Fertility Characteristics of Oklahoma Soil Associations

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Fertility Characteristics of Oklahoma Soil Associations as Measured by Chemical Tests

*By Roy M. Smith, Fenton Gray and Harry M. Galloway**

Chemical soil test data accumulated over a period of ten years were used as a basis for making the inventory of the fertility status of Oklahoma soils which is reported in this publication. Composite soil samples collected by Soil Conservation Service soil scientists had been tested from 1944 to 1954 at the State Soil Laboratory, operated cooperatively by the Soil Conservation Service and Oklahoma State University.

The senior author classified and interpreted the available data from 11,831 of these tests as part of his work for a master's thesis. This publication reports results of efforts to interpret the data and thus show fertility characteristics of Oklahoma soil associations.

Certain trends in the data are sufficiently massed (or weighted with adequate repetition) to provide a basis for broad interpretations. The interpretations of the data clarify the relationship between the nutrient status of Oklahoma soils and the factors responsible for the soils. For brevity and simplicity, only the most significant trends have been selected.

The results of this investigation are not intended to be used for specific fertilizer recommendations nor to serve as a substitute for soil testing. No attempt is made to rate soils as to their respective productivity because of the limitations imposed on soil testing results.

Methods and Materials

The available data included the location from which each sample was taken, and the analysis for total organic matter, exchange potassium, easily soluble phosphorus, and soil reaction for each sample.

For interpretation, these data were grouped by problem areas, soil units, and soil associations. Oklahoma problem areas are shown in Figure I. A descriptive legend for soil units is shown in Appendix I.

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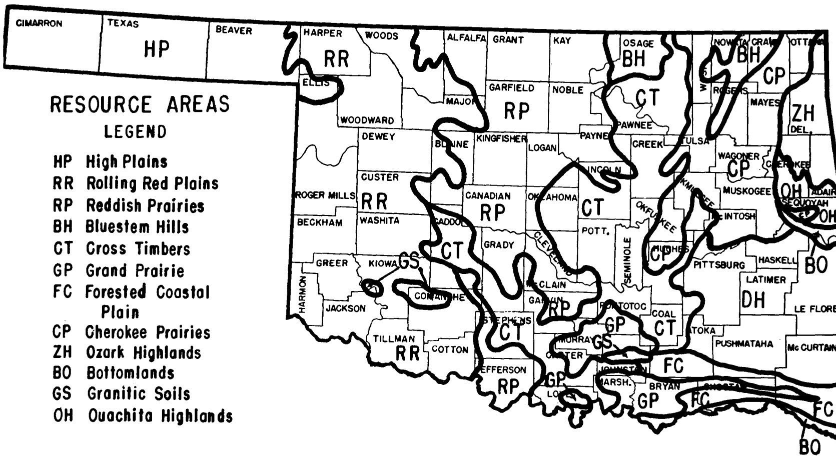

Figure 1. Map shows how data was grouped according to problem area, soil units and soil associations. See Appendix 1, page 17, for descriptive legend for this map.

In classifying soil units into soil series, some of the minor-occuring soil units were eliminated or combined with other (like) units in the problem area. All the major-occurring soil series in Oklahoma soil associations were represented by soil test data.

Laboratory Procedures

The soil tests for exchangeable potassium, easily soluble phosphorus, total organic matter, and soil reaction had been made by the following methods:

1. *Soil reaction.* The Beckman glass electrode pH meter was employed and the degree of acidity defined as strongly acid (pH 4.9 and below), moderately acid (pH 5.0-5.9), slightly acid (pH 6.0-6.4), neutral (pH 6.5-7.2), basic (pH 7.3-7.8), and strongly basic (pH 7.9+).

2. *Exchangeable potassium.* Each soil was extracted with two parts of neutral normal ammonium acetate at 70° centigrade for one-half hour, and the potassium in the filtrate was determined with a Perkin-Elmer flame photometer. Results were grouped into five classes: very low (0-99 pounds per acre), low (100-124 pounds per acre), medium (125-149 pounds per acre), medium plus (150-200 pounds per acre), and high (200+ pounds per acre).

3. *Easily soluble phosphorus.* The Harper method (4) was used, and results were grouped as very low (0-3 pounds per acre), low (4-7 pounds per acre), medium (8-13 pounds per acre), medium plus (14-20 pounds per acre), and high (20+ pounds per acre).

4. *Total organic matter.* The "wet combustion process" (4) of organic carbon oxidation was utilized and results were grouped into five classes: very low (0-.8%, low (.81-1.3%), medium (1.31-1.80%), medium plus (1.81-2.40%) and high (2.41+%).

Index Calculations

Soil tests results were grouped into three classes. The very low and low tests were combined and designated as low. The medium tests were designated as medium. The medium plus and high level tests were grouped and designated as high. Acidity levels were designated as strong, slight, and neutral. The neutral class includes both neutral and basic levels. Strong and moderate acidity levels were combined and designated as strong.

A weighted average index was calculated for each nutrient and acidity according to a method used by Parker, et al. (6). In order to obtain a single index for each test, the percentage of samples that fell in each of the groups—low, medium, and high—was multiplied by one, two, and three respectively. The sum of the figures thus obtained, divided by 100 gave the index, or weighted average for the soil.

Example: Index for 185 phosphorus tests

18 percent are low (1)	18 x 1= 18
27 percent are medium (2)	27 x 2= 54
55 percent are high (3)	55 x 3=165
	237

237/100=2.37 index

The weighted average index was calculated for (1) each problem area soil unit which had been classified according to soil series and (2) entire problem areas in Oklahoma. In some cases it was known that a single soil unit within a problem area would include two or more soil series with contrasting fertility levels. Where separable geographically, the tests on these soil units were calculated from data of individual counties and the index was figured on separate soil series. The indices were divided into eight ranges and a relative descriptive term for each range applied as follows:

Nutrient Index	Nutrient Designation	Acidity Designation
1.00-1.14	Very low	Very strong
1.15-1.42	Low—	Strong +
1.43-1.70	Low +	Strong —
1.71-1.99	Medium—	Slight +
2.00-2.28	Medium +	Slight —
2.29-2.57	High —	Neutral
2.58-2.85	High +	Neutral +
2.86-3.00	Very high	Very basic

Results and Discussion

Soil tests indices are grouped by problem areas in Appendix II, and problem area indices are shown graphically in Figures 2, 3, and 4.

