The Magruder Plots: Taming the Prairies Through Research

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Cover photo: OSU researchers (from the left) Dr. B. B. Tucker, Dr. R. L. Westerman, and Dr. B. B. Webb, examine wheat plants from the 1980 crop at the Magruder Plots.

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Researchers in Charge of Magruder Plots

A. C. Magruder 1893-95
J. H. Bone 1896-99
F. C. Burtis 1900-06
L. A. Moorehouse 1907-09
A. H. Wright 1910
O. O. Churchill 1911-14
M. A. Beeson 1915-21
A. Daane 1922-25
H. J. Harper 1926-51
F. Gray 1952-56
B. B. Tucker 1957-76
R. L. Westerman 1977-Present

Introduction

Since the beginning of civilization man has had to tame his surroundings in order to survive. This was especially true during frontier days on the Great Plains. The settlers broke the sod and planted crops so that families could be fed and clothed. Taming the prairies was no small task; many of those who tried were not successful. Those who did succeed, however, were rewarded with some of the most productive agricultural lands available anywhere.

Early agricultural leaders in Oklahoma realized the value and potential of the Oklahoma prairies. They had visions of developing a great agricultural state and initiated early research that was to be of tremendous value to Oklahoma agriculture in years to come.

The Early History

In the fall of 1892 A. C. Magruder, first professor of agriculture at Oklahoma A&M College (now Oklahoma State University), planted wheat on the Oklahoma Agricultural Experiment Station, in an area which became known as the Magruder Plots. Wheat has been planted on this reddish prairie soil every year since—for 87 years—making the Magruder site the oldest continuous research plots west of the Mississippi River.

The objective as stated by Magruder in 1892 was to obtain information about the ability of the prairie soil to produce continuous good wheat yields without fertilization. No fertilizer was applied to the research area from 1893 to 1898.

In 1896 the area was divided into two plots, in an effort to measure soil variation. Yields were taken separately from the north and south halves. From 1899 through 1929 the south half was fertilized with barnyard manure and the north half was unfertilized. No commercial fertilizer was used during this period.

In the fall of 1926, each half was divided into five plots. In order to determine the presence of soil variations, separate yields were taken from the ten plots the next three years. Beginning in 1930, fertilizer treatments were applied on the plots as shown in Figure 1.

During the summer of 1933 it was necessary to reduce the length of the plots from 255 feet to 155 feet, to make room for construction of a dormitory, Murray Hall. In the summer of 1947 another new dormitory, Stout Hall, was planned. It seemed that the remainder of the wheat test plots area might have to be abandoned. But the determination of the researchers, and the recognition of the tremendous value of the plots, resulted in moving some of the plots to another location.

