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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 443 MARCH, 1932

DIVISION OF CHEMISTRY

CHEMICAL COMPOSITION OF SOILS OF NORTHWEST AND WEST CENTRAL TEXAS

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**In cooperation with U. S. Department of Agriculture.
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This Bulletin contains analyses of various types of soils from 49 counties in Northwest and West-Central Texas. Tables interpreting the results are given. Methods for maintaining soil fertility are outlined, and the terms used are explained. The results show the fundamental basis of the soil fertility of the various types of soil, indicate their weakness or strength, and the probable deficiencies that may arise under continued cultivation. Some saline spots occur in the area, the salts being chiefly sodium chloride or common salt, with some sodium sulphate, magnesium sulphate, and magnesium chloride. The soils are fairly well supplied with nitrogen and phosphoric acid, and are very well supplied with potash and lime. Nitrogen is the element likely to become deficient first under continued cultivation, and phosphoric acid may become deficient on certain soils. The use of fertilizers is not advised at present on general farm crops, though their use may be advisable on alfalfa or fruit or vegetable crops, especially where grown under irrigation.

CONTENTS

BULLETIN No. 443 MARCH, 1932

CHEMICAL COMPOSITION OF SOILS OF NORTHWEST AND WEST CENTRAL TEXAS

G. S. FRAPS

This Bulletin deals with the chemical composition and fertility of samples of typical soils from 49 counties of Texas covered by reconnaissance soil surveys of the Bureau of Soils of the United States Department of Agriculture in cooperation with the Texas Agricultural Experiment Station. It is the thirteenth in a series dealing with the chemical composition of typical Texas soils.

Detailed reports of the surveys with maps of the areas showing the location of the soil types have been published by the Bureau of Chemistry and Soils, United States Department of Agriculture. Description of the important soils are given in Bulletin 431, The Soils of Texas, which can be obtained from the Texas Agricultural Experiment Station.

The reports from which the descriptions of soils given in this Bulletin were condensed are as follows:

Reconnaisance Soil Survey of Northwest Texas by William T. Carter, Jr. et al.

Soil Survey (Reconnaissance) of West Central Texas by W. T. Carter et al.

Requests for copies of reports of soil surveys should be addressed to the Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D. C. The Texas Agricultural Experiment Station has no copies of the soil surveys for distribution.

The Northwest Texas Survey includes 22 counties in three tiers just south of the Panhandle region, comprising an area of 19,404 square miles. The counties included are Bailey, Cochran, Cottle, Crosby, Dickens, Floyd, Foard, Garza, Hale, Hardeman, Haskell, Hockley, Kent, King, Knox, Lamb, Lynn, Lubbock, Motley, Stonewall, Terry, and Yoakum.

A detailed survey of Lubbock county was made in 1917.

The West Central Texas area comprises 27 counties in four tiers immediately south of the Northwest Texas area, containing an area of 26,784 square miles. It includes Andrews, Borden, Coke, Concho, Crane, Dawson, Ector, Fisher, Gaines, Glasscock, Howard, Irion, Jones, Loving, Martin, Midland, Mitchell, Nolan, Reagan, Runnels, Scurry, Sterling, Taylor, Tom Greene, Upton, Ward and Winkler.

Detailed surveys have been made of Dickens, Taylor, Lubbock and Midland counties. Analyses of soils of Taylor county have been published in Bulletin 301 and of Lubbock county in Bulletin 337. Analyses of types shown in the detailed survey but not in the Reconnaissance are not given.

Owing to the large areas covered by these surveys, only the chief types of soil were mapped and described. There are large areas of uniform types of soil in each area.

SOIL FERTILITY

In any discussion of the chemical composition of soils and the interpretation of the analyses, it should be borne in mind that the chemical composition of a soil is not a complete indication of its fertility or its agricultural possibilities. There are other factors contributing to the productiveness of a soil. Some of these are the physical character of the soil, location, drainage, rainfall and other climatic conditions, and so on. It may be too wet or too dry, too hard or too sandy, too irregular in topography, have too stiff or heavy surface or subsoil, and so on. Many of these conditions are considered in connection with the soil survey.

A soil may be lower in plant food than another and yet produce a better crop, owing to the fact that it may have a better physical character, be in better condition, or be in a better location. Under similar conditions, soils having the higher content of plant food will generally be found to be the more productive.

MAINTAINANCE OF FERTILITY

Moisture is probably the most important factor governing the production of crops on the soils in the areas here discussed.

The following are some of the factors essential to maintaining or improving the productiveness of a soil:

(1) The supply of nitrogen and vegetable matter should be maintained. A crop rotation that will include legumes to be plowed under or grazed off is often advised for this purpose. Some nitrogen may also profitably be purchased in commercial fertilizers.

(2) Any deficiency in phosphoric acid should be corrected by the use of a phosphatic fertilizer. Phosphoric acid is the element of plant food most frequently deficient in Texas soils.

(3) If the soil is too acid, limestone or some other form of lime should be added to correct it. Very acid soils are not suitable for growing general crops, especially legumes. Limestone is also valuable for improving the physical condition of heavy soils poor in lime. Lime should be used chiefly in connection with legumes in a rotation. The soils of West Texas are generally not acid.

(4) Any deficiency in potash should be corrected by the use of potash fertilizers.

(5) Erosion, or washing away, of the more fertile surface soil should be prevented.

MAINTAINANCE OF HUMUS AND NITROGEN

The maintenance of the humus and nitrogen of the soils of West Texas is not at present a pressing problem, but it is likely to become more and more important the longer these soils are in cultivation.

The maintenance of humus or vegetable matter in a soil is essential to *obtaining a high degree of fertility.* Partly decayed vegetable matter frequently called humus, in sufficient quantity, improves the physical condition of the soil by improving the tilth, making heavy clay soils easier to work and making sandy soil more compact and less porous. It also aids in increasing the water-holding capacity of a soil, enabling it to better withstand droughts. It helps to bind the soil particles together and reduce erosion. It acts as a home and provides suitable food for great numbers of soil bacteria. Humus contains most of the nitrogen of the soil, which is gradually changed to forms suitable for the use of the plant. The nitrogen from humus is not so easily lost from the soil as nitrogen in more soluble forms. Some virgin soils produce good crops for a long time without the addition of organic matter but sooner or later all soils will need the addition of vegetable or organic matter.

