not one of the crops used in the first dry-land rotation and tillage experiments which were begun in 1906. Winter wheat was grown on the general fields of the station, and on account of the favorable results obtained there, as well as on farms in the surrounding territory, it was given a prominent place in the experimental fields laid out later.

The results with winter wheat reported in this bulletin are from the 2 experimental fields 49 and 42. In field 49 winter wheat was grown on 25 plots for 23 years, on 3 plots for 14 years, and on 2 plots for 11 years. In field 42 the crop was grown on 44 plots for 12 years.

In field 49, the cultural treatment was as follows: Late and early plowing, under continuous cropping; disking only, early disking and late plowing, late plowing, and early plowing after oats or barley in 3-year rotations; disking and seeding without disking after corn in 2-, 3-, and 4-year rotations; fallowing in 2-, 3-, 4-, and 5-year rotations; green manuring in 4-year rotations; and early plowing and continuous cropping after 10-year preliminary periods of fallowing or plowing under rye for green manure.

In field 42 the following cultural program was carried out: Late and early plowing under continuous cropping; disking after wheat in 3-year rotations of two crops of wheat and one of corn or fallow; seeding in standing cornstalks without preparatory tillage; disking corn stubble in 2-year rotations of corn and winter wheat and in 3-year rotations of two crops of wheat and one of corn or two of corn and one of wheat; after plowed and listed alternate fallows; and after listed fallow in 3-year rotations of two crops of wheat and one of fallow.

WINTER WHEAT CONTINUOUSLY CROPPED OR AFTER OTHER SMALL GRAINS

In sections of the central Great Plains where winter wheat is the predominant crop it is commonly grown for 2 or more years in succession on the same land. Under these conditions and also where winter wheat follows other small grains, the tillage practiced between harvest and seeding time is an important factor in determining crop yields. In areas where the rainfall is usually less than sufficient for the needs of the crop during the time of its most rapid growth, any available water that has been stored within the root zone of the plants becomes greatly reduced. In the drier sections the normal condition is complete exhaustion by harvesttime. In sections of somewhat higher rainfall, a residue of available water is at times carried over. Also some water may be present at this season as a result of heavy late rains, although the soil may have been completely dry at an earlier date.

At North Platte, the rainfall between harvest and seeding time is about one-third of the annual total. Under high summer temperatures, weeds and volunteer grain develop rapidly when moisture is present. Evaporation losses are also high. When vegetation is allowed to grow, moisture storage is reduced to a minimum. In seasons when the soil remains too dry after harvest for vegetation to develop, early tillage contributes nothing to moisture storage. The benefits of early tillage therefore depend upon the frequency and adequacy of summer rains. At the Hays, Kans., station, on land continuously cropped to wheat, higher yields have been obtained on early than on late plowing in all years that a crop was produced. At the North Platte station, the higher yields have been obtained in a few instances on late plowing, but in a much greater number on early plowing, and the average difference has been distinctly in favor of early plowing.

At Colby, Kans., and Akron, Colo., where the rainfall is somewhat less and the soils are likely to remain dry for longer periods after harvest, early plowing has not resulted in consistent gains over late plowing. Although rather large increases occasionally have been obtained from early plowing, these are largely offset by reversals in other years and the average differences are small and of low significance. Under these conditions, the advisability of growing winter wheat in successive years is questionable. A rotation with intertilled crops or fallow is more apt to bring profitable returns.

TABLE 9.—*Annual and average yields of winter wheat from continuous cropping, early and late plowing, and annual and average increases from early plowing at North Platte Substation, field 49, 1912–34, and field 42, 1923–34*

[See pp. 26 to 27 for rotation schedules]

Year	Field 49 [1]			Field 42		
	Late plowing, plot A	Early plowing, plot B	Early plowing, increase	Late plowing [2]	Early plowing [3]	Early plowing, increase
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1912	7.2	7.7	0.5			
1913	3.2	3.8	.6			
1914	3.3	4.7	1.4			
1915	39.7	39.8	.1			
1916	23.5	28.3	4.8			
1917	0	0	0			
1918	0	0	0			
1919	19.8	18.3	−1.5			
1920	21.2	31.2	10.0			
1921	18.5	19.8	1.3			
1922	4.8	11.2	6.4			
1923	0	17.8	17.8	9.5	14.0	5.4
1924	16.3	53.8	37.5	10.1	39.1	29.0
1925	7.2	6.0	−1.2	3.0	4.2	1.2
1926	0	0	0	0	0	0
1927	5.7	20.8	15.1	7.4	18.3	10.9
1928	31.0	35.0	4.0	22.7	29.5	6.8
1929	12.3	16.2	3.9	10.3	14.4	4.1
1930	36.7	38.2	1.5	32.6	39.7	7.1
1931	22.5	23.2	.7	22.1	23.7	1.6
1932	0	0	0	0	0	0
1933	0	12.2	12.2	0	10.9	10.9
1934	0	0	0	0	0	0
Average	11.9	16.9	5.0			
Average, 1923–34	11.0	18.6	7.6	9.8	16.2	6.4

[1] Single plots.
[2] Series I and III, plots 4 and 16.
[3] Series II and IV, plots 4 and 16.

Early plowing and late plowing under continuous cropping of winter wheat were compared on adjacent single plots in field 49 for the 23 years 1912–34, and on four pairs of plots, each pair with ends facing across roadways, in field 42 for the 12 years 1923–34. Average dates of early plowing, late plowing, and seeding were August 10, September 14, and September 20, respectively. That is, the average difference in plowing dates was 35 days. Early plowing averaged 41 days and late plowing 6 days before seeding. If necessary to control weeds or volunteer grain, the early-plowed land was disked or duck-footed. This was done in about half of the seasons. The annual and average yields are shown in table 9. There were 7 years of crop failure on late plowing and 5 such years on early plowing. In field 49, slightly higher yields were obtained from the late plowing in 2 years, 1919 and 1925. In field 42, the higher yield was on early plowing each year that a crop was produced. For the 23-year period 1912–34 the average gain in yield of early over late plowing was 5 bushels, or 42 percent. For the 12-year period 1923–34 the gain for early plowing in field 49 was 7.6 bushels, or 69 percent, and in field 42, 6.4 bushels, or 64 percent.

A group of three 3-year rotations in field 49 furnish a comparison of the effects of three tillage methods on winter wheat yields for the 14-year period 1921–34. These are rotations 411, 413, and 410. Yields are presented in table 10. In each rotation, winter wheat follows barley, and the preparation culture includes disking, late plowing, and early plowing. The crops preceding barley were oats, corn, and milo in the respective rotations. Although differential effects of cropping and tillage at times persist for more than 1 year, these delayed effects are usually secondary to the effects of the cropping and tillage of the year immediately preceding. The predominating factor in determining the differences in winter wheat yields in these rotations is considered to be the tillage preparations for wheat on the barley stubble. The average dates of the various operations were: Early plowing, August 10; disking, September 2; late plowing, September 13; and seeding, September 21. The average times before seeding when early plowing, disking, and late plowing was done, therefore, were 42, 19, and 8 days, respectively. In 7 of the 14 years, disking or duckfooting was required after plowing on the early-plowed land to control weeds or volunteer grain. In 5 years, a second disking was required on the disked plots for the same reason. The yield from early plowing exceeded that from late plowing every year except 1932, when crop failure occurred for all methods, and that from disking every year except 1922. The average gains of early plowing over late plowing and disking were 10.7 and 8.7 bushels per acre, respectively. The difference in favor of early plowing in this case is greater than that for the same years reported in table 9.

TABLE 10.—*Annual and average yields of winter wheat on disking, late plowing, and early plowing after barley in 3-year rotations in field 49 at North Platte Substation, 1921–34*

Year	Disked (rotation 411)	Late-plowed (rotation 413)	Early-plowed (rotation 410)	Year	Disked (rotation 411)	Late-plowed (rotation 413)	Early-plowed (rotation 410)
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1921	14.0	11.7	22.8	1930	33.8	35.0	47.5
1922	18.0	8.0	16.2	1931	16.3	10.7	26.8
1923	0	0	19.8	1932	0	.8	0
1924	20.0	10.2	48.3	1933	0	3.8	11.3
1925	12.7	8.0	16.8	1934	0	0	0
1926	0	0	0				
1927	11.5	7.0	18.7	Average	12.1	10.1	20.8
1928	33.0	22.0	41.2				
1929	10.2	12.8	22.2	Failures	5	4	3

In field 42, wheat followed wheat in two sets of 3-year rotations. In one of these, the first crop of wheat was grown on fallow and in the other on disked corn stubble. Preparation for the second crop of wheat was disked wheat stubble. Annual and average yields of the second-year wheat crops and the gain in yield from the fallow rotation are shown in table 11. Gains varied from year to year, but were positive in all years that a crop was produced. The average gain was 3.1 bushels per acre. This is minor in comparison with the difference in first-crop wheat yields after corn and fallow, where the gain for fallow was 16.2 bushels. This gain is largely offset by an average yield of 18.3 bushels of corn produced in the corn rotation while land in the fallow rotation was out of production. On the basis of 2 years of cropping, production for the fallow-wheat rotation was 28.3 bushels of wheat; for corn-wheat, 30.4 bushels (18.3 corn and 12.1 wheat). This is a fair balance when the price of wheat is not too far above that of corn. Addition of the second-crop wheat yields, however, weigh the balance more heavily in favor of the fallow-wheat-wheat system. In this case the value of 42.8 bushels of wheat (0 plus 28.3 plus 14.4 bushels) exceeds the value of 41.7 bushels (18.3 corn plus 12.1 wheat plus 11.3 wheat) by a positive margin.

TABLE 11.—*Annual and average yields of winter wheat on disked stubble after wheat second year after corn and second year after fallow, and gains for second year after fallow in 3-year rotations in field 42, at North Platte Substation, 1923–34*

[See p. 26 for rotation schedules]

Year	Second year wheat— After corn [1]	Second year wheat— After fallow [2]	Gain in fallow rotation	Year	Second year wheat— After corn [1]	Second year wheat— After fallow [2]	Gain in fallow rotation
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1923	3.3	3.4	0.1	1930	38.1	45.7	7.6
1924	15.4	31.8	16.4	1931	19.0	20.6	1.6
1925	2.7	3.3	.6	1932	0	0	0
1926	0	0	0	1933	7.5	7.6	.1
1927	16.4	19.1	2.7	1934	0	0	0
1928	23.2	28.1	4.9				
1929	10.3	13.8	3.5	Average	11.3	14.4	3.1

[1] Series V and VI, plots 1, 2, or 3 and 10, 11, or 12.
[2] Series V and VI, plots 7, 8, or 9 and 16, 17, or 18.

WINTER WHEAT AFTER CORN

In the central Great Plains, corn is the crop most generally used for rotation with winter wheat. Where the acreages are about equal, a common practice is to alternate the two crops annually. Where one or the other crop predominates, a balance is maintained by growing one crop for two or more successive years on part of the acreage before changing to the other crop. Where winter wheat is seeded after corn, the usual practice is to seed in the standing stalks before the corn is harvested. A less common practice than seeding in the standing stalks is removal of the corn crop for fodder or ensilage and drilling wheat in the corn stubble either directly or after additional tillage, such as disking.

In field 40, winter wheat followed corn in nine crop rotations. The length of the rotations and their annual and average yields are shown in table 12. The corn crop was removed before wheat was seeded. The corn stubble land was disked except as indicated in the table. Plots not disked were drilled without other preparation. In paired comparisons the higher yield was more frequently from disked plots than from those not disked. The results are not conclusive, however, because of other complicating factors. In the 2-year rotations the lowest average yield was from rotation 113 in which no disking was done. The highest yield was from rotation 111, but this increase is considered to be due to the reduced (one-half rate) stands of corn alternating with the wheat crops. Five plots not disked in rotations 110 and 112 produced as well as companion disked plots.

In 3-year rotations, plots not disked in rotation 102 produced less than disked plots in rotation 103, four out of five times. In this case the results may be influenced by the use of barnyard manure as a top dressing on wheat in rotation 103.

In the six comparisons in the 4-year rotations, the higher yield occurred after disking in 3 years and after no disking in 3 years. The averages were practically the same.

TABLE 12.—*Annual and average yields of winter wheat from seedings on not-disked and disked corn stubble from nine crop rotations in field 40 at North Platte Substation, 1912-34*

[See pp. 25 to 26 for rotation schedules]

Year	2-year rotations				3-year rotations		4-year rotations		
	No. 113 [1]	No. 110	No. 111	No. 112	No. 102	No. 103	No. 81	No. 26	No. 97
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1912	5.8	9.3	7.3	9.0	11.8	14.2	11.3	14.8	6.5
1913	11.9	20.1	14.7	24.4	20.5	13.5	17.0	18.0	12.0
1914	9.4	9.2	7.2	4.7	8.7	4.8	10.0	9.3	9.0
1915	44.8	41.7	33.5	36.5	38.5	40.0	27.3	36.5	36.5
1916	28.0	40.7	35.0	35.5	36.2	42.3	34.2	44.2	47.5
1917	0	0	0	0	0	0	0	0	0
1918	4.3	10.5	3.2	2.0	7.5	5.3	5.8	8.5	7.0
1919	18.8	21.8	22.3	18.0	22.5	23.3	25.8	24.5	22.5
1920	24.0	27.0	27.2	30.0	28.8	30.5	26.3	29.8	31.2
1921	17.0	21.3	26.8	18.3	20.5	18.5	19.8	21.7	23.8
1922	7.7	12.3	7.2	6.3	9.0	10.3	15.7	10.0	7.7
1923	0	0	0	0	11.3	0	0	0	0
1924	19.2	29.0	43.5	30.5	32.8	36.8	36.7	39.3	40.3
1925	6.8	10.0	12.8	[1] 9.0	[1] 9.7	10.3	[1] 12.7	13.5	11.8
1926	0	0	0	0	0	0	0	0	0
1927	12.7	[1] 23.3	16.8	17.0	[1] 21.2	22.2	17.8	[1] 20.7	16.0
1928	20.3	[1] 30.8	27.0	25.8	[1] 28.0	32.5	32.0	[1] 26.2	33.3
1929	11.4	[1] 16.8	20.2	16.7	[1] 16.0	11.7	14.0	[1] 16.3	16.5
1930	39.3	[1] 34.3	44.5	39.2	[1] 35.0	46.3	40.0	[1] 41.2	46.5
1931	23.3	26.7	45.2	36.3	26.5	32.0	[1] 30.0	32.3	32.7
1932	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0
Average	13.2	16.7	17.1	15.6	16.7	17.3	18.4	17.7	17.4

[1] Yields from plots seeded without disking. All others were disked before seeding.

In field 42, for the 12-year period 1923–34, winter wheat was seeded on disked corn ground and in standing stalks in 2-year rotations and on disked corn ground after one and after two crops of corn in 3-year rotations. Each method was replicated four times. Annual and average yields are shown in table 13. The crop failed in 5 of the 12 years. For the seven crops produced, the higher yields in each case were from the disked stubble plots. The average of 7 bushels in favor of the disked plots is greater than that between any other tillage preparations for wheat on cropped land in this field. As judged by other corn yields of the same years the differences seem to be due more to depressed yields from seeding in standing stalks than from increased yields from the disked stubble plots. Although corn had generally reached fair maturity before being cut for fodder, it seems probable that the stalks left standing continued to use moisture for a longer time and that wheat on the stubble plots had the advantage of a greater residue of moisture. This difference in initial moisture was probably of greater importance in determining yield than was the difference due to tillage. Wheat in standing stalks at times benefits by moisture gained by a greater amount of snow held by the stalks. In these tests this seems to have been less important than the moisture lost by late growth of the stalks.

TABLE 13.—*Annual and average yields of winter wheat seeded in standing stalks and on disked corn stubble, and gain in yield from disked corn stubble in 2-year rotations in field 42, at North Platte Substation, 1923–34*

[See p. 27 for rotation schedules]

Year	Wheat seeded in standing stalks [1]	Wheat seeded on disked corn stubble [2]	Gain from disked corn stubble	Year	Wheat seeded in standing stalks [1]	Wheat seeded on disked corn stubble [2]	Gain from disked corn stubble
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1923	0	0	0	1930	31.8	49.0	17.2
1924	14.5	33.9	19.4	1931	20.2	45.5	25.3
1925	4.1	8.8	4.7	1932	0	0	0
1926	0	0	0	1933	0	0	0
1927	14.6	19.7	5.1	1934	0	0	0
1928	19.1	29.0	9.9				
1929	11.6	14.0	2.4	Average	9.7	16.7	7.0

[1] Series I and III, plots 2 or 3, 11 or 12.
[2] Series II and IV, plots 2 or 3, 11 or 12.