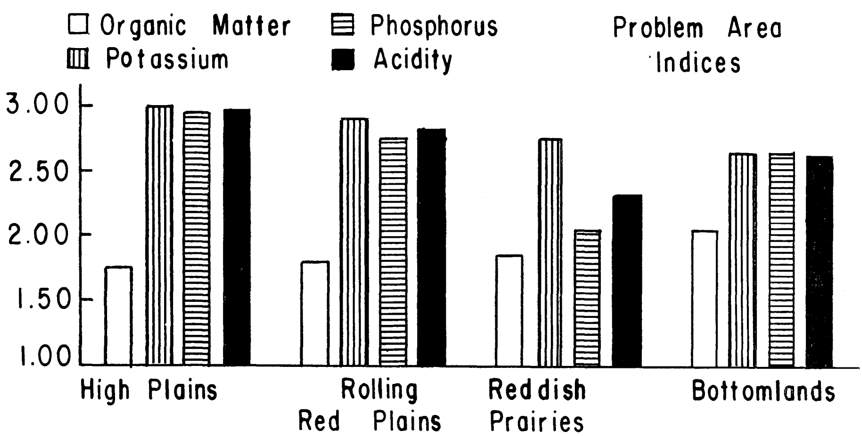

Figure 2. Problem area indices for High Plains, Rolling Red Plains, Reddish Prairies and Bottomlands. See Appendix II, page 18 for pH and nutrient levels.

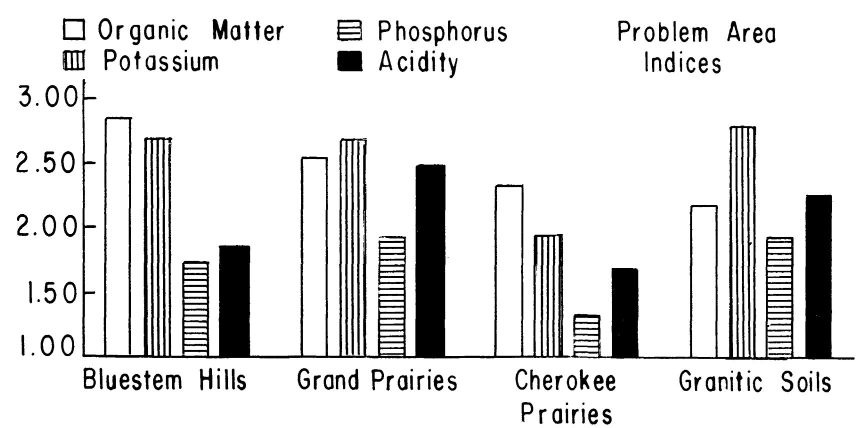

Figure 3. Problem area indices for Bluestem Hills, Grand Prairies, Cherokee Prairies and Granitic soils. See Appendix II beginning on page 18.

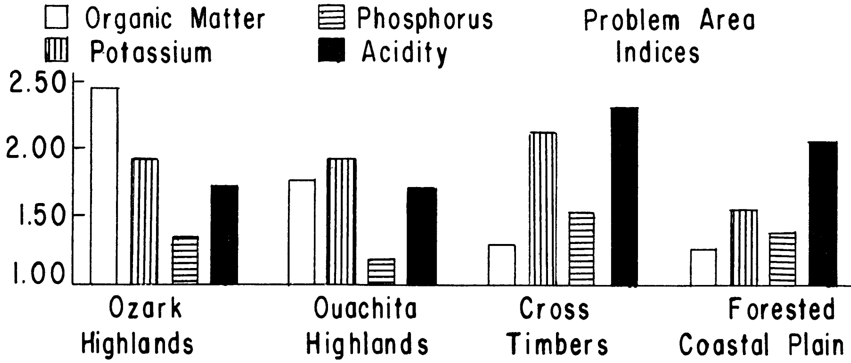

Figure 4. Problem area indices for Ozark Highlands, Ouachita Highlands, Cross Timbers and Forested Coastal Plain. See Appendix II beginning on page 18.

The relative degree of intensive utilization specific soils have undergone is expected to be reflected in the nutrient status level. This will not always be apparent from the index, because the "better" soils are the ones receiving the larger fertilizer increments. The greater the number of tests per soil unit the less is the effect of individual variation in past fertilizer and lime treatments, whether the treatment was unusually large or small.

Major Chemical Properties in Oklahoma Problem Areas

Appendix II and Figures 2, 3, and 4 show that pH levels and the nutrient levels for potassium and phosphorus decrease from west to east.

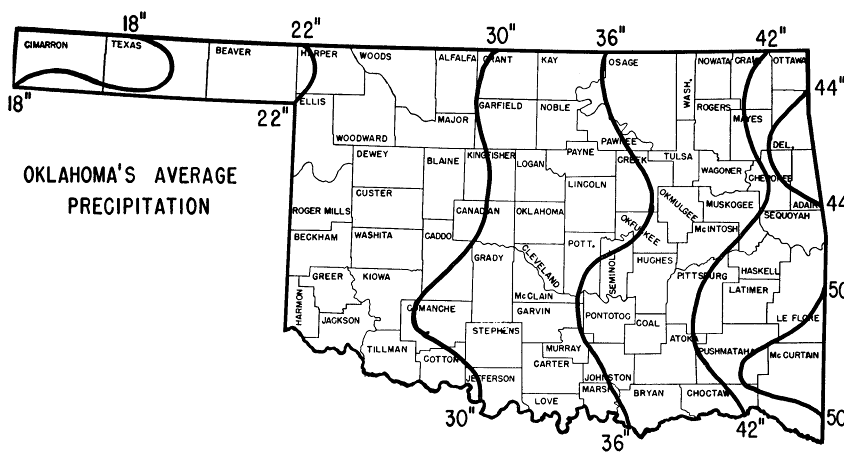

Figure 5. Average annual precipitation zones in Oklahoma. Average temperatures also increase from northwest to southeast though temperature varies less than precipitation.

The same relative levels for potassium, phosphorus and acidity occur for separate problem areas. In almost every case, phosphorus was the lowest of the three and potassium the highest. In general, these relationships exist for a single soil unit within a problem area. The exceptions may be attributed to parent material or known soil management practices.

Average annual precipitation zones in Oklahoma (1) are shown in Figure 5. Temperatures also increase from northwest to southeast, although temperature variability is not nearly so great as is precipitation variability.

Phosphorus

Figures 2, 3, and 4 indicate that easily soluble phosphorus indices tend to group into three levels: high, medium, and low.

The low phosphate levels of the humid eastern section can be partially attributed to anion fixation and insoluble iron and aluminum phosphate precipitates. The lower the pH, the greater the likelihood of having H_2PO_4-ions precipitated from solution by iron and aluminum.

Older, more weathered clays, especially kaolintic clays, and iron and aluminum hydroxides, exhibit a high capacity for absorbing phosphates. Presumably, an OH- ion is exchanged for an H_2PO_4- ion. Recent work (3) with radioactive phosphorus has shown that phosphate will migrate from within a plant root to kaolinite when the roots are moved from a medium without kaolinite to a kaolinite clay suspension. Eastern Oklahoma soils are both acid and comparatively high in kaolinitic type minerals.