Organic matter may be added by plowing under crop residues, or the entire crop may be used as a green-manure crop. Barnyard manure is excellent when sufficient quantities can be secured, but too often it cannot be secured in sufficient quantities. Legume crops, having the power of obtaining nitrogen from the air, should be grown in rotation with other crops and either turned under, grazed off, or made into hay and the manure derived from feeding the hay properly conserved and put on the soil. If the crop is heavy, it is best to allow it to mature before plowing it under. To graze off a crop is probably the most effective practice, as the feeding value of the crop is obtained, while the droppings of the animals together with the liquid excrement return the bulk of the plant food.

The organic matter decays more rapidly in Southern soils than in Northern soils. The warmer soils in the South, the unfrozen condition of the soil during the winter, and the sandy character of many of the soils, allow the more rapid oxidation of organic matter. Hence it follows that the humus and nitrogen are liable to be lower, and more difficult to maintain in Southern soils than in Northern soils.

Crops other than legumes add organic matter to the soil but add no increased amounts of nitrogen. Such crops add organic matter or serve as a cover crop to decrease the amounts of nitrates and soluble plant food being washed from the soil, which would occur to a greater extent if the land were left bare. Cover crops may also help to prevent the erosion of the soil.

The maintenance of nitrogen in soils is more important than maintenance of the humus content. One way to maintain the nitrogen content of the soil is to adopt a rotation that will include legumes so as to obtain the nitrogen from the air; this nitrogen can then be used for cotton, corn, kafir, or other crops. Nitrogenous fertilizers can of course be purchased.

Phosphoric Acid

Texas soils are frequently deficient in phosphoric acid. This Bulletin shows the probable deficiencies in phosphoric acid of the soils studied. Deficiency in phosphoric acid is easily remedied by the application of superphosphate.

Acidity

Some soils contain organic or inorganic acids. Some crops, such as alfalfa, barley, clover, and rye do not do well on acid soils. Acidity may be corrected by the use of finely ground limestone or oyster shells, air-slaked lime or hydrated lime. Practically none of the soils mentioned in this Bulletin are acid, so that lime is not needed on them at the present time.

Potash

Many soils of Texas contain sufficient potash to produce good crops, but some soils need potassic fertilizers. In general, however, potash is the least needed of the three important plant foods: nitrogen, phosphoric acid, potash. The potash needs of the soil here studied are indicated in the tables of analysis, and the interpretation is given later.

How to Use the Analyses

Analyses of the soils and interpretations of the analyses are given in connection with descriptions of the various types of soil.

If a soil is well supplied with plant food but does not give good yields, conditions other than content of plant food control the yields. The rainfall may be insufficient. The physical condition may be poor, in respect to cultivation, drainage, or otherwise. It may contain an injurious amount of alkaline salts, or some plant disease may be active.

If a soil is well supplied with total plant food but is low in available or active plant food, an effort should be made to increase the activities of agencies which make plant food available, by means of additions of manure, plowing under green crops, or additions of lime if needed.

If the crop yields are low and the plant food of the soil is deficient, fertilizers must be used. The depth of soil, character of the subsoil, and the season, influence the growth of crops almost as much as the amount of plant food, which can be seen by observing the variations in yield on the same land year after year.

EXPLANATION OF TERMS

Total nitrogen is the entire quantity of nitrogen present in the soil. As shown in Bulletin 151, there is a relation between the total nitrogen of the soil and the nitrogen that can be taken from it by crops in pot experiments. The total nitrogen is, therefore, an index as to the needs of the soil for nitrogen, although the nitrogen in worn soils is not as available as that in new soils.

Total phosphoric acid is the entire amount of phosphoric acid contained in the soil. Only a small portion of this is available for the use of plants at any given time.

Active phosphoric acid is the phosphoric acid soluble in dilute nitric acid (0.2N acid). As shown in Bulletins 126 and 276, there is a relation between the active phosphoric acid of the soil and the amount of phosphoric acid removed from the soil by plants in pot experiments. There is a closer relation between the active phosphoric acid of the soil and the need of the soil for phosphatic fertilizer than between total phosphoric acid and the needs of the soil.

Total potash is the entire amount of potash in the soil. Some of this is locked up in highly insoluble forms and may never become available to plants. The total potash does not show how much may be taken up by plants.

Acid-soluble potash is the potash soluble in strong hydrochloric acid. As pointed out by Hilgard, there is a relation between the acid-soluble potash of the soil and the wearing qualities of the soil (Fraps, Principles of Agricultural Chemistry, Page 171).

Active potash is the potash soluble in 0.2 N nitric acid. It represents potash which can readily be taken up by the plant, as shown by pot experiments and discussed in Bulletins 145 and 325.

Acid-soluble lime is the lime which is dissolved by strong hydrochloric acid. According to Hilgard, the amount of lime found by this method is a valuable indication of the wearing qualities of the soil under cultivation.

Basicity. This term is applied to the bases (chiefly lime) which neutralize the 0.2N nitric acid in the method for determining active potash and phosphoric acid. This term is merely used as a convenient one for the determination referred to. If all the acid is neutralized, the basicity is 10 per cent or equivalent to 200,000 pounds of base (calcium carbonates) in 2,000,000 pounds of soil.

pH refers to the hydrogen-ion concentration, and is a measure of the degree of acidity or alkalinity of the soil. A neutral soil has a pH of 7.0. The lower the number, the more acid the soil. A soil of pH 6.0 is acid. A soil of pH 5.0 is ten times as acid as pH 6.0. The higher the number above 7.0, the more alkaline the soil. All the soils described in this Bulletin have a pH around 7.0 or above it.

Corn possibility represents the average amount of plant food which is withdrawn in pot experiments by plants from soils containing similar amounts of active phosphoric acid, potash, and total nitrogen. It is based upon 2,000,000 pounds of soil. While the corn possibility does not indicate the yield of the soil under field conditions, its use gives a good basis for comparing the plant food present in different soils and in aiding to ascertain the strength or weakness of a given soil.

