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Soil Fertility Investigations

Rolling Prairie Land of Southwestern Missouri

(Eldorado Springs Experiment Field)

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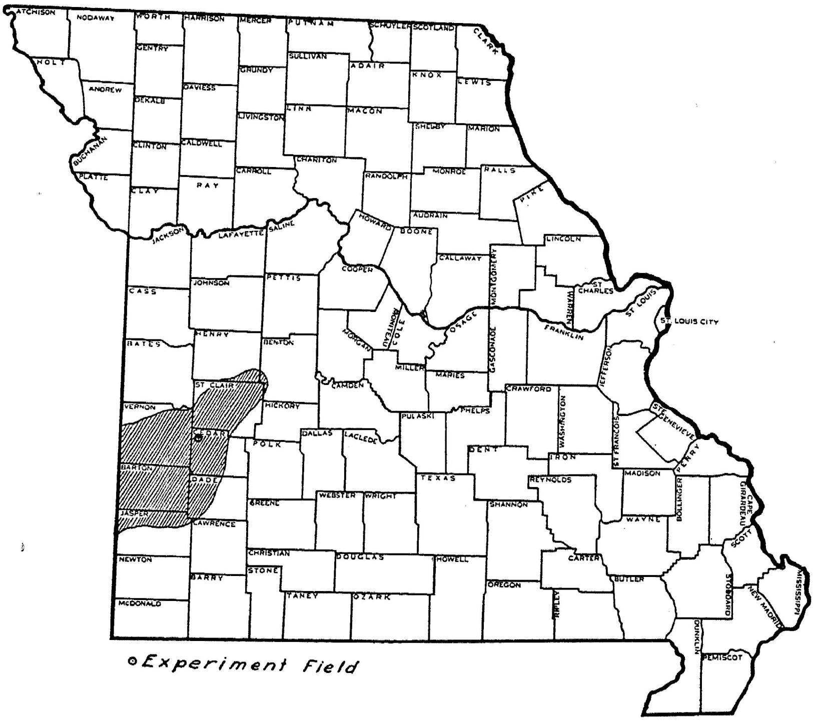

Fig. 1.—Map of Missouri showing location of Eldorado Springs experiment field. Shaded area indicates region of brown sandstone-shale soils.

Soil Fertility Investigations

Rolling Prairie Land of Southwestern Missouri

Eldorado Springs Experiment Field

H. H. Krusekopf

To maintain and improve the productivity of soils is essential to continued successful farming. To give guidance and assistance in this effort, the Missouri College of Agriculture operates experimental fields on some of the important soil types in the state. One of these fields was located near Eldorado Springs,* in the northwestern corner of Cedar county. It was established in 1918 and operated until 1927. The purpose of the field was to determine the effect of various fertilizer treatments on crop yields under a standard cropping system.

DESCRIPTION OF THE SOIL

The soil on the experiment field has been classified as Bates loam. It is very probable that in a revised classification it will be correlated with some other series, because the soil does not have some of the characteristics associated with the Bates series.

The surface soil is a grayish brown, fine loam to silt loam to a depth of 10 to 12 inches. The subsurface from 10 to 16 inches is a gray, friable silt loam, differing from the surface mainly in color. The subsoil below 16 inches is a drab or dull brown heavy, stiff clay, which changes at a depth of about 30 inches to a gray, mottled, friable clay loam. On the southwest part of field the surface soil is sandier and the subsoil is an open, gray and red mottled clay loam. In general, the soil is characteristic of much of the level to gently rolling upland, derived from sandstone and shale, in Barton, Cedar, Dade, St. Clair and Vernon counties. The original vegetation was open forest and grass. Soil of this type is considered to be below medium in quality. The heavy clay subsoil is unfavorable for such deep rooting crops as corn, and also tends to make the soil less resistant to dry weather.

*S. G. Banks operated the experiment field for 3 years, and J. N. Beals for remaining period of the experiment.

CROPPING SYSTEM

A four year crop rotation of kafir, soybeans, wheat and red clover was used. This rotation is not in general use in this region, but all the crops included are extensively grown in this part of the state. Kafir was used in place of corn, because it is more drought resistant, and under most conditions will give larger yields of grain than corn. The soybean is a crop of minor importance in this region, but probably should be grown more extensively. It is well adapted to the land, and desirable hay crop to grow preceding small grains. Wheat is one of the important crops of this region. Clover, the fourth crop in the rotation, does not ordinarily thrive on this soil without the use of lime or fertilizer. With such treatment it will grow except when destroyed by unfavorable weather conditions.

