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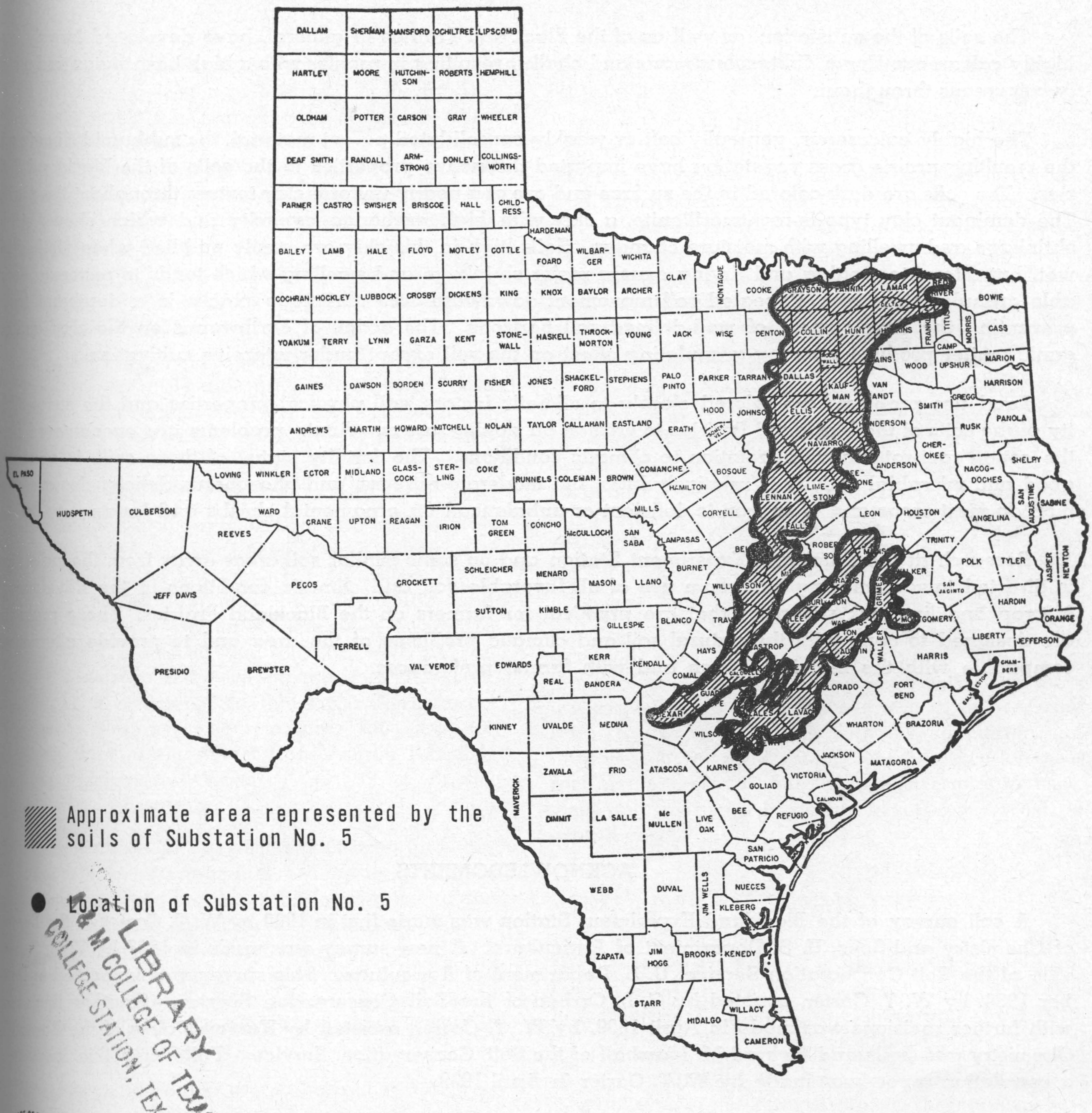
Soils of the Blackland Experiment Station

Substation No. 5, Temple, Texas



A PART OF THE TEXAS A&M COLLEGE SYSTEM

TEXAS AGRICULTURAL EXPERIMENT STATION

R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

IN COOPERATION WITH THE U. S. DEPARTMENT OF AGRICULTURE

SUMMARY

The soil types of the Blackland Experiment Station are Houston Black, Austin and Trinity clays. Results of research on these soils are, in general, applicable to the similar and related series, Houston, Hunt, Bell and Lewisville. The soils on the substation and related series throughout the Blackland Prairies represent well over 50 percent of the total area of the Blackland Prairies (11,500,000 acres). In the eastern portion of the major prairie, and to some extent throughout the minor prairies, soils occur which are more leached and have more strongly developed profiles than found on the substation. The Crockett and Wilson series are examples.

The soils of the substation, as well as of the Blackland Prairies in general, have developed largely from highly calcareous Upper Cretaceous marls and chalks, resulting in profiles with a high base status and usually calcareous throughout.

The highly calcareous, generally soft or weakly consolidated parent material, the subhumid climate and the resulting prairie grass vegetation have imparted distinctive properties to the soils of the Blackland Prairies. The soils are dark-colored in the surface and are of a nearly uniform clay texture throughout the profile. The dominant clay type is montmorillonite, a clay with high exchange capacity and which shows strong shrinkage and swelling with moisture changes. Soils high in this clay are easily puddled when worked too wet, but alternate wetting and drying causes major shrinkage and swelling which tends to restore a desirable granular structure. Repeated soil movement downward into shrinkage cracks is a dominant factor preventing the development of well-defined soil horizons. The action of earthworms on the clay and organic matter produce a strong granulating effect on the soil except under intensive cultivation.

Land use problems are related closely to climatic factors, soil physical properties and the susceptibility of the soils of the Blackland Prairies to erosion on sloping areas. Acute problems are encountered from the cotton root-rot fungus in relation to climatic conditions. The fertility status of these soils is generally good and microbial activity is relatively high, but moderate nitrogen and phosphorus deficiencies are common on most crops and often iron is deficient or unbalanced on ornamental shrubs and lawns.