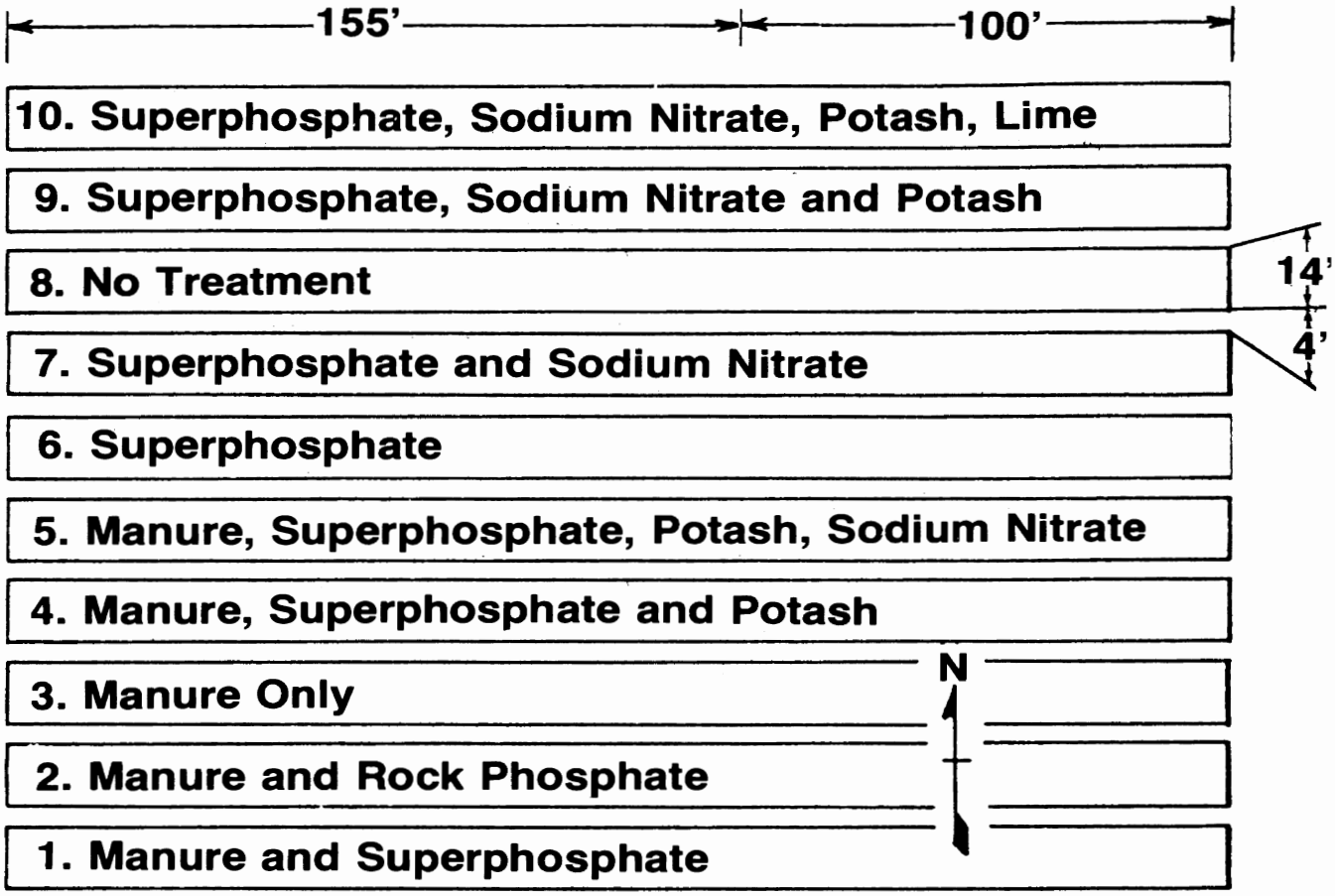


Figure 1. The Arrangement of the Magruder Plots in Their Original Location Before 1947.

The new location was about one mile west, on the present Agronomy Research Station, on plot series 7200. The surface and subsurface soils from plots 3, 6, 7, 8, 9, and 10 were moved. The top eight inches of soil was removed from the center 100 feet of each 155-foot plot and piled on the ends (see Figure 6). The subsurface soil, about 8 inches deep, was then taken up and moved to the new site. It was placed evenly into prepared trenches 16 inches deep, 17.5 feet wide and 100 feet long. The new site was oriented in an east-west direction. A four-foot strip of undisturbed soil was left as a border between plots. The reddish-gray subsoil below the 16-inch level was similar to the subsoil under the original plot site.

Since the move in 1947, the treatment and plot arrangements have been as shown in Figure 2. The plots were then given new number designations.

Procedures and Results

The original objective of the study was to obtain information on the ability of the soil to continue to produce good wheat yields without fertilization. As the study continued and fertilizers were added, the objectives broadened to include studies of the effects of continuous wheat production and long-term fertilization on soil productivity. Yields during the first four years were: 1893, 10.5 bushels per acre; 1894, 20.9 bushels per acre; 1895, crop failure due to severe fall and spring drought; and 1896, 6.9 bushels per acre. In 1897 the yield was 17.9 bushels per acre on the north half and 17.8 bushels per acre on the south half. In 1898 the yield was 7.5 bushels per acre on the north half and 7.0 bushels per acre on the south half.