SOIL TREATMENT

The soil treatment included fertilizer, manure and limestone. Fertilizer was applied at the rate of 175 lbs. per acre before kafir and wheat, or twice during the four year rotation. In all cases the fertilizer was applied with a grain drill. Numerous trials have indicated that with corn and kafir, better results are obtained if fertilizer is applied in the hill or row. Manure at 8 tons per acre was applied before corn. This rate of application was considered to approximate the amount of manure that can be produced under the adopted rotation.

Limestone at 2 tons per acre, was applied once in four years and before sowing wheat. The soil is rather acid, and according to the usual tests has a lime requirement of 4 or more tons per acre.

CROP YIELDS

Each of the crops included in the cropping system was grown each year. Tables 1 to 4 show the crop yields, by years, for the different soil treatments.

In general, the yields of all crops are low, but this reflects the quality of the soil. It should be noted, however, that unfavorable weather in several years during the period of the experiment, caused low yields. The response from any soil treatment was greatest in years of favorable weather. The results clearly indicate that under the prevailing soil and weather conditions, profitable returns can be obtained from any of the soil treatments used.

The average low yield of kafir is attributed in part to wet seasons, smut, and chinch bug damage.

All soil treatments more than doubled the yield above that from the unfertilized land. This can be taken as evidence of the responsiveness of the soil and crops to fertilization, and the importance of such treatment to profitable yields.

No soil treatment was made directly to soybeans. Differences in yield therefore were due to the residual effect of the fertilizer applied to the preceding crop. The increase in yields ranged from ¼ to ½ ton per acre. The soybeans were planted in rows like corn, cultivated and harvested as hay. No doubt larger yields would have been obtained if the beans had been drilled or planted in narrow rows.

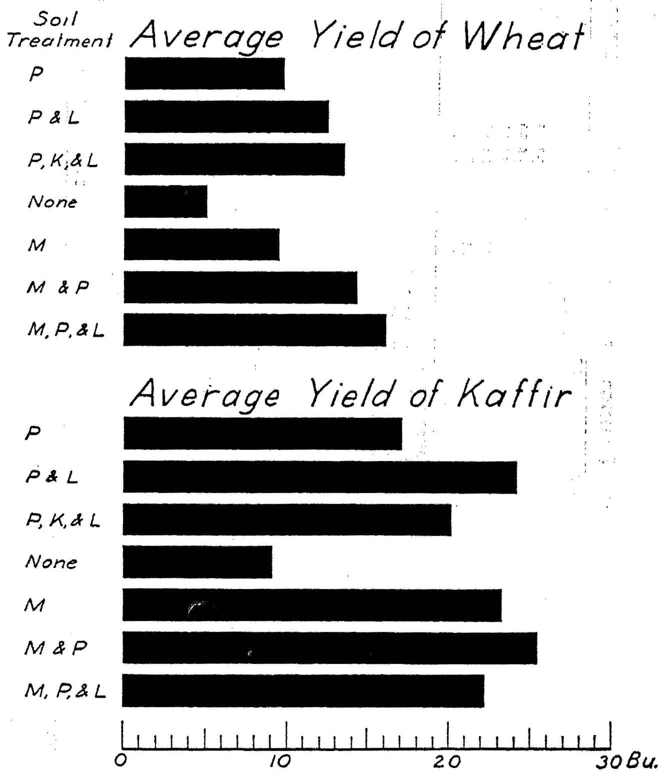

Fig. 2.—Diagram showing average yield of wheat and kaffir for different soil treatments. Abbreviations used in diagram: P, superphosphate; K, muriate of potassium; L, limestone; M, manure.

The response of wheat to fertilizer is well established, and the results on this field confirm the findings elsewhere. The impracticability of growing wheat on this type of soil without fertilizer

TABLE 1.—ELDORADO SPRINGS EXPERIMENT FIELD KAFIR YIELDS—1922-1927.

Treatment	1922	1923	1924	1925	1926	1927	Average	Increase
Superphosphate	24.07	12.88	13.88	20.70	26.97	4.34	17.13	7.99 bu.
Lime, Superphosphate	23.58	21.82	17.41	22.16	47.55	12.68	24.20	15.06
Lime, Potash, Superphosphate	19.62	25.38	15.68	16.90	25.95	17.30	20.14	11.00
None	9.82	12.50	4.75	11.72	15.11	.94	9.14	
Manure	36.56	32.44	9.03	24.59	25.51	11.81	23.32	14.18
Superphosphate, Manure	33.93	35.30	13.22	28.52	27.64	14.28	25.48	16.34
Superphosphate, Lime, Manure	27.60	32.72	15.61	30.45	11.99	15.21	22.26	13.12

Rate fertilizer application—
Superphosphate 16% .... @ 175 lbs. per acre
Potash .... @ 25 lbs. " "
Manure .... @ 8 tons " "
Lime .... @ 2 tons " "

Crop rotation—
Kafir, soys, wheat, clover

TABLE 2.—ELDORADO SPRINGS EXPERIMENT FIELD, SOYBEAN HAY YIELDS—1920-1926.

