AN EXAMINATION
OF THE
PHYSICIAL PROPERTIES
OF SOME
TYPICAL TEXAS SOILS
WITH REFERENCE TO
PROBLEMS IN FARM MANAGEMENT

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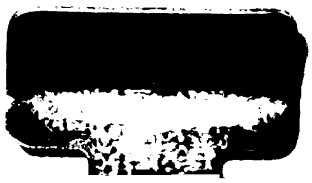

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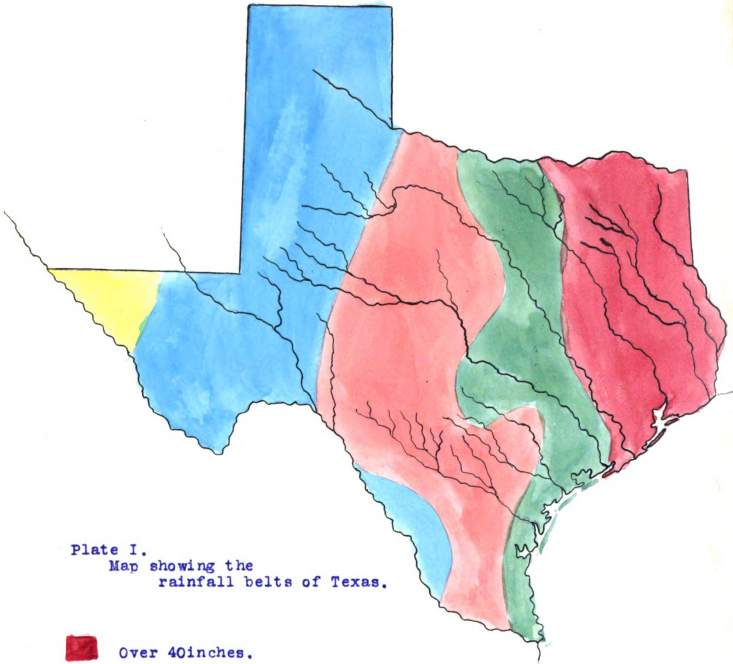


Plate I.
Map showing the
rainfall belts of Texas.

Over 40inches.

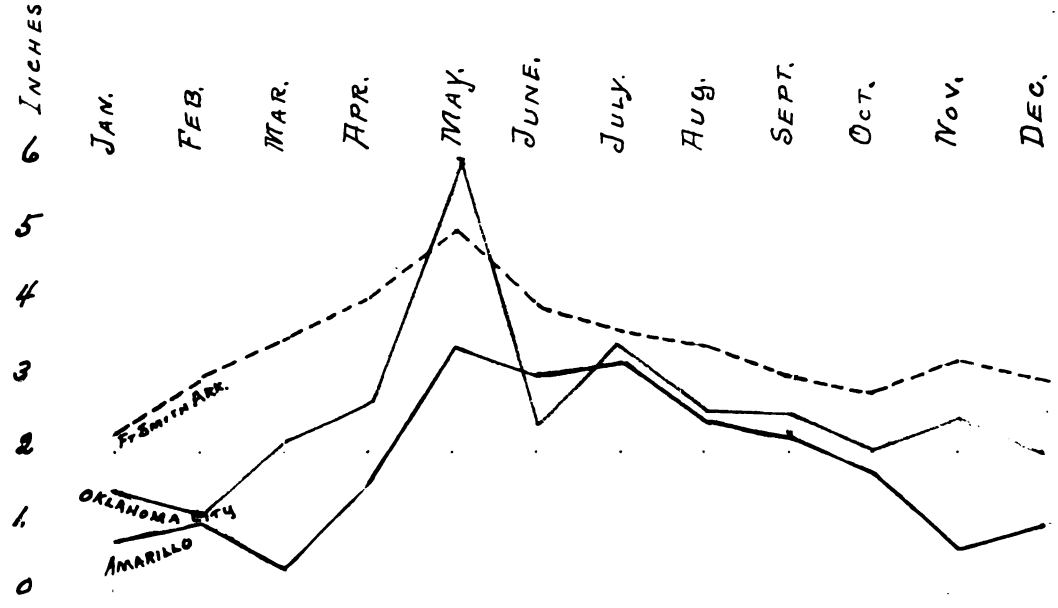
Between 30 and 40 inches.

Between 20 and 30 inches.

Between 10 and 20 inches.

Less than 10 inches.

Total Rainfall by Months.
(35° 30' N.)
Amarillo 102° W. Oklahoma City 98° W. Ft. Smith Ark. 94° W.



Total Rainfall by Months.
(33° N.)
El Paso 105° W. Dallas 97° W. Shreveport La. 94° W.

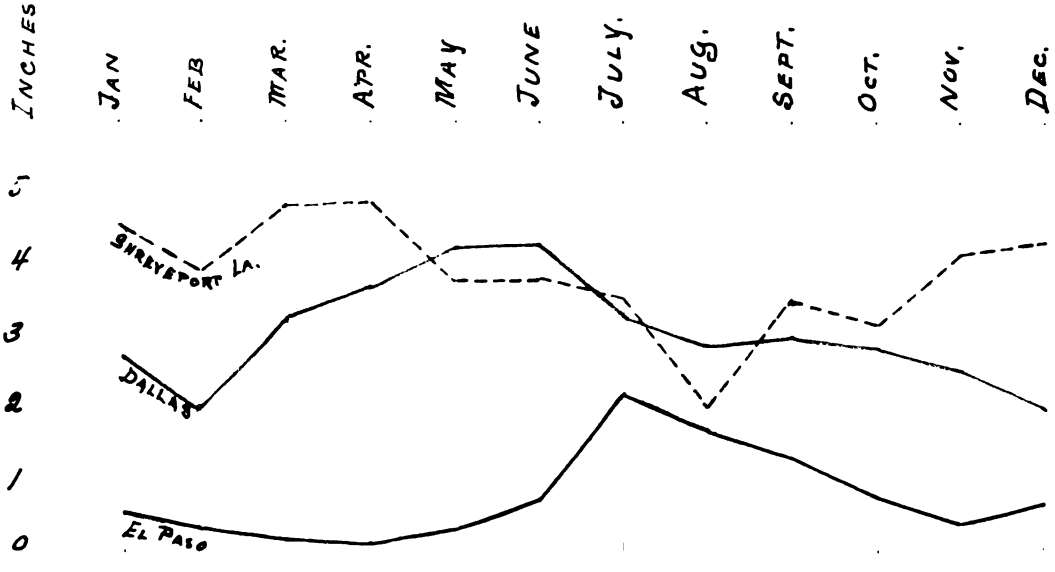
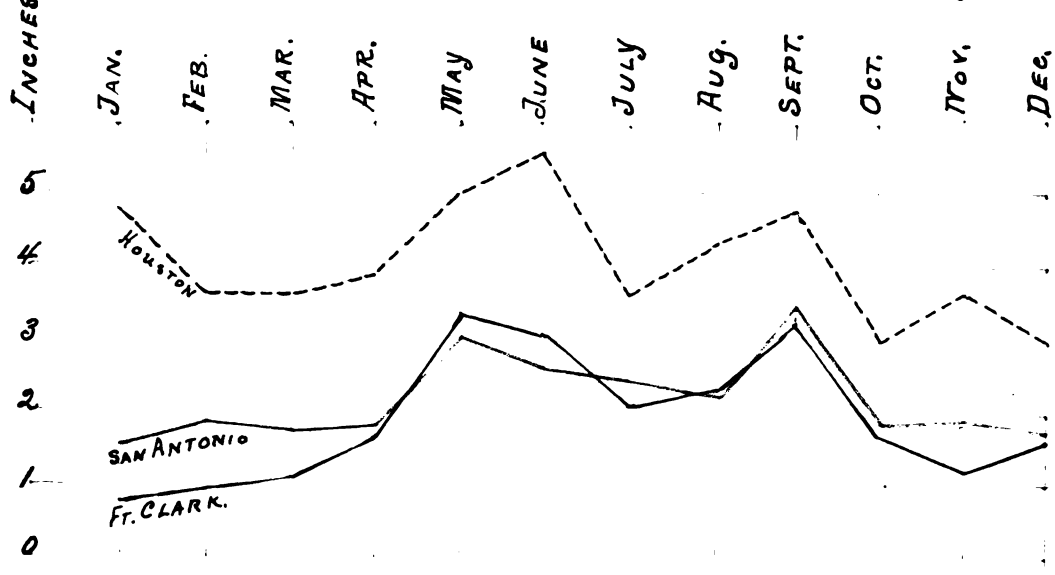