The high phosphorus test results for some of the western soils may be due to the high lime content. In the pH range from 7.5 to about 8.5, calcium combines with HPO_4^{--} and precipitates. This dicalcium phosphate is relatively insoluble in water and consequently not readily available for plant growth. The test for easily soluble phosphorus employed the process of acid leaching. This weak acidic solution probably solubilized some phosphate that would have been unavailable under field conditions. Supporting this reasoning, some response to phosphorus fertilization has resulted on these western soils recently.

Potassium

Exchangeable potassium is lost through leaching more readily than either calcium or magnesium. This, however, does not mean that acid soils are always destitute of potassium. Most of the parent rocks as well as some of the secondary minerals contain appreciable amounts of potassium. The solubilization of these materials is more difficult than those materials containing sodium, magnesium and calcium (and consequently affect soil pH). This may explain why potassium indices are generally higher than pH indices for soils developing under the same climate; the exchangeable potassium is being replaced as it is lost through leaching by the continuous weathering of primary and secondary minerals.

Reaction

Acidity indices, which were intermediate in almost all cases, are the result of leaching, parent material, vegetation and specific processes that accompany the climatic environments.

Organic Matter

Organic matter did not establish a trend, as the other properties did. The data suggest that total organic matter increases with increasing precipitation, grass vegetation and fine grained, calcareous parent material. In Oklahoma, rainfall is apparently the controlling factor, with the other variables acting as modifiers.

Problem Area Soil Units

Appendix II shows that bottomland soils were higher in nutrient status and soil reaction (more basic) than were upland soils, except for those in the High Plains and Rolling Red Plains. Bottomland soils in the High Plains and the Rolling Red Plains areas would be at least as fertile as the surrounding upland soils. This fact is not apparent because bottomland soil indices reflect the average status of all soils collected in through-flowing stream valleys throughout the state.

In all problem areas the physical group of soils having relatively high nutrient and pH indices are the deep, fine and medium textured, slowly or very slowly permeable soils. Within this group, the Planosols have the lowest indices. This probably is due to poor drainage, poor aeration and the other undesirable conditions which accompany these limitations.

In numerous instances, those groups of soils which were mapped as shallow, rough broken, or rough stony were found to be considerably higher in nutrient and acidity levels than might be expected from the soils' morphology or land use suitability. These groups reflect more closely the nutrient status of the rocks than do the deeper, better developed soils.

The three foregoing groups are not necessarily highly productive soils, nor are they always physically ideal for average methods of management. For instance, some of the bottomland soils are subject to overflow hazards; some others may be abnormally high in soluble salts. Many of the fine-textured, very slowly permeable soils are slowly drained and may have undesirable tilth. The shallow, rough, stony soils are, of course, unfit for economical crop production. These shallow soils are incapable of holding enough water for vigorous vegetative growth, and are often located on steep topography, making them inaccessible and especially susceptible to accelerated erosion.

Those groups of soils which were notably low in nutrient levels are coarse-textured, permeable and freely permeable soil units. This is probably due to inherently low fertility and low ion exchange capacity. In some cases, due to the small number of soil tests made, these coarse-textured, permeable soils were grouped with other soils having somewhat less "open profiles".

The largest number of tests for the upland soils was made on units which may be considered physically superior for the production of field crops (considering the comparative acreage cultivated). Soil-water relationships and tilth are ideal on soils which are deep, medium-textured and moderately permeable. Appendix II indicates that these units are not generally those with the highest indices.

These deep, medium-textured and moderately permeable soils are used intensively and, consequently, the nutrients as they become available to plants are assimilated quite rapidly. These continuously cropped soils are being fertilized and limed as heavily as any other physical

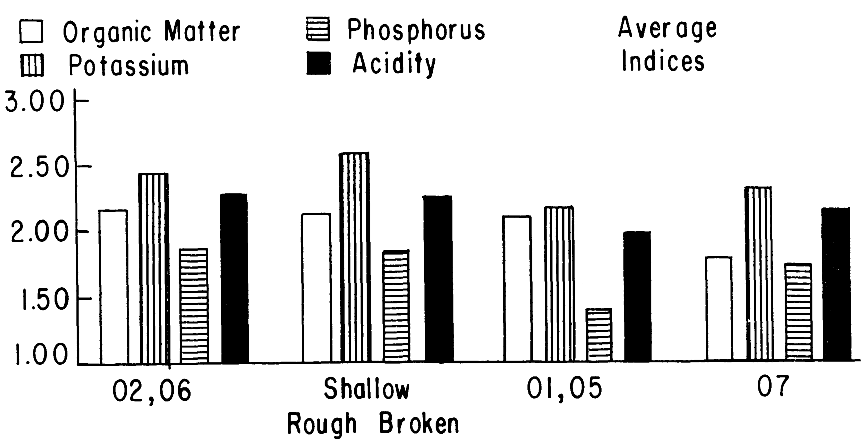

Figure 6. Average indices for Oklahoma soil units 01,05; 02,06; shallow-rough-broken; 07. See Appendix II beginning on page 18.

group of soils in Oklahoma. Generally, however, the amount of fertilizers being added to Oklahoma soils does not nearly approach the amount being removed by plants (2).

Some of these physically similar soil units occur in all problem areas; consequently, by averaging the indices for these soil units, the relative effects of physical properties (depth, texture, and permeability) on nutrient and acidity status become apparent. The averaged indices for these soils are shown in Figure 6.

Soil Associations

The results of soil tests are reported by soil associations in Appendix III. The data reported were taken from Appendix II soil unit tests.

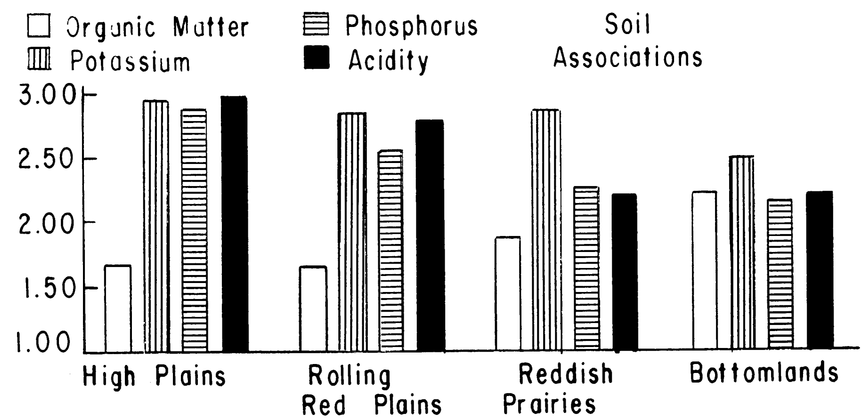

Figure 7. Average indices for Oklahoma soil associations by problem areas (High Plains, Rolling Red Plains, Reddish Prairies and Bottomlands). See Appendix III, page 24.

