SOIL SURVEY OF IOWA

DES MOINES COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Soils Section

Soil Survey Report No. 45
May, 1927
Ames, Iowa

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Report No. 45---DES MOINES COUNTY SOILS

By W. H. Stevenson and P. E. Brown, with the Assistance of L. W. Forman, T. H. Benton and A. J. Englehorn

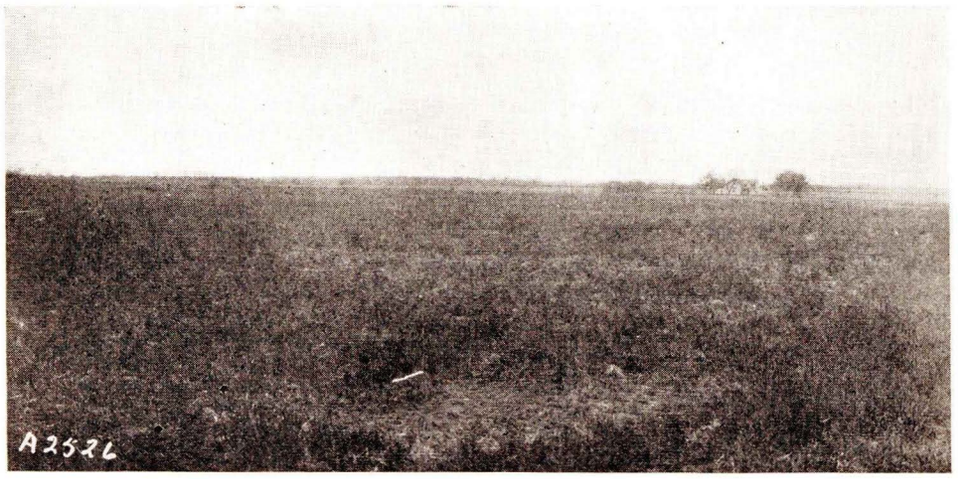

Fig. 1. Characteristic Topography of Grundy Silt Loam.

IOWA AGRICULTURAL
EXPERIMENT STATION
C. F. Curtiss, Director
AMES, Iowa

CONTENTS

DES MOINES COUNTY SOILS*

By W. H. Stevenson and P. E. Brown With the Assistance of T. H. Benton, L. W. Forman and A. J. Englehorn

DES MOINES County is located in southeastern Iowa along the Mississippi River and in the second tier of counties north of the Missouri state line. It is entirely in the Mississippi loess soil area and hence practically all of the soils of the county are loessial in origin.

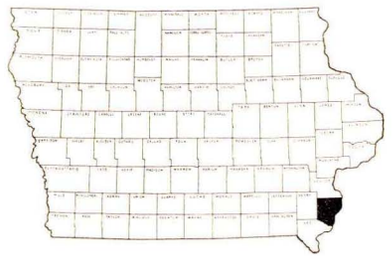

Fig. 2. Map showing the location of Des Moines County, Iowa

The total area of the county is 409 square miles or 261,760 acres. Of this area 248,593 acres or 95 percent is in farm land. The total number of farms is 1,907 and the average size of the farms is 130 acres. The farms are operated by 1,088 owners, 250 relative renters, 382 renters, 178 owning and renting and 9 unclassified. The following figures from the Iowa Yearbook of Agriculture for 1925 show the utilization of the farm land of the county.

Acreage in general farm crops	139,153
Acreage in farm buildings, public highways and feed lots	8,733
Acreage in pasture	93,782
Acreage in waste land not utilized for any purpose	3,452
Acreage in farm wood lots used for timber only	3,015
Acreage in crop land lying idle	170
Acreage in crops not otherwise listed	1,550

THE TYPE OF AGRICULTURE IN DES MOINES COUNTY

The predominant type of agriculture in Des Moines County at the present time consists of a combination of growing corn, oats and other general farm crops and raising and feeding hogs and cattle. It is the modified type of livestock farming which is sometimes referred to as general farming. The most important crops in the county are largely utilized for feeding purposes on the farms, the surplus corn and oats being sold from some farms. Wheat is a cash crop in the county. The raising and feeding of hogs and cattle are the important livestock industries and a large part of the income on most of the farms is derived from these industries. Dairying is practiced to some extent and other livestock industries are of minor or local significance in the county. On individual farms, considerable income is derived from trucking, from orcharding and from some special crops. The sale of surplus corn, oats, wheat and other general farm crops and of livestock, however, are the most important sources of income on the average farm.

A considerable area of waste land is found in the county and in some instances much of this land might be reclaimed and made productive by proper methods of soil treatment. General recommendations cannot be given for the reclamation of such land because of the fact that the infertility is due to

*See soil survey of Des Moines County, Iowa, by T. H. Benton of the Iowa Agricultural Experiment Station and E. B. Lowe of the U. S. Dept. of Agriculture, Field Operations of the Bureau of Soils, 1921.

various conditions and the same treatment will not serve for all. In a later section of this report, treatments which will be desirable for use under special soil conditions will be suggested. Where the conditions are more or less abnormal, farmers may secure advice regarding the treatment of their soils upon request, from the Soils Section of the Iowa Agricultural Experiment Station.

