B. GEOLOGICAL SCIENCES

I. A PRELIMINARY STUDY OF THE POTENTIAL FERTILITY OF OKLAHOMA SOILS

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The total plant food content of soil is important because it is an indication of total crop producing power. Soils with a high potential fertility will contnue to produce large crops under favorable conditions for a long period of time, whereas, all other factors being equal, soils having a low potential fertility will not continue to produce good crops unless a definite soil building program is followed.

Experimental

During the past year a large number of soil samples have been collected from various parts of Oklahoma in order to obtain some data on the relative fertility of the various soils in the state and also to compare the fertility of these soils with that found in the soils of adjoining states. Only the total nitrogen content, total phosphorus content and the acidity of these soils have been determined since these constituents are usually more likely to be the limiting factors than any others in the growth and yield of crops .

The total nitrogen content of these soils was determined by the Kjeldahl method. The total phosphorus was determined by the magnesium nitrate method and the acidity of each sample was determined by the Truog[1] and the modified Comber[2] test. The results of these analyses are given in Table 1. The largest amount of nitrogen was found in a virgin Houston black clay located north of Durant County which contained 6940 pounds of nitrogen per acre in the surface 6 2/3 inches of soil. The lowest amount of nitrogen was found in a cropped sample of sand located south of Antlers in Pushmataha County which contained 325 pounds of nitrogen per acre. The maximum amount of phosphorus was found in a somple of silt loam soil located south of Newkirk in Kay County which contained 2040 pounds of phosphorus per acre and the minimum amount of phosphorus was found in a sand near McAlester in Pittsburg County which contained 220 pounds of phosphorus per acre.

The average total nitrogen content of these soils were 2057 pounds and the average total phosphorus content per acre was 601 pounds. The amount of plant food in a good fertile soil

1. Wisconsin Agricultural Experiment Station, Bulletin 312.
2. Journal of the American Society of Agronomy, V. 17: 492-500.

should be about 4000 pounds of nitrogen and 1200 to 1500 pounds of phosphorus per acre, consequently the data secured from the soils analyzed would indicate that the average fertility in Oklahoma soils is only about one-half as much as a good fertile soil should contain.

About thirty percent of the soils tested should receive an application of ground limestone in order that alfalfa or sweet clover can make a maximum growth under Oklahoma conditions. There seems to be a marked difference in the response of acid soils to liming depending upon their location with respect to the amount of rainfall to which they are subjected and the total amount of other plant foods which they contain. This problem is being investigated at the present time, A larger percentage of light textured soils were found in the samples secured from western Oklahoma than from eastern Oklahoma, however, more samples were secured in eastern Oklahoma and this factor may alter the results considerably.

In Table II the results of the analyses of forty samples of soil taken from the Experiment Station Farm at Stillwater, Oklahoma, are given. These samples do not vary appreciably in total plant food content except in case of the cropped and virgin samples of soil taken from and near the continuous wheat experiment. The virgin soil contained over 3200 pounds of nitrogen per acre while the soil cropped to wheat for thirty-five years contained only about 1900 pounds of nitrogen which means that forty per cent of the total nitrogen content of this soil has been lost. The average plant food content in the soils taken from the Experiment Station Farm is less than the average of the 106 samples secured from various parts of the state. Also these soils are all acid except where ground limestone or other forms of lime have been applied to them. However, because of the fact that the nitrogen and phosphorus content of these soils is low, applications of ground limestone without any other plant food do not produce a very marked increase in crop growth. This same condition exists in many other parts of Oklahoma and many experiments should be conducted fin order to determine the best soil treatment for different crops.

In Table III the results of a comparison of the total nitrogen and total phosphorus of virgin and cropped soil are recorded. These soils yhich have been cropped in most cases less than thirty-five years have lost a large part of their potential fertility. Nitrogen is being lost more rapidly than the phosphorus but the phosphorus losses in all cases except one are appreciable.

Table III. Data on the comparison of the total nitrogen and total phosphorus content of cropped and virgin soils.