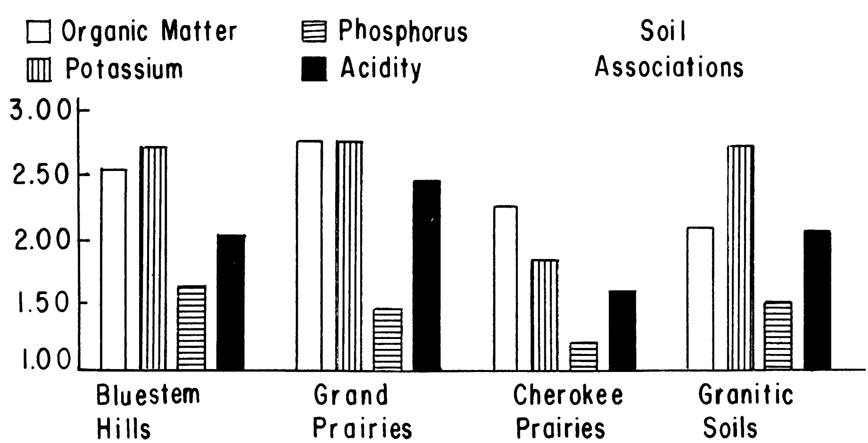

Figure 8. Average indices for Oklahoma soil associations by problem areas (Grand Prairies, Bluestem Hills, Cherokee Prairies and Granitic soils) See Appendix III.

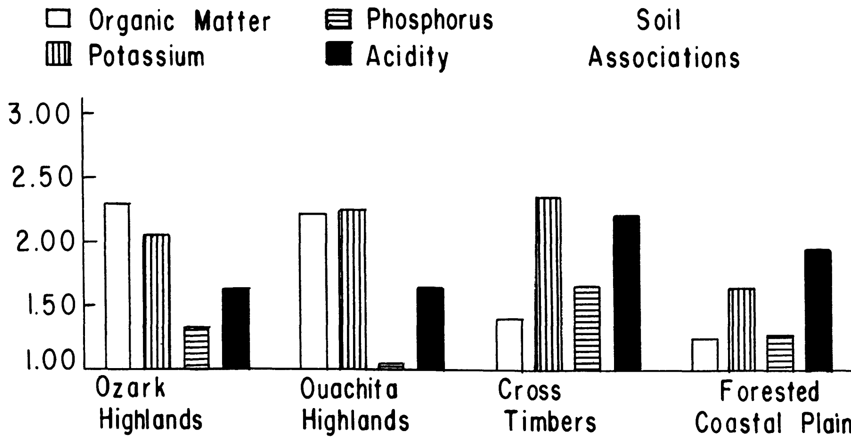

Figure 9. Average indices for Oklahoma soil associations by problem areas (Ozark Highlands, Ouachita Highlands, Cross Timbers and Forested Coastal Plain).

An arithmetical average of the indices for the named soil series in each soil association was calculated and these were then averaged for the soil associations occurring in each problem area. The indices thus derived were plotted graphically and appear in Figures 7, 8, and 9. A comparison of Figures 7, 8, and 9 to Figures 2, 3, and 4, respectively, shows that they are similar.

Major Factors Affecting Soil Indices

Since index curves are relatively identical for problem areas and for the soil associations that comprise the problem areas, the major factors which influenced the fertility and reaction levels of problem area soil units similarly affected the fertility and reaction levels of the soil associations.

Climate

Except for organic matter, indices are progressively lower for soil series occurring west to east geographically, indicating relatively lower available nutrient and pH levels. Both precipitation and temperature increase west to east. Leaching of soils has been greater in the east. One notable exception to this trend was some bottomland soils, which had considerably higher indices due to nutrient-enriched sediments deposited by the major streams. The available phosphorus levels for several bottomland soil series occurring in the Forested Coastal Plain, Ouachita Highlands, and Ozark Highlands were in the low range.

The most variable indices were those representing total organic matter percentage. The most apparent trend was in reverse of the other indices, i.e., organic matter increased with increasing precipitation.

Parent Material

The effect of parent material is obvious on soil series occurring on granitic rocks in south central Oklahoma. Even though these soils developed under an annual rainfall of approximately 30 to 35 inches, relatively conducive to leaching, they show high potassium indices. Another possible contributing factor is the comparative youth of these granitic soils. In granitic rock, through the process of weathering rather large amounts of exchangeable potassium become available (7).

At the other extreme the potassium indices for soils developed on the unconsolidated sand, sandy clays and neutral clays of the Forested Coastal Plain area were, generally, quite low. The geological formation (sandy marine deposits of the Cretaceous) on which these soils formed was originally deficient in potassium content (5).

Forested Coastal Plain soils are also low in total organic matter content. The Cross Timbers, also quite sandy on the surface, were similarly low in organic matter. In contrast those developing on limy materials had considerably higher organic matter indices than other soils within a similar climate. Those series within the Bluestem Hills, Grand Prairies, and Ozark Highlands were the highest in organic matter within the state, according to the tests employed. Increasing total organic matter apparently is not only correlative with increasing precipitation but is also affected by the type parent material.

Vegetation

Trees dominantly comprise the native vegetation of four of Oklahoma's 12 problem areas (Forested Coastal Plain, Ouachita Highlands, Ozark Highlands, and Cross Timbers). Appendix II data indicate that these soils have low indices, with certain reservations. Phosphorus levels were, almost without exception, low on these forested soils. The organic matter levels for some of these soils are low even where they have developed under a comparatively high rainfall. The trend previously suggested, i.e., that total organic matter shows an increase with increasing precipitation, does not adequately explain organic matter levels under all conditions. For instance, the Forested Coastal Plain indices are relatively low for organic matter. In the Ozark Highlands, where the soils are relatively high in organic matter, there are many glady areas where the soils have developed from mixed clayey deposits and limestones. The calcium influence on organic matter has been previously mentioned. From these data it appears that forest type vegetation gives rise to lesser organic matter accumulations than grass under comparable climatic conditions.

Summary

Chemical soil test data accumulated over a period of ten years were used as a basis for an inventory of the fertility status of Oklahoma soils. The soil tests represented the previously interpreted levels for total organic matter, exchangeable potassium, easily soluble phosphorus, and soil reaction. Soils which had been catalogued in the State Soils Laboratory according to problem area soil units were classified by soil series and subsequently to soil associations.