CROPS GROWN IN DES MOINES COUNTY

The general farm crops grown in Des Moines County in the order of their importance are: corn, oats, wheat, timothy and clover, clover, and rye. Barley, millet, sorghum, alfalfa and potatoes are crops of minor importance. The average yields and value of these crops grown in the county are given in table I.

Corn is the leading crop in the county being grown in 1925 on 29.98 percent of the total farm land. Average yields of this crop in that year amounted to 45.1 bushels per acre. The chief variety grown is Reid's Yellow Dent. Boone County White and Iowa Silvermine are popular varieties of white corn. The corn is largely husked from the standing stalks and fed to cattle and hogs. A small part is cut for silage. Hogging-down is becoming a more extensive practice. In good seasons some surplus produced in the northwestern part of the county is sold on the markets. Some seed corn, mostly Reid's Yellow Dent, is shipped out each year.

Oats is the second crop in acreage being grown, in 1925, on 11.82 percent of the total farm land. The value of this crop, however, is smaller than the value of the hay crop. Average yields of oats, in 1925, amounted to 39 bushels per acre. The chief varieties grown are Iowa 103, Iowa Silvermine, Iowa 105, Kherson, Early Champion and Texas Red. The early varieties usually yield much better than the later varieties, especially on the heavier soils. Over half the crop is generally fed, the remainder being sold as a cash crop mostly in Chicago and St. Louis. Large quantities are shipped from the elevators at Middletown, Yarmouth and Danville.

TABLE I. AVERAGE YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN DES MOINES COUNTY, IOWA*

Crop	Acreage	Percent of total farm land of county	Bushels or tons per acre	Total bushels or tons	Average price	Total value of crop
Corn	74,350	29.98	45.1	3,353,185	$0.56	$1,877,783
Oats	29,387	11.82	39.0	1,157,756	0.32	370,481
Winter wheat	10,590	4.26	16.0	169,440	1.36	230,438
Spring wheat	17	0.007	10.0	170	1.30	221
Barley	135	0.05	18.0	2,430	0.57	1,385
Rye	284	0.11	14.0	3,976	0.80	3,180
Potatoes	549	0.22	52.0	28,548	2.35	67,087
Tame hay	20,768	8.35	1.5	31,152	13.50	420,552
Wild hay	53	0.02	1.0	53	10.50	556
Alfalfa	1,095	0.44	3.1	3,394	17.50	59,395
Pasture	93,782	32.93	----	--------	-----	--------

*Iowa Yearbook of Agriculture, 1925.

The third crop in acreage is tame hay, which was grown in 1925, on 8.35 percent of the total farm land. The value of this crop is second only to that of corn in the county. Timothy and clover make up about half of the hay acreage. Average yields of tame hay amount to about one and one-half tons per acre. Considerable timothy is grown alone, particularly in Franklin, Pleasant Grove, and Yellow Spring townships. Seed is harvested from about four-fifths of this crop in some seasons. The area in 1925 devoted to timothy from which seed was grown, amounted to 666 acres, or 0.26 percent of the total farm land of the county. In the same year, clover was grown on 1,259 acres, the crop being used mainly for the production of seed and the value of the clover seed produced in that year was considerable. With the exception of the utilization of timothy and clover for the production of seed as noted, most of the hay is fed. Small quantities raised along the Mississippi River bottoms are baled and marketed at Burlington.

There is a very small area in wild hay and this crop is chiefly produced in old sloughs in the Mississippi River bottoms, where water stands for a part of the year.

Wheat is the fourth crop in acreage, being grown, in 1925, on 4.26 percent of the total farm land. Winter wheat is grown almost exclusively, there being only a small acreage in spring wheat. The average yield of winter wheat, in 1925, amounted to 16 bushels per acre. Turkey is the principal variety grown. In favorable seasons yields of wheat may be very much larger, especially on the soils of the Mississippi River bottoms in the northeast corner. Most of the crop is shipped out of the county. Elevators at Oakville, just over the county line and at Huron, handle most of the wheat grown. A small part is sold to the flour mills at Burlington.

Rye is grown on a small acreage and average yields of this crop amount to 14 bushels per acre. It is produced particularly on the sandy soils around Spring Grove, being pastured in the spring and plowed under the latter part of June when melons are planted. There are small areas of barley, buckwheat, kafir, and millet in various parts of the county. Some Sudan grass is grown and sorghum is raised in small quantities for forage and for syrup production.

Alfalfa is grown to only a limited extent but when the soil is properly drained and limed, and the seed is inoculated, good yields may be secured. Average yields, in 1925, amounted to 3.1 tons per acre. The value of the alfalfa crop is considerable and it should be more extensively grown.

Soy beans are being grown to some extent, chiefly the Ito San, Mongol, and Black Eyebrow varieties. Other legumes grown include beans, peas, vetch and sweet clover.