One soil may have a corn possibility of 6 bushels of corn per acre for active phosphoric acid, 28 for nitrogen, and 120 for active potash, while corresponding figures for another may be 35 bushels for phosphoric acid, 38 for nitrogen, and 150 for potash. The first soil is likely to be deficient in phosphoric acid, and probably in nitrogen. The possibility of increasing the crop by means of fertilizers would depend upon the rainfall, depth of soil, and other conditions relating to the soil.

The experiments on which this interpretation are based are published in Bulletins 126, 145, 156, 178, 267, 355, and the method is discussed in Bulletins 213 and 355.

SALINE SOILS

Soluble salts occur in sufficient quantity to be injurious to plants in spots in some of the counties in the area here discussed. Some of these spots are subirrigated. The only complete remedy for spots of this kind is to wash out the soluble salts, and this is not always an easy thing to do. Where the spot is subirrigated, it can sometimes be drained, which also prevents it from becoming larger. The salts present are usually sodium chloride and sodium sulphate: only in a few instances are soils containing sodium carbonate found in Texas. Although salty soils are sometimes called alkali soils, they are not really alkaline unless sodium carbonate is present.

The composition of the salts found in some of the spots in Reeves county, which is next to the territory here described, is given in Table 1. Calcium carbonate and calcium sulphate are not considered as injurious salts. Where the soils were high in soluble salts, the salts usually consisted chiefly of sodium chloride, or common salt, but magnesium chloride was also present, and in two cases, calcium chloride was found. Sample 19006 is an incrustation on the surface and was taken to a depth of one inch.

NORTHWEST TEXAS

The western half of this area is occupied by the High Plains, the eastern half by lower Rolling Plains. The Amarillo series is the most extensive series in the High Plains, and the Amarillo fine sandy loam the most extensive type, while the Amarillo clay loam is nearly as extensive. Both these types are important agricultural soils and are productive.

The Vernon series is the most extensive series on the Rolling Plains. The Vernon Clay is the most extensive type, while the Vernon clay loam and the Vernon fine sandy loam are next in extent. These are brown to red upland soils. The Vernon clay loam is probably the one most important agriculturally.

The Foard soils are dark-brown to black upland soils, which are not nearly as extensive as the Vernon soils, but are of considerable agricultural importance.

The chief alluvial soils belong to the Miller series and are red in color.

CLASSIFICATION OF SOILS OF NORTHWEST TEXAS AREA

Amarillo series. Surface soil, reddish-brown, brown or chocolate-brown. Subsoil reddish-brown to red. Lower subsoil usually calcareous and pale-yellow to buff or pinkish friable marly clay.

Pullman series. Some of the less red soils mapped with the Amarillo series are now considered to belong to the Pullman series.

Potter series. Soils mapped as Brackett or Ector soils are now termed the Potter soils.

Brackett series. Surface soil, very light-gray to white. Subsoil, chalky and very calcareous. (Now called the Potter series.)

Derby fine sand-dune phase. Surface soil, grayish-brown or light-brown fine sand. Subsoil, pale-yellow or brownish-yellow fine sand several feet

Table 1. Composition of some saline soils, from Reeves county, in parts per million.

	Depth	Calc. carb.	Calc. sulp.	Calc. chlor.	Mag. carb.	Mag. sulp.	Mag. chlor.	Sod. sulp.	Sod. chlor.
1373	12"	-------	25450	-------	-------	600	1563	-------	53670
1374	12"	-------	17725	-------	-------	-------	3975	-------	9610
1375	12"	-------	14225	-------	-------	4500	2915	-------	10770
1376	12"-24"	-------	11855	-------	-------	2370	-------	-------	8020
1379	24"-36"	-------	12700	-------	-------	750	1616	-------	8125
1382	36"-48"	-------	11355	-------	-------	1500	424	-------	5280
3933	-------	-------	-------	-------					
12524	1"-19"	190	5368	-------	-------	1029	-------	353	2186
12525	20"-40"	160	10232	-------	-------	590	-------	397	783
12526	1"-22"	175	3674	-------	-------	550	272	-------	2059
12527	22"-34"	160	10371	-------	-------	616	-------	312	783
12705	-------	213	4637	18667	-------	-------	2952	-------	1618
19726	0"- 6"	150	1501	689	-------	-------	404	-------	1084
19794	6"-12"	238	-------	-------	-------	134	-------	55	91
19795	12"-18"	325	107	-------	-------	137	44	-------	-------
19796	18"-24"	325	209	-------	-------	21	60	-------	-------
19797	24"-30"	188	70	-------	-------	119	12	-------	73
19798	30"-36"	313	51	-------	-------	134	-------	2	107
19799	36"-42"	325	58	-------	-------	116	14	-------	89
19800	42"-48"	202	-------	-------	19	80	-------	59	91
19005	-------	1250	2332	35016	-------	-------	8132	-------	11741
19006	0"- 1"	1500	155456	-------	-------	18899	-------	14407	102630

deep. (Now called the Enterprise series.)

Enterprise series. Soils mapped as the Derby series are now placed in the Enterprise series.

Richfield series. Surface soil, dark-gray, dark ashy-gray or dark-brown 3 to 8 inches deep. Subsoil, dark-brown or ashy gray clay about 24 inches deep, passing into gray or grayish-brown compact clay containing calcareous particles.

Alluvial Soils of the High Plains

Alluvial soils, undifferentiated. Surface soils, dark-colored ranging from fine sandy loam into clay. Subsoils are heavy in texture and are dark-brown to black in color.

Randall series. Surface soil, dark bluish-gray to black, 12 to 20 inches deep. Subsoil, gray or light-gray containing chalky fragments; soil and subsoil calcareous. This type occupies lake beds.

Alluvial Soils of Rolling Plains

Bastrop series. Surface soil, brown to reddish-brown. Subsoil, brown to reddish-brown passing at 18 to 20 inches into a reddish-brown to red sandy clay.

Miller sandy soils. Surface soil, Indian red to chocolate-brown fine sandy loam and loamy sand. Subsoil, Indian red fine sandy loam.

Miller heavy soils. Surface soil, dark-brown or chocolate-brown silty clay or silty clay loam about 10 inches deep. Subsoil, Indian red or brownish-red silty clay.