Winter wheat yields after one and two crops of corn, from 3-year rotations in field 42 are compared in table 14. In the 12-year period there were four wheat-crop failures. When crops were produced yields were consistently higher after two than after one crop of corn, averages were 14.7 and 12.1 bushels, respectively. The advantage of 2 over 1 year of corn is a result of more favorable moisture from the former. Corn exhausts moisture less thoroughly than small grain, and cornland usually has more moisture remaining at crop removal time than does small-grain land at harvesttime. The interval after winter wheat harvest allows some moisture to be restored in the upper soil before seeding time. Corn during this period is using moisture, and the surface soil may be too dry for good germination at wheat-seeding time. Imperfect stands occur more frequently on corn ground than after wheat where weeds and volunteer grain are controlled by early tillage. When good stands are obtained, however, wheat has the advantage of a better subsoil moisture supply following corn. Through a series of years the advantages from better stands in one case and from better subsoil moisture in the other tend to equalize each other, and wheat yields after corn and after wheat on early fall tillage have been similar.

TABLE 14.—*Annual and average yields of winter wheat after 1 and 2 years of corn in 3-year rotations in field 42, North Platte Substation, 1923–34*

[See p. 27 for rotation schedules]

Year	After 1 year of corn[1]	After 2 years of corn[2]	Increase by second year of corn	Year	After 1 year of corn[1]	After 2 years of corn[2]	Increase by second year of corn
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1923	0	0	0	1930	41.0	42.1	1.1
1924	19.3	26.3	7.0	1931	22.9	33.6	10.7
1925	4.8	5.0	.2	1932	0	0	0
1926	0	0	0	1933	3.8	5.5	1.7
1927	17.6	21.8	4.2	1934	0	0	0
1928	25.6	29.3	3.7				
1929	9.9	12.8	2.9	Average	12.1	14.7	2.6

[1] Series V and VI, plots 1, 2, and 3 and 10, 11, and 12.
[2] Series V and VI, plots 4, 5, and 6 and 13, 14, 15.

WINTER WHEAT AFTER POTATOES

In field 49 winter wheat was grown on disked potato land in rotation 109 and on disked cornland in rotation 102. These are 3-year rotations, with oats as the crop following wheat. Annual and average yields and increases after potatoes are shown in table 15. The yield averages are similar—17.6 after potatoes and 16.7 after corn. The chief differences are that wheat failed more frequently and also produced more high yields after potatoes. Failures were eight after potatoes and five after corn. Yields above 30 bushels were 6 after potatoes and 4 after corn.

TABLE 15.—*Annual and average yields of winter wheat on disked potato land and cornland, and yearly gains after potatoes in field 49 at North Platte Substation, 1912–34*

[See pp. 25 to 26 for rotation schedules]

Year	Wheat after potatoes, rotation 109	Wheat after corn, rotation 102	Increase, potato over cornland	Year	Wheat after potatoes, rotation 109	Wheat after corn, rotation 102	Increase, potato over cornland
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1912	0	11.8	−11.8	1925	10.0	9.7	0.3
1913	14.5	20.5	−6.0	1926	0	0	0
1914	7.5	8.7	−1.2	1927	15.2	21.2	−6.0
1915	36.3	38.5	−2.2	1928	41.3	28.0	13.3
1916	33.4	36.2	−2.8	1929	21.5	16.0	5.5
1917	0	0	0	1930	52.7	35.0	17.7
1918	0	7.5	−7.5	1931	51.3	26.5	24.8
1919	15.5	22.5	−7.0	1932	0	0	0
1920	29.0	28.8	.2	1933	0	0	0
1921	24.5	20.5	4.0	1934	0	0	0
1922	8.8	9.0	−.2				
1923	0	11.3	−11.3	Average	17.6	16.7	.9
1924	44.0	32.8	11.2				

As potatoes were harvested earlier than corn in these tests, there was more time for moisture storage before winter-wheat seeding time.

Moisture stored during this time may greatly improve wheat yields. On the other hand, when rainfall during this period is light and the soil dry at seeding time, potato land, finely pulverized by cultivation and digging machinery, is less resistant than corn stubble land to soil blowing, which may result in severe injury to poorly established wheat stands. Thus in some years potato land provides more favorable conditions than cornland for producing high wheat yields and in other years greater risks from loss of stands.

WINTER WHEAT AFTER FALLOW

Summer fallowing insures deeper penetration of moisture into the subsoil than has been obtained by any other dry-land tillage method. By keeping the land uncropped and free of weed growth for a crop season part of the moisture that would have been used by plant growth is stored for later use of crops. Usually by the end of a fallow season at North Platte, the soil is moist to its approximate carrying capacity to a depth of 6 feet. Extremes for driest and wettest years have been 3 to 10 feet. On the other hand, cropped soils at seeding time usually carry limited quantities of available moisture below depths greater than 2 or 3 feet.

TABLE 16.—*Length of storage periods, precipitation, inches of water stored, and percentage of precipitation stored in the fallowed plot of the winter wheat tillage series, field 49, at the North Platte Substation, for 20 periods during 23 years, 1912–34*

Period ending—	Time	Precipitation for period	Precipitation stored	
			Inches	Percentage of total
	Months	*Inches*		
August 1912	11	18.2	4.8	26.4
October 1913	14	18.8	2.9	15.4
October 1914	12	18.8	6.2	33.0
July 1915	10	21.5	7.0	28.6
July 1916	12	21.2	1.8	8.5
July 1917	12	16.7	5.0	29.9
September 1921	13	19.2	4.6	24.0
August 1922	13	23.6	7.7	32.6
July 1923	11	21.6	9.0	41.7
July 1924	12	18.5	4.1	22.2
August 1925	13	16.7	2.4	14.4
September 1926	14	18.8	3.5	18.6
August 1927	11	17.9	7.4	41.3
August 1928	12	24.9	6.4	25.7
September 1929	13	17.3	4.8	27.7
August 1930	13	23.5	5.6	23.8
November 1931	14	19.7	6.2	31.5
September 1932	11	19.0	4.9	25.8
September 1933	14	23.3	9.7	41.6
July 1934	12	10.7	2.4	22.4
Average	12.5	19.6	5.3	27.0

The moisture reserves accumulated by summer fallow are important when the needs of crops for certain periods of development exceed the supplies from the usual rainfall of such periods. Summer fallow is not highly efficient on the basis of the amount and proportion of the rainfall of the fallow season that is preserved for later crop use. Its limitations are due to storage or holding capacity and initial water content of the soil and to the nature and distribution of the rainfall. Summer rains frequently fall in hard, dashing showers. The puddling effect on bare soils rapidly reduces the rate of absorption, and runoff losses may be heavy. These may be reduced or prevented by terracing, contour furrowing, and the maximum use of crop residues for surface protection. The greatest unpreventable losses are from evaporation that takes place from surface soils. These are greatest from isolated light showers. Showers of less than one-half inch that fall on warm dry soils seldom contribute anything to soil-moisture storage. Table 6 shows that approximately one-third of the total seasonal rainfall at this station has been in rains of less than one-half inch. Table 16 shows the amount of water stored in the upper 6 feet of soil during 20 summer fallow periods.

FIGURE 5.—Winter wheat after fallow, showing lodging in year of favorable moisture. The yield was at the rate of 51.2 bushels per acre. North Platte Substation, July 4, 1930.

In years of above-normal rainfall and moisture storage, excessive straw growth on summer-fallowed land at times results in heavy lodging. If this occurs when the grain is immature it may interfere with the complete filling and a poor-quality grain results. Severe lodging of wheat on fallow in 1930 is shown in figure 5.

The increase in the water content of this section varied from 1.8 to 9.7 inches, and averaged 5.3 inches. The proportion of rainfall stored varied from 8.5 to 41.7 percent, and averaged 27.0 percent. The low increase in storage in 1916 was due to the high initial moisture content of the soil left by the high rainfall of the previous year. Low storage in 1913, 1925, and 1926 was due to high temperature and high evaporation losses during the summer.

In the Central Plains winter wheat is the leading crop on fallowed land. Its vigorous rooting habit enables it to recover stored moisture from greater depths than most spring-seeded crops. Its fall growth serves as a protection from soil blowing during the winter. At North

Platte, from soil samples collected in April or May live winter wheat roots have frequently been recovered at depths of 6 to 8 feet on fallowed land. By harvesttime moisture reduction has at times taken place at greater depths than this. Under spring-sown grains moisture reduction seldom extends deeper than 5 feet and under corn, 4 or 4.5 feet.

Cultivation of summer fallow in these tests was determined chiefly by the requirements for the control of weeds and volunteer grain for the entire fallow season. The usual practice was to give one or two disking or duckfootings in the fall, repeat in the spring for early weed control, and follow this by plowing June 1 to 15. By this time much of the weed seed had been germinated and later operations with springtooth harrow or duckfoot served the combined purpose of controlling weeds and loosening soil after compaction by rain for better penetration of later moisture and seedbed preparation. Variations from this standard practice were the omission of any tillage before plowing in one case, and the use of listing and listed corn-cultivation machinery to replace plowing and other level cultivation in other cases.

In field 49 winter wheat was grown in 2-year rotations alternating with fallow, and after fallow in 3-, 4-, and 5-year rotations containing other crops. In field 42, 2-year wheat-fallow rotations were used for comparisons of plowing and listing. In a 3-year rotation fallow was followed by two crops of wheat. All field 42 methods were used in four replications.

TABLE 17.—*Annual and average yields of winter wheat in alternate fallow-wheat rotations and after fallow in 2-, 3-, 4- and 5-year rotations in field 49 at North Platte Substation, 1912–34*

[See pp. 25 to 26 for rotation schedules]

Year	Rotation 114	Plots D or E	Rotation 101	Rotation 28	Rotation 120
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1912	5.2	14.8	13.2	13.3	17.0
1913	23.7	26.8	33.7	21.5	12.5
1914	6.8	9.3	8.7	14.5	11.2
1915	30.8	28.0	29.8	21.2	30.5
1916	41.2	30.8	24.5	27.2	36.2
1917	0	0	0	0	0
1918	7.2	12.7	12.5	16.3	0
1919	14.0	25.3	27.8	20.3	25.0
1920	28.8	27.0	31.3	31.2	28.5
1921	21.7	34.0	30.5	38.2	31.3
1922	17.2	21.8	15.7	18.7	25.0
1923	16.3	24.7	30.3	40.3	28.8
1924	46.2	57.0	51.7	58.2	43.7
1925	19.5	29.7	30.5	30.0	22.0
1926	0	4.2	22.8	0	7.0
1927	13.7	32.5	28.2	44.7	21.2
1928	35.3	39.0	61.0	63.0	51.1
1929	21.0	29.0	26.8	37.8	21.2
1930	44.0	52.2	51.2	57.0	50.7
1931	40.7	53.7	53.2	58.5	52.5
1932	0	0	0	0	14.7
1933	9.8	17.5	21.0	31.2	10.7
1934	3.7	13.2	17.8	19.3	8.7
Average	19.5	25.3	27.4	29.1	24.6

Winter wheat yields after summer fallow in field 49 are shown in table 17. In rotation 114 there was no fall tillage and no spring tillage previous to plowing. It is designated as a weedy fallow. In rotation 120 there was no fall tillage, as the sorghum crop preceding fallow occupied the land too late in the fall for weed growth to develop after harvest. With these exceptions tillage of summer fallow was similar for all rotations. A comparison of the 2-year fallow-wheat rotations 114 and D or E shows that with the exception of 1915, 1916, and 1920 the lower yield was from 114, which received no tillage previous to plowing. Weed growth during this period reduced moisture storage, and yields were reduced for 18 of the 21 years in quantities from 2.5 to 23.7 bushels, or an average of 6.8 bushels. The average yield after the weedy fallow was only 3.8 bushels more than the wheat yield after corn (table 12) and 2.6 bushels more than that from continuous wheat on early fall plowing (table 9).

The highest average yield in these comparisons is 29.1 bushels from the 4-year rotation No. 28. This is probably the result of its favorable location on the lower side of the field rather than of any difference between cropping systems. The lowest yield, except from the weedy fallow, was from the 5-year rotation No. 120. This is considered to be the result of the shorter fallow season where the fallow period comes after sorghum instead of a small-grain crop. Although yields were usually depressed by reduced moisture storage from weeds in rotation 114 and a shorter storage period in rotation 120, this reduction was an advantage in exceptional years, such as 1915 and 1916, when yields in the other rotations were reduced by severe lodging and poor filling of grain. No lodging occurred at any time in rotation 114 or 120.

Table 18 shows comparative yields of winter wheat from plowing and listing in 2-year fallow-wheat rotations and for the first crop of winter wheat after listed fallow in a 3-year rotation of fallow and two crops of wheat. The yield averages are practically the same from the 2-year rotations. The somewhat lower yield from the 3-year fallow probably is the result of causes other than differences in preparation of the fallow. With two crops of wheat after fallow any benefits from moisture not used by the first crop would be carried over to the second crop instead of being added to the moisture supply of the next fallow, as in alternate fallow-wheat cropping. The 3.3 bushel lower yield in this 3-year rotation in comparison with that from alternate fallow is practically the same as the gain of the second crop after fallow in comparison with the second crop after corn, as shown in table 11.

TABLE 18.—*Average and annual yields of winter wheat after listed and plowed fallow in field 42 at North Platte Substation, 1923–34*

[See p. 27 for rotation schedules]

Year	Plowed fallow [1]	Listed fallow [2]	Listed fallow [3]	Year	Plowed fallow [1]	Listed fallow [2]	Listed fallow [3]
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1923	30.0	28.3	25.3	1930	46.0	48.0	48.0
1924	46.4	45.4	39.9	1931	53.0	55.5	40.0
1925	21.4	10.3	16.7	1932	0	0	0
1926	14.1	22.7	15.5	1933	19.1	13.2	9.8
1927	25.6	24.3	24.7	1934	7.7	9.4	4.1
1928	62.1	64.2	56.6				
1929	25.4	23.0	22.8	Average	29.4	29.5	26.1

[1] Series II and IV, plots 9 or 10 and 17 or 18; 2-year rotations.
[2] Series I and III, plots 9 or 10 and 17 or 18; 2-year rotations.
[3] Series V and VI, plots 7, 8, or 9 and 16, 17, or 18; 3-year rotations.

In comparing yields after fallow with those from cropping systems that use all the land each year, consideration must be given to the loss of the land for cropping during the fallow year. For equal returns, the fallowed land must produce a yield increase approximately equal to the value of the crop that might have been produced upon it while under fallow. For exact comparisons, any differences in operating costs, amount of seed used, and other expenses should also be given consideration. Under ordinary conditions, the tillage required to maintain a clean fallow is not greatly in excess of that required for the intertilled crop, such as corn or potatoes. Neither do the costs exceed greatly those of thorough early tillage for continuous grain cropping. The increases in tillage costs of the fallow are not infrequently equalized by the saving in costs of seed and by the decreased acreage covered in seeding and harvesting. In the present studies, differences in operating costs are not considered. Yields after fallow are divided by two, hereafter referred to as half-acre yields, for comparison with wheat yields from continuous cropping. For comparisons between winter wheat after fallow and winter wheat after corn, the wheat increase from the former is compared with the corn yield of the latter.

TABLE 19.—*Annual and average yields of winter wheat from continuously cropped land plowed late and early, one-half of annual yields from clean fallow, and gains from one-half acre yields from fallow over yields from continuous cropping late and early plowing from fields 42 and 49 at North Platte Substation, 1912–34*

Year	Late-plowed	Early-plowed	Fallowed, ½ yield [1]	Fallow increase over—	
				Late-plowed	Early-plowed
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1912	7.2	7.7	7.3	0.1	0.4
1913	3.2	3.8	11.8	8.6	8.0
1914	3.3	4.7	5.5	2.2	.8
1915	39.7	39.8	14.8	−24.9	−25.0
1916	23.5	28.3	14.9	−8.6	−13.4
1917	0	0	0	0	0
1918	0	0	5.2	5.2	5.2
1919	19.8	18.3	13.1	−6.7	−5.2
1920	21.2	31.2	14.8	−6.4	−16.4
1921	18.5	19.8	17.2	−1.3	−2.6
1922	4.8	11.2	10.8	6.0	−.4
1923	7.6	15.4	14.3	6.7	−1.1
1924	11.4	42.0	23.1	11.7	−18.9
1925	3.8	4.5	10.7	6.9	6.2
1926	0	0	7.6	7.6	7.6
1927	7.0	18.8	13.3	6.3	−5.5
1928	24.4	30.6	30.4	6.0	−.2
1929	10.7	14.8	12.7	2.0	−2.1
1930	33.4	39.4	24.6	−8.8	−14.8
1931	22.2	23.6	26.7	4.5	3.1
1932	0	0	.5	.5	.5
1933	0	11.1	7.8	7.8	−3.3
1934	0	0	4.5	4.5	4.5
Average	11.4	15.0	12.7	1.3	−2.3
Failures [2]	10	8	3		

[1] One-half of average yield of clean-fallowed plots in fields 42 and 49, as shown in tables 17 and 18.
[2] Yields less than 5 bushels per acre.

Annual and average acre yields of winter wheat from continuously cropped land plowed early and plowed late, half-acre yields after clean fallow, and increases from the latter, are shown in table 19. The yields from fields 49 and 42 are averaged. Those for continuous cropping are those used in table 9 and those for fallow are one-half of the annual average yields of all clean-fallowed plots in the two fields. Whether more or less wheat was produced by fallowing half of the land than by growing wheat continuously was determined by the time of plowing.