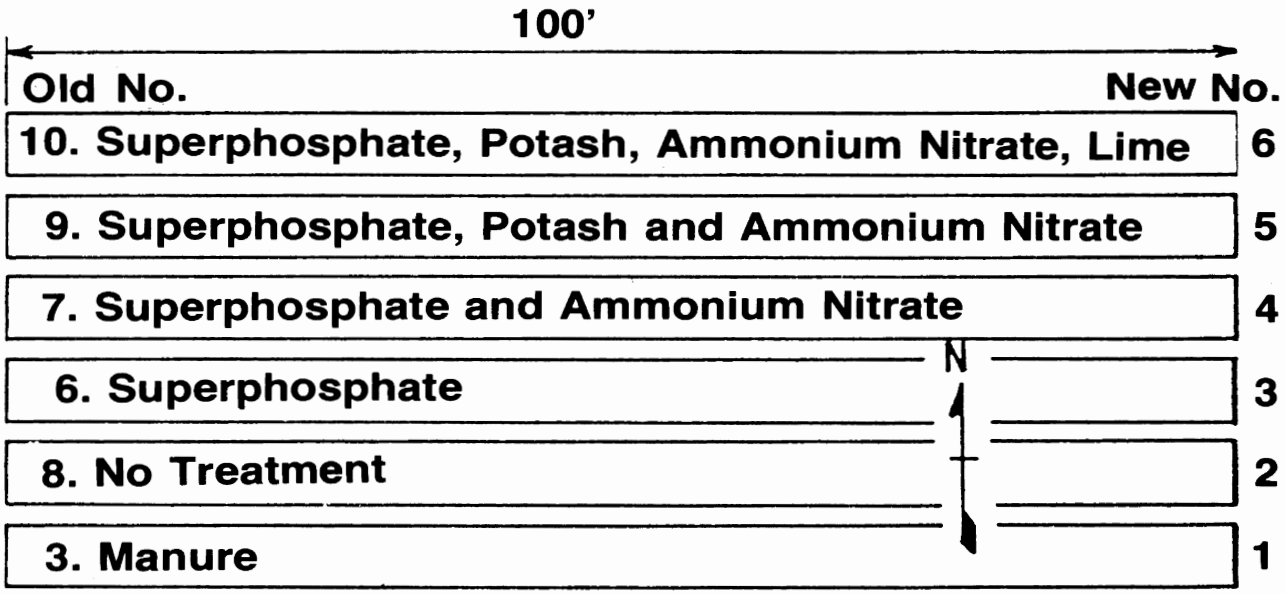


Figure 2. The Arrangement of the Six Transferred Magruder Plots at the Present Location Since 1947.

Varieties Planted

The wheat variety planted each year was the one which had been shown by research results to be the best available. The varieties planted in this study are shown in Table 1. Soft red winter wheat was planted until 1912, then hard red winter wheat was planted each year.

Seeding Rate

The wheat was drilled in 7" rows prior to 1934. All plantings from 1934 to 1957 were in 14" rows except in 1948 when a 7" spacing was used to decrease competition from henbit *(Lamium amplericaute)*. The rate of seeding was about 75 pounds per acre in the 7-inch rows and 50 pounds per acre in the 14-inch rows. Since 1957, the seeding rate has been 60 pounds per acre, planted in 10-inch row spacing.

Fertilizer Treatments

In July 1898, barnyard manure was applied to the south half of the plot. Until 1930 the study was devoted to yield comparisons of north half unfertilized with south half fertilized with manure. After 1930 the comparison was continued on smaller portions of the original manured and unmanured plots. The manure applications are described in Table 2. The average application rate has been 2.25 tons per acre per year. Until 1941 the manure was applied at the rate of 120 pounds of nitrogen per acre every fourth year.

Beginning with the 1930 crop, the 10 plots were given fertilizer treatments as shown in figure 1. Nitrogen was applied annually at the rate of 33 lbs of N per acre through 1967 at which time the annual rate was increased to 60 lbs per acre and it has been fall applied since the rate increase. Prior to 1947 sodium nitrate was the source of nitrogen, but ammonium nitrate has been used since that time.

Phosphorus and potassium have been applied at the annual rate of 30 lbs P_2O_5 and 30 lbs K_2O per acre, respectively.