Upland Soils of Rolling Plains

Derby series. Surface soil, brown, grayish-brown or reddish-brown loose loamy fine sand about 10 inches deep. Subsoil, brown, reddish-brown or brownish-red loamy fine sand (Now termed the Enterprise series.)

Foard series. Surface soils, dark-brown to black. Subsoils, yellowish-brown to grayish-brown to dark ashy-gray or black. Surface flat and level with rather poor drainage.

Miles series. Surface soil, grayish-brown or brown to reddish-brown. Subsoils, red in upper part and reddish-yellow or brown in the lower part. Lower part of subsoil calcareous. Type occupies high areas and ridges.

Vernon series. Surface soil, brown into Indian red. Subsoils, chocolate-brown, brownish-red or Indian red.

WEST CENTRAL TEXAS

The western part of this area is occupied by the High Plains, the northeastern part by the rolling plains, and the southeastern by the Edwards Plateau. In the extreme west are some soils of the Mountain and Basin group.

The most extensive soil in the area is the Amarillo fine sandy loam. Abilene silty clay loam, Abilene clay loam, Miles clay loam, and Reagan silty clay loam are all extensive types. These all seem to be of agricultural value, although the Reagan silty clay loam is usually so situated as to receive insufficient rain.

Classification of the Soils of West Central Texas

Alluvial Soils of the Mountain Basins and Valleys

Arno series. Surface soil, dark chocolate-red clay more than 36 inches deep, subsoil lighter red.

Pecos series. Surface soil dark-brown or mostly black; when dry it is much lighter being gray or grayish-brown. Subsoil to 36 inches chocolate-red clay. Gypsum crystals occur in soil and subsoil; both calcareous.

Reeves series. Surface soil light-brown to grayish-brown; subsoil light-buff to yellowish. Soil and subsoil calcareous.

Upland Soils of the High Plains

Amarillo series. Surface soil brownish-red to reddish-brown 8 to 12 inches deep. Subsoil red to chocolate-red. Soil and subsoil not generally calcareous. (Some of these areas are now classed with the Pullman series.)

Dune sand. Surface soil loose yellowish-gray fine sand 2 to 4 inches deep. Subsoil grayish-yellow compact sand to a depth of 12 inches and a depth of 6 feet or more of very pale-yellow sand.

Ector series. Surface soil: brown soil 3 to 15 inches deep containing an abundance of gravel consisting of angular fragments of hard white caliche. Soil is underlaid by solid white caliche. (Now called the Potter series.)

Richfield series. Surface soil; dark-brown. Subsoil; brown and lighter in color and at a depth of about 10 inches becomes a yellowish-gray or pale yellowish-brown; at a depth of about 30 inches whitish caliche occurs. Soil is calcareous.

Randall clay. Surface soil, ash-colored clay grading into a plastic lighter-colored clay. Soil occurs in shallow depressions, or playas.

Alluvial Soils of Edwards Plateau

Frio series. Surface soil to a depth of about 12 inches is dark-brown or brown. Subsoil and upper subsoil are brown, at a depth of 20 to 24 inches a lighter brown. Entire soil is calcareous.

Upland Soils of Edwards Plateau

Reagan series. Surface soil to a depth of one-fourth to one inch is buff or fawn-colored, fine cloddy silty soil, and grades into chocolate-brown silty clay loam 5 or 10 inches deep. The subsoil is a pale buff to pale brownish-yellow silty clay loam underlain by white caliche.

Valera series. Surface soil, dark-brown or black containing many fragments of limestone. These are shallow soils, in places resting on limestone, or on thin yellowish clay subsoils which lie on caliche resting on limestone.

Alluvial Soils of the Rolling Plains

Frio series. Surface soil is dark brown or brown to a depth of about 12 inches. The subsoil is a slightly lighter brown or yellowish-brown. It also occurs on Edwards Plateau.

Miller series. Surface soil, reddish-brown 10 to 15 inches deep; subsoil chocolate-red.

Spur series. Surface soil dark-brown or chocolate-brown 6 to 10 inches deep. Subsoil reddish-brown. When dry, surface soil has a distinctly gray cast. Soils calcareous.

Yahola series. Surface soil, dark reddish-brown, subsoil dark chocolate-red to light chocolate-red, soils calcareous.

Upland Soils of the Rolling Plains

Abilene series. Surface soil dark chocolate-brown 4 to 12 inches deep; subsoil upper portion brown or dark chocolate-brown, lower portion, chalky light loose caliche. Subsoil strongly calcareous.

Roscoe series. Surface soil, black, dark-gray, or very dark-brown 4 to 10 inches deep. The subsoil grades downward into a denser and heavier material with no perceptible change in color underlaid by lime bearing caliche, at about 5 feet.

Vernon series. Surface soil dark reddish-brown to chocolate-red about 10 inches deep; subsoil lighter-colored chocolate-red containing bluish-gray or white concretions. Surface soil and subsoil generally calcareous.

AVERAGE COMPOSITION OF SOILS BY GROUPS

The soils were classified into six groups, namely, upland soils of the High Plains, alluvial soils of the High Plains, upland soils of the Rolling Plains, alluvial soils of the Rolling Plains, upland soils of Edwards Plateau, and soils of the Mountains and Basins. The group last named is found only in the extreme western part of the area here discussed. The average composition of these groups is given in Table 2, and the interpretation of the analyses is given in Table 3. In the six groups, the upland surface soils of the Edwards Plateau average highest in nitrogen; the upland surface soils of the Rolling Plains and of the High Plains come next. The alluvial soils of both the High Plains and of the Rolling Plains average lower in nitrogen than the upland soils. This is the reverse of the case with humid sections, in which the alluvial soils are generally richer in nitrogen than the neighboring upland soils. Of course some of the alluvial soils are richer in nitrogen than many of the upland soils. As is shown in Table 3, the corn possibility of the nitrogen varies from 18 to 38 bushels to the acre, so that these soils must be considered as only moderately well supplied with nitrogen.

The averages for total phosphoric acid of the various groups are remarkably close together; they are higher than that of soils of East Texas, and about the same as that of many soils of the Blacklands. The content of active phosphoric acid is fairly good, the corn possibility ranging from 35

Table 2. Average composition of soils by groups.