	Total Nitrogen		Tot'l Phosphor's		Percent Loss	
Location	**Virgin**	**Cropped**	**Virgin**	**Croppd**	**Nitrogn**	**Phsphrs**
Durant	**6940**	**3390**	**1280**	**975**	**51.1**	**23.8**
Eufaula	**2550**	**1175**	**550**	**375**	**53.9**	**30.1**
Nowata	**2760**	**2070**	**565**	**495**	**25.0**	**12.3**
Purcell	**4340**	**3250**	**675**	**665**	**25.1**	**1.4**
Sapulpa	**1680**	**980**	**520**	**435**	**41.6**	**16.3**
Stillwater	**3205**	**1905**	**540**	**430**	**39.3**	**20.3**

Table IV. Data on the total nitrogen and total phosphorus content of Oklahoma soils as compared with certain other states.

State or Area	No. of Samples	Av. Nitrogen Content	Av. Phos. Content
North Dakota[3]	27	6429	1272
Minnesota[4]	64	5620	1700
Iowa[5]	257	4383	1296
Kansas[6]	239	3033	827
Missouri[7]	214	2385	1138
Oklahoma	106	2057	601
Arkansas[8]	—*	1828	674
Texas[9]	336	1722	459
North Texas	153	1545	415
Panhandle	28	1912	502
South Central Texas	49	1943	668
South Texas	106	1826	415
South Central Texas	49	1943	668

*about 500

In Table IV data are given comparing the average plant food content in Oklahoma soils with that of other states. One very interesting fact occurs in these data and that is, that there is a constant decrease in the average total nitrogen content of the soils in the different states which were studied beginning in the northern part of the Central United States with North Dakota and Minnesota and going south through Iowa, Kansas, Missouri, Oklahoma, Arkansas and Texas. This is due in all probability to climatic conditions which in the past have been more favorable for the accumulation of organic matter in the northern soils due to the fact that the rate of decay has been retarded due to the shorter period of hot weather in summer and due to the fact that the soil is frozen a considerable portion of the year.

The amount of total phosphorus in the soils of the different states varied considerably. Since this element is dependent to a large extent upon the origin of the sediments from which the soil was derived, it would not be expected that climatic conditions would affect its presence in the soil. However, this plant food is also found in larger quantities in the soils of the northern states, which were studied which means that the potential fertility of these states is greater than that of the other states given in table IV, and the problem of supplying plant food to those soils will not be as important for a long period of time as it will be in the near future for the states of Oklahoma, Arkansas and Texas.

Summary

A preliminary study of the total nitrogen, total phosphorus and the acidity in Oklahoma soils was made on 106 samples of soil taken from various parts of the Experiment Station Farm at Stillwater, Oklahoma.

It was found that there was a wide variation in the total nitrogen and total phosphorus content of Oklahoma soils varying from 6940 pounds to 325 pounds per acre in the case of total nitrogen and 2040 pounds to 220 pounds per acre in case of the total phosphorus. The average total nitrogen content was 2057 pounds and the average total phosphorus content was 601 pounds per acre. These data would indicate that Oklahoma soils on the average contain only about one-half as much total nitrogen and phosphorus as should be present in good fertile soil. About thirty percent of the soils tested should be limed in order to correct the soil acidity which is an important factor in obtaining the best growth of crops like alfalfa and sweet clover.

It was also found that there was a gradual decrease in the nitrogen content of the soils in the central part of the United States beginning from North Dakota and going south to Texas. Climatic conditions are apparently the cause of this condition. The total phosphorus content of the northern states studied was also higher than that of Oklahoma, Arkansas and Texas. The cause of this condition can only be explained on the basis that the original soil forming materials were higher in those regions.

Indications are that the soils in western Oklahoma are not as heavy in texture as the soils in eastern Oklahoma.

Table I. Data on the total nitrogen, total phosphorus and the acidity of soil samples collected from various parts of Oklahoma.