Research at the Blackland Experiment Station and on some similar soil areas away from the substation is directed toward making maximum use of all favorable soil and climatic conditions in the development of crop and livestock programs that are practical for farmers on the Blackland Prairies. These programs are designed to cope with the natural soil and climatic problems of the area and to provide alternatives compatible with the individual farm and with farmer preferences.

ACKNOWLEDGMENTS

A soil survey of the Blackland Experiment Station was made first in 1930 by W. T. Carter of the Bureau of Chemistry and Soils, U. S. Department of Agriculture. A new survey was made in 1937 by Elias Somerville of the Soil Conservation Service, U. S. Department of Agriculture. This survey was inspected in October 1938, by W. T. Carter, assisted by C. L. Orrben of the Soil Conservation Service. Another inspection with further revisions was made in April 1939, by W. T. Carter, assisted by Harvey Oakes of the Bureau of Chemistry and Soils and Richard M. Marshall of the Soil Conservation Service. Following this inspection, a correlation report was made by W. T. Carter in April 1939.

This report shows the most recent revision of the soil map of the substation made by soil scientists of the Soil Conservation Service. The map was revised by W. R. Elder and John W. Huckabee in March 1956, and the classification and field correlation of the soils were made by Harvey Oakes in March 1958. The description of the soils given in Table 1 also was prepared by these personnel. The correlation was approved by R. W. Simonson of the Soil Conservation Service in April 1958.

Soils of the Blackland Experiment Station

Substation No. 5, Temple, Texas

Curtis L. Godfrey, Harvey Oakes and Richard M. Smith*

THE BLACKLAND EXPERIMENT STATION serves as the main research center in soils and crops for the Blackland Prairies land resource area of Texas. This area comprises about 11,500,000 acres in Central Texas, extending as a narrow wedge-shaped belt from near the Red River northeast of Dallas southward for about 300 miles to the northern boundary of the Rio Grande Plain in the vicinity of San Antonio. East of this major prairie are minor prairies much smaller in area, as shown on the cover, but similar as to soils and native vegetation.

Substation No. 5 is located in Bell county near the southeastern edge of Temple just south of State Highway 36 and west of State Highway 95. The farm site is in undulating to rolling upland topography which varies in slope from 0 to about 5 percent and in elevation above sea level from 582 to 660 feet.

The Blackland Experiment Station was first established in 1913 between Temple and Belton as a result of State legislation enacted in 1909. It remained at this location until the fall of 1927 and was then relocated on an 88-acre tract nearer to Temple, with a nearby but separate well site included. This tract has been expanded to 542 acres. Ninety-two acres belongs to the Texas Agricultural Experiment Station. The remaining 450 acres are owned by the Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture.

The expansion of the original 88-acre tract has included 6 acres of land purchased by the Chamber of Commerce, Temple, Texas, and presented to the Texas Agricultural Experiment Station on August 22, 1929, making a total of 94 acres in the TAES tract. In 1937, the federal government purchased 448 acres of land for research and was given custody of 2 acres of the TAES land on April 2, 1938, to use for a building site.

The Blackland Station was authorized by Congress in 1930 as one of the locations for cooperative state-federal research related to soil and water conservation. This joint research program has been maintained since that time.

Prior to 1935, the research at the substation was cooperative among the Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering of the U. S. Department of Agriculture and the Texas Agricultural Experiment Station. In 1935, the responsibilities of the U. S. Department of Agriculture were assumed by the Soil Conservation Service. Early work at the substation involved research on cotton root rot, crop varieties, corn breeding and soil fertility and management.

The federal responsibilities at the substation were transferred in 1953 from the Soil Conservation Service to the Bureau of Plant Industry, Soils and Agricultural Engineering. This arrangement was altered again in 1954 when the federal research program of the substation was placed under the supervision of the Agricultural Research Service of the U. S. Department of Agriculture.

Soil erosion, water losses from runoff, evaporation and transpiration, soil physical properties, soil conservation crop rotations, conservation engineering practices and crop residue management, have been investigated since 1931. In addition to conservation research, programs dealing with the adaptation and improvement of field crops, control of cotton root rot, maintenance of soil fertility, livestock management and mechanized farming have been carried on continuously.

CLIMATE[1]

The annual variation in the climate at the Blackland Experiment Station is an especially important factor in soil and related research. Weather records have been maintained at the substation since 1913.

The mean annual rainfall at Substation No. 5 for 45 years (1913-57) has been 34.0 inches, Figure 1. The lowest annual rainfall during the 45 years was 13.8 inches in 1954; the highest was near 51.0 inches in 1913 and in 1944. The deviation from the mean is indicated by these extremes as well as by the fact

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[1]Climatic data were compiled by Ernest D. Rivers, Research Assistant, Texas Agricultural Experiment Station.

that during this 45 years of record, annual rainfall within 2 inches of the long-time average occurred during only 5 years. During this time, 23 years have been above average, and 22 have been less than average. However, for the 11-year period, 1947-57, 7 years were below average. Figure 1 shows also that the annual evaporation from a free water surface fluctuates in relation to the annual rainfall.

Mean monthly rainfall and evaporation are shown in Figure 2. Rainfall peaks occur in April and May. Drouths are common during the summer, with accompanying hot winds and high evaporation rates.

Evaporation from a free water surface with a BPI type pan averages 58.6 inches per year, but in 1956, a hot, dry year, 74.0 inches evaporated. In contrast, only 45.9 inches evaporated in the cool, wet year 1919.

Evaporation and temperature are interrelated with the relative humidity. The mean annual humidity at the substation is 72.1 percent and in 1956 the mean was a record low of 57.1 percent. An all-time high annual average of 78.5 percent was recorded in 1944. An all-time mean monthly low of 45.9 percent occurred in the unusually dry September 1956.

The mean annual temperature at the Blackland Experiment Station during the 45 years has been 67.4°F, with a maximum daily average of 79.3°F and a minimum daily average of 55.4°F. However, a wide range in temperature is common. A record high of 110°F has occurred and summer readings above 100°F are not uncommon. The lowest winter temperature ever recorded was –5°F in January 1930. Subzero temperatures are rare, but freezing temperatures are expected about 30 days per year. One or two light snows usually fall each winter, but complete melting commonly occurs within a few hours.