Plate II.

Total Rainfall by Months.
(29°30'N.)
Ft. Clark 100°W. San Antonio 98°W. Houston 95°W.



Total Rainfall by Months
(Coast Country)

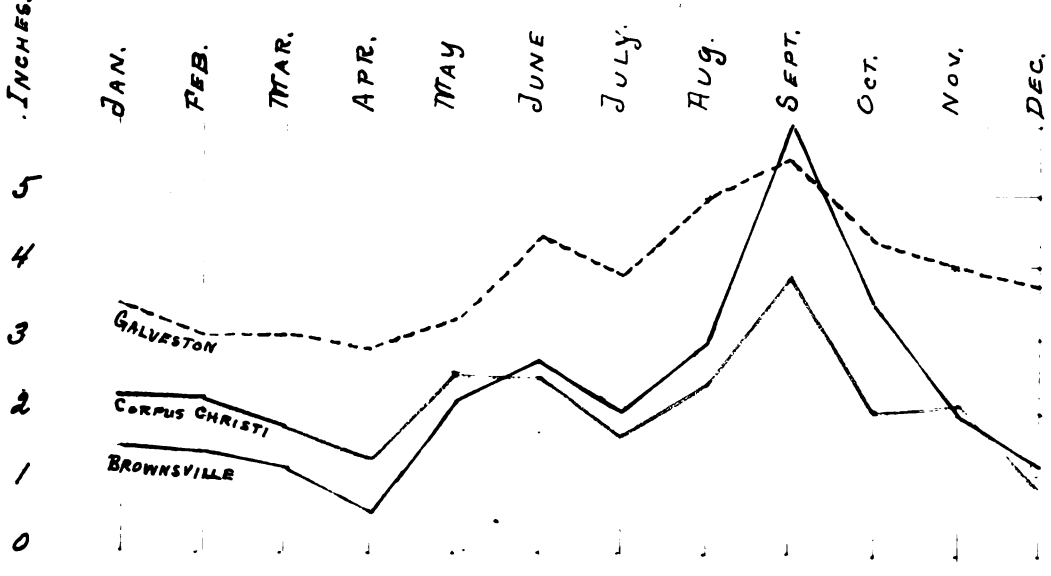
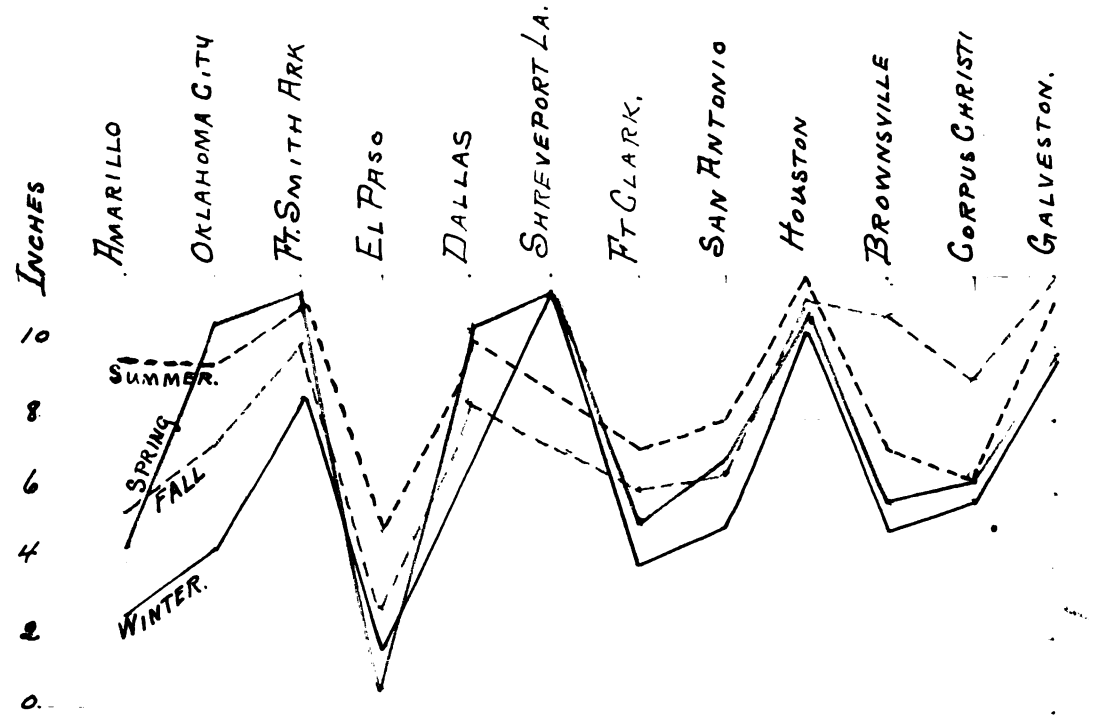


Plate III.

Rainfall in Inches by Seasons.



Mean Annual Rainfall in Inches.