No.	County	Location	Soil Texture	Total Nitro per 2,000,000 lbs. of soil	Tot. Phos per 2,000,000 lbs. of soil	Acidity Truog test	Acidity Comber test
1	Alfalfa	W. of Cherokee	fine sandy loam	2145	680	sl.	n. a.
2	Bryan	W. of Durant	sandy loam	1485	385	med.	med.
3	Bryan	N .of Durant	fine sandy loam	630	605	n. a.	n. a.
4	Bryan	W. of Caddo	clay loam	2380	550	v. sl.	n. a.
5	Bryan	S. W. of Caddo	loam	1980	415	sl.+	med.
6	Bryan	N. of Durant	loam	1625	425	st.	med.
7	Bryan	S. of Kenefick	clay loam	3320	725	v. sl.	n. a.
8	Bryan	E. of Ury	loam	3160	585	med.	sl.+
9	Bryan	S. of Kenefick	clay loam	4030	1090	v. sl.	n. a.
10	Bryan	N. E. of Durant	clay loam	3840	690	n. a.	n. a.
11	Bryan	N. of Durant*	clay loam	6940	1280	n. a.	n. a.
12	Bryan	N. of Durant	clay loam	3309	975	v. sl.	n. a.
13	Carter	N. of Ringling Junction	sand	1945	265	sl.+	v. sl.
14	Cleveland	N. of Moore	sandy loam	2020	430	n. a.	sl.
15	Cleveland	S. E. of Norman	fine sand	730	360	v. sl.	n. a.
16	Craig	W. of Centralia	silt loam	2120	405	med.+	st.
17	Craig	E. of Centralia	silt loam	4250	900	med.—	med.
18	Craig	N. of Vinita	silt loam	2735	720	st.	v. st.
19	Craig	N. W .of White Oak	silt loam	4000	990	v. sl.	v. sl.

20	Creek	N. of Heyburn	fine sand	700	435	v. sl.	n. a.
21	Creek	E. of Drumright	fine sand	1455	455	sl.+	n. a.
22	Creek	S. of Sapulpa*	silt loam	1625	405	n. a.	n. a.
23	Creek	S. of Sapulpa	silt loam a	1960	575	v. sl.	v. sl.
24	Creek	S. of Sapulpa*	sandy loam	1680	520	v. sl.	n. a.
25	Creek	S. of Sapulpa	sandy loam	980	435	n. a.	n. a.
26	Custer	S. of Clinton	loam	2070	890	sl.+	n. a.
27	Dewey	S. of Taloga	fine sandy loam	1690	650	v. sl.	n. a.
28	Dewey	S. of Seiling	fine sandy loam	1560	700	v. sl.	n. a.
29	Garfield	S. E. of Covington*	loam	2195	520	sl.	sl.
30	Garfield	S. E. of Covington	sandy loam	1790	570	v. sl.	n. a.
31	Garfield	N. of Fairmont	loam	1500	455	med.	sl.
32	Garfield	E. of Waukomis	silt loam	2185	810	sl.	sl.
33	Garfield	E. of Waukomis	silt loam	1920	780	sl.	sl.
34	Garfield	E. of Waukomis	silt loam	2845	715	sl.	sl.
35	Garfield	E. of Waukomis	silt loam	1710	560	sl.+	sl.+
36	Garfield	E. of Waukomis	silt loam	2580	780	sl.+	med.+
37	Garfield	E. of Waukomis	silt loam	1980	580	sl.	sl.
38	Garvin	N. of Pauls Valley	fine sandy loam	1455	425	sl.	n. a.
39	Grant	W. of Pond Creek	loam	2040	750	v. sl.	n. a.
40	Grant	W. of Pond Creek	silt loam	1485	680	n. a.	n. a.
41	Haskell	Near LeQuire	silt loam	1960	715	st.	st.
42	Haskell	N. of Cartersville	fine sand	490	245	n. a.	n. a.
43	Haskell	S. of Stigler	fine sandy loam	615	315	n. a.	n. a.
44	Haskell	E. of Keota	silt loam	1795	575	med.	st.