Wind movement is higher at the Blackland Experiment Station and throughout the Blackland Prairies in general than in areas farther east, especially in the spring. The average annual wind movement at the substation has been about 53,000 miles per year over a 44-year period. High winds cause no erosion damage, but they appear to increase moisture losses and to have detrimental effects on growing crops.

The average growing season at the substation is about 250 days[2]. The longest recorded frost-free period was 318 days in 1946; the shortest was 199 days in 1917. The first killing frost[2] comes about November 21 and the last about March 16, but killing frosts as early as October 9 and as late as April 22 are on record.

[2]"Killing frosts" and "growing seasons" are based on records at the substation and, in general, refer respectively to temperatures of approximately 32°F and the longest continuous warm growing season between such temperatures.

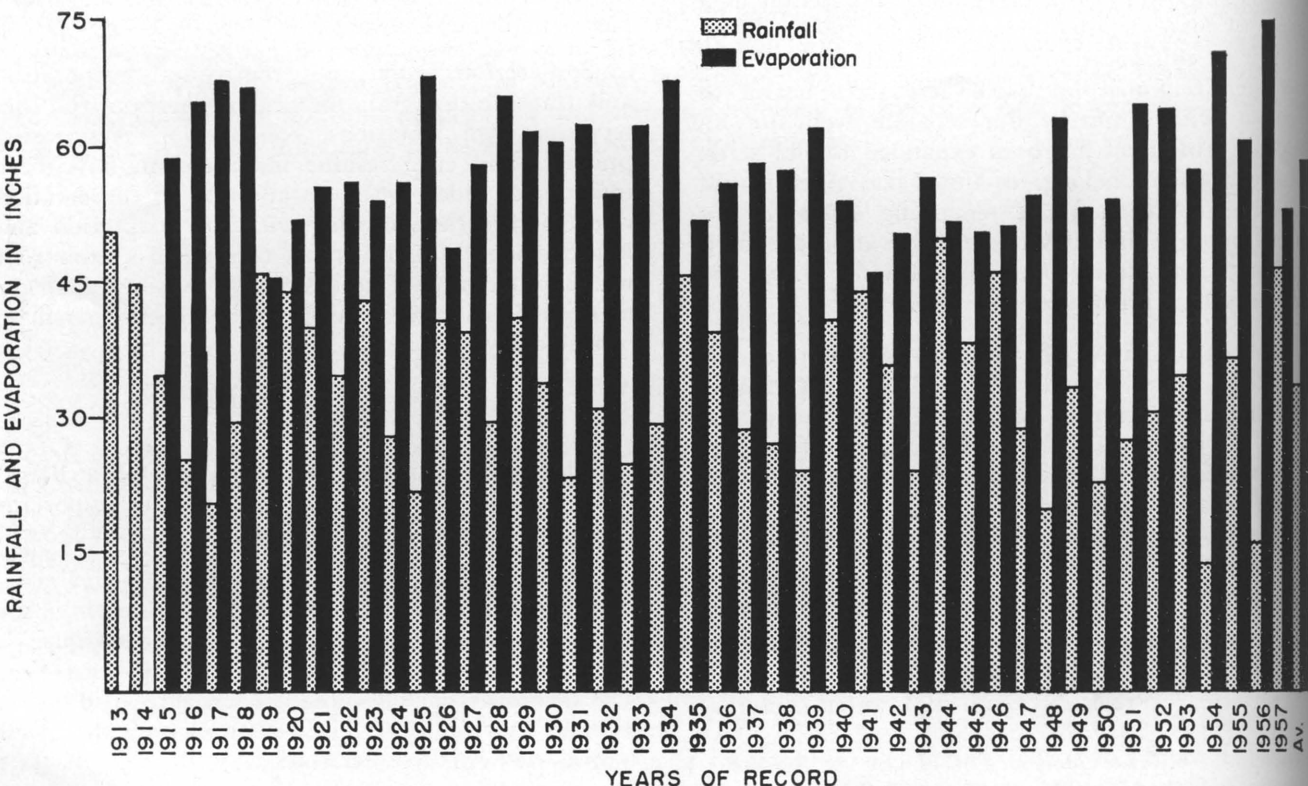


Figure 1 Annual rainfall, 1913-57, and evaporation (from a free water surface), 1915-57, at the Blackland Experiment Station. Mean annual rainfall, 34.0 inches; mean annual evaporation, 58.66 inches.

The climate at the substation headquarters is typical of much of the Blackland Prairies, but there are some differences. The northern portions of the Blackland Prairies are slightly colder in the winter and slightly warmer in the summer than in the Temple area. The southern extremes are warmer in the winter and slightly cooler in the summer. Crops are affected by these differences[3].

SOILS

The soils of the Blackland Experiment Station, Figure 3, are representative of more than 50 percent of the area included in the Blackland Prairies. The dark clay soils of the substation and throughout the Blackland Prairies are now classified mainly in the Grumusol great soil group. These soils also have been classified as Rendzinas in systems used prior to the Grumusol concept. They are dominantly deep, but some are shallow, dark granular calcareous clays developed under grass vegetation from parent materials of chalks, marls and calcareous shales. Soil drying results in wide shrinkage cracks into which surface soil frequently is moved by gravity and rains. This process, sometimes called "self-swallowing," is effective in deep distribution of organic matter and in rejuvenation of the soil profile. Earthworms and other organisms are naturally active in forming soil aggregates and in blending the soil mineral and organic materials.

Houston Black clay and Austin clay comprise the upland soils of the substation. A small area of Trinity clay, an alluvial soil, occupies a narrow strip along a natural drainageway on the farm. The upland soils of the substation are developed mostly from marls which are more calcareous than is average for the Blackland Prairies. The Trinity clay on the substation is representative of much of the dark clay alluvium in flood plains of streams that drain the Blackland Prairies.

Other somewhat similar soil series that occupy a considerable area in the Blackland Prairies, but do not occur on the substation, are Bell, Lewisville, Hunt, Houston, Catalpa and Kaufman. These soils have many characteristics similar to those of Houston Black and Austin clays and are related closely to them.

[3]Collier, J. W. An Evaluation of Certain Factors that Affect Corn Yields in the Blackland Prairie Region of Texas. Ph.D. thesis, Rutgers Univ. Library, New Brunswick, New Jersey. 1957.