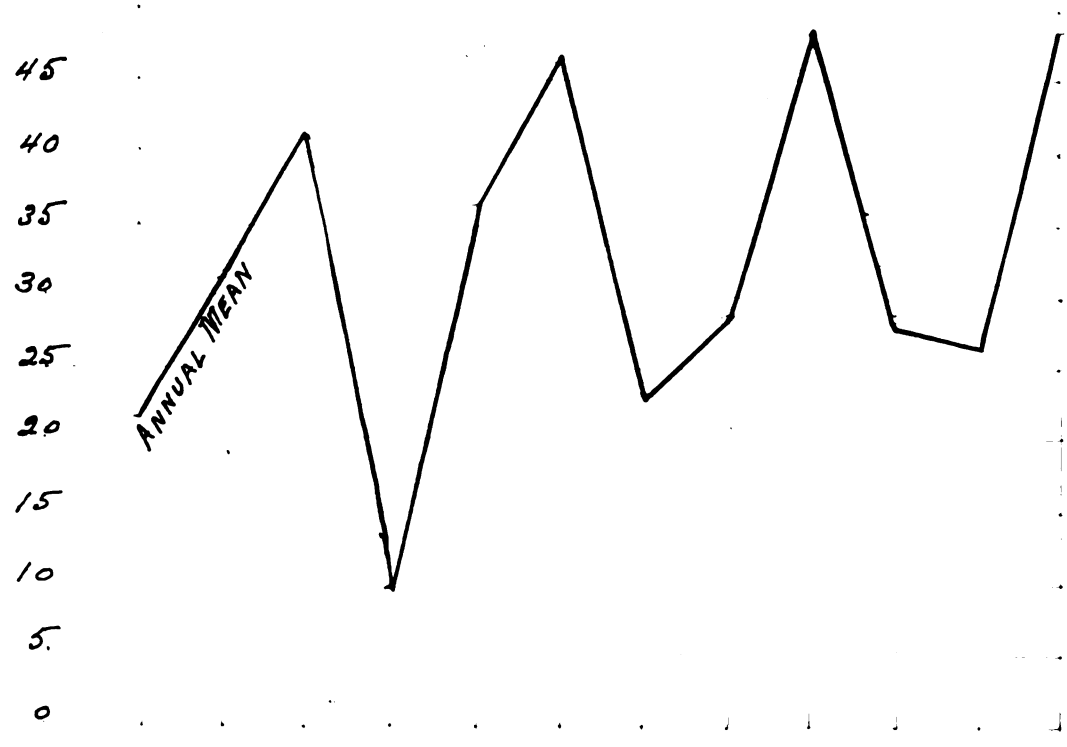


Plate IV.

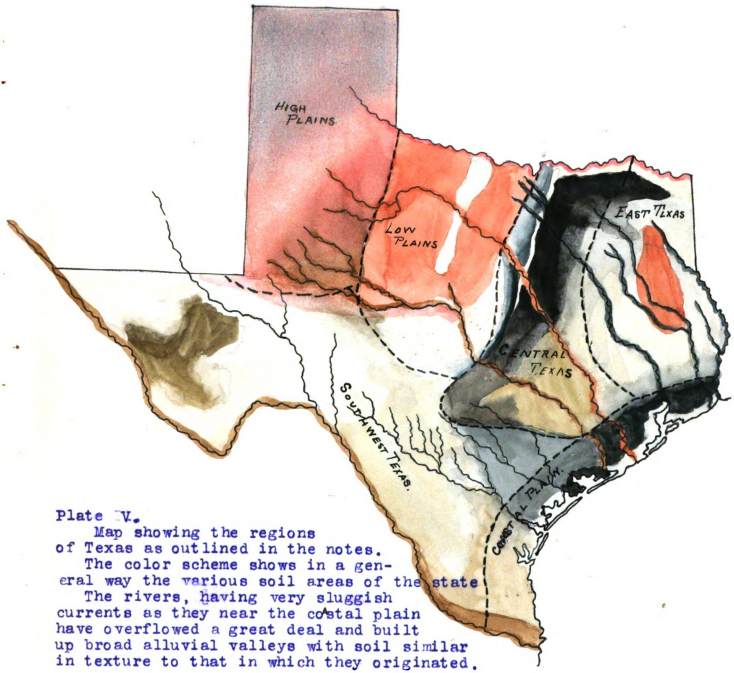


Plate V.

Map showing the regions of Texas as outlined in the notes.

The color scheme shows in a general way the various soil areas of the state

The rivers, having very sluggish currents as they near the coastal plain have overflowed a great deal and built up broad alluvial valleys with soil similar in texture to that in which they originated.

The control of the water supply is one of the most important problems in farm management. Without question, crop production is influenced and limited by this factor more than any one other; in fact, it is the determining factor that measures the return from investment and labor in crop production. The control of the water supply necessitates an understanding of, first; surface conservation and storage; second, the use of water for irrigation; third, the drainage of surplus water from the land; fourth, the cultivation of the soil in such manner as to maintain the maximum amount of moisture beneficial to plant growth. These problems, for the most part, are within the scope of the farmer, but in addition to these there are certain problems such as the organization of drainage and levee districts for the purpose of preventing the overflow of the rich bottom lands adjacent to our rivers; the drainage of the swamp district and level prairie lands of the coastal plain, and the extensive reclamation projects in the semi-arid district in the extreme western portion of the State. The purpose of this paper is to discuss only those problems relating to the control and conservation, or, disposal of the water which naturally falls on a given farm or in a given locality, with a special reference to crop production.

That there must be widely different systems of soil management in East, West and Central Texas, is certainly evident when we come to consider the great difference in rainfall between the three localities. However, these differences in total annual rainfall are not so important in forecasting the relative agricultural possibilities of a country as is the question of the season of the year when the greatest proportion of the rainfall may be expected. The regions of the greatest rainfall are found in the Eastern portion of the State and along the Northern area of the coastal plain. As we proceed westward there is a gradual decrease in the total rainfall, but a peculiar condition is here presented, in, that, the farther west we go, the later in the season comes the maximum precipitation. In East Texas, the heaviest rainfall is in the winter and spring, while in West Texas, the heaviest rainfall occurs during the late spring and summer months. The rains which fall in East Texas completely saturate the soil, and the greater portion of it must be removed before a crop can be planted. This surplus is collected in the creeks and rivers, and finds its way somewhat slowly to the Gulf of Mexico. The rains of West Texas come with great suddenness, and unless the soil is in proper condition to receive the water, it runs quickly into the streams and rushes down from the high elevations to the low valley lands, where, with its force impeded, it spreads out over large areas inudating the country, and bringing ruin and distruction to many prosperous farms. If the rainfall could be conserved

on the land where it falls, and made to percolate naturally through the soil to the underground channels, the probability of these devastating floods would be decreased. Then, with proper levees, the rivers could be confined to their banks and the adjacent lands fully protected. We thus see that the East Texas farmer has a problem of drainage; the West Texas farmer has a problem of conservation, and the Central Texas farmer, located in the valley lands, has a problem of the control of flood waters as well as the drainage of the water that naturally falls on his own land. This levee construction and, in many instances, the drainage construction must be accomplished by the assistance of the State. The problem is entirely too large to be handled by private enterprises.

Texas may roughly be divided into six regions materially differing from each other, but so gradually blending from one to the other that the line of separation cannot be distinctly drawn. Roughly speaking, the regions would be designated by the following boundaries:

East Texas, bordered on the east by the Sabine river and on the west by a line drawn from Paris to Corsicana, and from Corsicana to Houston.

Central Texas which comprises the territory west of this as far as a line drawn from Gainsville to San Antonio, and extending from the Red river on the north to a line drawn from Houston to San Antonio, on the south.

The coast country which extends from Beaumont on the east, west to Houston, and south to Brownsville, comprising

a territory ranging from fifty to seventy-five miles in width.

The lower plains country, comprising a territory lying west of Fort Worth and San Antonio, extending as far west as the southwest corner of Oklahoma.

The high plains area, comprising nearly all of the Panhandle and extending as far south as the Texas & Pacific Ry.