No.	County	Location	Soil Texture	Total Nitro per 2,000,000 lbs. of soil	Tot. Phos per 2,000,000 lbs. of soil	Acidity Truog test	Acidity Comber test
45	Haskell	E. of Stigler	fine sandy loam	615	305	v. sl.	v. sl.
46	Haskell	S. of Kinita	silt loam	2210	780	sl.	sl.
47	Haskell	N. of Cartersville	loam	980	390	sl.+	st.
48	Haskell	W. of Kinita	silt loam	12765	575	sl.+	med.
49	Jefferson	E. of Waurika	fine sandy loam	1135	410	sl.+	v. sl.
50	Kay	S. of Newkirk	loam	4550	2040	v. sl.	n. a.
51	Kiowa	S. of Roosevelt	sandy loam	1640	1000	sl.+	v. v. sl.
52	Kiowa	S. of Hobart	silt loam	1810	545	n. a.	n. a.
53	Kiowa	N. of Snyder	silt loam	2660	675	n. a.	n. a.
54	LeFlore	W. of Spiro	silt loam	1810	415	sl.+	st.
55	LeFlore	S. of Poteau	fine sandy loam	940	465	v. sl.	n. a.
56	Lincoln	Near Chandler	fine sand	500	325	v. sl.	n. a.
57	Major	N. W. Corner	sandy loam	1515	350	med.	sl.
58	Major	S. W. of Fairview	sand	1635	545	sl.	n. a.
59	McClain	E. of Washington	loam	3250	665	sl.+	sl.+
60	McClain	E. of Washington*	loamloam	4340	675	v. sl.+	sl.+
61	McIntosh	S. of Onapa*	sandy loam	3550	550	v. sl.	n. a.
62	McIntosh	S. of Onapa	sandy loam	1175	375	med.	v. sl.
63	Murray	E. of Davis	sandy loam	2595	530	sl.+	v. sl.
64	Murray	S. of Sulphur	loam	2860	700	v. sl.	n. a.
65	Noble	S. W. of Morrison	fine sandy loam	1120	320	med.	sl.

66	Noble	S. W. of Perry	fine sandy loam	2060	865	v. s.	n. a.
67	Noble	S. of Perry	clay loam	2580	620	n. a.	n. a.
68	Noble	S. of Perry	clay loam	1880	365	n. a.	n. a.
69	Nowata	W. of Nowata	fine sandy loam	1726	445	med.+	med.
70	Nowata	S. of Nowata	silt loam	2300	620	st.	st.
71	Nowata	E. of Nowata	silt loam	4480	1960	n. a.	n. a.
72	Nowata	E. of Watova*	silt loam	2760	565	med.+	med.
73	Nowata	E. of Watova	silt loam	2070	495	st.	st.
74	Okfuskee	Near Okemah	silt loam	2915	1070	v. sl.	n. a.
75	Oklahoma	S. of Edmond	loam	1830	410	med.	sl.
76	Osage	W. of Pawhuska	loam	3190	320	med.	sl.
77	Osage	S. of Fairfax	silt loam	1130	1090	sl.	n. a.
78	Ottawa	S.of Fairland	loam	1540	390	v. sl	sl.
79	Ottawa	S.of Fairland	loam	1960	885	v. sl.	v. sl.
80	Pawnee	W. of Pawnee	loam	2410	590	med.+	sl.+
81	Payne	W. of Cushing	fine sandy loam	1790	355	st.	sl.+
82	Payne	E. of Perkins	fine sand	1090	425	sl.	n. a.
83	Payne	S. of Stillwater	fine sandy loam	1640	600	sl.+	sl.
84	Payne	E. of Cottingham	fine sandy loam	1305	415	st.	sl.+
85	Pittsburg	W. of McAlester	fine sandy loam	840	350	v. sl.	n. a.
86	Pittsburg	Near McAlester	fine sandy loam	410	220	med.	st.
87	Pushmataha	N. of Albion	fine sandy loam	1640	495	st.+	med.
88	Pushmataha	S. of Albion	silt loam	1960	500	med.	med.
89	Pushmataha	E. of Albion	fine sandy loam	1640	525	sl.	med.
90	Pushmataha	S. of Antlers	sand	325	375	v. sl.	n. a.