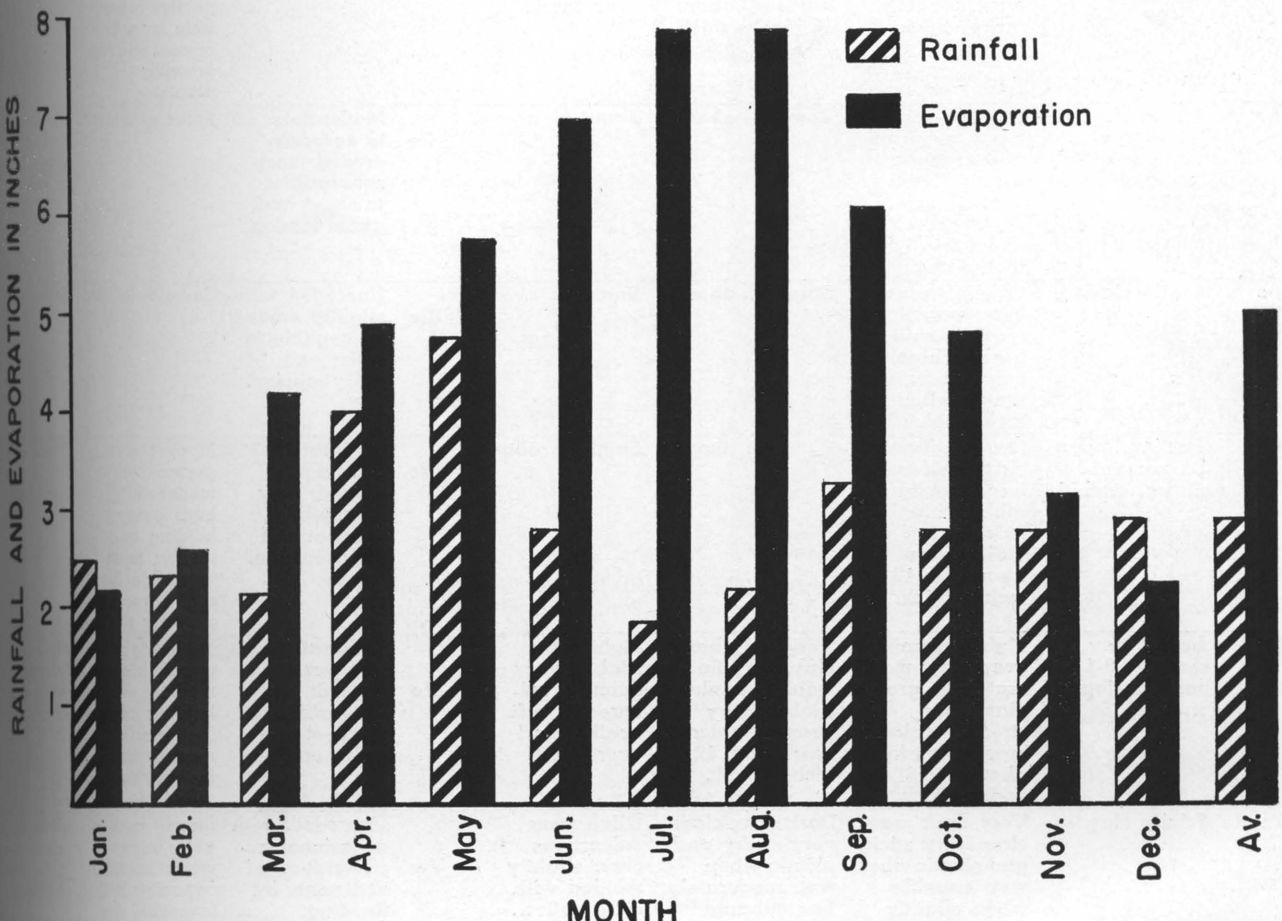
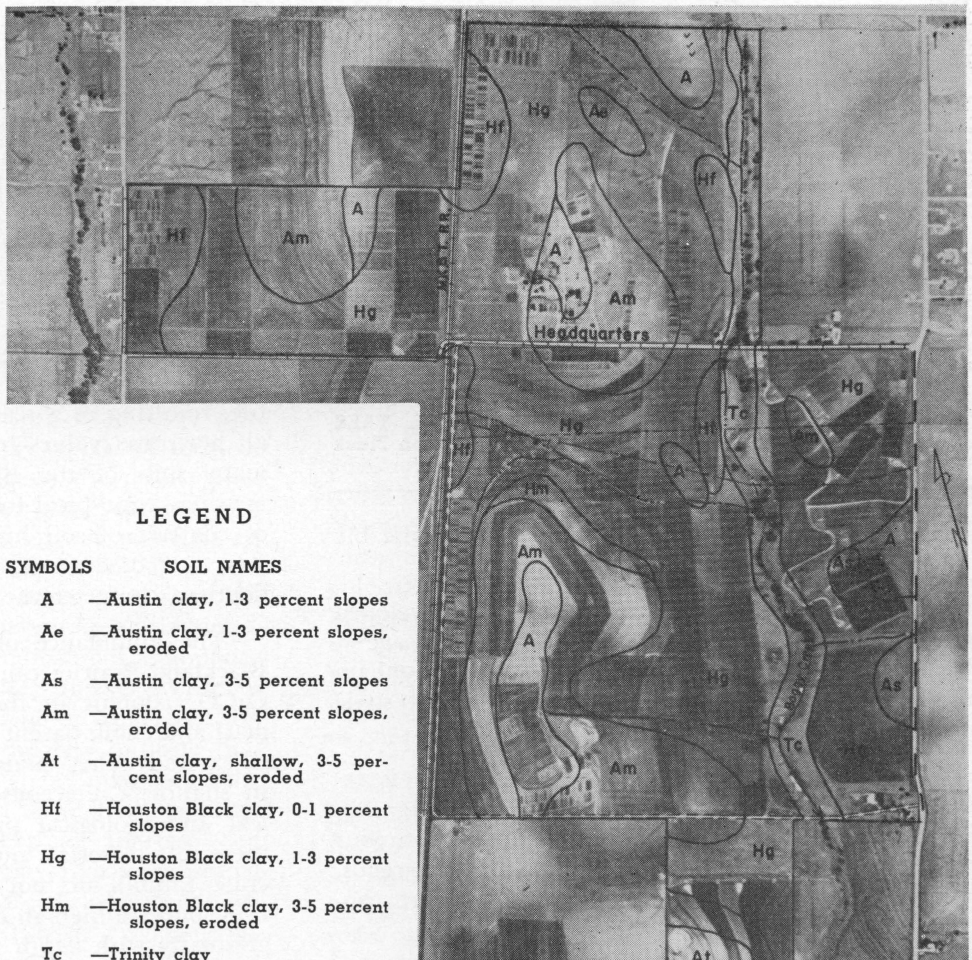


Figure 2. Mean rainfall, 1913-57, and evaporation (from a free water surface), 1915-57, by months at the Blackland Experiment Station. Mean monthly rainfall, 2.8 inches; mean monthly evaporation, 4.9 inches.