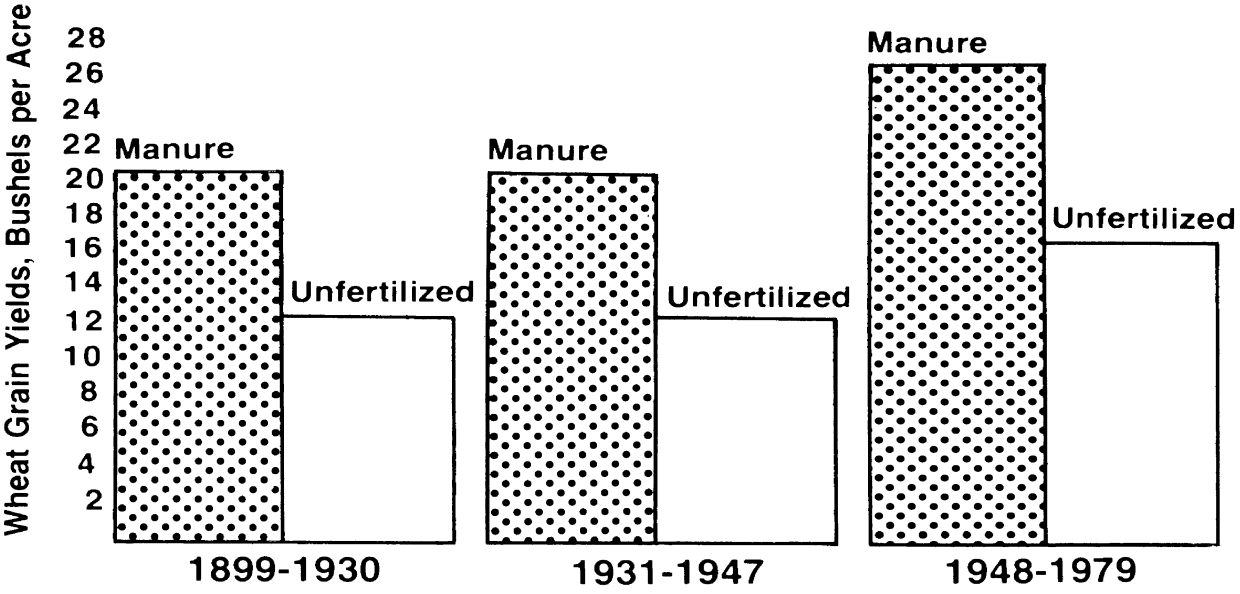
Lime is applied when soil analysis indicate a pH of 5.5 or less.

Changes in Soil Composition

Soil analyses have been made throughout the time the Magruder Plots have been in existence. Some very interesting results have been obtained in regard to changes in nitrogen and organic matter content, as shown in Figure 4.

Soil analysis results reflecting changes in nitrogen, phosphorus and potassium are recorded in Table 6.

Figure 3. Average Wheat Grain Yield Influenced by Unfertilized and Manure Treatment.



Discussion

Effect of Fertilizer Treatment on Wheat Yields

Because the manure treatment has been continuous since 1898, the average wheat yields as influenced by manure applications by various time periods are shown in Figure 3. Yields for each year are given in Table 3. Since the experiment was started manuring has increased wheat yields over the unfertilized check. Harper [1] gave a summary of all yields prior to 1957.

A summary of wheat yields from all the plots still in operation since 1930 is given in Table 7 and annual yields since 1957 are shown in Table 4. By showing the average yields in these time intervals, some important conclusions become evident. For many years the plots receiving manure and phosphate only yielded about the same but much more than the untreated plots. No response was obtained from nitrogen fertilization for the first 60 years of the experiment. In recent years the phosphate-only plot has yielded less than the plots receiving both nitrogen and phosphorus. The data suggest that after 60 years of continuous wheat, nitrogen became a limiting factor in wheat production on this soil and now both nitrogen and phosphorus are needed for maximum yields. Potassium and lime applications have not yet been beneficial in increasing yields.