In comparison with late plowing, there was an average gain of 1.3 bushels and higher yields from fallow in 16 of the 23 years. In comparison with early plowing, there was an average loss of 3.2 bushels and lower yields from fallowing in 14 of the 23 years. Fallowing did not prevent failure, but the failures (3 years) on fallowed land were 5 fewer than the number on early-plowed land and 7 fewer than the number on late-plowed land (fig. 6). Annual and average

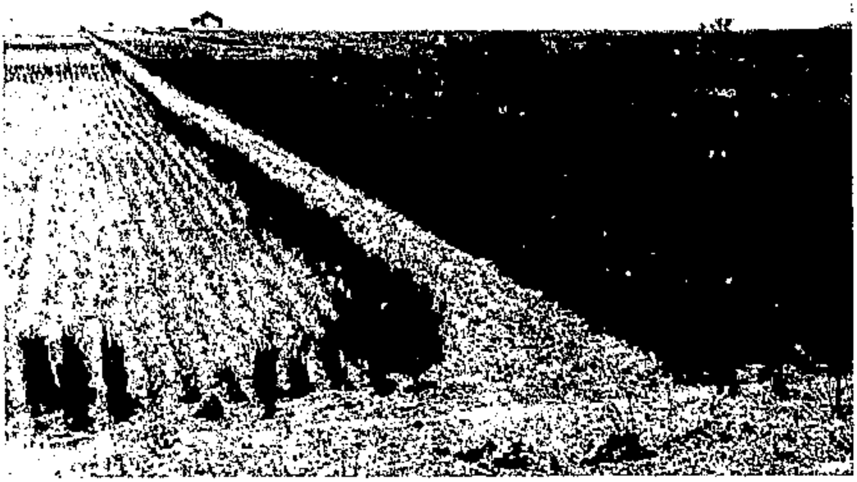

FIGURE 6.—Winter wheat in a very dry year. Left, second crop after fallow, yield 0; right, first crop after fallow, yield 2.3 bushels. North Platte Substation, June 9, 1934.

yields of winter wheat seeded on corn stubble and after fallow, the gains from fallow, and corn yields after wheat are shown in table 20. The yields from 1912 to 1922 are from field 49 only, and from 1923 to 1934 from all plots of the respective treatments in the two fields.

The average yield of wheat after fallow was 8.3 bushels per acre more than the average from seeding on corn stubble. The average yield of corn after wheat was 21.3 bushels to the acre. In other words, for each bushel of wheat gained by fallowing, 2.6 bushels of corn were produced in the rotations where corn preceded wheat. During the years covered, the average local market value of a bushel of wheat was about equal to that of 1.3 bushels of corn. On the basis of production alone, these comparisons indicate that each average bushel of wheat gained by fallowing was obtained at a loss equal to the value of 1.3 bushels of corn.

TABLE 20.—*Annual and average yields of winter wheat after corn and after fallow, gain in yields after fallow, and yields of corn after wheat from fields 42 and 49 at North Platte Substation, 1912–34*

[See pp. 25 to 27 for rotation schedules]

Year	Winter wheat		Gain, fallow over corn land	Corn after winter wheat[3]
	After corn[1]	After fallow[2]		
	Bushels	*Bushels*	*Bushels*	*Bushels*
1912	10.5	14.6	4.1	23.1
1913	17.5	23.6	6.1	0
1914	7.9	10.9	3.0	4.2
1915	36.3	29.6	−6.7	16.1
1916	30.5	29.7	−0.8	15.6
1917	0	0	0	10.0
1918	6.2	10.4	4.2	20.1
1919	22.6	26.1	3.5	34.8
1920	20.2	20.5	.3	43.7
1921	21.3	34.3	13.0	28.0
1922	9.8	21.6	11.8	38.3
1923	1.4	28.6	27.2	51.3
1924	36.1	46.1	10.0	21.1
1925	11.7	21.4	9.7	5.7
1926	0	15.2	15.2	2.3
1927	18.0	26.6	8.6	46.8
1928	30.1	60.8	30.7	35.0
1929	15.8	25.3	9.5	13.0
1930	43.3	49.1	5.8	31.6
1931	33.1	53.4	20.3	14.1
1932	0	.9	.9	7.1
1933	0	15.5	15.5	24.2
1934	0	9.0	9.0	0
Average	17.0	25.3	8.3	21.3

[1] Winter wheat after disked corn stubble, average of all disked plots, table 12.
[2] Average from all clean-fallowed plots, see tables 17 and 18.
[3] Average of all corn yields after winter wheat, fields 49 and 42; 1912–20, 9 plots; 1921–22, 10 plots; 1923–34, 35 plots.

It should be kept in mind that in this comparison winter wheat was grown on corn stubble. As shown in table 13, there was a marked difference in wheat yields from seedings on disked corn stubble and seedings in standing stalks. Yields of winter wheat from seedings in standing cornstalks and after fallow, the increase from fallow, and yields of corn are shown in table 21. In this case, the average increase

TABLE 21.—*Annual and average yields of winter wheat seeded in standing cornstalks and after fallow, increase in wheat yields after fallow, and corn yields after wheat in field 42 at North Platte Substation, 1923–34*

Year	Winter wheat after—		Increase, fallow over corn	Corn after winter wheat
	Corn	Fallow		
	Bushels	*Bushels*	*Bushels*	*Bushels*
1923	0	30.0	30.0	63.3
1924	14.5	46.4	31.9	22.0
1925	4.1	21.4	17.3	6.4
1926	0	14.0	14.0	0
1927	14.6	25.6	11.0	49.6
1928	19.1	62.1	43.0	38.8
1929	11.6	25.4	13.8	17.4
1930	31.8	46.9	15.1	35.4
1931	20.2	53.9	33.7	16.2
1932	0	0	0	7.3
1933	0	19.1	19.1	21.9
1934	0	7.7	7.7	0
Average	[1] 9.7	[2] 29.4	19.7	23.2

[1] From table 13. [2] From table 18.

from fallowing amounted to 19.7 bushels to the acre. The corn yield was 23.2 bushels to the acre. The ratio of increased wheat after fallow to the corn produced on the land where wheat was seeded in the standing stalks was 1 to 1.18. With 1 bushel of wheat equal in value to 1.3 bushels of corn, the fallow-wheat system produced slightly more value than the corn-wheat combination with wheat seeded in the standing stalks.

RESPONSE OF WINTER WHEAT TO MANURE

In field 49, winter wheat was grown in several cropping systems in which green manures or barnyard manure were used as soil amendments. In the 4-year rotations 28, 20, and 91, the cropping sequence after fallow, rye, or peas for green manure was winter wheat, corn, and oats. Rotations 81, 26, and 97 were the same, except that wheat and oats were interchanged so that wheat followed corn and was the third instead of the first crop after the treatments. Tillage preparation for the green manures was early fall plowing followed by surface cultivation to control later growth of weeds and volunteer grain. Fallow was tilled by the standard method for clean fallow described earlier. Rye was seeded and plowed under on the average dates of September 22 and June 7, peas on April 7 and July 1. Tillage after the green manures were plowed under was similar to that for fallow for the same period. Annual and average grain and straw yields of winter wheat immediately after fallow, rye, and peas for green manures are shown in table 22.

TABLE 22.—*Annual and average yields of winter wheat grain and straw after clean fallow (rotation 28), rye green manure (rotation 20), and peas green manure (rotation 91) in field 49 at North Platte Substation, 1912–34*

[See p. 25 for rotation schedules]

Year	Acre yields of winter wheat following—					
	Fallow (rotation 28)		Rye green manure (rotation 20)		Peas green manure (rotation 91)	
	Grain	Straw	Grain	Straw	Grain	Straw
	Bushels	*Pounds*	*Bushels*	*Pounds*	*Bushels*	*Pounds*
1912	13.3	1,920	28.2	3,250	23.8	2,480
1913	21.5	2,880	24.0	2,510	15.5	1,720
1914	14.5	2,130	8.3	1,050	11.7	1,770
1915	21.2	3,460	18.3	2,980	25.3	4,020
1916	27.2	4,470	34.3	4,600	25.3	4,150
1917	0	0	0	0	0	0
1918	16.3	920	16.2	1,230	8.7	1,260
1919	26.3	4,670	33.3	4,100	32.8	4,630
1920	31.2	3,930	28.8	4,570	30.5	4,370
1921	38.2	3,960	35.0	3,350	34.2	4,200
1922	18.7	2,480	24.2	3,150	21.3	2,940
1923	40.3	6,480	34.0	4,010	35.3	5,490
1924	58.2	5,310	57.7	4,840	58.3	6,600
1925	30.0	3,600	26.0	3,040	23.2	3,310
1926	0	0	0	0	0	0
1927	44.7	5,520	38.3	5,500	43.2	4,910
1928	63.0	6,520	55.0	4,700	45.8	4,050
1929	37.8	3,630	33.8	3,970	20.8	3,800
1930	57.0	6,880	54.7	6,720	49.3	6,840
1931	58.5	5,800	47.0	4,080	44.3	5,290
1932	0	0	0	0	0	0
1933	31.2	4,530	31.2	5,130	21.0	4,340
1934	19.3	2,840	14.2	2,200	10.3	2,080
Average	29.1	3,575	27.0	3,372	25.8	3,458

In general, the yields after the green manures were lower than after fallow. For the 20 years in which crops were harvested the yields after fallow and rye were equal in 1 case, higher after fallow 14 times, and higher after rye 5 times. After peas the yields were higher than after fallow 5 times and lower 15 times. The 23-year average after fallow was 1.2 bushels higher than that after rye and 3.3 bushels higher than after peas. The higher yields after fallow were due chiefly to the fact that more favorable moisture conditions occurred following this practice than after the green manures. Use of moisture by the green-manure crops shortened the season for soil-moisture storage and limited the amount accumulated. For the first crop following the treatments the disadvantage of a reduced moisture supply was a more important factor in determining yield than the increase in fertility resulting from use of the green manures.

TABLE 23.—*Annual and average yields of winter wheat grain and straw following corn 2 years after fallow, rye, and peas for green manure in 4-year rotations at North Platte Substation, 1912–34*

[See p. 25 for rotation schedules]

Year	Acre yields of winter wheat 3 years after—					
	Fallow (rotation 81)		Rye green manure (rotation 26)		Peas green manure (rotation 97)	
	Grain	Straw	Grain	Straw	Grain	Straw
	Bushels	*Pounds*	*Bushels*	*Pounds*	*Bushels*	*Pounds*
1912	11.3	1,590	14.8	1,690	6.5	1,100
1913	17.0	1,880	18.0	2,070	12.0	2,030
1914	10.6	1,570	9.3	1,450	9.0	1,460
1915	27.3	3,800	36.5	5,050	36.5	4,680
1916	31.2	3,610	44.2	4,850	47.5	4,900
1917	0	0	0	0	0	0
1918	5.8	1,050	8.5	840	7.0	780
1919	25.8	5,350	24.5	3,330	22.5	4,450
1920	26.3	2,020	20.8	2,510	31.2	3,130
1921	10.8	1,860	21.7	1,700	23.8	1,070
1922	15.7	1,160	10.0	1,300	7.7	1,040
1923	0	0	0	0	0	0
1924	36.7	3,200	39.3	2,840	40.3	3,250
1925	12.7	910	13.5	1,090	11.8	1,190
1926	0	0	0	0	0	0
1927	17.8	2,430	20.7	2,660	16.0	2,440
1928	32.0	2,480	26.2	1,030	33.3	2,700
1929	14.0	960	16.3	1,220	16.5	1,660
1930	40.0	3,300	41.2	3,230	46.5	6,010
1931	30.0	2,700	32.3	5,160	32.7	3,540
1932	0	0	0	0	0	0
1933	0	0	0	0	0	0
1934	0	0	0	0	0	0
Average:						
23 years	16.4	1,744	17.7	1,998	17.4	2,007
8 high years	31.5	3,307	34.3	3,612	36.3	4,114
8 low years [1]	13.0	1,474	13.9	1,657	10.8	1,474

[1] Eight years of harvest yield, excluding complete failures.

As nitrogen is the element of fertility most frequently low in dry-land soils, it would be expected that greater benefits would be derived from a legume than a nonlegume used as a green-manure crop. This does not appear in this comparison between peas and rye. An explanation is again found in moisture. Although rye occupied the land for a longer growth period than peas and may have as great capacity for water use, its earlier maturity and removal leaves a longer period for soil-moisture accumulation. This is especially important, since the 3-weeks' difference in plowing dates occurred in June, which is the month of highest rainfall. During this period the plowed rye land was in good condition to absorb moisture while peas were using moisture during the time of their most active growth. Another advantage of rye over peas in this case was the winter cover protection against soil blowing and washing furnished by rye. This difference could have been reduced by subtilling instead of fall plowing the land for peas.

Annual and average yields of winter wheat after corn in the 4-year rotations where wheat is the third crop after fallow and green manures are shown in table 23. On account of less favorable moisture conditions the yields are greatly reduced and the number of crop failures increased in comparison with those shown in table 22. The differences in wheat yields were not great, but these differences were generally somewhat higher from the green-manured than from the fallow rotations. Also with moisture conditions on a more nearly common level, peas made a more favorable showing when compared with rye as a green manure.

The differences are greater for straw than for grain, indicating the tendency for stimulated vegetative growth to exhaust soil moisture at the expense of complete development of grain. The effects of green manure crops in relation to moisture are more clearly shown by separating annual yields into high and low groups. There were 8 years in which wheat yields the third year after fallow were above 25 bushels per acre. There were 8 years in which all yields were below 20 bushels, 5 in which they were below 15 bushels. The 8-year average yields of the two groups are shown at the bottom of table 23. Obviously moisture was a more severely limiting factor in the second than in the first group. In the high-yielding group the average yields from the green-manured rotations were well above the average from the fallow rotation and the highest average yield of both grain and straw is from the rotation in which peas were used for green manure. On the other land for the low-yielding group the differences for the various rotations are small, except that the lowest average grain yield is from the rotation in which peas were the green-manure crop. The contrasting results indicate that high fertility is an advantage only when there is adequate moisture for complete crop development and may be a disadvantage under conditions of severe moisture shortage. Plowing under rye in an extremely dry year is shown in figure 7, and plowing under peas in a good year is shown in figure 8.

A further example of the effect of fertility levels on winter wheat grain and straw yields in relation to moisture is furnished by rotation 115. No crops were harvested from the two plots for the 10 years 1912 to 1921. Plot A was clean-fallowed. On plot B a crop of rye was grown and plowed under each year. Determinations of total carbon and nitrogen made at the end of this period are shown in table 24.

From 1922 to 1934 the plots were early fall-plowed and seeded to winter wheat. The 1922 yield is omitted on account of the difference in moisture conditions on the fallowed and cropped land. Grain and straw yields, arranged in ascending order of yields from the A plot, and precipitation for 12 months or wheat-crop-year periods ending

FIGURE 7.—Plowing under rye for green manure in an extremely dry year. No heads, except near cultivated alley. May 1934.

FIGURE 8.—Plowing under field peas for green manure in a good year. June 27, 1930.

June 30 are shown in table 25. Average precipitation for the 12-year period of 18.3 inches is practically equal to the long-time average at North Platte. Crop-year amounts ranged from 11.8 to 24.7 inches. In the severely dry years 1926, 1932, and 1934, with crop-year precipitation less than 14 inches, the wheat crops were total failures.

TABLE 24.—*Total carbon and nitrogen in adjacent plots of rotation 115 after 10 years of clean fallow or 10 crops of rye for green manure, North Platte Substation, 1912–21* [1]

[See p. 26 for rotation schedule]

Plot	Treatment	Depth	Total carbon	Total nitrogen
		Inches	*Percent*	*Percent*
A	Fallow	0–6	0.803	0.130
		6–12	.900	.115
B	Green-manure rye	0–6	1.428	.158
		6–12	1.114	.132

[1] Determinations by Oswald Schreiner, Bureau of Chemistry and Soils, 1922.

