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Fertility Studies on Kirkland Soil

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Experiment Station Bulletin No. 189. June, 1929.

FERTILITY STUDIES ON KIRKLAND SOIL

The Red Prairies of Oklahoma comprise essentially the western half of the state with the exception of the Panhandle and a small irregular strip along the extreme west side. The eastern boundary crosses essentially Kay, Pawnee, Payne, Lincoln, Oklahoma, Cleveland, McClain, Garvin, and Carter counties.

In this section of the state are found two major kinds of soils; namely, the red soil occupying the steeper areas and the brown soils occupying the level to undulating areas as a rule.

The brown soils of the Red Prairies are quite extensive in the area. These soils are classified as belonging to the Kirkland series and are described as having a rather impervious subsoil. The imperviousness is such that moisture movement is limited. The depth of the impervious layer varies but it is of such a depth that moisture cannot move freely enough either upward or downward through it to satisfy the needs of plants. Due to this nature, there is only a small reservoir for moisture accumulation as the depth at which the imperviousness begins ranges from zero on the eroded places to about two feet on the more level, less eroded places. Root extension into this zone is hindered by its imperviousness. Moisture conditions of the zone also are such during the growing season that even though the roots of plants were present, the moisture availability would be extremely low. It is thus a limitation to the food supply of the plant.

Table 1.—Showing 30 years results with wheat on manured and unmanured soil.

	Date Manure Was Applied to Plot 1	Tons Per Acre	Plot I Manured Bu. Per Acre	Plot II Unmanured Bu. Per Acre	Increased Yield of Plot I Over Plot II
1898-99	July, 1898	15	30.60	12.00	18.60
1899-00	July, 1899	11	36.80	18.10	18.70
1900-01	----------	--	37.70	28.00	9.70
1901-02	----------	--	17.40	15.30	2.10
1902-03	----------	--	27.60	20.30	7.30
1903-04	July, 1904	18	15.70	12.60	3.10
1904-05	----------	--	11.68*	4.75*	6.93
1905-06	----------	--	23.26	7.10	16.16
1906-07	----------	--	14.93	5.20	9.73
1907-08	----------	--	15.47	12.90	2.57
1908-09	----------	--	25.40	21.70	3.70
1909-10	----------	--	35 20	18.70	16.50
1910-11	----------	--	4.86*	2.28*	2.58
1911-12	Nov., 1911	24***	20.40	5.32	15.08
1912-13	Feb., 1913	12***	14.80	5.60	9.20
1913-14	----------	--	33.50	23.20	10.30
1914-15	----------	--	19.53	15.16	4.37
1915-16	----------	--	13.30	7.90	5.40
1916-17	July, 1916	12	32.00	21.00	11.00
1917-18	----------	--	29.22	10.75	18.47
1918-19	----------	--	11.65*	7.03*	4.62
1919-20	----------	--	34.03	27.30	6.73
1920-21	Sept., 1920	12***	15.66*	7.26*	8.40
1921-22****	----------	--	7.40	3.76	3.64
1922-23	----------	--	23.46	12.93	10.53
1923-24	----------	--	17.67	7.67	10.00
1924-25	Fall, 1924	12	20.06	11.37	8.69
1925-26	----------	--	7.02†	7.12†	—0.10
1926-27	----------	--	4.68	1.44	2.24
1927-28	----------	--	26.22	15.76	10.46
30 Yr. Ave.	----------	--	20.91	12.32	8.59

*Damaged greatly by rust and chinch bugs.
**Damaged by severe drouth.
***Applied as top dressing.
****Damaged greatly by black chaff disease.
†Unfavorable climatic conditions.

Continuous Wheat Experiment

The hard wheat section of the state comprises along with other areas the northern part of the Red Prairies. Winter wheat is, therefore, a very important crop on this soil. Its importance was recognized at the beginning of the establishment of fertility experiments at the Oklahoma Experiment Station. In 1892, an acre of virgin land was set aside for a wheat experiment. Up until 1898 the soil on this acre was studied for its uniformity. Since that time one-half of the acre has been manured from time to time and one-half has grown wheat continuously with no manurial treatment. Table 1 gives the results of this experiment since 1898.