Map Symbol	Soil name	Description of soil[1]: Surface soil	Subsoil	Substratum	Capability class and subclass	Erosion condition and susceptibility	Moisture relations	Natural fe[rtility] and responsive[ness] to manage[ment]
Hf	Houston Black clay, 0-1 percent slopes	Very dark gray clay; very sticky and plastic when wet; granular and crumbly when slightly moist; calcareous; averages about 18 inches thick, but varies from 12 to 36 inches.	Very dark gray calcareous clay; very sticky and plastic when wet; moderate fine subangular blocky. This layer is about 24 inches thick.	Light olive brown calcareous clay; moderate fine subangular blocky; numerous soft calcium carbonate concentrations	IIs	Uneroded to slightly eroded.	Slowly permeable; high water holding capacity; most favorable for warm season growing plants.	Medium to good crop yields when moisture is adequate.
Hg	Houston Black clay, 1-3 percent slopes	Same as above.	Same as above.	Same as above.	IIe	Slightly eroded; moderately susceptible to sheet erosion under cultivation.	Same as above.	Same as
Hm	Houston Black clay, 3-5 percent slopes, eroded	Very dark gray clay; very sticky and plastic when wet; crumbly when slightly moist; calcareous; varies in depth from about 5 to 15 inches.	Same as above.	Same as above.	IIIe	Moderately to severely eroded; very susceptible to sheet and gully erosion.	Same as above.	Medium; crop yield when mois[ture] is adequa[te]
A	Austin clay, 1-3 percent slopes	Grayish-brown clay; moderate fine granular; friable; highly calcareous; averages about 16 inches thick.	Light yellowish-brown clay; moderate fine granular; friable; highly calcareous; about 18 inches thick.	Light gray, friable, very strongly calcareous soft chalky marl over chalk.	IIe	Uneroded to slightly eroded; moderately susceptible to sheet erosion.	Moderately permeable; moderately high water holding capacity; favorable for warm or cool season growing plants.	Medium to good crop yields when moisture is adequate.
Ae	Austin clay, 1-3 percent slopes, eroded	Grayish-brown clay; moderate fine granular; friable; highly calcareous; varies from about 4 to 12 inches thick.	Same as above.	Same as above.	IIe	Moderately to severely eroded; very susceptible to sheet and gully erosion.	Same as above.	Medium; crop yield[s] when mois[ture] is adequa[te]
As	Austin clay, 3-5 percent slopes	Grayish-brown clay; very fine weak granular; friable; highly calcareous; averages about 12 inches thick.	Same as above.	Same as above.	IIIe	Uneroded to slightly eroded; susceptible to sheet and gully erosion.	Same as above.	Same as
Am	Austin clay, 3-5 percent slopes, eroded	Grayish-brown clay; moderate fine granular; friable; highly calcareous; varies from about 4 to 10 inches thick.	Same as above.	Same as above.	IIIe	Moderately to severely eroded; very susceptible to sheet and gully erosion.	Moderately permeable; moderately high water holding capacity; most favorable for cool season growing plants.	Same as
At	Austin clay, shallow, 3-5 percent slopes, eroded	Light brownish-gray clay; moderate fine granular; very strongly calcareous; varies from about 4 to 8 inches thick.	Very pale brown clay; very fine weak granular; friable; very strongly calcareous; about 12 inches thick.	Light gray, friable, very strongly calcareous, soft chalky marl over chalk.	IIIe	Moderately to severely eroded; very susceptible to sheet and gully erosion.	Moderately permeable; medium water holding capacity; drouthy; most favorable for cool season growing plants.	Medium to fair crop yi[elds] when mois[ture] is adequa[te]
Tc	Trinity clay	Very dark gray clay; very sticky and plastic when wet; crumbly when slightly moist; calcareous; averages about 20 inches thick.	Dark gray clay; very sticky and plastic when wet; moderately fine subangular blocky; calcareous; about 40 inches thick.	Olive gray calcareous clay; slightly mottled with olive yellow.	Vw	Uneroded; with occasional accumulation of sediments by flooding.	Slowly permeable; high water holding capacity; most favorable for warm season growing plants.	Medium to (Flooding in- hibits crop production)

[1]All soil horizons are gradual and irregular.
[2]Estimated.

...ility ...se	Acreage on this farm	Percent of farm	Representative of acres² in Blackland Prairies
...ood for ...d or ... land.	35	6.5	500,000
...ood for ...nd or ...g land.	297	54.8	2,000,000
...ately well ...l for ...nd or for ...g land.	5	.9	500,000
... good for ...and or for ...g land.	38	7.0	370,000
... suited for ...and or for ...g land.	4	.7	375,000
...as above.	9	1.7	130,000
...ne as ...s. Best ...d for cool ...on culti- ...d crops.	118	21.8	120,000
...able for ...and or for ...g land. ... suited for ... season cul- ...ted crops.	14	2.6	150,000
...ly sub. ... to frequent ...low. ...ly best ... for ...ial ...g crops.	22	4.0	600,000
...Total	542	100.00	4,745,000



LEGEND

SYMBOLS	SOIL NAMES
A	—Austin clay, 1-3 percent slopes
Ae	—Austin clay, 1-3 percent slopes, eroded
As	—Austin clay, 3-5 percent slopes
Am	—Austin clay, 3-5 percent slopes, eroded
At	—Austin clay, shallow, 3-5 percent slopes, eroded
Hf	—Houston Black clay, 0-1 percent slopes
Hg	—Houston Black clay, 1-3 percent slopes
Hm	—Houston Black clay, 3-5 percent slopes, eroded
Tc	—Trinity clay
√ √ √	Chalk rock outcrop

Figure 3. Soil map of the Blackland Experiment Station. Prepared by the Soil Conservation Service, U. S. Department of Agriculture, and the Texas Agricultural Experiment Station.