In order to obtain a single index for each nutrient and acidity, the percentages of samples in each of the three groups—low, medium, and high—were multiplied by one, two, and three respectively. The sum of the figures thus obtained divided by 100 gave the index, or weighted average, for each soil. The index was calculated for 1) entire problem areas, and 2) each soil unit within Oklahoma's 12 problem areas.

The various nutrient and acidity levels for different soils, as indicated by the indices, were attributed to the effects of the interrelated influences of the factors of soil formation.

Arithmetical averages for soil association indices were found to be relative and similar to indices representing all soils within the problem areas that contained those associations. Such a comparison provided a method of checking how well those "key" soils reflected the nutrient status of entire problem areas. The high degree of correlation shows that the factors that influence the nutrient and acidity levels of problem area soil units similarly affect soil associations.

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Appendix I: Soil Conservation Service Problem Area and Soil Unit Legend

HP	High Plains	GP	Grand Prairie
RR	Rolling Red Plains	ZH	Ozark Highlands
RP	Reddish Prairies	GS	Granitic Soils
CP	Cherokee Prairies	CT	Cross Timbers
OH	Ouachita Highlands (Arkansas Valley, Boston Mts. and Ouachita Mts.)	FC	Forested Coastal Plain
		BO	Bottomlands
		BH	Bluestem Hills

01	Deep, fine textured, very slowly permeable soils
02	Deep, fine textured, slowly permeable soils
03	Deep, fine textured, very slowly permeable bottomland soils
04	Deep, fine textured, slowly permeable bottomland soils
05	Deep, medium textured, very slowly permeable soils
06	Deep, medium textured, slowly permeable soils
07	Deep, medium textured, permeable soils
08	Deep, medium textured, slowly permeable bottomland soils
09	Deep, medium textured, permeable bottomland soils
10	Deep, coarse textured, very slowly permeable soils.
11	Deep, coarse textured, slowly permeable soils
12	Deep, coarse textured, permeable soils
13	Deep, coarse textured, freely permeable soils
15	Deep, coarse textured, permeable bottomland soils
16	Shallow, fine textured, very slowly permeable soils
17	Shallow, fine textured, slowly permeable soils
18	Shallow, fine textured, permeable soils
19	Shallow, medium textured, very slowly or slowly permeable soils
20	Shallow, medium textured, permeable or freely permeable soils
24	Very shallow, fine textured soils
25	Very shallow, medium textured soils
27	Rough broken or rough stony land, non-calcareous materials
28	Rough broken or rough stony land, calcareous materials
60	Deep, medium (coarser textured members) textured, slowly permeable soils
70	Deep, medium (coarser textured members) textured, permeable soils

Depth, Texture and Permeability Legend

Soil Depth	**Description**
Deep	20" plus
Shallow	10" to 20"
Very shallow	10"
Soil Texture	**Description**
Fine	Clay, silty clay, sandy clay, silty clay loam, clay loam, sandy clay loam
Medium	Silt loam, loam, very fine sandy loam, fine sandy loam, sandy loam
Coarse	Loamy fine sand, loamy sand, sand, coarse sand
Soil Permeability	**Description**
Very slowly permeable	Characterized by dense clays or semi-clay pans. Structure massive or irregular angular blocky.
Slowly permeable	Characterized by crumbly or granular clays, silty clays, clay loams. Structure fine to medium irregular angular blocky. Some granulation.
Permeable (moderate)	Characterized by sandy clay loam or highly granular silty clays, clays, or clay loams. Nuciform structure.
Freely permeable (rapid)	Characterized by fine sandy loam or coarser textures. Crumb to single grain structure.

Appendix II: Nutrient and Acidity Indices of Oklahoma Problem Area Soil Units

Soil Unit and Land Class	Major Soils	Number of Tests	Indices: Organic Matter[1]	Indices: Phosphorus[2]	Indices: Potassium[3]	Indices: Acidity
	High Plains Problem Area					
02, (1-4); 06 (3-7).	Richfield, Pullman Portales	20	2.05	2.90	3.00	3.00
07, (1-7); 70, (3-4).	Dalhart, Be.thoud	20	1.25	2.95	3.00	2.95
09, 04, (1-2).	Spur	4	2.75	3.00	3.00	3.00
12, (1-7).	Dalhart, Vona	5	1.40	3.00	3.00	3.00
17, (3-4); 18, (1-4); 20, (3-7).	Mansker, Potter	6	2.00	3.00	3.00	3.00
	Totals	55	1.74	2.94	3.00	2.98
	Rolling Red Plains Problem Area					
01, 05, (1-2).	Foard, Hollister, Tillman, Lebos[4] Calumet	130	2.18	2.87	2.97	2.72
01, 05, (3-4).	Tillman	162	2.13	2.78	2.97	2.75
01, 05, (5-7).	Eroded Tillman	8	1.88	2.62	3.00	2.25
02, (1-7).	Abilene, Kiowa La Casa, Stamford	114	2.21	2.90	2.96	2.84
03, (1-7).	Spur	19	2.31	2.95	3.00	3.00
04, 08, (1-7).	Norwood[5], Port	128	2.22	2.96	3.00	2.86
06, (1-7); 60, (1-4).	Abilene, St. Paul Carwile, Lawton[5], Carmen	185	1.89	2.90	2.96	2.87
07, (1-2).	Dill, Carey, Tipton, Enterprise, Albion	102	1.50	2.74	2.86	2.76
07, (3-4); 70, (1-7); 07, (5-7).	Woodward, Miles Sentinel, Enterprise	215	1.33	2.55	2.87	2.77
09, (1-7).	Port, Yahola, Spur, Sweetwater	145	1.63	2.93	2.92	2.98
12, (1-7).	Pratt, Nobscott	89	1.12	1.94	2.70	2.85
13, (3-7).	Tivoli	5	1.00	2.00	1.80	2.80
15, (3-7).	Lincoln	8	1.00	3.00	2.00	3.00
20, (1-7); 19, (3-4); 17, (3-7); 25, (1-7).	Quinlan-Woodward complex, Weymouth.	97	1.74	2.75	2.85	2.88
27, (1-2); 24, (1-7).	Vernon, rough broken land-Vernon, Harmon.	10	2.22	2.80	3.00	2.91
	Totals	1417	1.80	2.75	2.90	2.83