Southwest Texas includes all that vast area south of San Antonio and west of the coastal plain, extending practically the entire length of the Rio Grande river.

The East Texas region is, for the most part, a timbered country with sandy land and a heavy rainfall sufficient for the growing of any kind of agricultural crops adapted to this climate. It is somewhat hilly in places, and the land must be carefully cultivated or it washes badly. It produces a luxuriant growth of grass on the valley lands, and the soil responds quickly to intensive farming; producing early vegetables and fruit, especially peaches, of unexcelled quality. On some of the red soil tobacco is grown which sells in the open market for a price equal to that of the best Havana filler. The southeastern part of this region contain great forests of pine with some oak and hickory, but on account of the level condition of the country the drainage is very poor. The western edge of this area is mostly a postoak country with some hickory, and the sandy land gradually changes from a light or reddish color to a black. However, there are a great many varieties of

soil in this region, and in some sections there are considerable beddies of clay. The subsoils vary from red to yellow and brown, and in some instances may be called mottled. The upland soils were originally sedimentary in character, but have been so changed by process of weathering that the original types are hardly distinguishable. There are three or four large rivers that traverse this area which have alluvial bottom lands of sticky black soil.

Central Texas comprises the black land belt, the cross timbers country and the low postoak regions bordering on the East Texas area. The black prairies are, undoubtedly, the most desirable soils of this State. It was formerly a grass covered, rolling prairie from 400 to 700 feet higher than the waters of the gulf; for the most part without timber growth except along the river bottoms and the creeks. The cross-timbers country are two long narrow strips of sandy land in Central-North Texas extending considerable distance southward from the Red river. The soils are somewhat similar to the sandy postoak lands of East Texas, easy to cultivate, but not very productive unless heavily fertilized and intensively cultivated. The lower postoak area comprising the eastern and southern portion of the Central Texas region is somewhat similar to the cross-timbers country, except that the soils are more finely divided, containing more silt and underlaid by a more tenacious subsoil. The black land prairie belt contains the oldest settled portion of the State, and the largest cities of the State are located in this belt. The soil contains great stores of plant food and an abundance

of lime, and produces such good crops that the majority of the pastures have been plowed and nearly all of the land is in actual cultivation. The soils are especially adapted to the growing of corn, cotton, grass, wheat, oats, and alfalfa. The rainfall in this region varies from thirty to forty inches, per year, and the temperature is suitable for the crops mentioned. The oats and wheat are sown in the fall, and grazed extensively during the winter. On account of the heavy dews which prevail in the southern part of this area, during the spring months, the growing of wheat is somewhat restricted on account of the prevalence of different forms of rust. This region is, also, traversed by several large rivers which extend out in valleys varying more or less in width and showing a relatively variable kind of soil, depending upon their source. The principal river of this region is the Brazos which rises in the red soils of the northwest portion of the lower plains, and produces a bottom land varying from red to chocolate brown.

The costal plain is a flat, level prairie rising, for the most part, less than fifty feet above the level of the ocean. Close to the gulf, we find a narrow strip of country that is usually sandy, but scattered along the coast are numerous bays and inlets which are marshy and bordered by soils that are mostly silt and very finely divided clay. A few miles back from the coast, we find large bodies of black clay soil underlaid at varying depths with a clay subsoil, which varies from a white to a chocolate brown color. In places these black clays are mixed with considerable

quantities of sand and organic matter and, if sufficiently well drained, they are very productive; being adapted to the growing of vegetables, and some kinds of fruit. It is in this area that we find the most extensive orange planting in the State. Where the land is so level that drainage is impracticable it is, for the most part, left in sod for pasture, or is utilized for the growing of rice. The heavy clay subsoil prevents the downward seepage of the water, and makes this soil especially well adapted to the growing of this crop.

In the western area of this costal plain, South of the Brazos river, the rainfall is considerably decreased, and the black prairie land is developing into one of the best cotton growing sections of the State. The south part of the costal plain has not a sufficient rainfall for agricultural crops, and irrigation is necessary. The rivers which cross the costal plain spread out into wide valleys, the soils of which are very finely divided, and are very tenacious and sticky. When cleared of their extensive forest growth and put in cultivation they are especially well adapted to the growing of corn, cotton and sugar cane.

The lower plains region has an elavation of 1000 or more feet with a mild, relatively dry climate; the rainfall averages about 25 to 30 inches per annum. In the southern and eastern portion of this region it is somewhat rocky and hilly in character and not suitable for cultivation except on the level prairies, or in the river valleys. The rough land is

usually found in ranges of hills along the valleys, while the prairie is out on the broad plateaus at a somewhat higher elavation. These high, rolling upland soils have been derived from the weathering of shale, limestone, and sandstone, and vary in color from dark chocolate brown to a red. It is only recently that these soils have been developed, agriculturally, but during recent years a very great number of settlers from the Northern States have been located on these upland prairie soils, and have been producing abundant crops of corn, cotton, sorghum, milo maize and Kaffir corn.

The high plains region is separated from the lower plains region by the chalky limestone hills, which are known as the "breaks". The elavation of the high plains ranges from 2500 to 4000 feet. The climate is cool on account of this elavation, and the rainfall does not greatly exceed 20 inches, per annum. On account of the elavation and climate this area is not adapted to the growing of cotton, and where agricultural operations have been attempted those crops which require a short season of growth and are more or less drouth resistent, such as milo and the Kaffirs, have succeeded the best, although alfalfa has been established on some of the sub-irrigated sections, and wheat and oats have been grown to some extent. Owing to the splendid prairie grass, which grows all over this region, this country has long been used for ranching purposes, and with the development of such crops as Kaffir and milo, suitable for the production of feed for livestock, it will un-

doubtedly develop into a stock farming country. No trees are found growing on these high plains, and there are no rivers cutting across them; although many of the large rivers of the State have their origin in the dry canyons through which water flows after every heavy rainfall.

Southwest Texas is similar in many respects to the high plains region on account of the semi-arid condition of the country. The elavation gradually increases, as we proceed westward, attaining a maximum of 5000 feet in the vicinity of the Davis mountains. On account of the deficiency in the rainfall, irrigation has been found necessary, and when practiced, splendid crops of cotton, corn and vegetables are produced. During recent years artesian water has been located in the eastern part of this region, and a great deal of land that was formerlly used only as a cattle range has been turned into productive farms. The soils of this area represent two distinct types; (1) the fine sandy loam, running from one to two feet deep and underlaid by a sandy clay subsoil. These soils are easy to cultivate, are not puddled by irrigation, and are very productive when properly cultivated and fertilized. (2) The dark heavy upland soils ~~of this region are~~ very similar to the black prairie soils, consisting of a black or brown clay and underlaid by a brown chocolate or white clay subsoil. These dark soils are very productive when the rainfall is sufficient, and in the northern portion of this region are utilized for the growing of corn and cotton. The alluvial rich bottom soils of this region consisting of a mixture of sand and clay are

very productive when irrigated artificially or naturally sub-irrigated, and are adapted to the growing of cotton, corn, sugar cane and alfalfa. They are not utilized to any great extent for the growing of vegetables, except cabbage and onions.