Treatment	Peas 1920	1921	Peas 1922	1923	1924	1925	1926	Average	Increase
Superphosphate	1400	700	2025	700	1152	1102	808	1127	268 lbs.
Lime, Superphosphate	2000	775	2075	915	1387	1160	1002	1331	472
Potash, Lime, Superphosphate	1700	775	2300	1015	1342	1258	1043	1348	489
None	1025	400	1525	350	887	1160	663	859	
Manure	1025	725	1675	1190	1187	1711	964	1211	352
Superphosphate, Manure	1450	1000	2625	1165	1815	1781	882	1531	672
Manure, Lime, Superphosphate	1975	1125	3100	1125	2000	1682	1403	1773	914

Cowpeas substituted for soybeans in 1920 and 1922.

TABLE 3.—ELDORADO SPRINGS EXPERIMENT FIELD, WHEAT YIELDS—1919-1927.

Treatment	1919	1920	1921	1922	1923	1924	1925	1926	1927	Average	Increase
Superphosphate	14.25	6.87	7.58	7.16	8.66	11.95	8.52	16.77	6.05	9.76	4.86 bu.
Lime, Superphosphate	16.17	10.06	11.50	11.16	11.91	11.05	15.51	20.80	4.51	12.52	7.62
Lime, Potash, Superphosphate	17.08	11.77	11.83	8.33	12.41	12.94	16.59	21.26	9.59	13.53	8.63
None	7.92	8.04	2.16	3.50	2.41	7.18	3.45	6.98	2.48	4.90	
Manure	5.42	13.17	4.08	9.91	2.99	13.48	10.21	19.74	6.19	9.47	4.57
Superphosphate, Manure	15.83	12.29	13.00	14.08	11.49	10.80	14.70	25.25	11.56	14.33	9.43
Manure, Lime, Superphosphate	18.17	8.27	14.14	12.45	17.66	14.03	24.93	34.74	8.33	16.97	12.07

TABLE 4.—ELDORADO SPRINGS EXPERIMENT FIELD CLOVER HAY YIELDS—1921-1926.

Treatment	1920	1921	1922	1923	1924	1925	1926	Average	Increase
Superphosphate	Clover failure	1100	0	0	1440	2460	Clover failure	1000	409 lbs.
Lime, Superphosphate		1525	1040	924	2285	3245		1804	1213
Potash, Lime, Superphosphate		1475	965	1526	2180	3260		1881	1290
None		900	0	0	540	1515		591	
Manure		1775	0	270	740	2575		1072	481
Superphosphate, Manure		2476	0	2493	1465	4225		2132	1541
Lime, Manure, Superphosphate		2575	1355	2768	3265	4205		2834	2243

is indicated by the average low yield of 5 bushels per acre. The average yield for all treated land for the 9 year period was 12¾ bu. per acre. The value of lime is especially apparent. The effect of lime is probably indirect through the larger clover yields and the consequent larger amount of organic matter added to the soil.

Red clover is one of the most uncertain crops in this region because of soil and weather conditions. The use of limestone is essential in growing the crop. In general, a crop is obtained only about 50 per cent of the time. Even with soil treatments crop failures occur because of the weather. The clover is damaged most frequently in midsummer after the small grain nurse crop has been removed.

A summary of the average crop yields, estimated cost of soil treatments, and profit from treatment is given in Table 5. Each soil treatment gave a substantial return. On the basis of the assumed values, the more costly treatments gave the largest profit. The assumed values of the various crops is only relative, but indicate the importance of increasing crop yields by soil improvement.

TABLE 5.—ELDORADO SPRINGS EXPERIMENT FIELD.