Soil Unit and Land Class	Major Soils	Number of Tests	Indices: Organic Matter[1]	Phos-phorus[2]	Potas-sium[3]	Acidity
	Reddish Prairies Problem Area					
01, (1-2); 01, (3-4).	Tabler, Renfrow	85	2.12	2.41	2.96	2.76
02, (1-4); 02, (5-7).	Fairview, Rusk.	53	2.40	2.34	2.83	2.47
03, (1-7).	Lela, Roebuck, Miller.	28	2.57	2.39	2.92	2.57
04, (1-7); 08, (1-7).	Port, Kay, Brewer.	474	2.46	2.56	2.85	2.68
05, (1-2).	Tabler, Kirkland, Calumet.	270	2.23	1.78	2.82	1.85
05, (3-4).	Renfrow, Kirkland	510	1.92	1.46	2.68	1.94
05, 01, (5-7).	Eroded Renfrow	67	1.73	1.39	2.56	2.13
06, (1-2).	Pond Creek, Norge, Bethany, Kingfisher[4]	160	1.99	2.54	2.89	2.20
06, (3-7).	Zaneis, Norge	215	1.71	1.49	2.68	2.09
07, 70, (1-2).	Grant, Chickasha, Vanoss, Minco, Teller, Albion.	495	1.71	2.12	2.82	2.18
07, 70, (3-7).	Grant, Cobb, Teller, Minco.	882	1.57	1.65	2.66	2.23
09, (1-4); 09, (5-7).	Port, Yahola, Reinach.	616	1.72	2.59	2.74	2.64
12, (1-7).	Pratt, Cobb, Dougherty.	93	1.14	2.34	2.55	2.58
13, (3-7).	Derby, Tivoli	4	1.50	2.00	2.50	3.00
15, (1-7).	Lincoln	35	1.31	2.47	2.46	2.78
16, 17, (3-4); 19, (3-7).	Shallow phases of Renfrow.	33	1.82	2.30	2.91	2.67
20, (1-4); 20, (5-7).	Lucien, Nash	100	1.46	1.96	2.79	2.42
24, (3-7); 25, (1-7).	Vernon, Lucien	45	2.11	2.02	2.85	2.69
	Totals	4165	1.83	2.03	2.75	2.31
	Cherokee Prairies Problem Area					
01, (1-7); 02, (1-4).	Okemah, Woodson	43	2.54	1.48	2.06	1.98
03, 04, 08, (1-7).	Verdigris, Osage Lightning	164	2.54	1.86	2.30	2.10

Soil Unit and Land Class	Major Soils	Number of Tests	Indices: Organic Matter	Phos- phorus	Potas- sium	Acidity
	Cherokee Prairies Problem Area, continued					
05, (1-7).	Parsons, Taloka, Cherokee.	343	2.41	1.23	1.75	1.68
06, (1-7).	Dennis, Choteau	529	2 32	1.18	1.95	1.55
07, (1-7); 20, (3-7).	Bates	359	2.10	1.26	1.78	1.57
09, (1-7).	Verdigris, Cleora, Mason.	109	2.42	1.80	2.37	2.25
17, 24, 25, (3-7); 18, 27, (3-40); 19, (5-7).	Talihina, Collinsville.	45	2.69	1.22	2.62	1.76
	Totals	1592	2.33	1.33	1.95	1.70
	Ouachita Highlands Problem Area (Arkansas Valley, Boston Mts. and Ouachita Mts.)					
03, (1-2) (5-7).	Atkins	5	3.00	2.00	3.00	1.40
05, (1-7).	Parsons, Taloka, LeFlore	49	1.69	1.06	1.95	1.32
06, (1-7); 19, (3-7).	Conway, Enders	102	1.88	1.19	1.90	1.70
07, (1-7); 20, (3-7).	Linker, Cleburne Waynesboro.	280	1.60	1.22	1.83	1.82
08, (1-7); 04, (1-4).	Philo[5], Tyler	87	2.33	1.22	2.26	1.71
09, (1-7).	Pope	64	2.00	1.33	2.22	1.75
12, (3-7); 70, (1-7).	Dougherty, Stidham, Teller.	24	1.12	1.04	1.52	1.79
25, 27, (3-7).	Hector, Pottsville,	15	2.40	1.00	2.43	1.60
	Totals	626	1.80	1.20	1.96	1.73
	Grand Prairie Problem Area					
02, 01, (1-7).	Denton, San Saba[7]	304	2.81	1.96	2.74	2.63
03, (1-7).	Kaufman, Bell[5].	27	2.67	2.52	2.85	2.62
04, 08, (1-7); 09, (1-4).	Gowen, Catalpa[5].	314	2.68	2 39	2.84	2.72
05, (1-7).	Wilson[5], Irving[5], Grayson.	36	2 03	1.28	1.91	2.11
06, (1-7).	Durant.	205	2.26	1.44	2.54	2.21
07, (1-7).	Choctaw, Newtonia	99	1.85	1.39	2.34	2.06
24, 17, (3-7); 28, 25, (5-7).	Tarrant, Ellis, Crawford.	23	2.91	1.39	2.84	2.48
	Totals	1008	2.53	1.91	2.68	2.49

Soil Unit and Land Class	Major Soils	Number of Tests	Indices: Organic Matter	Phos-phorus	Potas-sium	Acidity
	Bluestem Hills Problem Area					
02, (1-7); 05, (1-2).	Summit, Woodson	31	2.76	1.39	2.41	2.13
03, 04, (1-4).	Osage, Muir[5], Verdigris	11	3.00	1.96	3.00	1.47
06, (1-7).	Labette	30	3.00	1.84	2.75	1.83
07, (1-4).	Newtonia	4	2.75	2.00	2.75	2.50
08, 09, (1-2).	Verdigris, Mason	9	2.78	2.11	3.00	1.22
28, (5-7); 20, (3-4).	Sogn	5	2.20	1.80	3.00	2.00
	Totals	90	2.83	1.73	2.69	1.84
	Ozark Highlands (Prairie) Problem Area					
01, (1-4); 17, (3-7).	Woodson	20	2.85	1.50	2.04	2.10
02, (1-7).	Summit	50	2.80	1.74	2.48	2.34
04, (1-2) (5-7).	Muir[5]	4	2.25	2.00	2.50	1.75
05, (1-7).	Parsons, Gerald[6]	57	2.35	1.12	1.36	1.46
06, (1-7).	Dennis, Lawrence[5], Choteau	136	2.64	1.21	1.50	1.43
07, (1-7); 19, (3-7); 25, (5-7).	Newtonia, Craig, Cabanal[5], Riverton.	134	2.38	1.19	1.70	1.67
08, (1-2); 09, (1-7).	Huntington[5]	26	2.69	1.31	2.12	1.62
20, (5-7).	Bodine	50	2.66	1.20	1.74	1.58
	Totals	477	2.56	1.27	1.73	1.66
	Ozark Highlands Problem Area					
01, (1-4); 02, (3-4); 17, (1-2).	Summit	5	3.00	1.20	1.40	1.80
05, (1-7).	Guthrie[5]	10	2.20	1.20	1.50	2.10
06, (1-7); 19, (3-4).	Lawrence[5]	40	2.32	1.17	1.77	1.72
07, (1-7).	Nixa[5], Baxter Cabanal[5], Stilwell.	85	2.10	1.34	2.10	1.66
09, (1-7); 08, (1-4).	Huntington[5], Roane[5] Melvern[*].	51	2.67	1.84	2.43	1.94
20, (1-7); 24, 25, (5-7).	Bodine	26	2.77	1.50	2.20	1.65
	Totals	217	2.38	1.44	2.09	1.76