The brief summary of the regions as outlined above, indicates the great necessity of the conservation of the natural water supply of the State, as more than four-fifths of the area of Texas fails to receive what may be considered a sufficient rainfall. With a view of studying the relation of various soils to water, a physical examination was made of the surface and, also, the underlying subsoil of several of the typical soils gathered from the best agricultural sections of the State.

There are some ~~different~~ principles of soil physics with which the farmer should be familiar in order that he may be proficient in handling the soils of his farm. It is a matter of common knowledge that there is a large variation in different soils with respect to the size of the individual soil grains and, also, with respect to their comparative weights or specific gravities. The difference in the actual weight in a given volume of ^ two different soil may be caused by the difference in the specific gravity of the rocks from which the original sample of soils were weathered, or it may be due to some other material, probably organic matter mixed with the two soils in varying quantities. The more organic matter a soil contains the less will be the weight of a given volume, or, in other words, the weight of a soil decreases as

its organic matter increases. The apparent weight of a soil, or the volume weight to which we refer, is the weight of the soil in its natural condition, and will vary also with the amount of packing it has received. When a soil has been plowed and is loose and mellow it weighs much less per cubic foot than it would have weighed before it was plowed. In other words, the soil has a real and an apparent weight, and the apparent weight of the soil in good field condition is much less than the actual weight.

The well plowed land appears in somewhat the form of a sponge and the particles being loosely separated from one another permits of a large amount of water being absorbed during every rainfall. The retention of this water in the soil depends on the fineness of the individual particles and the closeness with which they are compacted. If, however, the particles are so closely packed or the water is in so great supply as to exclude the air from the soil plant growth will be retarded. In other words, to produce maximum crops the proper conditions as regard heat, moisture and air must prevail. Any soil deficient in one of these essentials will be in crop producing powers, greatly reduced. As stated above, soils are cultivated in order that they may absorb more rain and retain more moisture. The cultivation of the soil will necessarily liberate some plant food, but this is somewhat dependent upon heat, moisture and air conditions; so ultimately the question of crop production depends primarily upon these three, and in this climate we have a sufficiency of heat during the long season; so we

may reasonably conclude that crop production will depend primarily upon the moisture and air conditions of the soil. When a soil is compacted it tends to lose moisture very rapidly by evaporation from the surface, and if the surface is hard there is a tendency for the rainfall to run off rapidly without percolating into the soil. The plowing and cultivating of the soil permits large quantities of water to be absorbed, and it would seem that most of the average soils in Central and West Texas should be plowed deeply before the season of heavy rainfall, and should have the best of cultivation in order that the most profitable use may be made of them as a medium of crop growth.

There is a wide difference between soils with reference to the rate at which they will allow water to flow through them, depending upon the size of the soil particles and their arrangement. Other things being equal, it is desirable that a soil should allow water to pass through it slowly, holding the moisture for the greatest length of time possible within reach of the crop roots, with a minimum amount of loss by percolation, and with the least possible amount of evaporation from the surface. It is a matter of common knowledge, however, that no waterlogged soil is productive, and it is also a well known fact that soils that are wet are cold. The problem which the farmer must solve, is how he should cultivate the soil on his own farm so as to retain the maximum amount of moisture available for the plant without the danger of permitting his soil to become waterlogged; in other words, he must always have moisture avail-

able for his crops, but never so much water in the soil as to exclude the air. The excess above the amount of water required to surround each individual particle of soil with a thin film must be disposed of by underdrainage, either natural or artificial, if neither of these are possible then it would be better to permit the surplus to run from the surface of the soil without entering it, provided, ofcourse, this surface run-off is so controlled as to prevent the washing and gullying of the land. It is a common practice in East and Southeast Texas to prepare the land for cotton or corn by "bedding" the soil. This practice consists in turning two furrows together forming a ridge varying from three to four feet in width, each ridge being separated from the adjacent one by a narrow, deep furrow. This practice permits the planting of the seed on the top of the bed, the soil of which undoubtedly contains, at the time of planting, a sufficient amount of moisture to germinate the seed and produce a healthy growth of the young plants, and is undoubtedly good practice where abundant rains continue throughout the growing season. In many instances, however, farmers have moved from the very wet lands of Southeast Texas to the drier regions of Central or West Texas, and have attempted the same methods of farming which they practiced in their former homes with lamentable failures. The bedding of these lands in West Texas naturally results in the complete drying of the seed bed, a consequent lack of germination of seed planted therein, and a resultant poor crop. The bedding of the land is advised only where the

rainfall is excessive and where the soil and subsoil conditions are such as precludes the possibility of underdrainage either natural or artificial.

The bedding of Southeast Texas lands and, also, the bottom lands, which are very flat and low and subject to overflow, is absolutely necessary in order that the soil may be properly ventilated. The air in the soil is essential to the existence of those forms of life called bacteria which assist in making available nitrogen and other elements of plant food. Generally speaking, the more readily the soil permits the air to circulate through it the more favorable will be the conditions for the formation of plant food. However, on account of the tendency of the air to dry the soil, if this movement is carried on to too great an extent there is a possibility that the moisture content of the soil would be reduced below normal, and plant growth would cease; although the amount of available plant food might be in excess of the requirements of the plant. The chemical analyses of the soils of the semi-arid regions indicate a great abundance of nitrogen, phosphoric acid and potash in available form, yet there is only a limited plant growth, undoubtedly due to a lack of moisture.

It has sometimes been contended that soil takes moisture from the air, but in reality the amount thus secured is very small indeed even when the air is thoroughly saturated. There is a certain amount of moisture precipitated from the air at night in the form of dew, yet, undoubtedly, in a great many instances at least, the moisture thus precipi-

tated comes from the soil air rather than from the air above the ground. The frequent stirring of the soil permitting the air to circulate freely through it undoubtedly has a tendency to dry the soil as deeply as it is stirred, and this method is employed to cover the moist ground below with a dry layer of earth protecting it from the heat of the sun and the drying effects of the wind. This covering of dry earth is called a mulch. The depth to which a mulch should be stirred will vary with the soil and the climatic conditions, especially the frequency of rainfall. If this mulch is four inches deep and loosely stirred it would undoubtedly take up a considerable amount of rainfall, yet this water so taken up will be of absolutely no benefit to the crop unless it sinks below the depth of the mulch into the ground occupied by the roots of the plant. If, on the other hand, the mulch is shallow, a very light rain will undoubtedly sink through the mulch on the soil and benefit the crop. It would appear, therefore, that in West Texas where the rains are infrequent, but heavy when they do come, a thick mulch not less than four or five inches should be maintained. On the other hand, in other sections of the State where rainfall is frequent the mulch should be more shallow and the roots of the plant permitted to form nearer the surface of the ground. The depth of this mulch must be determined to a certain extent by the character of the crop growing on the soil since the cultivation must not be deep enough to injure the feeding roots of the plant. In the dry portion

of the State where it is necessary to maintain a deep mulch a deeper rooting of the plant is obtained by planting the seed in what is known as a lister furrow, varying from two to four and even six inches below the general level of the ground. After the plant is established in the soil and has begun to form its roots the soil is generally plowed toward the plant, and the cultivation is continued as deep as practicable.