Averages	Nitrogen per cent	Total phos. ac. per cent	Active phos. ac. per million	Total potash per cent	Acid soluble potash per cent	Active potash per million	Acid soluble lime per cent	Basicity per cent
High Plains—Upland surface soils	.086	.067	80	1.29	.50	351	3.82	5.29
High Plains—Subsoil	.064	.063	51	1.46	.57	316	6.97	5.59
High Plains—Deep subsoil	.054	.048	88	1.68	.55	358	3.36	4.55
High Plains—Alluvial surface soils	.062	.076	237	1.32	.59	374	.60	1.00
High Plains—Subsoils	.061	.073	231	1.56	.82	570	.69	1.04
Rolling Plains—Upland surface soils	.095	.078	120	1.57	.57	353	2.50	3.29
Rolling Plains—Subsoil	.063	.059	123	1.86	.64	285	2.51	3.85
Rolling Plains—Deep subsoil	.046	.069	183	1.93	.70	228	5.17	5.04
Rolling Plains—Alluvial surface soils	.076	.075	273	1.49	.46	406	2.64	4.02
Rolling Plains—Subsoil	.058	.076	259	1.59	.58	324	3.84	6.19
Rolling Plains—Deep subsoil	.059	.088	119	1.74	.49	250	9.01	10.00
Mountains and Basins—surface soils	.059	.068	182	1.40	.56	293	7.67	7.12
Mountains and Basins—subsoil	.031	.077	122	1.24	.64	257	14.14	7.66
Mountains and Basins—deep subsoil	.019	.073	425	-----	.41	433	7.51	9.95
Edwards Plateau—Upland surface soils	.136	.074	116	1.45	.63	300	6.22	7.59
Edwards Plateau—subsoil	.067	.058	62	2.00	.59	214	4.55	8.81

Table 3. Interpretation of average analysis of surface soils.

Group	Corn possibilities in bushels per acre			Total phosphoric acid	Acid soluble potash	Acid soluble lime
	Nitrogen	Active phosphoric acid	Active potash			
High Plains—upland soils	28	35	163	good	good	high
High Plains—alluvial soils	23	50	163	good	good	high
Rolling Plains—upland soils	28	45	163	good	good	high
Rolling Plains—alluvial soils	23	50	180	good	good	high
Mountains and basins	18	45	135	good	good	high
Edwards Plateau—upland soils	38	45	144	good	good	high

to 50 bushels per acre (Table 3). The active phosphoric acid in the upland surface soils of the High Plains is the lowest, but even this compares favorably with that of many soils of East or Central Texas.

The quantities of total potash and acid-soluble potash are good. The corn possibility of the active potash is 135 to 163 bushels per acre (Table 3). The content of acid-soluble lime is high. The subsoil is generally more calcareous than the surface soil.

On the average, these soils are fairly well supplied with plant food, especially potash. Nitrogen is the element present in relatively small amounts, and as nitrogen is drawn in by crops and lost in percolating water to a greater extent than the others, the soils are likely to become low in nitrogen first under cultivation. This discussion refers to the averages. There are individual soil types not so well supplied with plant food, as can be seen by consideration of the tables presented later. Some of these soils are likely to be deficient in nitrogen and phosphoric acid, and if favorably located with respect to other conditions required to produce crops, will respond to fertilizers carrying these forms of plant food.

CROP-PRODUCTION POWER OF AVERAGE SOILS

The number of crops of 40 bushels of corn that could be produced by the plant food on an acre about 7 inches deep, provided all the plant food could be extracted by the plants, was calculated from the averages given in Table 1 and the results are given in Table 4. As shown in the previous section, the

Table 4. Number of crops of forty bushels of corn which would be produced by the plant food in two million pounds of soil (an acre 7 inches deep).

Group	Nitrogen	Total phosphoric acid	Acid-soluble potash
High Plains—upland soils	29	54	250
High Plains—alluvial soils	21	61	295
Rolling Plains—upland soils	32	62	285
Rolling Plains—alluvial soils	25	60	230
Mountains and Basins	20	54	280
Edwards Plateau	44	93	205

soils are lowest in nitrogen, and are likely to become deficient in this element before the others. They are better supplied with phosphoric acid and still more so with potash. The nitrogen would last 21 to 44 years, the total phosphoric acid would last 54 to 93 years, and the potash 205 to 295 years, if they were used entirely for plants, and none lost by washing out or otherwise.

FERTILIZERS FOR THE SOILS STUDIED

Fertilizers are being used to some extent in this area. In 1929-30, 710 tons were shipped into Howard county, 172 tons into Ward county, and 33 to 58 tons into Runnels, Taylor, and Jones counties. In 1930-31, 620 tons went into Howard county, 110 tons into Ward county, and 1 to 9 tons into Runnels, Taylor, and Jones counties. The fertilizer was chiefly 18% superphosphate, used on alfalfa under irrigation, though small amounts of other fertilizers were used.

The growth of crops in this area is limited by climatic conditions, especially rainfall, to a much greater extent than by plant food. Most of the soils have not been long under cultivation. At present the general use of fertilizers cannot be recommended. For fruit or vegetables on irrigated lands which have been under cultivation a number of years, the use of fertilizer might prove advisable, and should be tried out. As stated above, superphosphate is being used on alfalfa grown on irrigated land. Land under cultivation to crops different from alfalfa, which can take nitrogen from the air, is likely to need nitrogen first, and then phosphoric acid. Potash is not likely to be needed for a long time. Fruit or vegetable crops, especially under irrigation, are likely to respond to applications of nitrogenous and phosphatic fertilizers, since they need a good supply of easily-available plant food in order to make their best growth.

USE OF LIME

These soils are generally calcareous, contain an abundance of lime, and do not need applications of lime for the production of legume or other crops. Some of the soils contain too much lime for success with some plants. Some plants, such as peas, sorghum, and some trees and shrubs, suffer from a yellowing of the leaves, termed chlorosis, when grown on limestone soils. This trouble can frequently be remedied by the proper use of salts of iron.