TABLE 2. CHEMICAL ANALYSES OF A CULTIVATED HOUSTON BLACK CLAY FROM THE BLACKLAND EXPERIMENT STATION[1]

Constitutent	Depth in profile, inches			
	0-3	14-20	24-36	36-50
	Percent			
SiO_2	24.74	22.80	19.91	13.17
TiO_2	0.34	0.32	0.32	0.24
Fe_2O_3	2.68	2.84	2.65	2.55
Al_2O_3	6.69	6.96	6.06	4.48
MnO	0.03	0.05	0.05	0.04
CaO[2]	32.81	34.34	37.25	42.52
MgO	1.23	1.13	0.95	0.94
K_2O	0.65	0.50	0.48	0.39
Na_2O	0.21	0.27	0.19	0.29
P_2O_5[3]	—	—	—	—
SO_3	0.31	0.25	0.25	0.28
N_2	0.18	0.11	0.06	0.04
Organic matter	2.94	1.88	1.10	0.51
pH	8.1	8.1	8.2	8.2

[1]Middleton, H. E., et al. The Physical and Chemical Characteristics of the Soils from the Erosion Experiment Stations —First Report. USDA Tech. Bul. 316. 1932.

[2]Higher than average for the series and for the Blackland Prairies in general.

[3]Fraps, G. S. Chemical Composition of Soils of Texas. TAES Bul. 549. July 1937. Average total P_2O_5 in 45 Houston Black clay profiles = 0.081% in surface, 0.070% in subsoil.

Research results from Substation No. 5 are applicable wholly or in part to these soils.

The soils of the Blackland Prairies have developed mainly from calcareous materials of Cretaceous age[4, 5], largely Austin chalk, Taylor, Navarro and Bonham marls and to a slight extent from Eagleford shale and some younger, less calcareous formations.

The character of the soil parent material is reflected somewhat in the characteristics of the soil. That is, generally, the soils developed from calcareous materials are moderately to strongly calcareous, whereas those from noncalcareous materials are usually acid in reaction.

The soils of the substation and the Blackland Prairies, in general, are fine textured, calcareous, well granulated and dominantly deep with the clay uniformly distributed throughout the profile. However, along the eastern edge of the major prairie, and to a large extent throughout the minor prairies, the soils are more leached (some acid) with some series showing strongly developed textural profiles. The Hunt and Burleson soils are texturally similar to the Houston Black clay, but are slightly acid in the surface; the Wilson, Crockett and Bonham are leached and have strongly developed profiles. There also are significant acreages of shallow soils over chalk or marl (Eddy and Sumter series).

[4]Sellards, E. H., et al. The Geology of Texas. Vol. I, Stratigraphy. Bu. Eco. Geol., Univ. of Tex. Bul. 3232. Aug. 1932.

[5]Hydrology Div., Office of Research, SCS. The Agriculture, Soils, Geology and Topography of the Blacklands Experimental Watershed, Waco, Texas. USDA Hydrologic Bul. No. 5. 1942.

The native vegetation, as well as the parent materials, has had a strong influence on the soils of the Blackland Prairies. The cover of the virgin soils consisted mostly of tall bunch grasses, mainly Andropogon species, but, under grazing pressure, grasses such as buffalo and curley mesquite have become common on the uncultivated areas. Some small trees, such as mesquite and various species of small oak and elms, occur in most areas.

Houston Black clay is estimated to comprise about 25 percent of the Blackland Prairies, Table 2. Houston, Austin, Hunt and Bell are other extensive series in the area which have many properties in common with Houston Black clay. On this basis, physical and chemical data on some Houston Black clay profiles have been chosen as representative of the soils of the substation and of the major part of the dark clay soils of the area in general.

Table 2 shows the total chemical composition of the soil. Calcium is abundant throughout the profile, resulting in a reaction (pH) about the same in all horizons (values from 7.5 to 8.2 are common for many soils of the Blackland Prairies). Such pH readings are typical for highly calcareous soils. Lack of contrast of soil horizons can be noted from the slow rate of decrease of organic matter with profile depth, a characteristic feature of the Grumusol.

The abundance of calcium in the soils of the Blackland Prairies can be attributed to the high free $CaCO_3$ content in the soft or weakly consolidated marl and chalk parent materials. Calcium carbonate, silica and other materials apparently accumulated in shallow Cretaceous seas through physical, chemical and biological precipitation. Soils formed on these soft materials under grass vegetation and moderate rainfall do not have strongly developed profiles, but are high in clay. Organic matter decreases gradually with depth in the soil, with no accumulation of clay, iron or aluminum at any point in the profile. The total phosphorus level is moderate and it also is rather uniformly distributed in the profile. The abundant $CaCO_3$ likely has kept the iron, aluminum and phosphorus largely in a precipitated form. Total magnesium is low in relation to calcium. Less biological precipitation of magnesium from sea waters may have been a factor. The total potassium is low, but is associated mostly with the soil clays since these soils are known to be low in primary potassium minerals.

The average and range of values for the content of sand, silt and clay for five Houston Black profiles are given in Table 3. Average quantities of each fraction vary but little throughout the profiles. The quantity of sand is low; silt and clay are high with little variation in the clay content between profiles. The high amount of fine clay ($<0.2\mu$) in the clay fraction also is apparent. This abundance of fine

TABLE 3. PARTICLE SIZE DISTRIBUTION OF HOUSTON BLACK CLAY[1,2]

Horizon	Av. depth, inches	Sand Av.	Sand Range	Silt Av.	Silt Range	Clay Av.	Clay Range	% <0.2μ clay in <2.0μ fraction[3]
		%	%	%	%	%	%	
A_{11}	0-18	6.4	1.9-19.5	35.7	29.8-40.7	57.9	50.7-68.0	69
A_{12}	18-40	6.7	2.3-21.0	35.4	29.1-41.0	57.9	49.9-68.1	—
AC	40-60	5.8	3.0-13.5	36.5	30.3-40.8	57.7	55.1-61.0	—
C_1	60-78	4.6	0.8- 7.3	36.7	32.1-41.2	58.7	52.9-64.9	—
C_2	78-100	3.7	0.6- 8.8	35.5	20.5-51.4	60.8	39.8-76.4	60

[1]Adapted from Table 1. Kunze, G. W. and Templin, E. H. Houston Black clay, the type Grumusol: II. Mineralogical and chemical characterization. Soil Sci. Soc. Amer. Proc. 20:91-96. 1956. (Average of five profiles—four virgin areas, one from cultivated area.)