The frequency of cultivation is of much importance since the more often the ground is stirred the greater will be the tendency to dry out the soil. So much depends upon the character of the soil that no general rule can be applied, yet, so long as the mulch is maintained the cultivation should be as infrequent as is possible. It has been observed, however, that very finely divided soil will not maintain a satisfactory mulch as long as is found possible on soils of a course sandy texture. There is also a tendency in such soils, especially where alkali is present, to form a crust between the moist layer below and the mulch above, which prevents to a certain extent the free movement of the air through the soil.

There are two general movements of water in the soil. Under the influence of gravity the water in the soil tends to move downward until it strikes the impervious layer, or until it is entirely taken up by surface films surrounding the soil particles. After the water has been taken up in this way it tends to move through the soil laterally as well

as vertically to establish an equilibrium of tension between the various soil films. The distance to which moisture will rise in opposition to the force of gravity depends upon the fineness of the division of the soil particles and the closeness with which they are packed together. It has been noticed in many places in dry valleys or on level land adjacent to hills that there is a tendency for grass to remain green even during an excessive drouth, and I have seen very good crops of Johnson grass hay and alfalfa cut on land that did not receive twelve inches or rainfall in as many months, and that without irrigation. The moisture to produce this plant growth must have been supplied by seepage from high elavations and the rise of water through the ground due to capillary action or surface tension. Such tracts of land are spoken of as subirrigated and are highly esteemed, and considered very valuable. In some instances, however, where rainfall is abundant these subirrigated lands contain too much moisture and will not produce a profitable crop until they are properly underdrained. The movement of water in soil is retarded to a certain extent by the tendency of some soils to puddle or run together. This is particularly noticeable in soils containing an insufficient quantity of lime or organic matter, or on which water containing alkali, especially carbonate of soda, is used for irrigation. When soils are puddled plant growth is dwarfed, not only because the water supply will be insufficient, but also on account of the exclusion of the air from the soil. The gradation found in the mechanical

analysis of soils run from a gravel through course, medium, and fine sand to silt and clay, and the greater the proportion of the siltand clay in the soil the more will be the tendency of these soils to puddle, especially by tramping or working them when they are wet. A soil containing a large amount of organic matter may be sticky and wet, but it cannot easily be puddled unless the mineral particles of the soil are largely made up of silt and clay.

The black land belt of Central Texas is a very sticky soil when wet and very hard when dry, yet the presence of large quantities of lime practically prevents puddling of the soil, if reasonably well managed. On the other hand, the soil of Southeast Texas, such as the Houston black clay, are very easily puddled, and must be handled with great care. The sandy lands of East Texas, although they are deficient in organic matter are not injured by plowing when wet and, in fact, it is almost necessary to stir them immediately after a shower to prevent the silting of the soil, due to the cementing of the fine particles of silt when beaten by a heavy rain.

The drier lands of West Texas are benefitted by being plowed when reasonably moist as they are somewhat coarser in texture, and if in proper condition when plowed they settle together very compactly and are in proper condition to absorb and retain a maximum quantity of the rainfall which follows. The higher the percentage of organic matter in the soil the greater will be its water holding capacity, and for this reason it is advisable to plow under such crops

as will add organic matter to the soil. In practice, however, this is not done to any great extent, and the organic matter so necessary in the soil is relatively low. A noticeable feature, however, of Texas soils is that they are made up very largely of fine material, and, undoubtedly, this large proportion of fine material makes up, in a measure, for the lack of organic matter which is common in most of our soils. In a climate as warm as this, especially where moisture is present, organic matter decomposes very rapidly and it is, therefore, fortunate that our soils are relatively fine rather than coarse in texture. This condition, however, produces a tendency for these finely divided soils to run together, or to silt, as we say, after rains. If they contained more organic matter, which could be supplied from crop growth for this purpose, in regular rotation with standard crops of the country, they would be more mellow at all times, could be more easily worked, would retain more moisture, and would produce larger returns.

The analyses given below shows a deficiency in organic matter and, also, an excessive amount of fine sand, silt and clay. These soils were selected to represent the dominant types in the localities from which they were chosen. The following analyses were made from a mixture of the soil to a depth of one foot, the separation of the silt and sand being effected from the clay by the centrifugal method. The organic matter was determined by igniting a weighed portion of the soil after having driven off the capillary water and determined the hygroscopic moisture. This can only be an approximation,

yet it is of value for consideration in connection with the study of the size of the soil particles as shown by the mechanical analyses.

Table of Analyses.

Sample from Smith County, near Troupe. A typical sample of the slightly reddish sandy upland soil of East Texas.

	Percent
Organic Matter	.24
Gravel	.00
Course Sand	Trace
Medium Sand	6.2
Fine Sand	38.9
Very Fine Sand and Silt	42.77
Clay	12.3

Sample taken from Cherokee County, in the vicinity of Jacksonville. Brown sandy loam, considered a good type for general farming; early and fairly productive.

	Percent
Organic Matter	.65
Gravel	3.74
Coarse Sand	3.56
Medium Sand	1.64
Fine Sand	21.58
Very Fine Sand	36.40
Silt	24.08
Clay	9.00

Sample from Tyler County. A grey silt loam sample from the northeastern part of the county, representing the poorer class of the heavier soils of the East Texas area.

	Percent
Organic Matter.....	.92
Gravel.....	3.66
Coarse Sand.....	2.80
Medium Sand.....	.94
Fine Sand.....	3.3
Very Fine Sand.....	13.06
Silt.....	42.36
Clay.....	34.20

Sample from Hill County. Typical black sandy upland soil of the Central Texas region.

	Percent
Organic Matter.....	.785
Gravel.....	.00
Coarse Sand.....	.28
Medium Sand.....	32.70
Fine Sand.....	25.85
Very Fine Sand.....	17.80
Silt.....	.70
Clay.....	21.88

Sample from Williamson County, near Taylor, Texas. Sample of the very productive soil of the black land belt of the Central region.

	Percent
Organic Matter.....	.81
Gravel.....	.00
Coarse Sand.....	.155
Medium Sand.....	19.77
Fine Sand.....	36.60
Very Fine Sand.....	12.87
Silt.....	17.30
Clay.....	21.5

Sample from Bell County Texas, near Temple. Typical blackland soil, very similar in crop producing powers to the soil of Williamson County.

	Percent
Organic Matter.....	.831
Gravel.....	.00
Course Sand.....	.26
Medium Sand.....	16.20
Fine Sand.....	30.52
Very Fine Sand.....	15.77
Silt.....	18.30
Clay.....	17.81

Sample from Fayette County, near La Grange. Sample of the typical postoak soil of the South-Central region, somewhat rolling in character.

	Percent
Organic Matter.....	.882
Gravel.....	.00
Course Sand.....	Trace
Medium Sand.....	39.02
Fine Sand.....	.32
Very Fine Sand.....	35.10
Silt.....	13.75
Clay.....	11.04

Sample from De Witt County, near Cuero. Typical sample of the fine sandy loam, grayish chocolate in color; typical of the extreme southern part of the Central Texas area.

	Percent
Organic Matter.....	.28
Gravel.....	.00
Course Sand.....	.00
Medium Sand.....	18.3
Fine Sand.....	16.50
Very Fine Sand.....	35.10
Silt.....	17.
Clay.....	12.82

Galveston County, near Dickinson. Typical black clay loam of the Coastal plains.