The average yield of wheat on the unmanured soil is 12.32 bushels per acre. The 6-year average yield on the acre previous to treating one-half of the area with manure was 10.57 bushels. The average yield on the untreated area from 1898 to 1908 is 13.62 bushels; from 1908 to 1918 is 13.16 bushels; and from 1918 to 1928 is 10.16 bushels per acre. This falling off during the last ten-year period has been due largely to diseases and insects. Dry weather contributed also. The same decrease is noticeable where manure has been applied. The yield for the first ten-year period averages 23.11 bushels; for the second ten-year period 22.82 bushels; and for the last ten-year period 16.78 bushels per acre. The thirty-year average shows that manure gave an increase of 8.59 bushels of wheat per acre. The average application of manure amounts to 3.87 tons per acre calculated on an annual basis, thus each ton of manure increased the wheat yield 2.22 bushels per acre.

Wheat in Rotation

This experiment consists of a three-year rotation of kafir, wheat and cowpeas. It is located on Kirkland loam to silt loam soil. Three systems of farming are incorporated in this experiment; namely, (a) livestock system; (b) grain farming; and (c) diversified farming.

In the livestock system, manure is added equivalent to that which would be produced if the crops were fed to livestock with the exception that wheat grain is considered a cash crop. In the grain farming system, all of the crop residues are returned, while with the diversified system, manure is applied equivalent to that which would be produced if two-thirds of the grain and all the residues were fed to livestock. The cash crops sold off the farm under the diversified system consists of one-third of the kafir grain and all of the wheat grain. Rock phosphate is applied to certain plots under each system as can be noted under the heading of "Treatment" in Table 2. It is applied equivalent to 250 pounds per acre annually but is only applied every three years at which time the manure is applied.

Table 2.—Showing the twelve-year average yield per acre of crops growing in a three year rotation, (1917 to 1928, inclusive).

Treatment	WHEAT Grain Bu.	WHEAT Straw Lbs.	Cowpea Hay Lbs.	KAFIR Grain Bu.	KAFIR Stover Lbs.
Check	12.60	1665	1948	16.80	4224
Manure	17.18	2072	2064	22.21	4879
Manure Rock Phosphate	17.80	2179	2382	19.60	4619
Check	15.18	1958	2067	20.52	4623
Residues	14.05	1675	2166*	21.44	4508
Residues, Rock Phosphate	15.38	1933	2295*	22.40	4549
Check	14.40	1793	2259*	21.12*	4416*
Manure = ⅔ Grain and Res.	17.38	2285	2554*	21.94*	4584*
Manure = ⅔ Gr. and Res., and R. Phos.	16.82	2299	2499*	19.34*	4499*

*Eleven year average.

Manure in the livestock system has given an increase of 3.29 bushels of wheat, 57 pounds of cowpea hay, and 3.55 bushels of kafir over the average yield of the two closest plots left untreated. The results from residues showed a loss of 0.74 bushels of wheat and a gain of three pounds of cowpea hay and 0.62 bushels of kafir. The diversified system showed a gain over the closest untreated area of 2.98 bushels of wheat, 295 pounds of cowpea hay, and 0.82 bushels of kafir. Rock phosphate did not pay. The three systems of farming rank as follows: (1) livestock system; (2) diversified system; and (3) grain system.

Continuous Culture Experiment

This experiment was started in 1916, although the fertilizer treatments were not made until 1917; thus, there are twelve years results since fertilizers were applied. This experiment was planned similar to the wheat rotation experiment just mentioned except the various crops; namely, cotton, kafir, and oats are not rotated but are grown continuously on the same soil each crop formerly occupied. Cotton seed was considered feed. All of the cotton stalks were returned to every plot in cotton. Cotton lint was sold as a cash commodity. The results of this experiment are given in Table 3.

Table 3.—Showing twelve-year average yield per acre with crops in continuous culture on variously treated soil, (1917 to 1928, inclusive).

Treatment	Seed Cotton (lbs.)	Kafir Grain (bu.)	Kafir Forage (lbs.)	Oats Grain* (bu.)	Oats Straw (lbs.)
Check	733	17.89	2989	35.14	1150
Manure	805	19.55	3189	39.81	1250
Manure and Rock Phosphate	816	20.23	3124	41.78	1296
Check	760	19.85	2906	34.93	1104
Residues	747	20.26	3185	36.30	1170
Residues and Rock Phosphate	753	20.85	3388	37.71	1164
Check	746	21.44	3031	34.93	1197
Manure = Res. and ⅔ Grain	760	19.83	3304	35.44	1155
Manure = Res. and ⅔ Grain + Rock Phos.	754	20.51	3331**	34.81	1064

*Oats failure in 1923 due to late freeze.
**Ten-year average. Chinch bugs destroyed yields in 1917 and 1928.