Soil Unit and Land Class	Major Soils	Number of Tests	Indices: Organic Matter	Phos-phorus	Potas-sium	Acidity
	Granitic Soils Problem Area					
02, (1-7); 01, (1-4).	Garrett[4]	78	2.38	2.12	2.83	2.46
05, (1-7).	Garrett[4]	24	1.87	1.83	2.83	2.17
06, (1-7); 11, (3-7).	Lawton[5], Chigley, Roff, Gilson.	29	2.06	1.20	2.61	1.96
07, (1-7).	Tishomingo	16	2.00	1.88	3.00	2.06
09, (1-4).	Port, Pulaski.	13	1.92	2.38	2.83	2.28
	Totals	160	2.17	1.91	2.80	2.27
	Cross Timbers Problem Area					
03, (3-7).	Roebuck, Lela	4	1.25	1.50	2.50	2.25
04, (1-7); 08, (1-4).	Miller	32	2.00	2.00	2.51	2.65
06, 05, 01, (1-7); 60, (3-4); 02, (3-7).	Windthorst, Parsons, Nimrod[5].	95	1.40	1.47	2.20	2.17
07, 70, (1-4).	Stephenville, Noble, Dougherty, Stidham, Teller.	555	1.28	1.47	2.15	2.19
07, 70, (5-7); 19, (3-7); 20, (1-7).	Stephenville, Eroded and shallow phases, Windthorst.	222	1.28	1.24	1.95	2.22
09, 15, (1-7).	Pulaski, Port, Gowen, Mason.	214	1.38	1.86	2.23	2.65
12, (1-7).	Dougherty, Stidham	108	1.12	1.67	1.99	2.46
13, (3-7).	Eufaula, Derby	21	1.00	1.90	1.53	2.47
24, (1-2); 25, (3-4); 27, (3-7).	Darnell and rough sandstone lands	7	1.29	1.43	2.57	2.00
	Totals	1258	1.31	1.54	2.13	2.32
	Forested Coastal Plain Problem Area					
04, (1-4); 08, (1-7).	Iuka[5], Bibb.	10	1.50	1.00	1.40	2.00
05, (1-7); 01, (5-7).	Caddo, Lufkin Myatt.	14	1.42	1.07	1.92	1.50
06, (1-7); 10, (1-2); 11, (5-7).	Boswell, Kirvin, Sawyer, Susquehanna.	57	1.24	1.17	1.83	1.89

Soil Unit and Land Class	Major Soils	Number of Tests	Indices: Organic Matter	Indices: Phosphorus	Indices: Potassium	Indices: Acidity
	Forested Coastal Plain Problem Area, continued					
07, 12, (1-7); 13, (3-4).	Bowie, Ruston, Norfolk, Kalmia, Cahaba.	137	1.16	1.53	1.42	2.17
09, (1-7).	Ochlockonee	26	1.58	1.62	2.62	2.27
19, 20, (3-7).	Cuthbert	13	1.30	1.23	1.40	2.00
	Totals	257	1.27	1.40	1.59	2.07
	Bottomlands Problem Area					
03, (1-7).	Pledger, Lela, Perry	30	2.73	2.50	2.97	2.67
04, 08, (1-7).	Dale, McLain, Port, Miller, Norwood[5], Spur.	251	2.46	2.75	2.81	2.72
09, (1-7).	Yahola, Reinach, Canadian, Port.	357	1.76	2.56	2.56	2.55
15, (1-7).	Lincoln	33	1.18	2.77	2.13	2.76
	Totals	671	2.03	2.65	2.64	2.63

[1]Total organic matter.
[2]Easily soluble phosphorus.
[3]Exchangeable potassium.
[4]Provisional series or soil field name only.
[5]Not yet correlated in Oklahoma.
[6]Not correlated in Oklahoma as now defined.
[7]Soils like San Saba called Houston in Bryan Co. survey.

Appendix III: Nutrient and Acidity Indices of Oklahoma Soil Associations

Soil Associations			Indices					
Location and Parent Materials	Name	Symbol[1]	No. Tests	Organic Matter	Phosphorus[3]	Potassium[4]	Acidity[5]
Alluvial soils:	Miller*		30	2.70	2.87	2.93	2.93
a. Red River west to Denison Dam.	Yahola*	MYT	25	1.52	2.76	2.40	2.84
	Teller		32	1.27	1.47	1.49	2.00
b. Southeastern Oklahoma. Forested areas.	Atkins		5	3.00	2.00	3.00	1.40
	Pope	AP	64	2.00	1.33	2.22	1.75
c. Eastern Oklahoma. Prairie areas.	Verdigris		273	2.49	1.83	2.32	2.15
	Osage	VO	164	2.54	1.85	2.29	2.09
d. Along through-flowing streams throughout rest of Oklahoma.	Yahola		357	1.76	2.56	2.56	2 55
	Port	YPR	251	2.46	2.75	2.81	2.71
	Reinach		357	1.76	2.56	2.56	2.55
Ozark Highlands. Cherty Materials, local limestones and shales	Bodine		76	2.70	1.30	1.90	1.60
	Baxter	BBN	85	2.10	1.34	2.10	1.66
	Nixa		85	2.10	1.34	2.10	1.66
Southeastern Oklahoma. Mountain and valley areas. Shales and sandstones.	Hector	HP	15	2.40	1.00	2.42	1.60
	Pottsville		15	2.40	1.00	2.42	1.60
	Enders	ECH	102	1.88	1.19	1.90	1.70
	Conway		102	1.88	1.19	1.90	1.70
	Hector		15	2.40	1.00	2.42	1.60
Coastal plains. Sandy sediments and clayey beds.	Kirvin	KCB	57	1.24	1.17	1.83	1.89
	Cuthbert		13	1.30	1.23	1.40	2.00
	Bowie		137	1.16	1.53	1.42	2.17
	Bowie	BCB	137	1.16	1.53	1.42	2.17
	Caddo		14	1.42	1.07	1.92	1.50
	Boswell		57	1.24	1.17	1.83	1.89