	Percent
Organic Matter.....	.6
Gravel.....	.00
Course Sand.....	.00
Medium Sand.....	.387
Fine Sand.....	5.72
Very Fine Sand.....	21.7
Silt.....	34.25
Clay.....	38.92

Sample from Webb County, in the vicinity of Laredo. Typical adobe soil of the Rio Grande valley used extensively for the growing of onions, under irrigation.

	Percent
Organic Matter.....	.78
Gravel.....	.00
Course Sand.....	.00
Medium Sand.....	.5
Fine Sand.....	.00
Very Fine Sand.....	70.
Silt.....	13.
Clay.....	15.72

Sample from Webb County, from the prairie uplands in the northern part of the county; typical of large areas in Southwest Texas.

	Percent
Organic Matter.....	.42
Gravel.....	.30
Medium Sand.....	.30
Fine Sand.....	.70
Very Fine Sand.....	90.2
Silt.....	3.00
Clay.....	5.46

An inspection of the tables given above will show a considerable amount of variation in the physical condition of these soils, but it is especially noticeable that they are all very low in sand and relatively high in silt and clay. This condition has a vital effect upon the moisture conditions of the soil and the availability of plant food in the soil. Fertilizer tests made by farmers in various sections of the State indicate that nearly all Texas soils are benefitted by the application of phosphoric acid and nitrogen, while potash has given only indifferent results, but it has been a very noticeable fact that the best results with fertilizer has always been secured on those soils that were in fairly good tilth and supplied with the proper amount of moisture. This fact, taken into consideration together with the physicial condition of soils of average character, would indicate to us the desirability of giving consideration to the proper methods of handling the soil mechanically before we should attempt the extensive use of commercial fertilizers. Where a soil is so finely divided, as are the majority of Texas soils, water necessarily enters them very slowly. This would indicate a great amount of moisture available for plant use and a resulting benefit to the plants, if the soil could be prevented from silting or running together, under these conditions. The rate of the percolation through these soils was studied comparatively. Tubes eighteen inches long and two inches in diameter were uniformly filled with the soils evenly compact-

ed and water was kept at a constant level over each tube. As soon as the flow was regular the amount of water running through in one hour was measured. Some of the sandier soils, such as the one from Smith County, permitted a very rapid flow amounting to sixty cc, per hour. The adobe soil from Webb County ~~puddled~~ silted immediately, and the flow of water through it was absolutely prevented. The average rate of flow was less than ten cc, per hour, except those showing the higher percentage of sand. This condition would justify a question as to the advisability of attempting to depend exclusively upon underground drainage to remove the surplus water from such soils, especially where the rainfall is over forty inches per annum, and the country comparatively level as is the case in South-east Texas, the southeast portion of Central Texas, and the eastern portion of the coastal plains. The excess rainfall must be removed by surface ditches which are, as a rule, secured as stated above, by plowing the land in narrow beds, leaving a water furrow between each row.

The season of the year in which it is best to plow these soils will vary with the location. On soils of the region of heavy rainfall, in the Eastern portion of the State, land plowed in the fall will become very compacted; so solid through the action of the beating rains of the winter and early spring, and so waterlogged that they are late in drying out, and remain uniformly too cold for early planting. If under drainage were possible, it is probable that this condition would not occur, but since there is no natural underdrainage and the advisability of underground drains is still a debatable question, it would seem advisable to delay

preparation of the ground for the spring crops until the winter rains had practically ceased.

In those sections farther west, however, where it is necessary to conserve every drop of water, the plowing of the land early in the fall would be advisable. And on account of the fact that the loose soil would dry out rapidly when exposed to the air it would seem advisable to use some tool to compact the subsurface soil. If, however, there is a possibility of sufficient rain between the time of plowing and planting the same results would be secured through the natural action of the water as it percolates or seeps down into the soil. It is a noticeable fact that the soils farther west are courser in texture and permit a more rapid absorbtion of the rainfall. The writer has examined many soils in West Texas where the rainfall was less than twenty inches, and wherever these soils had been plowed before the rainy season and thoroughly compacted they retained a considerable amount of moisture, where a sufficient mulch had been maintained, while on soils of similar character that had not been plowed or cultivated there was absolutely no moisture perceptible; and, also, on soils that had been plowed, but not compacted or cultivated, a similar lack of moisture was noticeable.

The depth to which these soils should be plowed is very variable, the proper depth being indicated by the season of the year, the character of the soil and the rainfall. A great deal of contention has been made in favor of deep plowing (ten inches), but in the experience of the writer

there seems to be no justification of such practices, and on many of the stiffer and more tenacious soils six inches in depth would be very hard work for three mules pulling a fourteen inch plow. The ordinary plowing of the land is usually spoken of in this State as flat breaking, and where land is cultivated in corn and cotton exclusively this method of plowing is not considered necessary it being easier on the teams to bed the land, where the rainfall would indicate the necessity of this method, or to list it in the drier sections of the State. The listing is the reverse of the bedding system, and the crop is planted in the furrow between the two ridges. Sometimes when the land is "flatbroke" it is afterwards bedded or listed before planting, yet, as a rule, this is not a common practice. Considering the fineness of this soil and its tendency to silt and become very compact the process of bedding or listing may be considered good economy of farm labor as it permits of the stirring of the soil with less horse-power than would be required to produce as deep a seed bed by flat breaking.

A study of the rainfall charts indicates that there is no section of the State that may be said to have an excessive rainfall, and the greater portion of the agricultural area is deficient in rainfall. Considering the fact, also, that, as we proceed westward, the greater proportion of the rain comes in the later months of year, we are justified in concluding that the problem of conservation of moisture is the most important one which the farmer must solve. The plowing of the land and

the preparation of the seed bed following must put the soil in condition to receive and retain moisture. As indicated above, the amount of moisture retained by soils depends upon their physical structure, their mechanical condition, and the amount of organic matter they contain. The fineness of the particles in most of the soils examined would indicate large water holding capacity, and the conservation of this moisture, when once it is stored in the soil, must be secured by such cultivation as will produce a mulch of dry dirt at least three inches in depth. In the very dry regions of the western portions of the State, it may be necessary to increase the depth of this mulch to four or five inches; yet if the subsoil has been properly compacted, the extreme deep mulches are not required. In those regions of rainfall of 30 inches or less, the soil should never be plowed and left loose and rough, but should always be harrowed immediately after plowing, and the mulch thus secured must be maintained until the crop is planted, and on intertilled crops, such as corn, Kaffir, of cotton, the cultivation should maintain the mulch until the crop is harvested. On land cultivated in wheat or oats, where it is expected that some crop will be planted immediately following the harvest, it is a good practice to run a double disc harrow immediately behind the binder to stir the surface of the ground and prevent evaporation and excessive drying of the soil. If light rains should follow this loose mulch will assist in retarding run-off and facilitate the percolation of the water down into the soil. It also sometimes happens that the season in which the ground can be plowed is very short, and before this work can be completed, the ground becomes so hard as to make plowing impracticable. In such cases it will be advisable to go over the