The effect of manure in the livestock system was to increase the yield of seed cotton, 58 pounds per acre; kafir grain, 0.68 bushels; and oats 4.78 bushels per acre. Cotton stalks were returned to all plots in cotton, so no data are available for comparison with land where the cotton stalks were removed. For the kafir crop, kafir stalks slightly reduced the yield of grain. Oats straw showed a slight gain of 1.37 bushels of oats grain per acre. The diversified system showed slight gains for all the crops; namely, for seed cotton, 14 pounds; kafir grain, 1.61 bushels; and oats grain, 0.51 bushels per acre. The value of manure and crop residues is very low in this experiment.

Commercial Fertilizers on Wheat

In the fall of 1924, an experiment was started to ascertain the needs of fertilizer for wheat on Kirkland soil. A rather complex triangular system of fertilizer treatment was established on what would be considered a fairly good Kirkland loam soil. The ingredients used were superphosphate (16% phosphoric acid), kainit, and nitrate of soda. The rate of application was 300 pounds per acre. This rate was recognized to be high but facts were to be established as to general needs and so it was thought best to start at a higher rate than what would ordinarly be recommended. Besides these treatments, since that time some plots have been included where nitrate of soda and ammonia sulfate could be compared. The rate of application is 100 pounds per acre for nitrate of soda and 75 pounds per acre for ammonium sulfate. The four-year average yields for these treatments are given in Table 5.

Table 4.—Showing the effect of fertilizer on the yield of alfalfa.

	Limed	Unlimed	Cost of 2 Years' Treatment Limed	Cost of 2 Years' Treatment Unlimed	Net Gain for 2 Years* Limed	Net Gain for 2 Years* Unlimed
450 lbs. ap. (Every 3 years)	3155	3358	$ 7.30	$ 4.50	$16.35	$20.68
150 lbs. ap.	2670	4366	7.30	4.50	12.72	28.24
150 lbs. ap., 50 lbs. KC1	2466	1279	10.30	7.50	8.19	2.08
150 lbs. ap., 50 lbs. KC1, 200 lbs. $NaNO_3$ ***	3084	1808	25.30	22.50	—2.17	—8.94
200 lbs. nitrate of soda	170	372	17.80	15.00	—16.53	—12.21
150 lbs. Am. sulfate	366	746	14.05	11.25	—11.31	—5.66
150 lbs. Am. Sul., 50 lbs. KC1	—1287	—1229	17.05	14.25	—26.69	—23.46
150 lbs. gypsum	—1108	—195	3.55	.75	—11.86	—2.20
200 lbs. 12-2-6	5759	5075	10.80	8.00	32.38	30.05
150 lbs. sulphur	1116	1538	10.30	7.50	—1.93	4.03
8 tons manure (Every 3 years)	2749	2784	8.13	5.33	12.48	15.55
8 tons M., 450 lbs. ap. (Every 3 years)	8176	8966	12.63	9.83	48.69	57.41

*Alfalfa, $15.00 per ton.

**Calculations are on a 2 yr. basis and the cost of fertilizers used are as follows:

ap. = superphosphate @ $30.00 per ton;
Lime = limestone @ $2.10 per ton;
KC1 = muriate of potash @ $60.00 per ton;
$NaNO_3$ = nitrate of soda @ $75.00 per ton;
Ammonium sulfate @ $75.00 per ton;
Gypsum @ $5.00 per ton;
Sulphur @ $2.50 per 100 pounds;
12-2-6 @ $40.00 per ton; and
Manure @ $1.00 per ton.

***A minus sign indicates loss.

12-2-6 means 12% phosphoric acid, 2% nitrogen and 6% potash. All of the fertilizers except those noted and limestone are applied broadcast each year in early spring. Limestone is applied every three years, the first application being in the year 1927.

Table 5.—Showing the effect of fertilizer on yield of wheat.