TABLE 25.—*Annual and average yields of winter wheat grain and straw after 10 years of fallow and rye green manure, arranged in ascending order of yields after fallow; and seasonal and average rainfall for 12-month period ending June 30 at North Platte Substation, 1923–34*

[See p. 27 for rotation schedules]

Year	Acre yields of winter wheat after—				Precipitation, year ending June 30
	10 years fallow, plot A (rotation 115)		10 years rye, green manure, plot B (rotation 115)		
	Grain	Straw	Grain	Straw	12 months
	Bushels	*Pounds*	*Bushels*	*Pounds*	*Inches*
1926	0	0	0	0	12.8
1932	0	0	0	0	13.3
1934	0	0	0	0	11.8
1925	6.7	600	2.3	660	16.9
1933	12.0	680	10.5	870	18.7
1929	17.7	1,790	14.8	2,010	19.2
1923	17.8	2,230	11.3	3,520	20.7
1931	19.0	1,960	16.3	2,520	18.5
1927	19.3	1,840	18.2	2,710	20.7
1928	24.2	1,750	28.3	2,300	18.4
1924	29.8	2,310	32.2	3,570	20.9
1930	33.3	2,700	45.5	4,720	24.7
Average	15.0	1,322	15.0	1,907	18.3

For the 5 years 1925, 1933, 1929, 1931, and 1927, precipitation was in the 17- to 21-inch range. Plot A yields ranged from 6.7 to 19.3 bushels. In all cases grain yields were higher on the less fertile A plot and straw yields were higher on the more fertile B plot. The year 1923 also falls within this group, as a large part of the higher precipitation of that year came too late in the season to benefit the crop. The three years 1928, 1924, and 1930 were unusually favorable for wheat production on cropped land. Precipitation for the crop year was normal or above and favorably distributed. The response to high fertility was positive. Both grain and straw yields from plot B were substantially higher than those from plot A. Under favorable moisture conditions increased vegetative growth was able to mature a correspondingly higher yield of grain. For the 12-year period average grain yields on the two plots were identical. Higher grain yields from the less fertile plot under approximately average moisture conditions were balanced by the higher yields from the more fertile plot under favorable conditions. Straw yields were uniformly higher from the more fertile soil.

Plots B and C in the winter wheat tillage series in field 49 furnished limited information on the effect of barnyard manure on winter wheat. The two plots lay side by side and were given the same tillage treatments. They were continuously cropped to winter wheat, and preparation for the succeeding crop consisted of plowing as soon as possible after each crop was removed. Plot C was given a light top dressing of barnyard manure late in fall of each year to determine the effect of such protection on winter survival. There was no apparent benefit on survival from this treatment. The repeated applications of manure, however, resulted in a growth stimulation. Annual and average grain and straw yields are shown in table 26.

TABLE 26.—*Annual and average grain and straw yields of winter wheat on continuously cropped land, with and without top dressing with barnyard manure in field 49 at North Platte Substation, 1912–34*

[See p. 26 for rotation schedules]

Year	Acre yields of winter wheat			
	No manure, plot B		Manure, top dressing, plot C	
	Grain	Straw	Grain	Straw
	Bushels	*Pounds*	*Bushels*	*Pounds*
1912	7.7	1,120	0.3	1,220
1913	3.8	600	2.2	540
1914	4.7	1,330	4.5	2,000
1915	39.8	4,200	31.2	4,720
1916	28.3	3,280	31.3	3,820
1917	0	0	0	0
1918	0	0	0	0
1919	18.3	2,800	10.5	4,210
1920	31.2	3,630	26.0	3,840
1921	19.8	1,300	21.3	2,890
1922	11.2	1,330	10.3	2,180
1923	17.8	3,030	16.3	3,520
1924	53.8	4,670	51.8	5,400
1925	6.0	940	2.8	1,030
1926	0	0	0	0
1927	20.8	2,550	15.7	2,060
1928	35.0	2,500	32.5	3,050
1929	16.2	1,830	15.3	1,130
1930	38.2	3,910	37.3	7,660
1931	23.2	2,610	0.3	2,700
1932	0	0	0	0
1933	12.2	1,570	13.0	2,220
1934	0	0	0	0
Average	16.9	1,885	15.2	2,390

During the 23-year period there were 5 total failures and 18 crops were harvested. The higher yield of straw was from the manured plot with 2 exceptions. The higher grain yield was from the unmanured plot with only 4 exceptions. The average grain yields from the manured and unmanured plots were 15.2 and 16.9 bushels, respectively, and straw yields were 2,390 and 1,885 pounds. In this case a light application of barnyard manure applied late in the fall on winter wheat incrased straw production 26 percent and decreased grain production 11 percent.

The 3-year rotations 102 and 103 contained oats, corn, and winter wheat. Tillage in the 2 rotations was similar, except that in rotation 102 the corn stubble was not disked for winter wheat in 5 of the 23 years (see table 12) and wheat in rotation 103 received a light top dressing of barnyard manure late in the fall. The rotations were not adjacent but separated by 4 intervening plots. The yields of grain and straw are shown in table 27. As manure was applied to the same ground only once in 3 years, its accumulating effect was slower than on the continuously cropped plot C (table 26) and the grain and straw yields were less affected. There were 5 years of wheat failure in the rotation without manure and 6 in the rotation with manure. The higher yield of straw was produced on the manured plot 13 times and on the unmanured plot 5 times. The 23-year average yield of straw was 86 pounds to the acre greater on the manured than on the unmanured plot. Vegetative growth was not sufficiently stimulated to depress grain yields, the difference being only 0.6 bushel to the acre and in favor of the manured rotation. The higher grain yield was on the manured plot 12 years and on the unmanured plot 6 years.

TABLE 27.—*Annual and average yields of winter wheat grain and straw after corn in 3-year rotations; not manured, 102, manured, 103, in field 49, at the North Platte Substation, 1912–34*

[See p. 25 for rotation schedules]

Year	Acre yields of winter wheat			
	Not manured, rotation 102		Manured, rotation 103	
	Grain	Straw	Grain	Straw
	Bushels	*Pounds*	*Bushels*	*Pounds*
1912	11.8	1,600	14.2	1,870
1913	20.5	2,310	13.5	1,620
1914	8.7	1,440	4.8	1,960
1915	38.5	4,480	40.0	4,730
1916	36.2	3,920	42.3	4,210
1917	0	0	0	0
1918	7.5	850	5.3	480
1919	22.5	3,800	23.3	3,200
1920	28.8	2,770	33.5	3,140
1921	20.5	1,620	18.5	1,740
1922	9.0	2,160	10.3	1,950
1923	11.3	1,720	0	0
1924	32.8	2,030	36.8	2,490
1925	9.7	820	10.3	1,080
1926	0	0	0	0
1927	21.2	2,130	22.2	2,470
1928	28.0	1,920	32.3	2,360
1929	16.0	1,540	11.7	2,300
1930	35.0	3,500	40.3	4,520
1931	26.5	2,610	32.0	2,980
1932	0	0	0	0
1933	0	0	0	0
1934	0	0	0	0
Average	16.7	1,789	17.3	1,875

SPRING WHEAT

Except in limited areas and occasionally for reseeding when winter wheat is abandoned, spring wheat is of minor importance in Nebraska. By the time land has been prepared and spring wheat has been seeded and germinated, winter wheat usually has gained considerable headway. This advantage, which under normal conditions continues until harvest, enables the winter wheat to complete its growth and mature earlier and therefore under more favorable temperature conditions than usually prevail later. On this account, when the survival of winter wheat is good, its yields are usually higher. At this station for the 23-year period 1912–34, a comparison of the averages for all methods of tillage given in table 8, shows that the yield of spring wheat was 76 percent of that of winter wheat. Improvement of earliness and yield of spring wheat, and at the same time a greater than normal abandonment of winter wheat, has to some extent reduced the lead of winter over spring wheat in recent years.

The varieties used were Kubanka durum from 1907 to 1928 and Ceres from 1929 to 1934.

TABLE 28.—*Annual and average yields of spring wheat after different crops and fallow land and tillage methods in field 41 at North Platte Substation, 1907–34*

[See pp. 21 to 25 for rotation schedules]

Year	Acre yields of spring wheat following—						
	Corn			Small grains		Sorgo	Fallow [7]
	Spring-disked [1]	Spring-plowed [2]	Fall-plowed [3]	Spring-plowed [4]	Fall-plowed [5]	Spring-plowed [6]	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1907	21.5	23.7	22.5	20.8	26.2	23.5	29.0
1908	24.2	21.0	28.7	17.6	29.0	20.3	41.3
1909	14.7	17.2	21.3	16.7	15.8	16.3	22.8
1910	7.3	5.2	7.6	8.7	6.7	8.7	10.3
1911	0	0	0	0	0	0	0
1912	4.0	5.3	6.4	8.8	6.9	3.8	9.9
1913	3.0	1.6	4.1	1.8	1.4	3.3	8.7
1914	5.1	5.0	6.5	2.2	5.8	5.2	12.8
1915	28.6	22.3	27.0	26.6	20.0	25.5	28.0
1916	10.5	17.0	18.5	14.5	17.8	13.3	18.4
1917	5.9	5.8	4.4	5.5	6.0	5.7	10.0
1918	3.0	2.2	4.2	2.3	3.2	6.2	17.5
1919	10.1	12.0	12.1	17.0	14.3	12.7	10.8
1920	15.3	16.2	19.3	18.5	17.8	21.3	21.0
1921	8.4	11.5	11.6	5.7	10.7	4.3	18.5
1922	3.3	1.3	4.4	3.8	4.3	4.3	11.0
1923	10.7	10.7	18.4	18.2	20.3	16.7	21.5
1924	14.5	15.5	15.8	14.6	21.8	9.7	22.2
1925	7.2	5.0	6.0	7.3	7.0	6.3	20.6
1926	0	0	0	0	0	0	10.8
1927	18.6	17.7	16.7	18.5	17.1	13.8	20.3
1928	21.1	24.8	20.2	17.2	30.1	20.7	34.4
1929	11.0	14.2	14.1	12.0	20.1	9.3	24.7
1930	26.9	27.0	26.4	17.2	28.1	23.5	27.2
1931	15.0	16.5	17.9	12.2	20.0	11.0	20.6
1932	5.8	6.0	7.0	6.5	5.8	5.3	25.4
1933	11.9	14.7	14.9	11.0	14.6	9.7	16.5
1934	0	0	0	0	0	0	3.4
Average	12.1	11.8	12.7	10.9	13.5	10.7	19.1

[1] Rotations 1, 14, 16, 19, 41, 42, 44, 49.
[2] Rotation 2.
[3] Rotations 3, 43.
[4] Rotation 9.
[5] Rotations 4, 8.
[6] Rotation 48.
[7] Rotations 5, C or D.

Spring wheat yields on disked, spring-plowed, and fall-plowed corn stubble land after small grain on spring and fall plowing, after sorgo on spring plowing, and on summer fallow are shown in table 28 for field 41. On cropped land yield differences due to crop sequence and tillage were not great. No crops were harvested on cropped land in the years 1911, 1926, and 1934. All cropped land yields were below 5 bushels in 1913 and 1922. Following corn, average differences in yields as a result of tillage methods were less than 1 bushel. Fall plowing produced the highest yields, disking the next highest, and spring plowing produced the lowest yields. After small grain there was an average difference in yield of 2.4 bushels in favor of fall plowing. In this case an advantage is gained by plowing early and preventing loss of moisture from weed growth that occurs on land left for spring plowing. The lowest average yield was on spring plowing after sorgo.

The low yield in this case is due to the late growth of the sorgo crop and its thorough exhaustion of soil moisture.

After fallow there was only one complete spring wheat failure, and but three yields were under 10 bushels. In the drier years, yields after fallow were generally more than double the yields on cropped land. The average yield of 19.1 bushels after fallow was less than double that on cropped land, and on the basis of these tests greater stabilization of yields was obtained at the expense of somewhat less total production.

Spring wheat yields from field 49 are shown in table 29. Preparations included plowing under of peas and rye for green manures and fallow treatment in 4-year rotations and after potatoes in a 3-year rotation. In these rotations yields were influenced greatly by location. Rotation 15, with spring wheat following rye for green manure, was on the lowest corner of the field and this plot at times received runoff water from land above it. The consistently higher yield from rotation 15 was without doubt due more largely to this moisture advantage than to any other cause. Rotation 17 with peas for green manure and rotation 18 with fallow before the wheat crop were in comparable locations. The higher yield after fallow was due to better moisture storage after the fallow. That is, any advantage from increased fertility from plowing under the peas was more than offset by the moisture used in their growth and lost to the wheat crop. Rotation 108 with potatoes preceding the wheat crop was located at considerable distance from the other rotations. The average yield of 14.9 bushels of spring wheat after potatoes was somewhat greater than spring wheat yields after corn, as is shown in table 28.

TABLE 29.—*Annual and average yields of spring wheat after crops and fallow and tillage methods in field 49, at North Platte Substation, 1912–34*

[See pp. 25 to 26 for rotation schedules]

Year	Acre yields of spring wheat after—			
	Rye, green manure [1]	Peas, green manure [2]	Fallow [3]	Potatoes [4]
	Bushels	*Bushels*	*Bushels*	*Bushels*
1912	14.2	4.8	1.7	5.2
1913	3.2	1.3	3.0	4.2
1914	8.7	5.0	11.8	0.9
1915	15.8	23.7	24.2	24.5
1916	18.3	13.7	10.7	17.0
1917	13.5	6.7	9.3	11.3
1918	13.5	3.5	10.5	7.7
1919	14.3	7.0	7.8	12.2
1920	24.0	19.3	21.2	20.0
1921	17.2	13.8	12.8	16.3
1922	32.8	4.2	13.5	10.3
1923	25.5	14.0	18.8	21.8
1924	25.5	16.3	23.0	22.7
1925	18.7	13.8	14.3	8.0
1926	7.5	0	2.7	0
1927	32.2	18.5	10.7	22.0
1928	33.0	16.7	33.0	25.0
1929	31.0	21.8	25.8	24.8
1930	26.7	22.2	30.3	29.8
1931	28.8	17.2	20.5	20.0
1932	27.0	5.0	28.3	10.0
1933	20.2	18.0	14.8	17.7
1934	7.5	2.2	5.0	0
Average	20.0	11.7	16.0	14.9

[1] Rotation 15.
[2] Rotation 17.
[3] Rotation 18.
[4] Rotation 108.

OATS

The record of oats production in the central Plains has been one of occasional good crops, numerous mediocre yields, and a considerable number of failures. The crop generally has been among the least profitable of the extensively grown small grains. An acreage unjustifiable by its performance has been maintained on account of the popularity of both grain and straw for feed and the ease with which it is handled in harvesting and threshing. Varietal improvement has been an important factor in maintaining acreages. Earlier maturing, higher yielding, and more drought-resistant varieties and selections have been introduced from time to time and have replaced less well-adapted sorts. These changes have reduced the spread between oats and some of the other small grains, but the crop still remains relatively unprofitable. Grasshopper injury is another heavy handicap suffered by oats. The open heads and slender exposed pedicels permit the kernels to be clipped off easily, and losses from this source frequently run into high percentages.

As in the agriculture of the surrounding territory, oats were given a more prominent place in the crop rotations at this station than the results have justified. In field 41 oats were used on 23 plots for 28 years, in field 49 on 20 plots for 23 years and on 3 additional plots for 14 years, and in field 42 on 16 plots for 12 years. The seedbed preparations included disking, spring plowing, early fall plowing, late fall plowing, green manuring, and fallow. Preceding intertilled crops were corn and potatoes; drilled annual crops included continuous oats, spring wheat, winter wheat, barley, and sorgo. Sod crops were bromegrass and alfalfa. Rotations varied in length from 2 to 6 years. Seed used was standard Kherson from 1907 to 1915, and Nebraska 21, 1916–34.

Results from the three fields and from similar treatments and crop sequences are shown in table 30. All yields previous to 1912 and those after sod crops, green manures, and sorgo were from field 41. Yields after small grains were averages of all plots with similar treatments in fields 41 and 49 from 1912 to 1922 and included yields from field 42 beginning with 1923. Yields after fallow were from fields 41 from 1907 to 1934, and field 49, 1912–34. The sequence most frequently low and with the lowest average yield was oats after alfalfa. In only two very favorable years, 1915 and 1924, were the yields of oats from this rotation above those on early-plowed land after small grain or those following intertilled crops. The early growth of oats after alfalfa was usually luxuriant, but limited moisture as the oats approached maturity except in the most favorable years resulted in deterioration. Oats after alfalfa in dry and in wet years are shown in figures 9 and 10.

During 9 years, that is practically 1 out of 3, yields of oats after alfalfa were under 5 bushels per acre. Crops were complete failures in 4 of these years.

The next lowest average yields were after bromegrass and sorgo and on spring plowing after small grain. After bromegrass and sorgo, there was less stimulation of early growth than after alfalfa. and yields in some of the poor years were not so low. On spring-plowed land after small grain, yields were not so high in favorable years as from the treatments just considered, but the average was main-

[illegible] 9.—Oats in a dry year. Foreground, following alfalfa, yield 0.0 bushels; [illegible] yield 22.8 bushels to the acre. North Platte Substation, July 1918.

[illegible] 10.—Oats in a good year. Right foreground, following alfalfa, yield 48.1 [illegible], yield 70.6 bushels to the acre. [illegible] shown in a dry year in figure 9. North Platte Substation, [illegible] tained by a greater number of better intermediate yields. Annual and average yields from fall plowing after small grain and following intertilled crops were similar and from about 4 to 6 bushels per acre above the yields after the sod crops, sorgo, and spring plowing after small grain. These gains were due to better moisture conditions resulting from control of weeds after harvest where early plowing was practiced after small grain and from less complete moisture exhaustion by intertilled crops.