AVERAGE COMPOSITION OF TYPES OF SOILS

The average composition of the various types of soil found in the areas studied is given in Table 5. In the making of these averages, analyses exceptionally high or low were excluded, so that the analyses represent the average run of the soils. The interpretations of the analyses are given in Table 6.

The Abilene clay loam, Abilene silty clay loam, Foard clay, Richfield clay loam, and Spur clay loam, average appreciably higher in nitrogen than the other soils in their group. The Miles fine sand and Yahola clay loam are low in nitrogen. The Amarillo fine sandy loam, Amarillo loam, Bastrop fine sandy loam, Foard fine sandy loam, and Miles fine sand are lower than the average in active phosphoric acid, and are likely to be deficient in this substance. The soils in general are well supplied with plant food, especially potash, and contain an abundance of lime.

Table 5. Average analysis of soils.

Group	Nitrogen Per cent	Phosphoric acid		Potash			Lime Acid-soluble per cent	Basicity per cent
		Total per cent	Active per million	Total per cent	Acid-soluble	Active per million		
Abilene clay loam—surface soil	.145	.064	88	1.81	.66	522	1.25	1.67
Abilene clay loam—subsoil	.102	.064	94	1.85	.69	408	1.07	3.12
Abilene clay loam—deep subsoil	.047	.053	106	1.77	.65	277	7.35	5.72
Abilene silty clay loam, prob'ly—surface soil	.140	.055	75	1.07	.58	495	1.47	4.28
Abilene silty clay loam, prob'ly—subsoil	.090	.061	17	2.45	.71	378	5.91	7.64
Abilene silty clay loam, prob'ly—deep subsoil	.094	.051	25	2.33	.85	563	4.36	7.40
Amarillo clay loam—surface soil	.107	.064	70	1.72	.53	511	.66	2.91
Amarillo clay loam—subsoil	.074	.070	43	2.07	.63	487	6.60	2.63
Amarillo clay loam—deep subsoil	.063	.051	42	2.25	.60	378	4.35	4.35
Amarillo fine sandy loam—surface soil	.052	.035	27	1.16	.33	283	.33	.52
Amarillo fine sandy loam—subsoil	.044	.037	30	1.20	.33	287	1.84	2.05
Amarillo fine sandy loam—deep subsoil	.041	.030	17	1.37	.43	314	.33	3.15
Amarillo loam—surface soil	.058	.039	29	1.01	.27	284	.34	.85
Amarillo loam—subsoil	.067	.045	29	1.02	.40	314	.30	1.20
Arno clay—surface soil	.066	.125	215	1.64	.89	341	9.88	10.00
Arno clay—subsoil	.048	.109	138	1.61	.89	410	11.33	10.00
Bastrop fine sandy loam—surface soil	.051	.035	29	.81	.24	96	.23	.35
Bastrop fine sandy loam—subsoil	.071	.038	8	1.00	.66	361	.42	.63
Brackett clay—surface soil	.064	.134	91	1.27	1.03	760	9.19	9.80
Brackett clay—subsoil	.059	.116	100	1.95	1.05	855	1.040	9.85
Brackett fine sandy loam—surface soil	.054	.041	54	.69	.28	230	3.94	5.98
Brackett fine sandy loam—subsoil	.045	.038	32	.73	.31	279	13.76	5.69
Brackett gravelly loam—surface soil	.133	.058	53	1.33	.39	184	11.09	8.15
Brackett gravelly loam—subsoil	.092	.060	14	.83	.54	42	14.82	10.00
Derby loamy fine sand—surface soil	.035	.045	66	.73	.15	170	.17	.40
Derby loamy fine sand—subsoil	.036	.046	32	.....	.25	147	.20	.50
Ector gravelly loam—surface soil	.105	.068	58	1.28	.73	581	.77	1.51
Foard clay—surface soil	.133	.133	.....	3.08	1.35	.....	.90	.....
Foard clay—subsoil	.082	.133	224	2.54	1.57	580	3.51	4.65
Foard clay—deep subsoil	.068	.136	216	.....	1.31	294	10.06	8.15
Foard fine sandy loam—surface soil	.093	.016	9	.....	.52	384	.22	.46
Foard fine sandy loam—subsoil	.070	.017	40	.....	.42	361	.32	.71
Frio loam—surface soil	.092	.076	211	1.23	.36	465	1.05	3.92

Table 5. Average analysis of soils continued).

Group	Nitrogen per cent	Phosphoric acid		Potash			Lime Acid-soluble per cent	Basicity per cent
		Total per cent	Active per million	Total per cent	Acid-soluble	Active per million		
Frio loam—surface soil	.100	.074	189	1.04	.49	557	1.58	4.17
Frio silt loam—surface soil	.118	.102	433	1.16	.56	725	6.86	8.83
Frio silt loam—subsoil	.062	.099	262	1.55	.54	358	7.86	9.85
Frio silt loam—deep subsoil	.059	.088	119	1.74	.49	250	9.01	10.00
Miles clay—surface soil	.095	.105	408	1.49	1.07	421	4.01	6.75
Miles clay—subsoil	.053	.089	415	1.51	.87	173	4.27	7.35
Miles clay—deep subsoil	.036	.101	475	1.51	.92	220	4.69	7.05
Miles clay loam—surface soil	.093	.049	47	1.62	.63	430	1.19	1.98
Miles clay loam—subsoil	.068	.057	33	2.00	.75	295	3.08	3.77
Miles clay loam—deep subsoil	.027	.049	41	1.81	.58	213	9.22	6.76
Miles fine sand—surface soil	.029	.019	31	.91	.08	80	.13	.22
Miles fine sand—subsoil	.035	.021	13	1.30	.18	47	.17	.28
Miles fine sand—deep subsoil	.026	.021	13	.99	.21	77	.19	.25
Miles fine sandy loam—surface soil	.054	.039	47	1.22	.24	260	.30	.94
Miles fine sandy loam—subsoil	.060	.045	29	1.48	.49	239	.82	1.66
Miles fine sandy loam—deep subsoil	.039	.032	31	1.43	.37	212	.34	.64
Miles very fine sandy loam—surface soil	.050	.030	73	1.81	.21	202	.36	.59
Miles very fine sandy loam—subsoil	.052	.047	57	1.77	.24	90	1.71	2.18
Miles very fine sandy loam—deep subsoil	.022	.051	163	1.67	.37	58	4.66	5.77
Miller clay—surface soil	.104	.086	331	1.20	.66	446	2.33	4.80
Miller clay—subsoil	.051	.070	196	1.04	.64	338	4.65	8.90
Miller fine sandy loam—surface soil	.046	.037	9	.72	.27	208	.62	.40
Miller fine sandy loam—subsoil	.046	.032	42	.78	.51	239	2.21	4.31
Miller silty clay loam—surface soil	.099	.073	116	2.53	.77	412	5.93	7.21
Miller silty clay loam—subsoil	.055	.063	92	2.54	.71	200	4.25	6.89
Miller very fine sandy loam—surface soil	.046	.066	270	1.84	.26	217	1.45	2.07
Miller very fine sandy loam—subsoil	.047	.064	229	1.92	.38	175	1.79	2.36
Pecos clay—surface soil	.085	.091	94	1.95	.98	300	13.40	10.00
Pecos clay—subsoil	.039	.161	144	2.01	1.10	226	11.76	10.00
Randall clay—surface soil	.072	.117	516	1.83	.94	652	.96	1.65
Randall clay—subsoil	.051	.108	453	2.12	.98	778	.96	1.45
Reagan gravelly silty clay loam—surface soil	.105	.072	59	1.14	-----	109	-----	10.00
Reagan gravelly silty clay loam—subsoil	.070	.063	49	-----	-----	52	-----	10.00