[2]County locations of profiles—Fannin, Ellis, McLennan, Bell and Fayette.

[3]Carbonate and organic matter removed.

clay tends to produce physical problems in the soil, but the mineralogical nature of the clay and the generally high level of organic matter and $CaCO_3$ offset many of the potential physical problems.

Chemical data on five Houston Black clay profiles are given in Table 4. As is typical of most of the soils of the Blackland Prairies, these soils have a high exchange capacity and are well supplied with organic matter which provides a good nitrogen reserve. (Virgin soils usually contain 5.0 to 7.0 percent organic matter in the 0-6 inch layer; this soon decreases to about 1.5 to 3.5 percent under cultivation.) The $CaCO_3$ equivalent results indicate an abundance and increasing amount of $CaCO_3$ in the profile in relation to depth. The ethylene glycol retention values and the high exchange capacity indicate that montmorillonite is the dominant clay mineral in the soil. This also has been shown to be true by X-ray diffraction and differential thermal analysis. In some soil profile horizons the clay is base saturated in the order of Ca>Na>Mg>K. It is unusual for the exchangeable Na to exceed both exchangeable Mg and K except in saline-sodic soils. The relatively high sodium can be attributed to the marine origin of the parent material and lack of intensive leaching of the subsequent soils formed.

Soil tests and the crop response to fertilizers on soils of the Blackland Prairies indicate that the available supply of nitrogen and phosphorus is somewhat limited, but that the available potassium is adequate even though the total and exchangeable levels of potassium found in these soils are not high. Nitrogen and phosphorus fertilizers tend to produce consistent, but often small, yield increases. In favorable years, considerable crop response is obtained from nitrogen, but in hot, dry years the only response may be from phosphorus. Crops as yet do not respond to potassium applications except in some cases on the more highly weathered soils of the eastern portions of the Blackland Prairies.

In field-plot experiments with crops, no response has been obtained from adding minor elements to the soil. Nitrogen and phosphorus have produced as much growth as nitrogen and phosphorus plus minor elements. However, leaf yellowing, or chlorosis, is common on ornamental shrubs, some fruit and nut trees, and on lawn grasses, especially St. Augustine. This condition appears to be an iron

TABLE 4. CHEMICAL PROPERTIES OF HOUSTON BLACK CLAY[1,2]

Horizon	Av. depth, inches	Exchange capacity, me/100 g. Untreated soil	Exchange capacity, me/100 g. <0.2μ, fraction[3]	Exchangeable cations me/100 g.[5] Mg	Exchangeable cations K	Exchangeable cations Na	Ethylene glycol retention, mg/g.[4] Unheated	Ethylene glycol retention Heated	$CaCO_3$ equiv., %	Organic matter, % Virgin	Organic matter, % Cult.
A_{11}	0-18	64	95	2.0	0.7	4.6	82	26	17.3	4.78	1.45
A_{12}	18-40	58	—	2.1	0.6	1.4	81	26	20.1	2.37	1.20
AC	40-60	53	—	2.5	0.6	2.6	—	—	25.7	1.00	0.77
C_1	60-78	47	—	1.8	0.6	3.2	—	—	32.0	0.46	0.23
C_2	78-100	40	87	2.5	0.5	2.7	69	22	42.5	0.16	0.19

[1]Adapted from Tables 3, 4, 5 and 6. Kunze, G. W. and Templin, E. H. Houston Black clay, the type Grumusol: II. Mineralogical and chemical characterization. Soil Sci. Soc. Amer. Proc. 20:91-96. 1956. (Average of five profiles—four virgin areas, one from cultivated area.)

[2]County locations of profiles—Fannin, Ellis, McLennan, Bell and Fayette.

[3]Organic matter and carbonates removed.

[4]Organic matter removed.

[5]Kunze, George W. Unpublished "Summaries of laboratory data for five profiles of Houston Black clay." 1958.

deficiency or an iron-manganese unbalance resulting from the high free $CaCO_3$ content of the soil. No research has been done on chlorosis at the substation, but it is known that foliage and soil-applied ferrous sulfate is effective in temporarily eliminating chlorotic conditions. Barnyard manure fortified with superphosphate also is believed to be helpful against chlorosis. Permanent correction is unlikely since the soils contain so much $CaCO_3$.

The highly calcareous clayey parent materials of the soils of the Blackland Prairies and grass vegetation have led to the formation of soils higher in organic matter content than normally would be expected for the climatic and drainage conditions in the area. However, under intensive cultivation, the surface soil organic fraction has been found to decrease more than 50 percent and to approach a rather stable level when the percentage in the plow layer and that in the immediate subsurface become similar[6].

Total microbial populations and activities are relatively high[7], and the rate of release of nitrogen from organic matter in the soils of the Blackland Prairies indicates a rather high rate of decomposition of organic residues. Decomposition in wet, cold periods is slow and crops may suffer from nitrogen deficiencies in combination with other limiting factors. However, with warm-season crops, the greatest demand for nitrogen occurs in advanced stages of growth whenever other growing conditions are favorable. Thus, the extent of a need for nitrogen fertilizer varies with seasons and with years. The type of crop and the previous crop also are important factors. The depletion of soluble soil nitrogen by cotton is less pronounced than is the case with grain sorghum and corn.

Phosphorus exists in soils in organic and inorganic forms. It is known to be released from organic to inorganic forms through organic matter decomposition processes similar to those which release nitrogen[8]. In addition, some phosphorus is more or less continuously released from inorganic forms into the soil solution and organic matter apparently enhances this release and aids in the maintenance of the phosphorus in a form available to plants.