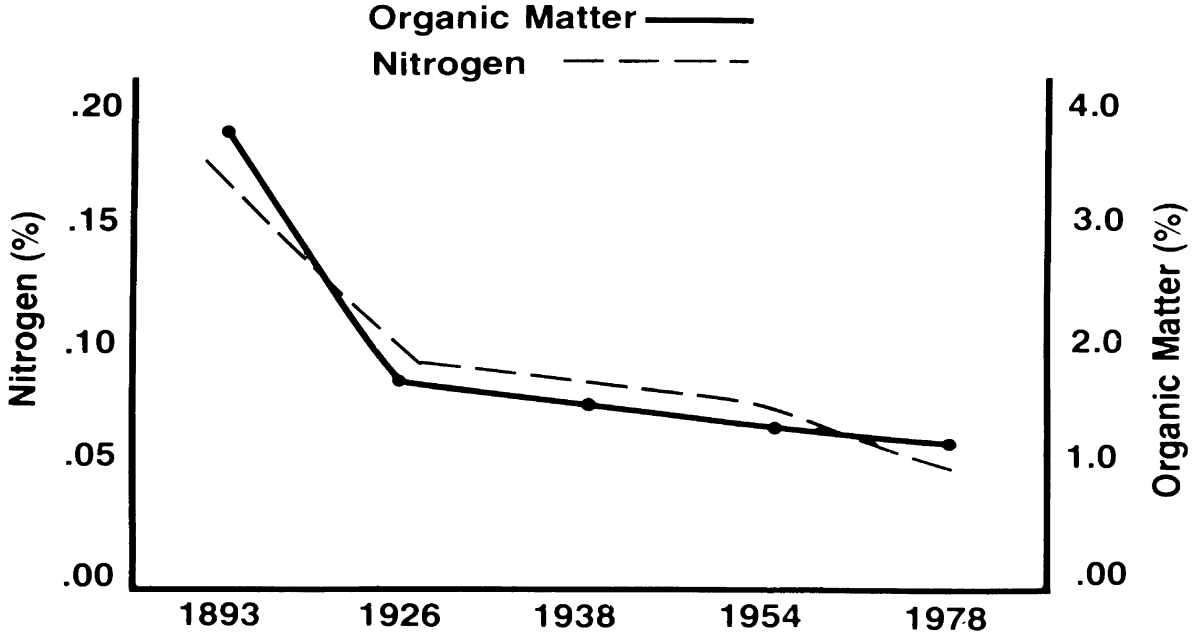
Effect of Fertilizer Treatment on Soil Composition

As stated by Harper [1] in an earlier publication concerning the Magruder Plots, much of the nitrogen and organic matter originally present in the virgin soil on which the continuous wheat plot was located has disappeared (Table 5). The loss in soil organic matter is shown graphically in Figure 4. This dark reddish prairie soil (Kirkland Silt Loam) had more than 3½ percent organic matter in 1892 when the virgin sod was broken. The organic matter was rapidly oxidized in the early years and by 1926 about half of the original organic matter remained. There is evidence that indicates an equilibrium has been reached and further decomposition will be quite slow.

The application of barnyard manure each four years on plot No. 1 has not maintained the soil organic matter content, but as shown in Table 4 the loss was slowed on this plot as compared to the check over the years. It should be noted that the plot receiving barnyard manure application has not produced higher yields than the ones receiving nitrogen and phosphorus applications from commercial fertilizer.

Estimations of nitrogen mineralization from the oxidized organic matter on the phosphorus fertilized plot is about 2350 pounds of nitrogen per acre

Figure 4. Changes in Organic Matter and Nitrogen Content of Surface Soil on Unfertilized Soil, 1893-1970.



through 1970 and up until that time approximately 1800 pounds of nitrogen per acre has been removed in the grain.

All of the surface soils except the plot receiving aglime are strongly acid. Soil acidity in the no-lime plots is increasing at a slow rate. The lowest pH values are found in the nitrogen plus phosphate plot. In spite of the higher pH values in the limed plot, liming has not increased yields on this soil.

Those plots receiving manure and phosphate applications test relatively high in available phosphorus. The check plot shows only a moderate level of available phosphorus, but well within the range for expected response to applied phosphorus fertilizer. Applications of barnyard manure have not maintained phosphorus soil test levels to those obtained where phosphate fertilizers have been applied.

Summary

Wheat has been grown on a reddish prairie soil near Stillwater, Oklahoma, every year for 87 years. The first harvest was in 1893. Through 1930, no commercial fertilizer was applied but half of the area received barnyard manure, while the other half received no fertilizer. In 1930, the area was divided into 10 plots. In addition to the check and barnyard manure, eight combinations of commercial fertilizer were applied. In 1947, six of the plots were moved to the Agronomy Research Station. A comprehensive summary of information obtained from these plots was published in 1959 (OSU Experiment Station Bulletin B-531). It was found early in these studies that phosphorus applications increased wheat yields, but through 1957 no yield increases were obtained from nitrogen, potassium, and liming.

Since 1957 more valuable information has been obtained and new lessons learned. They can be summarized as follows.

1) After 87 years of cultivation and crop production, nitrogen is also deficient for crop production on this soil. Now both nitrogen and phosphorus are required for maximum yields.
2) Yield levels have increased with each fertilizer treatment, but the greatest increase has been on plots receiving both nitrogen and phosphorus.
3) Application of commercial fertilizer has improved yields as much as applications of barnyard manure.
4) Potassium additions have had no noticeable effects on crop yields to date and liming has been only slightly beneficial.
5) Soil organic matter has declined further since 1957, but seems to be reaching a stable level. Soil test levels of phosphorus have been increased by phosphate fertilization and the application of manure. Levels of available soil phosphorus on all plots except the no fertilizer treatment are nearing optimum levels as a result of these long term applications.