Table 5. Average analysis of soils continued).

Group	Nitrogen per cent	Phosphoric acid		Potash			Lime acid-soluble per cent	Basicity per cent
		Total per cent	Active per million	Total per cent	Acid-soluble	Active per million		
Reagan silty clay loam—surface soil	.131	.094	248	2.34	.94	502	6.57	9.56
Reagan silty clay loam—subsoil	.079	.080	74	2.29	.92	234	10.51	9.99
Reeves chalk—surface soil	.047	.026	85	.92	.19	117	6.84	3.40
Reeves chalk—subsoil	.008	.023	74	.92	......	151	......	2.59
Reeves fine sandy loam—surface soil	.049	.049	232	1.01	.47	330	4.16	5.68
Reeves fine sandy loam—subsoil	.041	.070	130	1.00	.48	242	8.67	8.03
Reeves fine sandy loam—deep subsoil	.019	.073	425	......	.41	433	7.51	9.95
Reeves gravelly loam—surface soil	.050	.048	283	1.50	.28	376	4.06	6.50
Reeves gravelly loam—subsoil	.020	.021	......	.66	.10	......	24.81	......
Richfield silty clay loam—surface soil	.123	.084	106	1.55	.56	478	2.05	4.70
Richfield silty clay loam—subsoil	.076	.073	107	1.62	.73	463	4.31	3.97
Richfield silty clay loam—subsoil	.059	.064	205	1.43	.61	381	5.41	6.15
Roscoe clay—surface soil	.100	.066	112	1.28	.69	517	3.36	5.36
Roscoe clay—subsoil	.069	.060	59	1.68	.90	361	3.43	5.16
Spur clay loam—surface soil	.140	.111	374	2.13	.71	651	1.43	1.89
Spur clay loam—subsoil	.086	.096	275	1.95	.74	350	2.02	2.77
Spur clay loam—deep subsoil	.063	.058	134	1.81	.58	322	2.09	1.75
Spur loam—surface soil	.098	.096	334	1.57	.55	455	4.48	6.44
Spur loam—subsoil	.058	.080	166	1.54	.56	218	7.28	9.57
Spur very fine sandy loam—surface soil	.059	.076	436	1.89	.32	491	.48	.95
Spur very fine sandy loam—subsoil	.056	.081	406	1.97	.33	547	1.09	1.98
Valera clay—surface soil	.116	.074	95	1.76	.70	447	2.24	5.76
Valera clay—subsoil	.088	.069	64	1.71	.69	356	2.90	6.43
Valera stony clay—surface soil	.192	.057	61	.56	.26	141	9.85	5.03
Valera stony clay—subsoil	.030	.020	......	......	.17	......	.25	......
Vernon clay—surface soil	.093	.086	165	1.52	.88	525	3.66	4.04
Vernon clay—subsoil	.063	.074	256	1.65	.90	298	3.36	4.71
Vernon clay—deep subsoil	.043	.087	427	2.99	1.83	249	4.52	6.52
Vernon clay loam—surface soil	.103	.075	283	2.76	.64	360	1.61	2.79
Vernon clay loam—subsoil	.073	.082	192	2.70	.66	223	4.50	4.38
Vernon clay loam—deep subsoil	.048	.102	252	2.63	.63	146	6.87	5.59
Vernon fine sandy loam—surface soil	.056	.052	81	.67	.32	270	.52	.87
Vernon fine sandy loam—subsoil	.054	.056	36	1.10	.53	355	1.29	2.35

Table 5. Average analysis of soils continued).

Group	Nitrogen per cent	Phosphoric acid		Potash			Lime Acid-soluble per cent	Basicity per cent
		Total per cent	Active per million	Total per cent	Acid-soluble	Active per million		
Vernon fine sandy loam—deep subsoil	.052	.047	8	......	.52	330	5.30	3.35
Vernon gravelly clay loam—surface soil	.083	.056	46	1.47	.62	265	9.92	9.77
Vernon gravelly clay loam—subsoil	.035	.063	321	2.48	.93	175	2.01	7.03
Vernon loam—surface soil	.082	.072	139	1.10	.57	416	1.27	1.58
Vernon loam—subsoil	.065	.058	82	1.13	.50	319	3.39	.88
Vernon loam—deep subsoil	.048	.066	118	1.96	.48	196	5.86	2.23
Vernon very fine sandy loam—surface soil	.061	.361	244	2.49	.31	258	2.82	3.89
Vernon very fine sandy loam—subsoil	.052	.061	154	2.46	.34	190	3.19	3.20
Vernon very fine sandy loam—deep subsoil	.042	.100	509	2.18	.41	129	3.75	6.05
Yohola fine sandy loam—surface soil	.065	.091	481	1.70	.47	494	2.98	5.25
Yohola fine sandy loam—subsoil	.033	.083	474	1.56	.37	220	4.13	7.35
Yohola clay loam—surface soil	.036	.049	110	1.08	.39	143	.24	.31
Yohola clay loam—subsoil	.073	.117	531	1.95	.58	384	3.51	6.47

Table 6. Interpretation of analyses, West Central and Northwest Texas.