TABLE 30.—*Annual and average yields of oats following different crop sequences and tillage treatments at North Platte Substation, 1907–34*

[See pp. 24 to 27 for rotation schedules]

Year	Acre yields of oats after—							
	Alfalfa, fall-plowed [1]	Brome-grass, fall-plowed [2]	Sorgo, spring-plowed [3]	Small grains		Corn and potatoes, spring-plowed or disked [6]	Rye and peas green manure [7]	Fallow [8]
				Spring-plowed [4]	Fall-plowed [5]			
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1907	24.1	22.2	29.7	32.8	30.5	36.5	28.4	34.3
1908	36.6	40.0	45.0	43.2	60.2	48.5	74.8	87.0
1909	14.4	16.6	28.8	32.2	23.6	28.3	25.5	28.0
1910	2.5	4.7	8.1	12.1	7.9	12.1	15.5	26.2
1911	0	0	0	0	0	0	0	0
1912	12.5	7.2	12.5	18.7	11.1	10.3	12.0	19.1
1913	0	0	0	0	0	0	0	0
1914	7.2	5.6	7.8	7.7	9.5	9.5	9.8	13.6
1915	73.4	63.4	72.2	59.2	64.4	62.6	60.7	70.9
1916	30.3	31.6	30.6	31.3	36.9	49.1	38.3	47.7
1917	.3	.3	4.4	5.3	5.5	11.4	11.1	20.4
1918	.9	1.3	9.8	4.9	4.8	9.5	6.2	23.1
1919	15.8	30.3	27.5	41.3	37.7	41.2	35.0	46.5
1920	32.2	40.0	42.2	39.8	37.2	41.9	43.4	45.6
1921	7.8	15.0	10.9	12.2	16.1	20.5	23.7	25.6
1922	3.4	5.0	12.8	10.1	14.6	20.9	16.2	28.2
1923	37.2	48.8	48.8	48.3	57.6	52.9	66.7	71.2
1924	55.6	49.7	35.3	31.9	54.7	48.9	60.5	72.2
1925	4.4	13.1	8.4	13.8	14.2	14.7	34.2	39.0
1926	0	0	0	0	0	2.6	0	20.8
1927	26.9	33.1	24.4	29.7	35.0	39.7	47.9	46.8
1928	42.8	59.7	40.3	38.2	57.7	51.2	59.7	85.1
1929	12.5	31.6	16.3	21.4	34.8	31.3	39.4	49.4
1930	48.1	55.0	50.3	42.3	60.6	61.3	65.6	60.7
1931	16.9	28.4	28.1	24.2	34.6	33.9	35.3	41.4
1932	5.6	7.8	15.0	7.3	10.6	17.3	24.5	41.0
1933	19.1	18.8	22.2	14.1	20.6	21.3	25.0	20.5
1934	0	0	0	0	0	0	3.9	5.3
Average	19.1	22.5	24.6	22.2	26.5	28.1	31.4	38.4

[1] Rotation 42.
[2] Rotation 41.
[3] Rotation 47.
[4] Rotations 2, 48, CC–A, I–7 and –15, III–7 and –15.
[5] Rotations 1, 3, 5, 6, 43, 101, 102, 103, 411, 412, 414, II–7 and –15, IV–7 and –15.
[6] Rotations 4, 7, 9, 16, 17, 18, 20, 28, 91, 104, 105, 106, 107, 120, 131.
[7] Rotations 14, 16, 26, 45, 46, 97.
[8] Rotations 8, 19, 50, C or D, 81.

On fallowed land many good and few poor yields were obtained. Yields exceeded 85 bushels per acre twice and 70 bushels five times. There were only 2 years of complete failure, and 3 additional years with yields below 20 bushels per acre. The increase in yield from fallowing was not sufficient, however, to make up for the loss in use of the land during the fallow years. In only 7 years were the yields after fallow double or more than double those from some one or all of the methods used for annual cropping. This is a frequency of 1 year out of 4. On the basis of average yields, one-half of the yield after fallow was 7.3 bushels, or 28 percent, less per acre than the yield on early plowing after small grain and 8.9 bushels, or 32 percent, less than the yield after intertilled crops.

The average yield of oats after fallow was 10.3 bushels per acre more than the yield following corn and potatoes. The yield of corn on early fall plowing after small grain was 19.3 bushels per acre (see table 33). Using these yields to compare fallow-oats with corn-oats sequences, each bushel of oats gained by the former was offset by 1.9 bushels of corn gained by the latter.

The response of oats to green manuring was less favorable than the response to fallowing. The average yield after green manures exceeded that after fallow in only 2 years, 1927 and 1930. The average yield of 31.4 bushels after green manure was 7.0 bushels per acre less than the average after fallow.

The difference between the effects of rye and peas for green-manure crops was within the limits of error. The yields of oats were somewhat better after peas than after rye in field 41, and the reverse was true in field 49.

The yields of oats were depressed rather than increased by the use of barnyard manure in one 3-year rotation (No. 43, field 41). The manure was applied on wheat stubble before plowing in the fall in preparation for oats. An adjacent rotation, No. 3, was similar in crops and tillage but with no manure. The 28-year average yields were 25.3 and 27.9 bushels per acre, respectively. The higher yield of oats was from the manured rotation 6 times and from the unmanured rotation 18 times.

Barley

In the central Plains during the past 10 to 20 years, the increase in acreage of barley has not been equaled by that of any other spring grain crop. In Nebraska, the acreage ratio of barley to oats has increased from about 1 to 6 in 1920–25 to the present ratio of nearly 1 to 3. In some sections, barley exceeded oats in acreage and quite generally outyielded oats in pounds of hull-free grain per acre.

Barley was less extensively used in the crop rotations at this station than would have been justified by its importance in the region. Barley was seeded for the 28 years, 1907–34, in field 41 in one 3-year rotation on disked cornland and in one 3-year rotation on spring plowing after oats, on continuously cropped land spring-plowed and early fall-plowed, and in alternation with fallow. In field 49, barley was used for the 14 years, 1921–34, in 2-, 3-, and 4-year rotations on disked cornland and disked milo land; and in 3-year rotations on disking after oats, and spring plowing and early fall plowing after rye and after fallow. Yields are shown in table 34. From 1907 to 1920, the yields were from field 41. For the period 1921–34, plots having similar treatments in the two fields were combined and the average yields used.

Barley was a total failure in 1911 on all methods of preparation, and in 1926 and 1934 on all methods except fallow. After small grains fall plowing produced higher yields than spring plowing 16 times and lower yields 9 times. The 28-year average was 4.4 bushels higher for fall plowing. For the 15-year period 1921–34, the higher yield was from fall plowing 12 times and from spring plowing 2 times, the average difference being 7.5 bushels. Disking after small grain represented by one plot only for the 14 years 1921–34 produced about the same as spring plowing for that period.

TABLE 31.—*Annual and average yields of barley from different crop sequences and tillage treatments at North Platte Substation, 1907–34*

[See pp. 24 to 26 for rotation schedules]

Year	Acre yields of barley following—					
	Small grains			Corn, disked [4]	Milo, disked [5]	Fallow [6]
	Spring-disked [1]	Spring-plowed [2]	Early fall-plowed [3]			
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1907		39.5	40.0	30.0		39.0
1908		21.0	43.3	24.8		67.7
1909		20.0	10.4	21.5		23.8
1910		14.0	12.5	7.9		26.0
1911		0	0	0		0
1912		20.4	14.0	12.3		20.0
1913		6.4	5.0	5.0		16.5
1914		4.5	11.0	5.2		20.8
1915		38.4	44.2	25.4		39.6
1916		25.7	33.3	20.2		30.8
1917		11.0	8.8	18.1		35.0
1918		8.0	0.9	7.1		21.3
1919		31.2	26.3	38.1		44.0
1920		25.3	28.8	11.0		30.0
1921	17.1	9.1	25.4	21.7	16.9	35.9
1922	5.0	13.7	11.5	0.0	0.0	12.0
1923	31.5	33.3	26.7	29.0	29.5	40.3
1924	23.5	10.0	44.6	27.5	17.8	48.2
1925	6.0	8.6	10.4	11.0	11.4	27.6
1926	0	0	0	0	0	8.6
1927	30.0	30.5	33.2	35.6	32.3	37.3
1928	25.6	33.4	48.7	30.1	30.9	60.1
1929	18.3	17.5	30.3	20.2	19.2	45.8
1930	38.3	27.2	42.5	34.7	30.7	44.2
1931	15.8	14.6	28.6	21.3	16.4	26.4
1932	3.8	3.1	3.5	3.3	3.3	29.0
1933	9.0	13.4	23.4	13.4	11.2	23.2
1934	0	0	0	0	0	3.2
Average:						
28 years		17.5	21.9	17.9		31.1
14 years	16.6	16.0	23.5	18.9	16.8	32.0

[1] Rotation 411.
[2] Rotations 7, 417, CC–A. CC designates continuous cropping.
[3] Rotations 415, CC–B. CC designates continuous cropping.
[4] Rotations 6, 60, 409, 410, 416.
[5] Rotations 408, 412, 413, 601.
[6] Rotation 414, C or D.

On disked cornland barley made a relatively poorer showing than other grain crops on that preparation. For the 28-year period yields on disked cornland and on spring plowing after small grain were about equal. For the 14-year period the difference was 2.9 bushels in favor of the cornland. After corn, barley yields averaged 2.1 bushels more per acre than after milo.

After fallow, barley failed completely in only 1 of the 28 years. There were only 2 yields below 10 bushels and 4 yields below 20 bushels to the acre. The yields of barley after fallow were double or more those after small grain 9 times when the preparation of the latter was fall plowing and 13 times when the preparation was spring plowing, and double or more those on disked cornland 11 times. One-half of the 28-year average yield of barley after fallow was 6.3 bushels per acre less than the average yield on early plowing after small grain. The average loss from fallowing is offset to some extent by the greater stability of yields from this method during dry years. Failures and low yields tend to increase prices, and moderate yields at such times may have more value than higher yields with lower prices.

The 28-year average yield of barley after fallow was 13.2 bushels more to the acre than the yield on disked cornland. The yield of corn on fall plowing after small grain was 19.3 bushels to the acre (table 33). Using these yields to compare fallow-barley with corn-barley practice sequences and treatments, each bushel of barley gained by the former practice was offset by 1.5 bushels of corn gained by the latter practice.

Winter Rye

The chief values of winter rye are its superior winter hardiness, adaptation to sandy soils, and ability to furnish pasture in fall and late spring when many other plants are dormant. On the better hardland soils, rye is less productive than winter wheat and is not usually grown there except for pasture or under conditions where wheat is less apt to survive. Rye and corn are the chief annual crops grown in the Nebraska sand hills. Rye is usually seeded in the standing cornstalks, and corn is listed into rye stubble. In this way, maximum protection is obtained against soil blowing. The market price of rye is usually well below that of winter wheat and often below that of corn. As it has a feed value approximately equal to these grains when fed in mixtures with other grains, it should be used more extensively for feed on the farms than as a market crop.

At this station, rye was used as a green-manure crop in comparison with field peas and fallow. The yields of crops after rye for green manure were usually higher than those after peas for green manure. This was due to more favorable moisture conditions after rye. Its early development allows it to be plowed under several weeks before peas, and the additional length of the fallow period after plowing permits a longer time for moisture accumulation. On the other hand, less moisture was stored after rye green manure than during a full season of fallow. That the difference in moisture was of greater importance than the increased fertility supplied by the green manure was indicated by greater crop yields after fallow than following either of the green-manure crops.

Winter rye was one of the crops grown in five crop rotations in field 49 from 1921 to 1934 (table 32). Previous cultural treatments were as follows: Disking after barley on one plot, fall plowing after barley on two plots, disking after corn on one plot, and fallowing on one plot. The average date of fall plowing barley stubble was August 11, and of disking, September 9. The later date for disking, which permitted greater use of moisture by weed growth than after plowing, was probably a greater factor in reducing yields than the difference in manner of tillage. Average yields were 11.4 bushels on disking and 14.5 on plowing. The yield on disked cornland was 11.8 bushels, or only slightly more than for disking after barley. The 27.1 bushels average yield of rye after fallow was more than double the average yield from cropped land, indicating that rye like winter wheat is able to make good use of stored moisture. A plot of rye on fallowed land is shown in figure 11. Average yields of winter rye ranged from 75 to 85 percent of the yield of winter wheat following similar preparations, for the 14-year period 1921–34.

FIGURE 11.—Winter rye on fallowed land in a dry year, showing heavy straw growth and [illegible] grain. Yield [illegible] bushels per acre. North Platte Substation, June 1925.

TABLE 32.—*[illegible] in different crop sequences and [illegible] North Platte Substation, 1921-34*

Year	[illegible]	[illegible]	Corn ground	Fallow
[illegible]	[illegible]	[illegible]	16.8	[illegible]
[illegible]	[illegible]	[illegible]	8.2	28.2
[illegible]	[illegible]	[illegible]	10.4	[illegible]
[illegible]	[illegible]	[illegible]	15.9	[illegible]
[illegible]	[illegible]	[illegible]	16.7	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	22.2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

CORN

Corn is the principal intertilled crop grown in the central Plains. Under certain rainfall conditions it is produced successfully on both hardland and sandy soils. It is the chief crop with which small grains are rotated and supplies the most economical preparation for their seeding. Listing is the usual method of planting. This method requires a minimum of preparation and tillage. It also retards too rapid early growth, and the smaller plants that have not used excessive moisture in vegetative growth have a better chance to mature grain on a limited moisture supply. Where corn is followed by winter wheat, the most common method of seeding the wheat is drilling between the rows of standing corn. Limited areas are drilled on corn stubble after the corn is removed for ensilage or fodder. The usual preparation of cornland for spring grains is disking.

The average yields of corn in the section are low, and annual variations are great. These handicaps are offset to some extent by low production costs, and corn has long been regarded as one of the most satisfactory dry-land crops. Recently its position has been challenged somewhat by improved earlier maturing types of grain sorghum. The superior drought-resisting qualities of the sorghums has enabled them at times to make fair yields when corn has failed completely. The sorghums are also less severely injured by grasshoppers. On the other hand, they start slowly and replanting is more often necessary than with corn. Also, sorghums dry the soil more thoroughly and frequently depress the yields of the crops that follow them. There is little doubt that the improvement in grain sorghums will allow them to become permanently established farther north in the central Plains.

On account of the importance of corn as a rotation crop and its established feeding and market value, it is probable that it will retain a high proportion of its acreage even where yields are somewhat lower and more variable than from the grain sorghums.

Corn was more extensively used than any other crop in the dry-land crop rotations at this station. It was grown after each of the small grains, after sorgo, after milo, and continuously on the same land. Tillage preparations were fallow, fall plowing, spring plowing, disking, and listing only. All planting was done with a lister regardless of previous preparation. Substation White, a medium-early variety selected for smooth kernel type and purity of color was used in all years.

In field 41 corn was grown in 2-, 3-, 4-, and 6-year rotations after small grain on nine spring-plowed and nine fall-plowed plots in one 3-year rotation on fall plowing after sorgo, continuously cropped on fall and spring plowing, and alternating with fallow on one pair of plots. The yields by preceding crops and tillage are shown in table 33.

After a small grain there were 4 years in which yields of less than 1 bushel on both spring and fall plowing were obtained, 4 years of practically equal yield, 3 years with the higher yield on spring plowing, and 17 years with the higher yield on fall plowing. Average yields were 17.4 bushels with spring plowing and 19.3 with fall plowing. One of the fall-plowed plots (rotation No. 49) was plowed about a month later than the others. Its yield was only 14.1 bushels per acre. Barnyard manure was applied before oats in rotation No. 43 and before sorghum in rotation No. 47. Corn yields on fall plowing in these rotations were 15.1 and 17.6 bushels per acre, respectively. Corn yields after fall plowing in the six remaining rotations were all above 20 bushels and their average was 21.2 bushels, which is 3.8

bushels more than the average yield of the nine plots on spring plowing. Corn yields from rotations in which green manures were used were no greater than from rotations without such treatment.