Plot	Treatment	4-Year Average Yield Per Acre in Bushels	Protein Content of 1928 Crop at Threshing Time Calculated at 13% Moisture
1	No treatment	7.08	14.80
2	300 lbs. superphosphate	11.96	12.28
3	225 lbs. superphosphate; 75 lbs. kainit	11.96	12.45
4	225 lbs. superphosphate; 75 lbs. nitrate of soda	10.29	13.50
5	No treatment	9.87	13.70
6	150 lbs. superphosphate; 150 lbs. kainit	11.67	12.72
7	150 lbs. superphos.; 75 lbs. kainit; 75 lbs. nitrate of soda	10.83	13.80
8	150 lbs. superphosphate; 150 lbs. nitrate of soda	10.08	14.87
9	75 lbs. superphosphate; 225 lbs. kainit	12.04	13.25
10	No treatment	9.12	13.90
11	75 lbs. superphos.; 150 lbs. kainit; 75 lbs. nitrate of soda	10.79	14.00
12	75 lbs. superphos.; 75 lbs. kainit; 150 lbs. nitrate of soda	9.44	14.10
13	100 lbs. nitrate of soda, applied in fall	8.61*	13.90
14	75 lbs. ammonia sulfate, applied in fall	9.28*	13.50
15	No treatment	10.88	13.05
16	300 lbs. kainit	11.12	13.75
17	225 lbs. kainit; 75 lbs. nitrate of soda	10.54	13.38
18	150 lbs. kainit; 150 lbs. nitrate of soda	9.41	14.65
19	No treatment	10.08	13.05
20	75 lbs. kainit; 225 lbs. nitrate of soda	8.71	14.30
21	300 lbs. nitrate of soda	7.21	14.52
22	150 lbs. superphosphate; 50 lbs. nitrate of soda	10.37	12.51
23	No treatment	9.08	13.20
24	100 lbs. nitrate of soda, applied in early spring	15.00**	14.72
25	75 lbs. ammonia sulfate, applied in early spring	17.33**	14.10
26	No treatment	18.67**	13.88

*Three-year average

**1928 crop only.

Notes taken in 1928:

Plots 3 and 9 ripened several days earlier than the other plots. The next plots to ripen were plots 6 and 2. Plots 11 and 7 ripened in order. All of the other plots ripened about the same time with plot 22, a little earlier than the others.

Alfalfa Fertility Studies

A. This experiment was started in 1913. Manure was applied in 1913 with no further application since on the manured plots. Limestone at the rate of 2½ tons per acre was applied to the limed plots in 1916 after the first cutting of alfalfa. No further application has been made. The soil is classified as Kirkland silt loam. Alfalfa was reseeded in 1923. On the untreated plot, the stand had become very poor and since reseeding it has practically died out. This year (1928) there was practically no alfalfa present on the untreated plot and in the rest of the plots, the stands were not any too good.

The average results from 1916 to 1927, inclusive, are:

Untreated plot—1779 pounds of hay per acre.
Limestone plot—2676 pounds of hay per acre.
Manured plot—5224 pounds of hay per acre.
Manure and limestone combination—5550 pounds of hay per acre.

The treated plots have always yielded a grade of alfalfa which was much better than on the untreated area. The hay from the untreated area often was principally grass. In 1928, the first cutting weights were lost. The second and third cuttings were as follows:

Untreated plot—803 pounds of hay per acre.
Limestone plot—1359 pounds of hay per acre.
Manured plot—2614 pounds of hay per acre.
Manured and limestone combination—2100 pounds of hay per acre.

Counting the year 1928, out of the last four years the manured plot has yielded the most hay each year except for the year 1926. Previous to that time the manure and limestone combination yielded the highest with the exception of the first year that limestone was applied and in the year 1919 when the yield was practically the same (6785 pounds for the limestone plot and 6783 pounds for the combination plot).

B. This alfalfa experiment was started in the spring of 1927 on Kirkland silt loam. The fertilizers were applied broadcast on alfalfa which had been growing on the field for sometime, i. e., it was an old alfalfa field. No renovation had been practiced nor was anything done to the field in the way of cultural treatment after the fertilizers were applied. The land which was limed received ground limestone at the rate of two tons per acre. The total yield for two years for the limed area is 11500 pounds of alfalfa per acre. The unlimed area has yielded for the two years 11542 pounds of alfalfa. The figures given in Table 4 show the gain of the various treatments above these figures.

The effect of phosphorus in this experiment is more or less pronounced. Superphosphate alone or with manure has given excellent returns. Manure alone on this soil does not furnish the alfalfa plant with enough plant food. Manure reinforced with superphosphate has given the greatest net returns. A 200 pound application of a 12-2-6 fertilizer gave excellent results. Not all farmers have manure available and, thus, this fertilizer can be substituted to good advantage for alfalfa on this type of soil. The net gain for superphosphate on unlimed soil for the 150 pound application applied annually was $14.12 each year. The 12-2-6 mixture gave an annual net return of $15.02, while the manure reinforced with superphosphate gave an annual net return of $28.70. These figures are quite significant. They are net returns on an acre above that which is secured where no fertilizers are used. Such returns as these would increase the income of many farmers operating farms on which the brown soils are found.