Type Name	Corn possibility two million pounds			Phosphoric acid	Potash	Lime	Acidity	Acres	Per cent of area
	Active phosphoric acid	Total nitrogen	Active potash						
Abilene clay loam—surface	40	43	211	good	good	good	0	1,373,184	4.6
Abilene silty clay loam—surface	35	38	204	good	good	good	0	1,320,192	4.4
Amarillo clay loam—surface	35	33	211	good	good	good	0	2,718,720	9.6
Amarillo fine sandy loam—surface	30	18	135	good	good	good	0	5,582,622	19.0
Amarillo loam—surface	18	18	135	good	good	good	0	648,208	2.3
Arno clay—surface	50	23	154	good	good	high	0	55,296	0.2
Bastrop fine sandy loam—surface	18	18	50	good	good	good	0	42,624	0.1
Brackett clay—surface	40	23	273	good	good	high	0	110,592	0.4
Brackett fine sandy loam—surface	30	18	115	good	good	high	0	27,648	0.1
Brackett gravelly loam—surface	30	38	94	good	good	high	0	Type Not Mentioned	
Derby loamy fine sand—surface	35	13	84	fair	fair	fair	0	85,248	0.3
Ector gravelly clay loam—surface	30	33	232	good	good	good	0	———	——
Foard clay—surface	—	38	——	good	good	good	0	232,704	0.8
Foard fine sandy loam—surface	6	28	171	low	good	good	0	11,520	.04
Frio loam—surface	50	28	196	good	good	good	0	Type Not Mentioned	
Frio silt loam—surface	55	33	262	good	good	high	0	Type Not Mentioned	
Miles clay—surface	55	28	180	good	good	high	0	32,252	0.1
Miles clay loam—surface	30	28	188	good	good	good	0	1,285,632	4.4
Miles fine sand—surface	24	13	50	good	fair	fair	0	87,552	0.3
Miles fine sandy loam—surface	30	18	125	good	good	good	0	1,490,688	5.0
Miles very fine sandy loam—surface	35	18	205	good	good	good	0	34,560	0.1
Miller clay—surface	50	33	188	good	good	high	0	11,520	.04
Miller fine sandy loam—surface	6	18	105	good	good	good	0	152,064	0.5
Miller silty clay loam—surface	45	28	180	good	good	high	0	48,384	0.1
Miller very fine sandy loam—surface	18	23	105	good	good	good	0	39,168	0.1
Pecos clay—surface	40	28	135	good	good	high	0	25,344	0.1
Randall clay—surface	55	23	251	good	good	good	0	6,912	.02
Reagan gravelly silty clay loam—surface	30	33	61	good	——	——	0	364,032	1.2
Reagan silty clay loam—surface	50	38	211	good	good	high	0	1,109,528	3.7
Reeves chalk—surface	40	18	61	low	fair	high	0	55,296	0.1
Reeves fine sandy loam—surface	50	18	154	good	good	high	0	258,048	0.8
Reeves gravelly loam—surface	50	18	171	good	good	high	0	532,224	1.7
Roscoe clay—surface	45	28	211	good	good	high	0	69,120	0.1
Spur clay loam—surface	50	38	251	good	good	good	0	66,816	0.1

Table 6. Interpretation of Analyses, West Central and Northwest Texas—Continued.

Type Name	Corn possibility two million pounds			Phosphoric acid	Potash	Lime	Acidity	Acres	Per cent of area
	Active phosphoric acid	Total nitrogen	Active potash						
Spur loam—surface	50	28	196	good	good	high	0	25,344	0.1
Spur very fine sandy loam—surface	55	18	204	good	good	good	0	25,344	0.1
Valera clay—surface	40	33	188	good	good	high	0	135,936	0.4
Valera stony clay—surface	35	53	73	good	good	high	0	1,797,120	6.0
Vernon clay—surface	45	28	211	good	good	high	0	1,029,388	3.4
Vernon clay loam—surface	50	33	163	good	good	good	0	10,561,160	3.5
Vernon gravelly clay loam—surface	30	28	125	good	good	high	0	Type Not	Mentioned
Vernon fine sandy loam—surface	45	18	125	good	good	good	0	977,076	3.3
Vernon loam—surface	45	28	180	good	good	good	0	304,128	1.0
Vernon very fine sandy loam—surface	50	23	125	good	good	high	0	743,192	2.6
Yohola fine sandy loam—surface	55	23	204	good	good	high	0	39,168	0.1
Yohola clay loam—surface	45	13	73	good	good	good	0	39,168	0.1
								33,114,097	42.10

SUMMARY

The chemical composition and fertility of typical soils representing 49 counties in Northwest and West Central Texas, are discussed in this Bulletin.

Methods of maintaining fertility are outlined and explanations of terms given.

Saline soils are found in spots in some counties; the salts consist chiefly of sodium chloride, though sodium sulphate, magnesium sulphate, and magnesium chloride are also found.

The upland surface soils of the Edwards Plateau are, on an average, highest in nitrogen; the upland surface soils of the Rolling Plains and of the High Plains come next in nitrogen. Some of the soils are low in nitrogen while many of them are only moderately well supplied.

The soils are fairly well supplied with total phosphoric acid, being on an average higher in phosphoric acid than those of East Texas. Some of the soils are low in active phosphoric acid.

The quantities of total potash, of acid soluble potash, and of active potash, are good to excellent.

The soils are well supplied with lime, many of them contain large percentages of lime. The subsoils generally contain more lime than the surface soils.

Nitrogen is the element present in the smallest amounts, and as the supply of nitrogen is drawn on heavily by crops, and some of it is lost in drainage waters, the soils are likely to become deficient in nitrogen first, under cultivation.

Moisture is generally the limiting condition in the territory. Fertilizers are not at present recommended for general farm crops, though their use may be advisable for special crops, such as alfalfa, and fruit or vegetable crops.