TABLE 33.—*Annual and average yields of corn from different crop sequences and tillage methods in field 41 at North Platte Substation, 1907–34*

[See pp. 24 to 25 for rotation schedules]

Year	Acre yields of corn following—					
	Small grains		Sorgo, fall-plowed [3]	Corn		Fallow [6]
	Spring-plowed [1]	Fall-plowed [2]		Spring-plowed [4]	Fall-plowed [5]	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1907	19.0	19.0	10.4	28.7	27.7	17.9
1908	24.0	27.3	11.9	38.6	24.6	38.2
1909	25.8	20.1	27.6	29.0	31.6	25.0
1910	6.0	2.6	1.0	8.9	6.3	21.9
1911	.6	.8	0	0	0	0
1912	26.0	26.1	19.6	31.1	39.0	35.1
1913	0	0	0	0	0	.4
1914	3.2	4.0	1.3	8.5	15.5	27.9
1915	29.5	27.2	33.8	26.8	30.9	19.7
1916	5.2	7.1	6.3	13.4	10.4	17.8
1917	5.2	8.2	0	14.5	17.7	26.6
1918	18.4	22.9	15.3	26.7	27.3	28.7
1919	33.0	34.0	23.6	42.5	38.4	37.7
1920	34.4	34.3	30.0	20.3	36.0	32.0
1921	10.1	17.8	0.7	22.7	25.3	30.0
1922	25.9	30.1	21.8	20.0	35.1	35.0
1923	51.0	47.2	43.7	41.2	31.2	40.6
1924	20.0	25.7	13.3	22.8	23.4	30.8
1925	7.4	11.2	1.7	12.3	15.6	35.1
1926	.8	.5	0	2.7	.7	27.3
1927	45.6	47.6	47.3	36.5	38.4	30.0
1928	25.9	33.2	21.4	32.3	33.4	24.9
1929	12.4	14.4	2.0	16.9	16.0	22.1
1930	25.4	29.6	37.7	24.7	18.8	13.6
1931	8.6	15.0	4.5	14.0	17.8	17.5
1932	6.0	6.0	2.8	8.9	5.3	8.8
1933	18.8	23.9	23.3	26.5	31.0	19.0
1934	0	0	0	0	0	2.5
Average	17.4	19.3	14.9	21.1	21.4	24.0

[1] Rotations 2, 7, 9, 14, 16, 19, 41, 42, 50.
[2] Rotations 1, 3, 4, 6, 43, 45, 46, 47, 49.
[3] Rotation 44.
[4] Continuous corn A.
[5] Continuous corn B.
[6] Alternate fallow C/D.

The single plot of corn following sorgo produced an average yield of only 14.9 bushels. There were five complete failures and five yields below 5 bushels per acre. This poor record is the result of the thorough drying out of the soil by the sorgo crop. Barnyard manure applied before sorgo in this rotation was probably a contributing factor in producing good corn yields in years of more favorable moisture, as 1915, 1920, 1923, 1927, and 1930. More frequently, with moisture a limiting factor, yields were further depressed rather than increased by manure.

The average yields of continuously cropped corn were essentially the same on spring and fall plowing, the 28-year averages being 21.4 and 21.1 bushels per acre, respectively. For the full 28-year period the average yield of continuously cropped corn was 21.3 bushels (table 33, columns 5 and 6) in comparison with 18.4 bushels for corn in rotations after small grain (columns 2 and 3).

The gains for continuous corn were usually greatest in years of relatively low yield when moisture limitations were most severe and for the earlier years of the comparisons. Omitting years of failure and yields of less than 1 bushel and dividing the remaining 24 years into two yield classes of 12 years each, the averages of the low groups were 11.2 and 17.5 bushels, respectively, following small grain and corn. This is a gain of 5.3 bushels, or 47 percent, for continuous corn. On the other hand averages of the high-yielding group were essentially the same, 31.5 following small grain and 32 for continuous corn. Failure of continuously cropped corn to maintain the gains made in the earlier years is shown by dividing the 28-year period into two 14-year periods, again using average yields of columns 2 and 3 and 5 and 6 of table 33. For the first 14 years average yields were 16.7 and 21.7 bushels after small grain and corn, respectively, while for the second 14-year period the averages were, respectively, 20.8 and 21.3 bushels. That is, the gain for the first period was 5 bushels, or 30 percent, and for the second period it was only 0.5 bushel, or 2 percent.

Continuous-cropped corn declined progressively in stover as well as in grain yield. For the first 14-year periods stover yields after small grain and for continuous corn averaged 2,353 and 2,220 pounds per acre, respectively. For the second 14-year period the averages were, respectively, 2,770 and 1,920 pounds. In other words, following small grains the average stover yield of the second period gained 417 pounds over the first period, but there was a loss of 300 pounds between these periods in the case of continuous corn. The sum of these differences is 717 pounds, or 33 percent of the average stover yield for the first 14 years, and indicates that a decline in plant vigor and yield may be expected from long-time cropping to corn alone.

Corn made the poorest relative showing of any of the crops grown on fallowed land. In only 4 years—1910, 1914, 1925, and 1926—were good yields on fallowed land associated with poor yields on cropped land. These were the only years in which the yields on fallowed land were more than double the yields on cropped land. There were 3 other dry years—1911, 1913, and 1934—in which corn was a failure or produced low yields on cropped land and in which it was a failure or produced low yields on fallow. Hail damage was the cause of low yields on all methods in 1932.

There were 11 years in which lower yields were obtained after fallow than from continuous corn on spring plowing, and 10 years in which there were lower yields after fallow than on fall plowing after small grain. The average yield of 24 bushels after fallow was a gain of only 2.9 bushels over the average from continuous corn on fall plowing and 4.7 bushels over the average of corn on fall plowing after small grain. In most years, the early growth of corn after fallow was slower than on cropped land. Frequently the plants were lighter green in color. Lack of vigor was indicated by sparse tillering. In years of high temperatures and light rainfall, these differences were overcome by midsummer, and the plants on fallowed land made good growth after the plants on cropped land began to deteriorate. In more favorable seasons, the growth frequently was less on fallowed land than on cropped land throughout the season.

The results with corn from field 49 are summarized in table 34. In this field, corn was grown in 2-, 3-, 4-, and 5-year rotations following small grain listed with no previous preparation, listed after disking, spring-plowed, and fall-plowed; and on disked milo stubble. Some of these results were for the 23-year period, 1912–34. All were for the 14-year period, 1921–34. Averages are shown for both periods.

In this field, differences between the average yields on spring-plowed and on fall-plowed land were not significant. For the 14-year period, disking gave practically the same result as plowing. In most years the yields were lower from listing without previous preparation than from the other methods, the average difference being about 2 to 3 bushels per acre. With no preparation previous to listing, weed growth and volunteer grain usually had made considerable headway before corn planting time and the soil was reduced in moisture and broke up in clods. The average yield of corn on disked milo was 2.6 bushels less than after small grain with the same preparation. Milo grows late in the fall and exhausts soil moisture thoroughly. Corn on disked land in this sequence apparently had about the same moisture handicap as with no disking on small-grain stubble. The resulting 14-year average yields of 21.1 and 20.9 bushels to the acre were approximately the same.

The yields of corn in field 42 from 2-year rotations and from continuous cropping are shown in table 35. Each yield was the average of four replications. In the 2-year rotations, the preparations were spring disking and early fall plowing after oats and winter wheat and disking and late fall plowing after corn.

TABLE 34.—*Annual and average yields of corn from different crop sequences and tillage methods in field 49 at North Platte Substation, 1912–34*

[See pp. 25 to 26 for rotation schedules]

Year	Acre yields of corn following				
	Small grain				Milo, disked [5]
	No cultivation [1]	Disked [2]	Spring-plowed [3]	Fall-plowed [4]	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1912	17.1		25.9	24.1	...
1913	0		0	0	...
1914	1.5		3.0	4.2	...
1915	15.4		21.2	18.0	...
1916	8.4		12.8	13.1	...
1917	4.9		6.7	12.7	...
1918	18.5		21.6	23.5	...
1919	39.8		30.4	31.3	...
1920	10.7		12.4	13.5	...
1921	16.0	19.3	23.6	27.6	21.3
1922	28.1	29.4	30.8	37.8	21.0
1923	54.6	57.1	41.6	44.1	55.6
1924	22.5	29.2	29.5	24.9	17.5
1925	11.5	10.3	7.7	9.5	5.3
1926	1.6	.8	5.1	5.0	.2
1927	40.8	47.0	46.6	48.4	47.2
1928	35.6	40.1	33.1	35.4	33.9
1929	12.4	10.0	20.2	18.8	8.0
1930	27.3	32.1	35.8	28.4	39.6
1931	12.9	15.4	27.0	18.2	20.1
1932	7.9	8.9	12.1	12.4	4.9
1933	21.3	26.6	20.2	28.2	21.3
1934	0	0	0	0	0
Average:					
14 years	20.9	23.7	24.2	24.4	21.1
23 years	19.3		22.0	22.2	...

[1] Rotations 60, 115, 416.
[2] Rotations 408, 410, 417.
[3] Rotations 15, 17, 18.
[4] Rotations 20, 26, 28, 81, 97, 102, 103, 104, 106, 111, 112, 120.
[5] Rotation 409.

TABLE 35.—*Annual and average yields of corn on spring disking and early fall plowing after oats and winter wheat in 2-year rotations, and on spring disking and fall plowing from continuous cropping of corn in field 42 at North Platte Substation, 1923–34*

[See pp. 26 to 27 for rotation schedules]

Year	Acre yields of corn following—					
	Oats		Winter wheat		Corn	
	Disked [1]	Early fall-plowed [2]	Disked [3]	Early fall-plowed [4]	Disked [5]	Fall-plowed [6]
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1923	50.2	58.1	63.3	54.3	46.9	51.8
1924	18.5	25.5	22.6	25.4	21.8	18.4
1925	5.4	6.4	6.4	4.1	11.8	6.0
1926	.6	1.5	0	1.6	1.3	.8
1927	46.2	52.4	52.1	54.0	46.0	49.5
1928	25.6	32.1	38.8	35.1	34.4	32.7
1929	8.0	16.1	17.4	10.2	19.5	13.8
1930	20.6	34.3	35.4	29.3	22.2	27.6
1931	6.3	11.6	16.2	11.8	17.3	17.4
1932	6.4	7.3	7.5	6.6	8.5	6.1
1933	17.8	28.5	21.9	26.2	32.4	31.0
1934	0	0	0	0	0	0
Average	18.2	22.8	23.5	22.1	22.0	21.3

[1] Series I and III, plots 5 or 6, 13 or 14.
[2] Series II and IV, plots 5 or 6, 13 or 14.
[3] Series I and III, plots 2 or 3, 11 or 12.
[4] Series II and IV; plots 2 or 3, 11 or 12.
[5] Series I and III, plots 1 and 8.
[6] Series II and IV, plots 1 and 8.

After oats, corn yields were consistently higher after early fall plowing than after spring disking and the 12-year average was 4.6 bushels higher on the early fall-plowed land. After winter wheat, disking produced the highest average yield of any preparation or crop sequence. In this case it is probable that another factor was of greater importance than the tillage preparation in determining results. This was the time of harvesting the corn crop. In all other groups, corn was harvested with a corn binder and removed from the land before winter wheat was seeded. In the group of plots that were spring-disked for corn, winter wheat was seeded in the standing stalks and the corn was husked at a later date. Although corn was usually well-matured when cut with a binder on the other plots, it was apparent that the grain on the plants left standing filled more completely, and that the relatively higher yields were a result of this development rather than from a difference in the tillage preparation.

In this field, continuous cropping of corn did not make so favorable a showing as it did in the early years of the longer period in field 41. This may have been due to a somewhat higher proportion of favorable years during the later period. As shown by the results from field 41, corn continuously cropped made a more favorable showing in comparison with corn after small grain in years of low or medium yield.

In the 3-year rotations in field 42 (table 36) the average corn yields were higher by about 1 bushel to the acre where one of the two preceding crops was corn than where both crops were winter wheat. The order of the crops when both corn and wheat were used preceding corn did not affect the average yield of corn.

In these 3-year rotations, the preparation for corn was spring disking before listing and fall disking of winter wheat stubble when conditions were such that the growth of weeds and volunteer wheat would have interfered with soil-moisture storage.

Table 36.—*Annual and average yields of corn following corn and wheat, wheat and corn, and two crops of wheat, in 3-year rotations, in field 42 at North Platte Substation, for the 12 years, 1923–34*

[See p. 27 for rotation schedules]

Year	Acre yields of corn following—			Year	Acre yields of corn following—		
	Corn and wheat [1]	Wheat and corn [1]	Wheat and wheat [2]		Corn and wheat [1]	Wheat and corn [1]	Wheat and wheat [2]
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
1923	50.4	56.9	40.2	1930	37.3	34.0	32.7
1924	10.3	14.7	16.6	1931	13.1	10.3	11.3
1925	3.0	4.0	3.2	1932	6.6	2.9	2.9
1926	.8	.5	.3	1933	22.0	20.2	10.1
1927	45.4	47.3	40.8	1934	0	0	0
1928	33.3	32.2	32.4				
1929	8.4	6.7	5.4	Average	19.4	19.3	16.3

[1] Series V and VI, plots 4, 5, 6, and 13, 14, 15.
[2] Series V and VI, plots 1, 2, 3, and 10, 11, 12.

Milo

In discussing the results with corn, mention was made of changes during recent years in corn and grain sorghum acreages. Dwarf Yellow milo, which was used in these experiments, has been shown by recent trials to be inferior in yield and early maturity to several of the improved grain sorghums now available. Its performance in comparison with corn was less favorable than would be expected from the newer types. Milo was grown in five rotations in field 49 for the 14-year period 1921–34. The preceding crops were corn, rye, oats, winter wheat, and barley. The tillage preparation was spring plowing in all cases. The seed was surface-planted in 42-inch rows, and the plants were thinned to uniform stands spaced at an average distance of about 6 inches.

Table 37.—*Annual and average yields of milo after small grain and corn and of corn after small grain and milo in field 49 at North Platte Substation, 1921–34*

[See p. 26 for rotation schedules]

Year	Acre yields of milo following—		Acre yields of corn following—		Year	Acre yields of milo following—		Acre yields of corn following—	
	Small grains [1]	Corn [2]	Small grains [3]	Milo [4]		Small grains [1]	Corn [2]	Small grains [3]	Milo [4]
	Bushels	*Bushels*	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*	*Bushels*
1921	21.5	24.5	18.2	21.3	1929	18.7	21.4	10.3	8.0
1922	31.6	26.6	27.6	21.0	1930	45.3	53.3	31.0	30.6
1923	49.3	46.0	56.9	55.6	1931	32.0	43.4	14.2	20.1
1924	17.7	21.0	20.8	17.5	1932	7.1	14.7	9.0	4.9
1925	11.7	11.4	16.7	5.3	1933	28.4	15.2	24.6	21.3
1926	1.4	.9	.7	.3	1934	0	0	0	0
1927	20.9	37.2	44.7	47.2					
1928	28.2	34.1	39.2	33.9	Average	23.3	25.0	22.9	21.1

[1] Rotations 409, 412, 413, 601.
[2] Rotation 408
[3] Rotations 408, 410, 410, 417.
[4] Rotation 409.

Yields of milo and corn are shown in table 37. The higher yield of milo was obtained more frequently after corn than after small grain, and the average after corn was higher by 1.7 bushels to the acre. Corn, however, made its higher yield more frequently after small grain than after milo, and the average was higher after small grain by

1.8 bushels to the acre. The average yield of milo after corn was 3.9 bushels to the acre more than the average yield of corn after milo. In this field, barley followed milo and corn each in four rotations. The 14-year average yields of barley were 16.8 bushels to the acre after milo and 19.5 bushels after corn, or 2.7 bushels less barley from the milo sequence. With Dwarf Yellow milo as the grain sorghum crop there was little difference in its average yield and that of corn.

The market value of milo is somewhat below that of corn, and also, as yields of the crops by which it is followed in rotations were depressed, there was clearly no advantage in most years in these tests in substituting milo for corn. If years like 1930 and 1931 were more frequent or if one of the improved types of grain sorghum had been used, a better showing for the use of grain sorghum would doubtless have been made.

Sorgo

Sorgo has been for many years the most dependable dry-land forage crop of the Central Plains. Its ability to recover and continue growth after drought periods of varying intensity enables it to make fair yields when many other crops are complete or near failures. The crop is usually consumed on the farms where grown. When cured and stacked, its feed value does not deteriorate rapidly and many farmers carry over a supply as insurance against a feed shortage in very dry years.

Sorgo was grown for forage following wheat, oats, and corn in 3-year rotations and in alternation with fallow in one 2-year rotation in field 41, and after wheat in one 5-year rotation in field 49. Except on fallow, the preparation was spring plowing in all rotations. Barnyard manure was applied before plowing at the rate of about 10 tons to the acre in two rotations. Yields are shown for the 21 years 1914–34 in table 38. First results from fallow were obtained in 1914. The omissions of results for earlier years from the other rotations does not materially change comparative yields.

TABLE 38.—*Annual and average yields of drilled sorgo on spring plowing, after small grain with and without manure, after corn with manure, and after fallow, in fields 41 and 49 at the North Platte Substation, 1914–34*

[See pp. 24 and 26 for rotation schedules]

Year	Acre yields of sorgo following—			
	Spring wheat, manured [1]	Oats [2]	Corn, manured [3]	Fallow [4]
	Tons	*Tons*	*Tons*	*Tons*
1914	2.27	2.80	3.48	3.62
1915	4.00	4.97	6.35	4.05
1916	2.93	1.54	2.14	3.40
1917	2.40	2.16	1.98	2.65
1918	.68	2.13	1.38	3.50
1919	5.00	4.25	5.20	4.65
1920	4.98	4.36	4.85	5.05
1921	2.65	2.81	3.75	3.90
1922	4.00	3.28	2.50	4.40
1923	5.50	5.17	4.50	6.25
1924	.65	2.08	1.90	2.00
1925	3.45	3.32	3.60	4.05
1926	1.60	1.99	2.90	4.00
1927	5.00	5.63	6.09	5.50
1928	5.35	4.33	5.45	6.15
1929	3.55	2.92	2.95	3.45
1930	3.70	3.75	4.10	3.45
1931	2.90	2.28	3.20	3.00
1932	2.00	2.10	2.60	3.10
1933	3.30	2.60	4.10	3.60
1934	.40	.56	1.10	2.85
Average	3.09	3.11	3.53	3.98

[1] Rotation 44.
[2] Rotations 48, 130.
[3] Rotation 47.
[4] Rotation 40.