Phosphorus in the soils of the Blackland Prairies probably exists largely as inorganic calcium phosphates, as adsorbed phosphorus on clay surfaces and as organic phosphorus. Response of crops to phosphorus fertilizers generally is greater relative to nitrogen in dry than in wet years. Root extension of the plant, decomposition of organic matter, CO_2 in the soil and the solubility of calcium phosphates and other forms native to the soil are involved in phosphorus availability. Utilization of native or applied phosphorus also is affected by the type of crop grown. Clovers and other legumes, for instance, are more efficient in the uptake of phosphorus from tri-calcium phosphates than are non-legumes.

Available potassium levels in soils are influenced by the kind and amount of clay present and the presence of weatherable potassium minerals. The soils of the Blackland Prairies are high in montmorillonite, which has some tendency to fix potassium, but other clays that are high fixers, such as illite and vermiculite, are scarce. These soils also are low in weatherable potassium minerals, such as feldspars. This is indicated by a rather low total potassium content. However, the exchangeable potassium is relatively high, indicating that a favorable proportion of the potassium present is in the available form. These soils also contain significant amounts of exchangeable sodium, and sodium is known to substitute in part for potassium in plant metabolism. Calcium, which always is abundant, is strongly attracted to clay and can be expected to increase the proportion of potash in solution by replacement from the exchangeable form. These factors explain, at least in part, the lack of response to potassium fertilizers in the Blackland Prairies. However, continuous cropping eventually may produce potassium deficiencies.

The primary limitations to crop production on the Blackland Prairies seemingly are determined more by climatic factors in relation to soil physical properties and the cotton root-rot organism than by soil fertility. The soils of the Blackland Prairies are high in montmorillonite clay which shrinks in drying and expands greatly when wet. The drying process produces large cracks in the soil which increase the loss of soil moisture by evaporation, but which allow rapid penetration of water supplied from rainfall or irrigation. When wet, the soils become slowly permeable, leading to considerable runoff. Erosion is serious on the more sloping areas used for cultivated row crops.

Tillage operations too soon after rainfall or irrigation result in puddling and compaction of the soil. This problem can be reduced by careful timing of operations and by capitalizing on the naturally favorable soil physical and chemical properties[9,10].

[6]Smith, R. M., Thompson, D. O. and Collier, J. W. Soil Organic Matter, Crop Yields, and Land Use in the Texas Blackland. Soil Sci. 77:377-388. 1954.

[7]Hervey, R. J. Some Microbial and Chemical Characteristics of Blackland Soils. Tex. Reports on Biol. and Medicine, 15:62-63. 1957.

[8]Thompson, L. M., Black, C. A. and Zoellner, J. A. Occurrence and Mineralization of Organic Phosphorus in Soils with Particular Reference to Associations with Nitrogen, Carbon and pH. Soil Sci. 77:185-196. 1954.

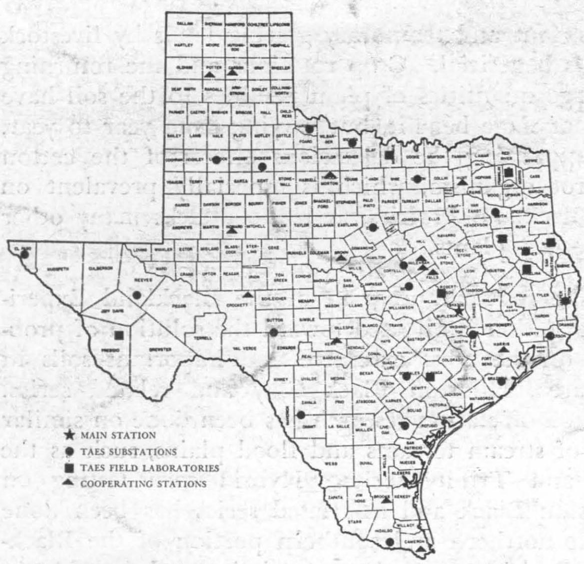
[9]Smith, R. M., et al. *op. cit.*

[10]Smith, R. M. Some Structural Relationships of Blackland Clay Soils with Special Attention to Shrinkage and Swelling. In process of publication in the ARS-41 Series.

Seedbeds should be prepared early enough to allow soil to slake from wetting and drying action prior to planting. By this process, the soil expands, loosens and naturally aggregates, thus alleviating the puddling effect brought about by cultivation when it is too wet, or the cloddy effect resulting when the soil is plowed when too dry. A satisfactory seedbed can be obtained by this process.

Climatic factors result in crop yields below normal expectations based on the soil properties of the Blackland Prairies. Supplemental irrigation would alleviate many of the climatic hazards, but economic water supplies are limited. Surface incorporation of plant residues from close-growing crops, such as small grain and legumes, and the growing of sod crops have been beneficial in erosion control and in improving surface soil structure. A minimum of properly-timed tillage operations also is helpful in the improvement of soil structure. Limiting the use of permanent and temporary grazing lands by livestock also is beneficial. Crop rotations and the returning of large quantities of plant residues to the soil have been of some benefit, but varying from year to year, in suppressing the deleterious effects of the cotton root-rot organism, which is especially prevalent on the Blackland Prairies, and also attacks many other tap-rooted plants.

The research program of the Blackland Experiment Station is directed toward the solution of problems on the most extensive and important soils in the area, Houston Black Clay and related series. Limited off-station research has been done on similar soils of stream terraces and flood plains, such as the Bell and Trinity series. Hybrid corn testing on Houston Black and associated series has been done in the northern and southern portion of the Blackland Prairies to evaluate varieties and hybrids in relation to climatic variations.



Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

Conservation and improvement of soil	Beef cattle
Conservation and use of water	Dairy cattle
Grasses and legumes	Sheep and goats
Grain crops	Swine
Cotton and other fiber crops	Chickens and turkeys
Vegetable crops	Animal diseases and parasites
Citrus and other subtropical fruits	Fish and game
Fruits and nuts	Farm and ranch engineering
Oil seed crops	Farm and ranch business
Ornamental plants	Marketing agricultural products
Brush and weeds	Rural home economics
Insects	Rural agricultural economics

Plant diseases

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tommorrow's Progress