Treatment	1919-1927 Average Yields				Value of crop increase	Cost of soil treatment for four year period	Net return in 4 year period
	Kafir	Soybeans	Wheat	Clover			
	Bu.	Lbs.	Bu.	Lbs.			
Superphosphate	17.13	1127	9.76	1000	$13.56	$ 3.72	$ 9.84
Lime, Superphosphate	24.20	1331	12.52	1804	26.10	7.72	18.48
Lime, Potash, Superphosphate	20.14	1348	13.53	1881	24.73	9.09	15.64
None	9.14	859	4.90	591			
Manure	23.32	1211	9.47	1072	18.29	12.00	6.29
Manure, Superphosphate	25.48	1531	14.33	2132	31.24	15.72	15.52
Lime, Manure, Superphosphate	22.26	1773	16.97	2834	36.11	19.72	16.39

Figures used for determining value of crops, and cost of fertilizer treatment are as follows:

Kafir grain	@ .70 bu.
Soybean hay	$8.00 ton
Wheat	1.00 bu.
Clover hay	10.00 ton

Superphosphate 16%	@ $21.30 ton
Potash	54.80 "
Limestone	2.00 "
Manure	1.50 "

TABLE 6.—RAINFALL BY MONTHS AND YEARS AT NEVADA, MISSOURI, 1918 to 1927 INCLUSIVE.*

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1918						1.38	1.77	2.46	5.27	4.80	4.77	3.10	
1919	.00	1.77	1.10	5.71	4.70	10.69	1.92	4.99	.89	7.76	1.17	1.15	41.85
1920	1.28	.26	5.68	3.70	8.48	1.36	1.69	5.08	7.34	3.57	.93	.92	40.29
1921	2.08	.25	3.23	5.69	4.95	10.30	4.69	4.66	6.46	1.48	1.02	1.47	46.28
1922	6.15	1.08	8.26	11.32	3.03	1.25	6.02	1.83	4.86	1.17	4.44	.61	50.02
1923	1.84	.70	4.32	1.96	2.70	9.36	3.91	1.53	5.02	4.28	2.02	2.94	40.58
1924	2.84	2.08	2.05	3.36	6.76	6.45	7.52	4.67	4.15	1.32	2.86	3.00	47.06
1925	.56	.84	1.30	5.45	2.76	5.05	.90	2.17	8.51	1.72	3.24	.57	33.07
1926	1.80	1.41	1.81	2.28	1.22	2.98	2.46	4.55	8.74	3.75	2.23	2.30	35.53
1927	1.55	.37	3.70	8.08	4.22	7.74	5.82	13.51	2.50	4.13	2.34	3.32	57.28

*From U. S. Weather Bureau.

COMPARATIVE VALUE OF THE DIFFERENT FERTILIZER MATERIALS

Superphosphate has consistently caused increased yields of kafir, wheat and clover. All of the soils of this region are low in soluble phosphorus. The need of applying this element to the soil is therefore evident. All small grains and grasses in particular, should be fertilized at rates of 150 to 300 pounds per acre. Potash was used in only moderate amounts, and gave only small increases, mainly on wheat.

The light colored soils represented by this experiment field are low in organic matter. Manure therefore has a special value, and gave the greatest response on corn. Under the cropping system used in this experiment, manure could not be produced in amount equal to that applied to the land. The importance of returning all stalks, straw, etc., to the soil is therefore apparent.

The lime content of the soil is low. Red or sweet clover will not thrive without liming. In this experiment limestone was applied at the rate of 2 tons every four years. More recent investigations indicate that frequent applications can be omitted if the first application is at a rate of 2 to 4 tons an acre. At the present time lespedeza has largely replaced red clover. Sweet clover has a place in the farming system, and in order to grow this legume, the continued use of limestone is recommended.

It should be noted that the production of crops on the soils of this region is subject to various hazards. Chief of these is the weather. Dry periods in late summer are frequent, and do most damage to corn and clover. Moreover, the structure of the soil is such that it is not drought resistant. Damage from wet weather in spring or fall is infrequent. The soil erodes easily, and cultivated slopes tend to deteriorate rapidly. Chinch bugs are a frequent pest. The value of soil treatments as a preventive to these varied hazards is, that it favors the more rapid growth and earlier maturity of the crops.

The cropping system used in this experiment is no longer considered adapted to the majority of soils of this region. It is better adapted to soils of higher fertility, where corn and clover make larger and more dependable yields. It is assumed that if corn had been used in place of kafir, the results would have been about the same. Kafir will probably give larger yields than corn in seasons of low rainfall. Wheat, barley, soybeans, timothy, orchard grass, and lespedeza are the crops best adapted to the soil conditions. The production of these combined with the raising of livestock, is the type of farming best suited to this region. Such a farming system will require a moderate but regular use of fertilizer for best results. The response that can be expected from such treatment is indicated by the results from this experiment.