The yields after oats were averages from 2 rotations; those from other sequences were from single rotations. The yields following wheat with manure and oats without manure were approximately the same. The yield after corn was higher than that after small grain 14 times in the 21 years. The average increase in favor of the cornland was 0.41 ton, or 14 percent.

The yield after fallow was higher than that after corn 15 times in 21 comparisons. The average yield after fallow was 0.45 ton, or 13 percent, more than the yield following corn, and 0.88 ton, or 28 percent, more than the average after small grain.

It has been shown in tables 30 and 33 that the yields of crops following sorgo were frequently lower than from other sequences. A crop season is lost during the fallow preparation, and this loss is lowest where crop prospects are least. This is more apt to be true following sorgo than after small grain. The fallow season is shorter after sorgo than after small grain. Consequently, in some years the subsoil within reach of crop roots may carry less water at seeding time, and this difference in moisture is reflected in crop yields. It is shown in table 17 that the average yield of winter wheat on fallowed land after sorgo in rotation 120 was 1.7 bushels less than from the D and E plots, which were nearby and alternately cropped to winter wheat and fallowed. The reduction in the yield of winter wheat on fallow after sorgo was apparently due to less favorable moisture storage in this sequence in dry years. On the other hand, in seasons of more plentiful rainfall there was little if any lodging of winter wheat on fallow after sorgo, whereas on fallowed land in other sequences lodging was often a cause of considerable loss. All factors considered, where sorgo and fallow are used in a system of diversified farming, fallowing after sorgo appears to be preferable to fallowing before sorgo.

Potatoes

The commercial production of potatoes in the central Great Plains is confined mainly to the irrigated areas. Some market potatoes are grown on sandy soils, and the production of certified seed potatoes has been developed into an important industry on both dry land and under irrigation in western Nebraska and eastern Wyoming.

At this station, potatoes were grown in six 3-year rotations in field 49 for the 23 years 1912–34. Preceding treatments given were as follows: Disking after wheat, early fall plowing after wheat and oats, spring disking after corn, and fallow. Yields are shown in table 39.

The 1923 results were affected by irregular stands and flooding injury on some plots and were not used in the table. The yields on early fall plowing after small grain were averages from 3 rotations. Other yields were from single rotations. Following small grain, spring disking and early fall plowing preparations gave higher yields from the former 5 times and from the latter 16 times. The average gain in favor of early fall plowing was 17.2 bushels, or 21 percent. The advantage of early fall tillage is in moisture saved by control of weeds for the after-harvest season.

The poorest showing was on disked cornland. The average yield after corn was 21 bushels less than that on early plowing after small grain, and there was a tendency for the difference between these preparations to increase with increasing years of comparison. For the 11 years 1912–22, the average decrease in yield of corn ground in comparison with that from early plowed grain land was only 2.6 bushels per acre. For the 11 years 1924–34, the decrease was 39.3 bushels. It is not improbable that potato diseases were a factor in the increasingly poorer relative yields from corn ground.

TABLE 39.—*Annual and average yields of potatoes from different crop sequences and tillage methods in field 49 at North Platte Substation, 1912–34 (1923 omitted)*

[See pp. 25 to 26 for rotation schedules]

Year	Acre yields of potatoes following— Small grains: Disked [1]	Small grains: Early fall-plowed [2]	Corn, disked [3]	Fallow [4]
	Bushels	*Bushels*	*Bushels*	*Bushels*
1912	80.6	102.5	91.5	107.7
1913	17.8	21.7	28.7	28.2
1914	20.0	21.1	25.0	20.0
1915	95.0	123.0	114.2	125.8
1916	65.0	60.6	45.0	70.0
1917	53.8	61.5	68.9	87.4
1918	83.7	77.9	75.3	113.8
1919	106.0	103.4	117.5	119.5
1920	111.7	121.1	107.3	114.3
1921	48.3	54.3	56.0	61.7
1922	126.2	100.3	99.2	181.0
1924	103.5	112.8	82.8	141.3
1925	86.2	105.0	85.3	128.2
1926	70.0	121.4	65.5	237.3
1927	161.5	195.6	106.0	109.8
1928	211.7	283.3	187.5	283.3
1929	71.0	130.7	77.0	138.7
1930	103.7	123.1	66.8	119.2
1931	60.8	87.2	43.7	98.3
1932	45.7	80.7	102.3	190.8
1933	26.2	51.9	51.1	78.5
1934	0	0	0	15.8
Average	80.9	98.1	77.1	110.5

[1] Rotation 131.
[2] Rotations 105, 108, 109.
[3] Rotation 106.
[4] Rotation 107.

When only 2 years intervened between potato crops, as in these 3-year rotations, the rotation furnished favorable conditions for carry-over of potato-disease organisms. The yields indicated that corn residues may be better carriers of potato-disease organisms than was grain stubble.

After summer fallow, potato yields were higher than after any of the cropped land methods 16 times and lower 6 times. Half of the gains were substantial in amount, the rest unimportant. The average gain of 21.4 bushels over that from early plowing after small grain approximated the value of the wheat crop that could have been produced during the time that the land was being prepared by fallowing. A gain in yield usually sufficient to offset the increased cost and an occasional gain much in excess of this cost justified the use of fallow for potato production on dry land. Figure 12 shows potatoes after oats, prematurely killed by low moisture and high temperature, in rotation 109. Figure 13 shows potatoes on fallow where stored moisture has kept the vines growing and made a good yield possible.

Alfalfa and Bromegrass

The rank growing habit and resulting high water requirement of alfalfa limit its best production in the central Great Plains to locations where the natural rainfall can be supplemented by water from some other source. Most of its acreage is located under irrigation or in river valleys where the water table is within reach of its deeply penetrating roots. On uplands, good crops are produced on limited areas where runoff water can be converged from higher levels. Crops in these areas are uncertain on account of the high variability in amount,

FIGURE 12.—Potatoes following oats. Vines killed by drought. Yield, 63.3 bushels (31.0 bushels No. 1 grade) to the acre. North Platte Substation, July 1932.

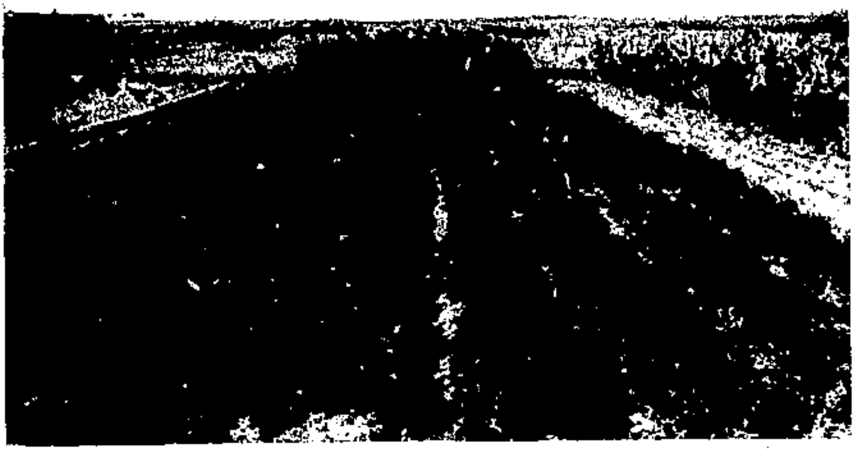

FIGURE 13.—Potatoes on fallowed land. Yield, 190.8 bushels (138.5 bushels No. 1 grade) to the acre. North Platte Substation, July 1932.

distribution, and nature of the rainfall from which runoff water is derived. Where no supplemental water is available, good crops are produced in the infrequent years of highest rainfall, or more particularly in those less frequent periods when more than one such year occurs in succession. Stands on uplands are difficult to establish and difficult to maintain, as the plants deteriorate rapidly when the moisture supply is insufficient to support normal growth.

When alfalfa is established in locations where deep subsoils have accumulated moisture below the feeding depth of other crops, it may persist for some time by extension of its roots and use of water from this source. After the limits of this process are reached and stands have died out, it may be many years before moisture is restored and alfalfa can be reestablished. On account of its palatability and high nutritive value, alfalfa is one of the most profitable forage crops obtainable for the areas where it can be grown. It will also repay considerable effort and expense in obtaining supplemental water for limited areas where the general rainfall is inadequate.

Smooth bromegrass (*Bromus inermis*) is one of the few introduced grasses that has been grown with a measure of success in many locations in the central Great Plains. After establishment, it approaches the native grass mixtures closely in persistence and production. In contrast with most of these grasses, it starts growth earlier in the spring, persists later in the fall, and tends to greater dormancy during hot, dry periods in midsummer. On upland, at this station, bromegrass seeded in 1905 was alive with good stands when plowed up in 1935. Stands at times were reduced during dry periods, but recovery by spread of rootstalks from surviving plants was rapid with a return of favorable conditions. In the severe drought of 1934, 25 to 60 percent of the plants perished, but recovery was rapid in the wet spring of 1935, and complete recovery was indicated when the area was abandoned in midsummer.

Alfalfa and bromegrass were used as sod crops in single adjacent 6-year rotations in field 41 for the 28 years 1907–34. The sod was left for 3 years, and the crops for the following 3 years were oats, corn, and spring wheat. Annual and average yields of hay for the first, second, and third years after seeding are shown in table 40. The yields shown in table 8 are the averages of the second- and third-year crops. Yields from the year of seeding were obtained twice for bromegrass and only once for alfalfa. Yields for the second and third years after seeding were highly variable and the averages low. In practically half of the years, no recoverable hay yields were obtained. In about half of the years of failure for hay, some pasturage was available. In the remaining years, the cover was largely weeds. Maximum yields were slightly below 1 ton per acre for bromegrass and slightly below 2 tons per acre for alfalfa.

Average yields were higher for the third than for the second year crop. For the 28-year period, the average yields for the third year were slightly above one-fourth ton to the acre for bromegrass and slightly above one-half ton for alfalfa. It is thought that yields would have been improved if the sod had been left down for longer periods.

There was a distinct gain in the number and size of crops produced for the second over the first 14-year period. The factors contributing to this gain were a somewhat lower incidence of adverse weather conditions and changes in the methods of seedbed preparation and seeding. In the earlier years seed was broadcast and harrowed in the fall or late in the spring on fall-plowed ground that was at times quite dry and loose. As the advantages of early plowing, weed control after harvest, and firm seedbeds became apparent for all crops, greater care was given to timely and thorough seedbed preparation for the sod crops. After the first 10 years, plowing was done soon after harvest, packing was consistently practiced, and broadcast seeding and harrowing were done early in the spring after the land was corrugated with a press drill. During the first 14-year period, there were 13 reseedings of bromegrass and 12 of alfalfa. For the second 14-year period, there was 1 reseeding of bromegrass and 4 of alfalfa. Average yields of the second period were more than double those of the first period for bromegrass and nearly triple for alfalfa. These results indicate that conservation of moisture and thoroughly firmed seedbeds are highly important practices in seedbed preparation for these crops.

TABLE 40.—*Annual and average yields of bromegrass and alfalfa hay from first-, second-, and third-year stands in single 6-year rotations in field 41 at the North Platte Substation, 1907–34*

[See p. 24 for rotation schedules]

Year	Acre yields of hay					
	Bromegrass [1]			Alfalfa [2]		
	First year	Second year	Third year	First year	Second year	Third year
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1907	800	1,270	1,270	0	2,170	2,176
1908		630	905	0	1,170	1,640
1909	0	0	0	0	0	0
1910	0	0	0	0	0	0
1911	0	0	0	0	0	0
1912	0	0	0	0	0	0
1913	0	0	0	0	0	0
1914	0	0	0	0	0	0
1915	0	0	0	0	0	0
1916	0	0	0	0	0	0
1917	0	550	1,060	0	1,250	2,500
1918	0	0	0	0	0	0
1919	0	0	0	0	0	0
1920	0	1,050	1,450	0	2,100	1,150
1921	0	0	350	0	650	750
1922	0	450	550	0	450	700
1923	0	430	1,050	0	3,150	2,080
1924	0	1,300	1,300	0	3,200	2,800
1925	0	400	650	0	500	950
1926	0	0	0	0	0	0
1927	0	0	1,150	0	0	2,000
1928	300	1,950	1,800	3,450	3,850	3,850
1929	0	650	900	0	2,000	1,900
1930	0	1,000	1,450	0	3,500	3,550
1931	0	400	830	0	2,400	2,550
1932	0	0	0	0	0	0
1933	0	400	600	0	650	950
1934	0	0	0	0	0	0
Average:						
1907–20		250	330		478	533
1921–34		534	761		1,454	1,577
1907–34		392	546		966	1,055

[1] Rotation 41.
[2] Rotation 42.

As a result of moisture limitations, the crops following sod were more often affected adversely than beneficially. This is shown for oats in table 30. The average yields of corn the second year and of spring wheat the third year after sod were also somewhat lower than in other rotations of the same immediate treatment and sequence.

The combination of relatively unprofitable yields of the sod crops as such and their tendency to depress the yields of annual crops that follow leaves but one factor that is distinctly in favor of their use. This is the conserving effect upon the soil. This effect is shown by the high yields of crops in the relatively few years when inadequate moisture is not a seriously limiting factor. In 1915, the 73.4-bushel yield of oats after alfalfa was the highest of any crop sequence for that year. In 1924, 1928, and 1930, the yields of oats after alfalfa were high, but the moisture handicap operated sufficiently to prevent their exceeding those from other methods. In 1928, the yield of 59.7 bushels after bromegrass was higher than from any other sequence except green manure and fallow. Relatively high yields after bromegrass were also obtained in 1920 and 1930. The highest yields of corn of record in field 41 were 64.9 bushels the second year after alfalfa and 60.2 bushels the second year after bromegrass in 1923.

When good stands of sod crops are obtained, the cover affords all-year protection from wind and water erosion. The residue of fibrous roots prolongs a part of this protection for several years after the sod is broken up. These factors retard to a marked degree the rate of nitrogen and organic matter loss in comparison with that resulting from the continuous use of annual crops.

Determinations of soil weight and nitrogen content were made on all plots in the experimental fields and upon adjacent native sod areas when the investigations were closed in 1934. These data for the two 6-year sod rotations and for seven nearby 3-year rotations cropped one-third to corn and two-thirds to small grains are shown in comparison with native sod in table 41.

TABLE 41.—*Weight per cubic foot, percentage, and amount of nitrogen per acre from first and second 6-inch sections and surface foot of soil in 1934 from native sod, 6-year rotations half time in sod, and 3-year rotations of annual crops; calculated total and annual losses for 44-year period 1890–1934, 16-year preliminary period 1890–1906, and 28-year experimental period 1907–34 in field 41 at North Platte Substation*

Item	Native sod [1]			Sod rotations [2]			3-year rotations [3]		
	1 to 6 inches	7 to 12 inches	1 to 12 inches	1 to 6 inches	7 to 12 inches	1 to 12 inches	1 to 6 inches	7 to 12 inches	1 to 12 inches
Soil weight per cubic foot ... pounds	72.9	68.0	70.7	76.1	78.9	77.5	76.3	81.0	78.9
Nitrogen ... percent	.148	.107	.127	.107	.104	.106	.098	.098	.098
Nitrogen per acre ... pounds	2,350	1,586	3,936	1,773	1,771	3,544	1,629	1,742	3,371
Nitrogen loss per acre:									
44 years ... pounds	---	---	---	577	−185	392	721	−156	565
16 years ... do	---	---	---	262	−57	205	262	−57	205
28 years ... do	---	---	---	316	−129	187	459	−99	360
Annual loss of nitrogen per acre:									
44 years (1890–1934) ... pounds	---	---	---	13.1	−4.2	8.9	16.4	−3.6	12.8
16 years (1890–1906) do	---	---	---	16.4	−3.6	12.8	16.4	−3.6	12.8
28 years (1907–34) ... do	---	---	---	11.3	−4.6	6.7	16.4	−3.6	12.8

[1] Weight per cubic foot and nitrogen (percent and pounds) determined from average of 144 cores from 12 loentions in native sod.

[2] Weight per cubic foot and nitrogen (percent and pounds) determined from average of 216 cores from 12 plots comprising rotations 41 and 42.

[3] Weight per cubic foot and nitrogen (percent and pounds) determined from average of 376 cores from 21 plots comprising seven 3-year rotations.