Soil Associations			Indices				
Location and Parent Materials	Name	Symbol	No. Tests	Organic Matter	Phos-phorus[3]	Potas-sium[4]	Acidity[5]
Coastal plains. Clayey sediments, marls and limestones.	Durant		205	2.26	1.44	2.54	2.21
	San Saba	DST	304	2.81	1.96	2.74	2.63
	Tarrant		23	2.91	1.39	2.83	2.48
	Tarrant	T	23	2.91	1.39	2.83	2.48
Northeastern Oklahoma prairie. Limestones and limy shales.	Labette	LSS	30	3.00	1.84	2.75	1.83
	Summit		31	2.76	1.39	2.41	2.13
	Sogn		5	2.20	1.80	3.00	2.00
	Sogn	SS	5	2.20	1.80	3.00	2.00
	Summit		31	2.76	1.39	2.41	2.13
Eastern Oklahoma prairie. Shales and sandstones.	Parsons	PDB	343	2.41	1.23	1.75	1.68
	Dennis		529	2.32	1.18	1.95	1.55
	Bates		359	2.10	1.26	1.78	1.57
Central Oklahoma. Sandstones and clays.	Darnell	DS	7	1.29	1.43	2.57	2.00
	Stephenville		555	1.28	1.47	2.15	2.19
	Windthorst	WS	95	1.40	1.47	2.20	2.17
	Stephenville		555	1.28	1.47	2.15	2.19
South central Oklahoma. Granitic rocks and granite conglomerates.	Tishomingo	TCD	16	2.00	1.88	3.00	2.06
	Chigley		29	2.06	1.20	2.61	1.96
	Durant		205	2.26	1.44	2.54	2.21
Central Oklahoma. Unconsolidated loams and sandy loams near through-flowing streams.	Dougherty	DTY	555	1.28	1.47	2.15	2.19
	Teller		495	1.71	2.12	2.82	2.18
	Yahola		357	1.76	2.56	2.56	2.55
Central Oklahoma prairies. Clayey "Red beds", silts, and sandstones.	Renfrow	RZV	510	1.92	1.46	2.68	1.94
	Zaneis		215	1.71	1.49	2.68	2.09
	Vernon		55	2.12	2.16	2.87	2.73
	Bethany*	BTK	20	2.40	2.85	2.94	1.85
	Tabler*		55	2.71	1.94	3.00	1.25
	Kirkland*		191	2.35	1.86	2.85	1.87

Soil Associations			Indices				
Location and Parent Materials	**Name**	**Symbol**	**No. Tests**	**Organic Matter**	**Phosphorus[3]**	**Potassium[4]**	**Acidity[5]**
Central Oklahoma. Sandstones and sandy "Red beds".	Grant*	GPN	79	1.76	2.88	2.84	2.08
	Pond Creek*		11	2.18	3.00	3.00	1.82
	Nash*		20	1.65	2.85	2.95	2.60
	Cobb*	CQ	251	1.26	1.79	2.84	2.49
	Quinlan		96	1.74	2.75	2.85	2.82
Central Oklahoma. Unconsolidated loams near through-flowing streams.	Vanoss	VMY	495	1.71	2.12	2.82	2.18
	Minco		882	1.57	1.65	2.66	2.23
	Yahola		616	1.72	2.59	2.74	2.64
Western Oklahoma prairies. Clayey "Red beds".	Tillman	TV	170	2.12	2.78	2.97	2.72
	Vernon		55	2.12	2.16	2.87	2.73
	Foard	FHT	130	2.18	2.86	2.97	2.71
	Hollister		130	2.18	2.86	2.97	2.71
	Tillman		170	2.12	2.78	2.97	2.72
	Rough brokenland—Vernon	RBV	55	2.12	2.16	2.87	2.73
Western Oklahoma prairies. Red sandstones and silts.	Rough broken-land Quinlan	RBQ	97	1.74	2.75	2.85	2.88
	Woodward	WCQ	215	1.33	2.55	2.87	2.77
	Carey		102	1.50	2.74	2.86	2.76
	Quinlan		97	1.74	2.75	2.85	2.88
	Carey	CS	102	1.50	2.74	2.86	2.76
	St. Paul		185	1.89	2.90	2.96	2.87
	Woodward	WDQ	215	1.33	2.55	2.87	2.77
	Dill*		50	1.30	2.14	2.90	2.54
	Quinlan		97	1.74	2.75	2.85	2.88
Western Oklahoma plains. Duney sands and sandy loams.	Pratt	PT	182	1.13	2.14	2.57	2.70
	Tivoli		9	1.22	2.00	2.11	2.88
	Nobscott*	NMT	28	1.00	1.79	2.68	2.95
	Miles*		24	1.13	2.74	2.83	2.93
	Tivoli		9	1.22	2.00	2.11	2.88

Soil Associations			Indices				
Location and Parent Materials	Name	Symbol	No. Tests	Organic Matter[2]	Phosphorus[3]	Potassium[4]	Acidity[5]
Western Oklahoma plains. Unconsolidated loams and clay loams near through-flowing streams.	Enterprise	ETY	317	1.38	2.60	2.86	2.77
	Tipton		102	1.50	2.74	2.86	2.76
	Yahola		145	1.63	2.93	2.92	2.98
Southwestern Oklahoma.	Granitic Mountains		—	—	—	—	—
Western Oklahoma High Plains	Potter	PM	6	2.00	3.00	3.00	3.00
a. Rolling "breaks" to the High Plains. Unconsolidated limy loams.	Mansker		6	2.00	3.00	3.00	3.00
	Richfield	RDP	20	2.05	2.90	3.00	3.00
	Dalhart		20	1.25	2.95	3 00	2.95
b. Unconsolidated limy loams and sands.	Portales		20	2.05	2.90	3.00	3.00
	Vona	VDT	5	1.40	3.00	3.00	3.00
	Dalhart		20	1.25	2.95	3.00	2.95
	Tivoli		9	1.22	2.00	2.11	2.88
c. Nearly level, deep on silts and loams	Pullman	PR	20	2.05	2.90	3.00	3.00
	Richfield		20	2.05	2.90	3.00	3.00
d. Hill and valley areas. Loams and hard rocks.	Travesilla	TBRS	—	—	—	—	—
	Berthoud		20	1.25	2.95	3.00	2.95
	Rough Stony land		—	—	—	—	—

*These tests were selected from counties where these soils were known to predominate. Even though the number of tests representing each series was thereby lessened, it is believed that these tests more nearly represent these particular soils in the respective soil associations.

[1]Symbol used in Oklahoma Soil association map.
[2]Total Organic Matter. (Wet combustion method)
[3]Easily soluble Phosphorus (Harper method)
[4]Exchangeable Potassium (ammonium acetate extractable)
[5]Soil reaction (Glass electrode method)