unplowed ground with a disc harrow, cutting the surface so as to form a loose mulch. A large area can be covered in a few days, and if dry weather should follow, the ground will remain for a long time in condition suitable for plowing. If rains should follow the discing, more water will be absorbed by the soil than would be possible if the ground was hard and smooth. The frequency with which the ground should be stirred to maintain this mulch will depend upon the character of the soil, and the rainfall. It has been quite definitely determined that a mulch is more easily maintained on a sandy soil than is possible on a soil containing a high percentage of silt or clay. Considering the fact, as we proceed westward, that the soils are coarser, and contain more sand, we find it easier to conserve the limited rainfall of this area for plant growth than is possible in Southeast Texas, where the soil silts so quickly and becomes hard even before dry, and when stirred does not pulverise readily. In Southern climates, and especially in the regions of low rainfall, there is usually a deficiency in the organic matter content of thesoil. Nearly all upland soils of Texas, and especially those in the Central and Western regions are deficient in organic matter, and their water holding capacity is correspondingly decreased. As stated above, this is overcome to a certain percent by the fineness of the soil particles, yet it is undoubtedly true that organic matter introduced into these soils by application of barnyard manure, or by the plowing under of stubble, corn and cotton stalks, or cowpeas, would be of remarkable benefit to them. It is a practice in some sections to clear the land by burning all the stubble and stalks. This is unquestionably a bad practice, and should be discontinued, except where plowing has been necessarily

delayed till nearly planting time, when, if the stalks were plowed under, the ground would be left in so loose condition that a sufficient amount of moisture could not be retained to germinate the seed placed in the ground. This condition would undoubtedly occur only in those sections of the State where the rainfall is less than 30 inches, and it should be avoided there, if possible, by completing all plowing sufficiently early before planting as to permit the ground to become compacted and the organic matter, to a certain extent, decomposed and changed into humus.

The use of leguminous crops, especially cowpeas, for the purpose of increasing the organic matter in the soil, and also building up its nitrogen content, is one of the most important phases of recent agricultural development in the Southwest. The amount of barnyard manure which can be secured is very limited on account of the fact that cattle and horses are maintained in open pastures during a large portion of the year, and very little manure accumulates in the barns or yards. The "Southwestern Farmer" is therefore of necessity compelled to resort to green manuring to maintain the organic content of his soil. Another factor which must not be lost sight of is that in the Southwest there is no grass which can be used in the same way as timothy or Kentucky blue grass to resod the land. After a pasture has been plowed and put in cultivation, it must lie idle many years before it will be resodded. Such grasses as Johnson grass or Bermuda grass, which have a creeping root stock, cannot be used in rotation, since when once established in the soil, it is impossible to eradicate them. In some localities, especially on the black land or in the alluvial bottoms, alfalfa can be grown

yet it is so difficult to secure a stand of this crop that when once secured the farmer hesitates to plow it up until necessity compels him to do so. For these reasons the cowpea is practically the only crop that can be used for green manuring. There are three methods in which it may be used: First, it may be planted in the corn after the last cultivation. Second, it may be planted in alternate rows with the corn, placing the corn rows about four and one-half feet apart. Third, it may be grown in rotation with the crop occupying the soil one entire season. The first method is unreliable, except in those sections of the State where the rainfall is 40 inches or more per annum. The second method has several advantages, and may be recommended as good farm practice. The land is bedded or listed as the necessity may require and after the corn is up, the peas are planted in single or double rows, midway between the corn. The following year the land is bedded on the middles which grew the cowpeas, and the corn is planted on this bed., and the cowpeas this season are planted on the ground which grew the row of corn the previous season. When it is desired to grow cotton, it is impossible to use cowpeas, as their climbing habits would make them a nuisance in a cotton field. In this case the Spanish peanut would be used, in place of the cowpea. When cowpeas are grown in regular rotation, the following has generally been adopted: Plant one-third of the land in cotton, one-third in corn, and one-third in oats, to be followed by cowpeas after the oats have been harvested. The land which is planted in cotton is given clean cultivation and fertilized with ordinary fertilizer. As soon as the cotton crop is removed, bed the land and prepare it for the corn crop, which will follow. Cowpeas can be sown in the corn at the last cultivation, if desired, and after the corn

has been gathered, hogs and cattle are turned into the field to feed on the cornstalks and cowpeas. Early in the fall the land is plowed or disced and sown to winter oats. As soon as the oats are removed, the land is replowed and planted to cowpeas, to be followed the succeeding year by cotton. This will add a large amount of organic matter to the soil, and greatly increase its water holding capacity. On soils as finely divided as the majority of those in the Central and East Texas regions, the addition of organic matter will also have a very beneficial effect of producing better aeration and a consequent increase in productiveness due to the liberation of more plant food.

Summary and Conclusion.

1.- The rainfall in all regions of Texas except East Texas and the eastern part of the coastal plain is deficient, and care must be exercised to conserve as much moisture as is possible for crop production.

2.- A physical examination of typical upland soils of the central and eastern portions of the state, as well as the coast country, shows them to be very finely divided and deficient in organic matter.

3.- The productive power of these soils would be increased by the addition of organic matter, which to a certain extent would prevent silting and increase their water holding capacity.

4.- The East Texas region on account of its heavy rainfall is adapted to the growing of good pastures and

forage crops, and being supplied with plenty of springs and running water its is a good stock farming country and should develop large dairy interests. In connection with the dairy, the growing of hogs will be found profitable, and the careful husbanding of the manure and the growing of leguminous crops in rotation with corn, other forage crops, and cotton, should improve the sandy lands of this region.

5.- The black land belt of the central region possesses a soil of such texture and productive capacity that it is especially adapted to the growing of hay, corn and cotton, and in some instances alfalfa. By proper rotation this land can be maintained without the use of livistock, and on account of the value of this land for crop production, very little of it should be devoted to pasture purposes.

6.- The alluvial valley lands are the most productive soils of the state when protected from overflow and properly drained.

7.- Where drainage is necessary, furrows and open ditches must be depended upon to remove the surplus surface water, as the land is very level and low, and the soil is too finely divided to permit the rapid percolation of water into tiles.

8.- The lower plains region possesses a fertile and productive soil, and should develop into a stock farming country, growing a great deal of forage and grain and fattening cattle, sheep and hogs for the market. The greater portion of this country should remain in pastures, only those areas free from rocks and possessing a deep soil suitable for the conservation

of moisture should be plowed.

9.- The high plains region should be left, for the most part, in cattle and sheep ranges, only sufficient land being plowed to provide the necessary feed stuffs. The country is too high and too arid for Indian corn and cotton, but very satisfactory crops of Milo and Kaffir can be produced.

10.- Agricultural operations in the Southwest Texas region should be confined to those lands either naturally subirrigated or susceptible of surface irrigation.

11.- Dry farming methods practiced extensively in Western Nebraska under what is known as the Campbell system of soil culture will not be very successful in West Texas on account of the deficiency of the rainfall in the winter season.

12.- The agricultural development of East and Central Texas regions, naturally well watered and possessing a good climate, is very much below its normal possibilities, and these lands should be fully occupied and developed before agricultural operations are pushed extensively into the very dry regions of West and Southwest Texas.

(The end.)

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