Magruder Plot Publications

1. Harper, H.J., 1959. *Sixty-Five Years of Continuous Wheat.* Okla. Agr. Exp. Sta. Bull. B-531.

2. Agriculture at OSU, 1975. "Long-Time Experimental Plot Record — The History of Oklahoma Wheatlands." Vol. 5, No.3.

3. Banks, P.A., P.W. Santelmann, and B.B. Tucker, 1976. "Influence of Long-Term Soil Fertility Treatments on Weed Species in Winter Wheat." *Agron. Jour.,* Vol. 68, p. 825-827.

4. Tucker, B.B. 1972. *Long-Term Fertilizer Studies on Winter Wheat.* Okla. Agr. Exp. Sta. Progress Report. P-662, p. 15-17.

5. Tucker, B.B., 1974. *Long-Term Fertilizer Studies on Winter Wheat.* Okla. Agr. Exp. Sta. Progress Report. P-695, p. 19-20.

6. Tucker, B.B. 1976. *Long-Term Fertilizer Studies on Winter Wheat.* Okla. Agr. Exp. Sta. Progress Report. P-735, p. 36-37.

7. Causley, F., 1978, "The Agricultural Experiment Station," *OSU Outreach,* p. 21-23.

8. Tucker, B.B., 1975, "We're on the Right Track," *Okla. Farmer-Stockman.*

9. Chapman, B.B., 1943, "First Faculty set Standards," *The A&M College Magazine,* p. 3, 4, 12, 14 and 16.

10. Musherraf, Sayed Noor-ul-Huda, 1961, "Soil Phosphorus Test Values and Wheat Production," Master of Science Thesis, Department of Agronomy, OSU.

11. Fell, Glen T., 1976, "Nitrogen Mineralization Potential of Some Key Oklahoma Soils in Relation to Nitrogen Treatment, Sample Depth, and Wheat Yields," Master of Science thesis, Department of Agronomy, OSU.

12. Congressional Notification of Acceptance of Magruder Plots into National Register of Historic Places, U.S. Department of Interior Heritage Conservation and Recreation Service, August 29, 1979.

Figure 5. Unfertilized plot (No. 8 in original location) is shown in center in this June, 1940, photo. Soil phosphate deficiency caused this plot to mature several days later than others.

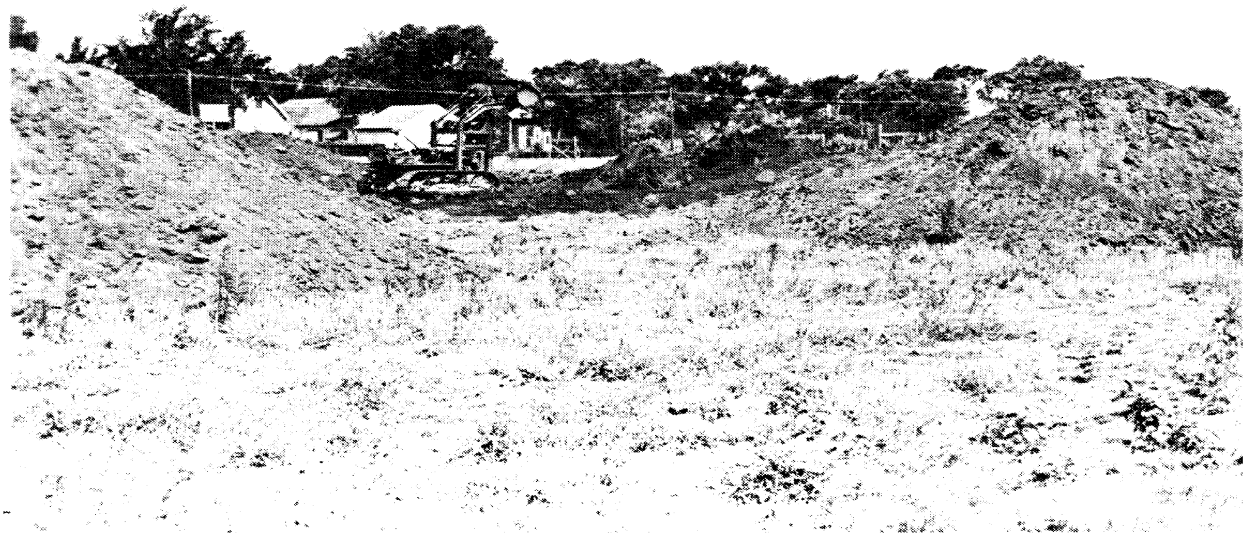


Figure 6. Surface soil from six of the old plots was piled so subsurface soil could be removed and transferred to the new location in July, 1947.