No.	County	Location	Soil Texture	Total Nitro per 2,000,000 lbs. of soil	Tot. Phos per 2,000,000 lbs. of soil	Acidity Truog test	Acidity Comber test
91	Rogers	N. E .of Claremore	silt loam	2390	785	st.	st.
92	Rogers	W. of Oologah	silt loam	2215	430	st.	med.
93	Rogers	W. of Talala	silt loam	2720	565	med.+	med.
94	Rogers	E. of Claremore	silt loam	2980	809	med.+	med.
95	Rogers	Near Chelsea	silt loam	2200	535	med.+	med.
96	Rogers	N. of Foyil	silt loam	2565	650	sl.+	sl.
97	Stephens	S. of Comanche	loam	1315	435	v. sl.	v. sl.
98	Stephens	S. of Marlow	sand	1130	390	sl.+	v. sl.
99	Tulsa	E. of Tulsa	silt loam	1980	470	med.+	med.+
100	Wagoner	E. of Stone Bluff	silt loam	1960	475	med.+	st.
101	Wagoner	E. of Stone Bluff	fine sandy loam	1850	465	st.	sl.
192	Washington	S. E. of Bartlesville	loam	3690	650	sl.+	v. v. sl.
193	Washita	Near Rocky	loam	2070	645	n. a.	n. a.
104	Woods	S. E. of Waynoka	sand	785	375	v. sl.	n. a.
105	Woods	S .of Hopeton	sandy loam	3500	725	v. sl.	yellow color
106	Woods	E. of Waynoka	sand	575	350	n. a.	n. a.
	Average (106 samples			2057.+	601.+		

*Virgin samples.

Table II. Data on the total nitrogen ,total phosphorus an the acidity of soils collected from various parts of the Experiment Station Farm at Stillwater, Oklahoma.

No.	Location or Plot No.	Fertilizer Treatment	Soil Texture	Total Nitro. per 2 mil. lbs. soil	Total Phos. per 2 mil. lbs. soil	Acidity Truog	Acidity Comber
1	Lewis Field	—	loam	2800	585	st.	st.
2	1300	—	sandy loam	1420	465	st.	sl.
3	Cotton Burr Stud.	north check	loam	1865	410	med.+	med.
4	Cotton Burr Stud.	south check	loam	1735	375	st.	st.
5	2300 N.	—	sandy loam	1640	435	sl.	n. a.
6	3100	—	loam	1530	435	med.+	sl.+
7	3200 W.	—	silt loam	2130	535	st.	st.
8	5100	—	loam	1725	505	med.+	med.
9	5200 E.	—	silt loam	2720	480	st.	st.
10	5200 W.	—	silt loam	2660	470	st.	st.
11	6201	check	silt loam	1935	485	st.	st.
12	6205	check	silt loam	1950	450	st.	med.
13	6209	check	silt loam	1790	535	st.	st.
14	6216	check	silt loam	1710	570	st.	med.
15	6220	check	silt loam	1860	560	med.+	st.
16	6224	check	silt loam	1540	565	st.	st.
17	6300	check	silt loam	1650	560	st.	st.
18	7201	check	loam	1670	540	st.	med.
19	7202	5T. $CaSo_4$	loam	1810	560	n. a.	n. a.
20	7203	2. 8T, CaO	loam	1670	550	v. sl.	n. a.

21	7204	$CaCo_3$+8T. Manure	loam	1865	515	v. sl.	n. a.
22	7205	CaO+8T. Manure	loam	1765	495	v. sl.	n. a.
23	7206	check	loam	1905	505	st.	med.
24	7207	3T. $CaCo_3$	loam	1880	500	sl.	n. a.
25	7208	1.68T. CaO	loam	2045	425	n. a.	n. a.
26	7209	$CaCo_3$+8T. Manure	laom	1990	445	sl.	n. a.
27	7210	CoO+8T. Manure	loam	2160	450	n. a.	n. a.
28	8200 N.W.	—	loam	1710	440	med.+	med.+
29	8200 S.	—	loam	2775	570	med.+	sl.
30	Field O	Manured Wheat	silt loam	2490	545	med.	sl.+
31	Field O	Subsufrace 12"-18"	clay loam	1735	320	sl.	sl.
32	Field O	Unmanured Wheat	silt loam	1905	430	st.	st.
33	Field O	Virgin Soil	silt loam	3205	540	sl.	v. sl.
34	8201	check	loam	1875	410	med.+	sl.
35	8202	Subsoiled+7T. $CaCo_3$	loam	1905	430	sl.	n. a.
36	8203	Subsoiled+2T. CaO	loam	2010	440	sl.	n. a.
37	8204	Subsolied+20T. Manure	loam	2490	525	med.+	sl.+
38	8205	Subsoiled	loam	2185	425	st.	sl.+
39	8206	20T. Manure	loam	2310	530	med.	v. sl.
40	8207	check	loam	2130	435	st.	sl.
	Average (39 samples)			2010	490		