This table shows nitrogen losses in pounds per acre for the 44 years of cultivation and separately for a 16-year preliminary and 28-year experimental period. It is assumed that nitrogen in the native sod land has remained constant, although it is probable there has been a slight increase both in organic matter and nitrogen. It is assumed also that the nitrogen loss during the 16-year preliminary period when the land was used chiefly for corn was at the same rate as from the 3-year rotations during the 28-year experimental period. This assumption is probably even less correct than the one just mentioned. There is considerable evidence indicating that losses are more rapid during early than during later years of cultivation. If this is true, the differences would be greater than those indicated in the table. The cultivated soils have a higher volume weight than the native sod, and those in the 3-year rotations were slightly heavier than those in the sod rotations. The percentage of nitrogen was in inverse order to the amount of cultivation. In the upper 6-inch section and for the entire foot section, nitrogen per acre was also in inverse order to the amount of cultivation. In the 7- to 12-inch sections, however, on account of their higher volume weights, the cultivated soils contained more pounds of nitrogen. The nitrogen loss for the 28-year period was approximately twice as great from the 3-year rotations as from the 6-year rotations, in which the land was in sod one-half the time.

The change in the location of the nitrogen in the surface foot of the cultivated soils—a loss in the first 6-inch layer and an increase in the second—indicated that some of it may have been carried below the first foot. If this be true, the total loss from the soil might be less than that shown by these determinations, which were from the first foot only.

SUMMARY AND CONCLUSIONS

The North Platte Experimental Substation is one of a number of locations in the Great Plains area at which dry-land crop rotation and tillage investigations have been conducted cooperatively by the United States Department of Agriculture and State experiment stations. The results reported in this bulletin cover the 28-year period 1907–34, in which the staple farm crops of the section were grown in various cropping and methods-of-tillage experiments.

The experimental fields were located on tableland at an elevation of approximately 3,000 feet, or 200 feet above the Platte River Valley. The soil is Holdrege very fine sandy loam, which is fertile, easily tilled, and capable of producing good crop yields under favorable weather conditions.

Weather data have been recorded at the substation since its establishment. The United States Weather Bureau has continuous data at North Platte since 1874. Adverse weather is the highest ranking of the hazards with which the farmer has to deal. Rainfall, with its limitations and unpredictable variations, occupies first place. Wind and temperature extremes are also destructive at times.

Crop yields were determined more by the amount and distribution of precipitation than by any other single factor. The 28-year (1907–34) average yearly precipitation measured near the experimental fields for the April–September season and at the North Platte Weather

Bureau, October-March, was 18.89 inches. This is adequate for production of most annual crops if distribution is favorable and other weather factors normal. Annual amounts varied between the extremes of 11.18 inches in 1910 to 34.85 inches in 1915.

Normal distribution is favorable, as the largest amounts occur in the summer months when crop needs are greatest. Departures from monthly normals are frequent and at times wide. Each month had a low precipitation record of one-half inch or less at some time during the years covered. Two factors contribute to low rainfall efficiency. Heavy rains often occur in hard, dashing showers that cause losses from runoff. Heavier losses result from evaporation on account of the high proportion of the rainfall that occurs in small isolated showers. For the April to September season the average number of days of rain of different amounts and the proportion that each class contributed to the total were as follows: 1 inch or more, 3 days and 33 percent, respectively; one-half to 1 inch, 6 days and 31 percent; less than one-half inch, 37 days and 36 percent.

The combined effects of humidity, wind movement, and temperature are reflected in evaporation. The average seasonal (April to September) evaporation was 42.02 inches. Annual amounts ranged from 34.21 inches in 1923 to 55.34 in 1934. The highest month was 13.30 inches for July 1934, and the highest single day 0.732 inch on July 21, 1934. The average evaporation-precipitation ratio was 2.83 to 1. Extremes were 1.33 to 1 in 1915 and 6.06 to 1 in 1931. The average ratio for 11 years with corn yields below 15 bushels was 4 to 1, and for 7 years with yields above 30 bushels, 2 to 1.

Temperatures for the 28-year period covered the range from −30° to 109° F. The average number of days per year with subzero minimum temperature was 18, and the average number of days with maximum temperature above 100° was 4. The annual average temperature was 50°. Number of days between temperatures of less than 32° from spring to fall ranged from 127 in 1931 to 176 in 1933 and averaged 151 days.

The different rotation and tillage experiments were located in three fields. The experimental units were plots of one-tenth acre in size, and the total number used was 326. The number of plot-year records involved was 6,446. The tillage methods under trial were disking, spring plowing, fall plowing, listing, summer fallowing, and green manuring. There were 74 rotations involving differences in tillage or crop sequence, and 5 crops were grown continuously on the same land under different methods of preparation or in alternation with fallow.

The leading small-grain crop in the central Great Plains is winter wheat. In Kansas its acreage exceeds that of any other crop, and in Nebraska it is second in acreage only to corn. In western Nebraska winter wheat exceeds corn in acreage by a ratio of 3 or more to 1.

Under continuous cropping or after other small grain higher yields were more frequently produced on early than on late plowing. In 54 comparisons the average gain in favor of early plowing was 4.5 bushels per acre, or 39 percent, and late plowing produced higher yields in only 5 instances. In a 14-year comparison the average yield of winter wheat from plowing on the average date of August 10 was 20.8; from disking on the average date of September 2, 12.1; and from plowing on the average date of September 13, 10.1 bushels. The yield increases from early tillage are chiefly the result of moisture conserved by the destruction of weeds and volunteer grain and to some extent to the better conditions furnished by early tillage for development of nitrates. Early tillage contributes to a reduction of weed infestation, while delayed tillage, by allowing a greater amount of weed seed to mature, builds up infestation.

After several years there is usually a sharp contrast between weed populations in grainfields where tillage has been practiced promptly after harvest and in fields where tillage preparations have been delayed until near seeding time.

The major effects of tillage and previous croppings are reflected in the immediately succeeding crop. In certain instances, measurable effects are carried over to later crops. In 3-year rotations comparing fallow and two crops of wheat with corn and two crops of wheat, the 12-year average yields of the second crops of wheat were 14.4 and 11.4 bushels per acre, respectively.

In 2-year rotations of corn and winter wheat, 12-year average yields of wheat were 9.7 bushels from seeding in standing stalks and 16.7 bushels where the stalks were removed and the stubble disked before seeding to wheat. It is probable that there was a further use of moisture where the stalks were left standing and that the following wheat yields were reduced on this account. Disking where the stalks were removed might have been a benefit to the wheat crop in this rotation, but this is considered to be of less importance than the soil-moisture factor.

In 3-year rotations, comparing two crops of corn and one of winter wheat with one crop of corn and two of winter wheat, the 12-year average yield of wheat after corn for 2 years was 14.7 bushels and after corn for 1 year 12.1 bushels. As corn exhausts soil moisture less thoroughly than wheat, a more favorable moisture reserve is established from two corn crops than from one of corn and one of wheat.

Winter wheat on disked potato and on disked cornland produced about equal average yields. In dry years wheat stands were injured more by soil blowing on the finely pulverized potato land and a greater number of complete failures resulted. On the other hand in years of favorable moisture the gains made on potato land were sufficient to offset the losses from the drier years.

Summer fallowing is an effective method of building up a supply of subsoil moisture, and winter wheat, more than any other crop, has made the most efficient use of this supply. On clean fallow in field 49 the 23-year average yield of winter wheat was 26.9 bushels to the acre, and in field 42 the 12-year average was 28.3 bushels. Wheat failures on summer fallow were below 10 percent and less than from any of the other tillage methods under trial. When winter wheat yields after fallow were divided in half to allow for the loss of a crop during the year of fallow, the yield after fallow was 2.2 bushels less to the acre than from continuous cropping and early plowing and 1.3 bushels less than from late plowing.

In field 49 the 23-year average yield of winter wheat was 8.3 bushels more per acre after fallow than following corn. The average corn yield in this field was 21.3 bushels. For each bushel of wheat gained by fallow, 2.6 bushels of corn might have been produced if corn had been substituted for fallow. In field 42 for 12 years the ratio was 1 bushel of wheat to 1.18 bushels of corn.

In field 49 for a 23-year period the growth of weeds and volunteer grain on fallowed land in fall and early spring reduced the yield of the following crop of wheat by 6.8 bushels, or 16 percent, in comparison with the yield after clean tillage for the entire fallow period.

Green manuring, like fallowing, involves the loss of the use of the land for a crop season. Winter wheat yields the first year after plowing under rye or peas for green manure were less than after clean fallow. Benefits that might have been gained from increased fertility were more than offset by the moisture lost in producing the green-manure crops.

On account of earlier plowing and a longer fallow period after rye, yields were depressed less after rye than after peas. In 4-year rotations with winter wheat as the third instead of the first crop after the green manures or fallow, yields were somewhat higher after the green manures. With moisture differences equalized by the intervening crops, winter wheat yields were improved slightly by the use of green manures.

Adjacent plots were prepared for a 10-year period by continuous clean fallow on one plot and by growing and plowing under rye for green manure each year on the other plot. Winter wheat was grown on these plots for the following 12 years. The average yield of straw was 44 percent higher on the green-manured plot than on the fallowed plot. There was no difference in average grain yields. Increased grain yields in years of favorable moisture were offset by decreased yields in dry years when the stimulated early growth of straw on the green-manured soil exhausted soil moisture before the grain was mature.

Top dressing of barnyard manure depressed the yield of grain and increased the yield of straw on adjacent plots of continuously cropped wheat. In 3-year rotations top dressing of barnyard manure on wheat on the same plot each third year had little effect on the yield of either straw or grain.

Spring wheat is unimportant except in limited areas in the northern part of the central Great Plains. It is grown to some extent on abandoned winter wheatland. At the North Platte Substation, the average yield of spring wheat from all methods of tillage was 76 percent of that of winter wheat. After corn, 28-year average acre yields of spring wheat were 12.1 bushels from disking, 11.8 bushels from spring plowing, and 12.7 bushels from fall plowing. After small grain, the average acre yields were 11.2 bushels on spring plowing and 13.5 bushels on fall plowing. After sorgo, the average acre yield was 10.7 bushels and after fallow 19.1 bushels. When allowance was made for the loss of land in fallowing, less wheat was produced by fallowing every other year than by continuous cropping. By fallowing, however, the number of crop failures and low yields were considerably reduced.

Oats are generally the least profitable of the grain crops extensively grown in the central Great Plains. Good yields are obtained in favorable years, but low yields and crop failures are frequent. Yields at the substation were lowest after alfalfa, bromegrass, and sorgo. After small grain, average acre yields were 22.5 bushels on spring-plowed land, and 26.5 bushels on fall-plowed land. On disked corn and potato lands the average yield was 28.1 bushels. The number of crop failures and low yields were reduced by fallowing, but yields after fallow were double those on cropped land in only 1 year out of 4. The average half-acre production after fallow was 28 percent less than the average acre production on early plowing after small grain and 32 percent less than the average acre yield on disking after intertilled crops. For each average bushel of oats gained by fallowing, 1.9 bushels of corn was produced where this crop replaced the fallow. Average yields after green manures were lower than after fallow. Average yields were also depressed by the use of barnyard manure.

Barley acreages in recent years have increased more than have the acreages of any of the other spring grains. At this station the 28-year average yields after small grains were 21.9 bushels on early plowing and 17.5 on late plowing. On disked cornland the average was 17.9 bushels. For the 14-year period 1921–34 the average yield on disked cornland was 19.5 bushels, and on disked milo land 16.8 bushels. After fallow the average yield of 31.1 bushels exceeded the yield after corn by 13.2 bushels. Each bushel of barley gained by fallowing was offset by 1.5 bushels of corn that might have been produced by substituting corn for the fallow. In 1 year out of 3, however, barley yields after fallow were more than double the yields after corn, and there was only one total failure of barley after fallow, while three occurred following corn.

Rye in this section is grown chiefly on sandy soils. It is used both for pasture and grain production, and the stubble furnishes good protection against soil blowing. On hard-land soils, rye is usually less productive than winter wheat and it has a lower market value. At this station, the yields of rye on different preparations ranged from 75 to 86 percent of the yields of winter wheat. After barley, average acre yields for the 14-year period 1921–34 were 14.5 bushels on early fall plowing and 11.4 bushels on stubble land disked at a later date. On disked corn-stubble land, the average acre yield was 11.8 bushels. The average acre yield of 27.1 bushels after fallow was more than double the yields of other treatments except early fall plowing.

Corn is the leading intertilled crop in the central Great Plains. It is the chief crop with which small grains are rotated. Listing is the predominating method of planting. Tillage costs are low, and profitable production is possible from moderately low yields. In recent years, a part of the corn acreage has been taken over by improved grain sorghums. These are more drought-resistant than corn but less suitable for rotation with other crops.

In field 41, the 28-year average acre yield of corn in rotations after small grain was 17.4 bushels on spring-plowed land and 19.3 bushels on fall-plowed land. The lowest average yield was 14.9 bushels after sorgo. Corn after corn produced more than corn after small grain, but long continued growing of corn on the same land resulted in decreased vigor of stalk and its ability to respond to favorable conditions. Corn made the poorest response to fallow of any of the crops grown on that preparation. The average yield of 24.0 bushels to the acre on fallow was less than 3 bushels gain over continuously cropped corn. In field 49, after small grains the average acre yields of corn for a 14-year period were 20.9 bushels with no tillage previous to listing, 23.7 bushels where the land was disked before listing, 24.2 with spring plowing, and 24.1 with fall plowing. The average yield on disking after milo was 21.1, or 2.6 bushels less than the same treatment after small grain. In 3-year rotations in field 42 for a 12-year period, the average yield of corn was about 1 bushel higher when one of the two previous crops was corn than when both crops were winter wheat. In this field, the yields of corn from continuous cropping were about the same as after small grain.

Milo for a 14-year period produced average acre yields of 23.3 bushels after small grain and 25.0 after corn. The yields of milo and corn after small grains were practically equal, but milo after corn produced 3.9 bushels to the acre more than corn after milo. The yields of barley after milo averaged 16.8 bushels to the acre, and after corn 19.5.

For a 21-year period, the average acre yield of drilled sorgo was 3 tons after small grain, 3.5 tons after corn, and 4 tons after fallow. In a farming system using both fallow and sorgo there are more advantages in placing fallow after, than before, the sorgo crop.

Potatoes were grown in 3-year rotations for a 21-year period. After small grains, the average acre yields were 82.8 bushels on disked and 99.1 bushels on early fall-plowed land. On disked cornland, the average yield was 75.8 bushels, and a greater decline in yield occurred in this sequence as the investigations were prolonged. It is probable that 2 years of other crops between potatoes were not sufficient to rid the soil of potato-disease organisms. After fallow, the average yield was 113.9 bushels to the acre. There were no complete failures and only three yields below 50 bushels. The increased yield and quality of the crop on fallowed land exceeded the value of a grain crop that might have been produced during the year of fallow.

Alfalfa and bromegrass used as sod crops for 3 years in 6-year rotations produced low yields and depressed the yields of the succeeding crops. The sod crops were beneficial with regard to the loss of organic matter and nitrogen from the soil and to the protection of the soil from wind and water erosion. The rate of nitrogen loss from these 6-year rotations was practically half the rate of loss in adjacent 3-year rotations containing annual crops only.

The results obtained with all crops show a high relationship between crop yield and amount of rainfall during and preceding the growing season. Available moisture is the chief limiting factor in crop production. Crop yields follow an irregular pattern of very good to excellent yields in a relatively few years of high rainfall, fair to good yields in a larger number of years with more nearly normal rainfall, and very low yields or crop failure in years of great rainfall deficiency. The irregular occurrence and uncertain direction of rainfall departures stimulate the hope that each approaching year will bring a bumper crop and at the same time keep alive in the mind of the experienced farmer the risk of possible failure. Risks of crop loss can be reduced by use of summer fallow, and moisture can be conserved by a continuing program of weed control. As some losses from runoff from hard dashing rains and heavier losses from evaporation are frequent, storage of moisture by summer fallow for later use by crops is not highly efficient. For 20 summer fallow periods at North Platte, the amount of precipitation stored varied from 8.5 to 41.7 percent, and averaged 27.0 percent. Depth of soil moisture at the end of a summer fallow season has usually been 5 to 6 feet and occasionally 8 to 10.

Under continuous cropping soil moisture seldom extends to depths of more than 3 feet.

With continuing years of cropping and tillage, decreasing fertility becomes of increasing importance. Under dry-farming practices in general use, soil organic matter and nitrogen are exhausted more rapidly than they are restored and the capacity of soils to produce gradually declines. Yield trends are difficult to follow on account of the wide fluctuations resulting from rainfall variations, and, paradoxically, under dry-land conditions there is at times an inverse relationship between high fertility and crop yield. High fertility associated with favorable moisture and temperature conditions stimulates excessive vegetative growth that may exhaust the moisture supply before the crop is matured. Under these conditions yields may be lower than where early growth has been retarded by limited fertility and moisture supports growth through a longer period. Farm manures are valuable in maintaining fertility but must be used sparingly where moisture is limited, to prevent stimulation of vegetative growth, premature exhaustion of moisture, and injury to crops before maturity. Green manures have in general produced disappointing results.

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