Table 1. Wheat Varieties Planted on the Magruder Plots (1893-1980).

Year or Period	Variety
1893	Fultz
1894	Currell
1895-1907	Fultz
1908-1911	Sibley's New Golden
1912-1916	Kharkov*
1917-1942	Turkey
1943-1945	Tenmarq
1946-1953	Pawnee
1954-1957	Ponca
1957-1963	Concho
1963-1968	Kaw
1968-1973	Scout 66
1973-1977	Triumph 64
1977-1980	Osage

*A Selection from Turkey wheat.

Table 2. Time, Method and Quantity of Barnyard Manure Applied to the Continuous Wheat Plots from 1898 to 1976.

Year	Month Applied	Tons per acre	Method of Application
1898	July	15	Before plowing
1899	July	11	Before plowing
1904	July	18	Before plowing
1911	November	24	Top dressed on wheat
1913	February	12	Top dressed on wheat
1916	July	12	Before plowing
1920	September	12	After plowing
1928	August	24	After plowing
1932	October	12	After plowing
1936	August	12*	Before plowing
1941	January	12**	Top dressed on wheat
1944	August	12**	After plowing
1948	July	12**	Before plowing
1952	July	12**	Before plowing
1956	November	12**	Top dressed on wheat
1960	September	12*	Before seeding
1964	August	12*	Before plowing
1968	July	16***	Before plowing
1972	July	16***	Before plowing
1976	July	16***	Before plowing

* Dry manure applied at the rate of 4 tons per acre.
** Applied at the rate of 120 pounds of nitrogen per acre.
*** Applied at the rate of 240 pounds of nitrogen per acre.

Table 3. Wheat Yields on the Manured and Unmanured Plots in the Continuous Wheat Experiment, 1899 to 1979.

Harvest Year	Yield (bushels per acre)		Harvest Year	Yield (bushels per acre)	
	Fertilized with farm manure	Unfertilized		Fertilized with farm manure	Unfertilized
1899	30.6	12.0	1940	28.2	15.2
1900	36.8	18.1	1941	6.4	.9
1901	37.7	28.0	1942	12.5	2.6
1902	17.4	15.3	1943	11.3	4.3
1903	27.6	20.3	1944	23.3	16.1
1904	15.7	12.6	1945	8.1	6.7
1905	11.7	4.8	1946	28.4	11.7
1906	23.3	7.1	1947	21.2	18.7
1907	14.9	5.2	1948	24.9	18.1
1908	15.5	12.9	1949	20.9	9.8
1909	25.4	21.7	1950	23.4	20.3
1910	35.2	18.7	1951	25.9	8.4
1911	4.9	2.3	1952	12.0	8.7
1912	20.4	5.3	1953	21.6	14.7
1913	14.8	5.6	1954	15.0	12.8
1914	33.5	23.2	1955	3.3	7.8
1915	19.5	15.2	1956	12.3	19.6
1916	13.3	7.9	1957	20.8	13.3
1917	32.0	21.0	1958	37.5	28.7
1918	29.2	10.8	1959	44.5	28.1
1919	11.6	7.0	1960	21.9	11.5
1920	34.0	27.3	1961	33.6	10.5
1921	15.7	7.3	1962	24.6	14.1
1922	7.4	3.8	1963	37.9	27.6
1923	23.5	12.9	1964	10.1	6.0
1924	17.7	7.7	1965	40.2	25.8
1925	20.1	11.4	1966	37.1	29.7
1926	7.0	7.1	1967	11.7	6.6
1927	5.3	1.7	1968	16.1	14.4
1928	28.9	17.8	1969	20.8	14.8
1929	17.3	10.0	1970	24.6	19.5
1930	19.1	7.9	1971	29.1	24.3
1931	25.0	25.6	1972	33.6	18.2
1932	30.2	19.3	1973	42.1	19.2
1933	28.0	12.5	1974	34.4	18.1
1934	12.7	12.7	1975	46.7	18.7
1935	27.7	14.0	1976	42.3	18.3
1936	21.8	19.3	1977	12.7	14.7
1937	28.3	22.0	1978	27.2	17.9
1938	10.2	3.4	1979	49.3	25.3
1939	25.2	15.3	Average	23.13	14.26+

Table 4. Grain Yields, Magruder Plots, 1958-79.

Treatment	Plot	1958	1959	1960	1961	1962	1963	1964
Manure	1	37.5	44.5	21.9	33.6	24.6	37.9	10.1
Check	2	28.7	28.1	11.5	10.5	14.1	27.6	6.0
P	3	24.2	27.0	29.8	17.5	18.9	22.7	17.0
N,P	4	36.9	39.5	34.0	26.1	28.5	41.5	20.7
N,P,K	5	35.7	39.4	35.2	27.6	27.0	32.3	22.2
N,P,K, Lime	6	37.5	43.0	33.8	29.3	30.6	44.1	23.5

Treatment	Plot	1965	1966	1967	1968	1969	1970	1971
Manure	1	40.2	37.1	11.7	16.1	20.8	24.6	29.1
Check	2	25.8	29.7	6.6	14.1	14.8	19.5	24.3
P	3	25.8	25.2	6.5	13.6	12.5	20.8	33.1
N,P	4	30.7	49.3	10.1	23.5	25.4	23.5	36.2
N,P,K	5	29.9	34.5	9.9	23.8	27.1	31.0	29.6
N,P,K, Lime	6	38.6	38.1	11.3	25.2	28.2	30.2	33.4

Treatment	Plot	1972	1973	1974	1975	1976	1977	1978
Manure	1	33.6	42.1	34.4	46.7	42.3	12.7	27.2
Check	2	18.2	19.2	18.1	18.7	18.3	14.7	17.9
P	3	14.6	17.4	14.3	16.2	19.6	25.8	16.9
N,P	4	38.9	44.1	38.8	51.4	45.6	32.3	32.2
N,P,K	5	37.1	43.3	30.4	47.8	45.3	23.8	33.7
N,P,K, Lime	6	39.4	42.6	42.7	50.1	46.2	--	32.8

Treatment	Plot	1979	Ave.
Manure	1	49.3	30.82
Check	2	25.3	18.73
P	3	39.5	20.86
N,P	4	52.6	34.63
N,P,K	5	50.3	32.59
N,P,K, Lime	6	52.3	35.85

Table 5. Nitrogen and Organic Matter Content of Surface Soil from Manured and Unfertilized Wheat Plots, 1893-1978.

	Percent Nitrogen					*Percent Organic Matter*				
Treatment	**1893**	**1926**	**1938**	**1954**	**1978**	**1893**	**1926**	**1938**	**1954**	**1978**
Manure	0.160	0.125	0.119	0.078	0.054	3.58	2.68	2.32	1.76	1.54
Unfertilized	0.160	0.095	0.087	0.077	0.051	3.58	1.85	1.69	1.35	1.18

Table 6. Soil Test Values, Magruder Plots, 1967

			Available P Lbs/A		**Available K Lbs/A**	
Plot	**Treatment**	**pH**	**0-6**	**6-12**	**0-6**	**6-12**
1	Manure	5.4	29.98	27.33	360.25	370.50
2	Check	5.4	19.49	17.72	286.25	316.00
3	P	5.3	69.78	50.59	330.75	259.50
4	NP	5.2	64.09	35.18	369.75	311.75
5	NPK	5.5	55.31	37.51	449.25	383.4
6	NPK, Lime	6.4	47.01	30.63	391.00	350.25

Table 7. Summary of Wheat Grain Yields from the Magruder Plots, in Bushels per Acre.

	1930-47	**1948-57**	**1958-61**	**1961-70**	**1971-79**
Manure	20.4	18.0	34.4	25.4	35.3
Check	12.6	13.3	19.7	16.8	19.4
P	18.3	19.1	24.6	19.1	21.9
N,P	19.6	19.8	34.1	28.8	41.3
N,P,K	20.1	19.9	34.4	26.6	37.9
N,P,K, Lime	19.6	22.5	35.9	28.9	42.4

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