Potatoes are produced to a limited extent. In most cases not enough are grown to supply the home demand. Average yields of potatoes amount to 52 bushels per acre.

The trucking industry is developed somewhat extensively in the vicinity of Burlington and at Spring Grove on the sandy terrace soils. Large quan-

tities of sweet corn, tomatoes and cucumbers are grown and supplied to the canning factories at Burlington and sold on the local markets. Onions, asparagus, sweet potatoes, celery and other vegetables are produced for local use. Melons are grown on the sandy terraces and on the river bottom soils and considerable income is derived in many cases from this crop. Ordinarily most of the crop is sold on the local markets.

Orchards are found on practically all farms but in most cases the fruit produced serves merely to supply the home demand. There are a few commercial orchards. The chief varieties of apples which are grown in these orchards are the Jonathan, Grimes Golden, Northwestern Greening and Ben Davis. Most of the small fruits and tree fruits grown commercially are produced in the vicinity of Burlington. Plums, cherries and pears do well. Small fruits including strawberries, blackberries, gooseberries and currants are grown in quantities for the local markets. There are some vineyards along the Mississippi River bluffs and in normal seasons some grapes are shipped out of the county. Many years from 125 to 200 carloads of apples are sold on the outside markets.

THE LIVESTOCK INDUSTRY IN DES MOINES COUNTY

The extent of the livestock industry in Des Moines County is indicated in the following figures taken from the Iowa Monthly Crop Report of July 1, 1926. These figures are the January 1, 1926, estimates of the U. S. Department of Agriculture, Division of Crop and Livestock estimates:

Horses	8,700
Mules	700
All cattle	24,800
Hogs	67,400
Sheep	7,500

The raising of hogs is the most extensive livestock industry. The Poland China breed predominates, followed in order by the Duroc Jersey, Chester White and Hampshire. There are a large number of purebred herds in the county but on most farms the herds are Poland China grades. Some hogs are shipped in for feeding. The hogs are sold on the Chicago, St. Louis and Boston markets. About half of the livestock shipped is marketed thru the nine farm co-operative shipping associations.

The raising and feeding of cattle is the second livestock industry in importance. The beef cattle raised on the farms are mostly grade Shorthorns, with some Angus, Durham and Herefords. Purebred herds are Herefords, Durhams, Shorthorns, and Angus, in the order of their popularity. Western feeders, grade Herefords and Shorthorns are shipped in annually for feeding. On January 1, 1926, there were 24,800 head of cattle in the county. A large proportion of this number represents the beef cattle. Most of the finished cattle are marketed in Chicago, the rest going mainly to St. Louis.

Dairying is practiced to some extent in the vicinities of some of the larger towns. Most of the commercial dairy herds are Holsteins. There are some Guernseys, Jerseys and milking Shorthorns. The average farmer keeps from 7 to 12 cows, mostly Shorthorns. The cream is separated on the farm and

sold to the local creameries or cream-buying stations. Very little butter is made on the farms. In 1921, there were 163 silos in the county and 11,464 tons of silage were put up. The dairy industry is not extensively developed in the county but dairying provides considerable income on many farms.

In the southwestern and northern parts of the county, a few purebred Percheron horses are raised. In general, however, very few horses are raised in the county. Likewise there are very few mules.

There are a number of small flocks of sheep, especially in the rougher sections. They are mostly grades of the Shropshire and Delaine breeds. Some western grade feeders are shipped in, in certain parts of the county. On January 1, 1926, there were 7,500 sheep. There are a few small herds of goats.

There is some poultry on every farm and in some cases the sale of poultry and poultry products provides a considerable source of revenue. Chickens are raised mostly, with some ducks and geese and a few guineas and turkeys. Rhode Island Reds, Plymouth Rocks, White Leghorns, Wyandottes and Orpington are the most popular breeds. Poultry products are handled largely by the local dealers who ship the eggs and live and dressed poultry to Boston and Chicago.

THE FERTILITY CONDITIONS IN DES MOINES COUNTY SOILS

Crop yields are in the main quite satisfactory on most of the Des Moines County soils but in many cases much larger crops might be secured if proper methods of handling the soils were employed.

Many of the types are lacking in organic matter and applications of farm manure would be very valuable. The preservation and application of all the farm manure produced on the farms of the county would mean considerable increases in crop yields. Where farm manure is not produced in sufficient quantities to supply all the land on the farm, leguminous crops should be grown as green manures and turned under to supply organic matter to the soil. Especially on the coarser textured or sandy soils, the turning under of leguminous crops would be of particular value. Green manuring is an important farm practice as a supplement to farm manuring or as a substitute for that treatment and it should undoubtedly be practiced to a greater extent in the county than is the case at present.

The soils of the country are all acid in reaction and if the best growth of general farm crops, particularly of legumes, is to be secured, the application of lime is very necessary to many of these soils. They should all be tested for acidity or lime requirement and the amount of lime shown to be necessary according to such tests should be applied. In many cases the application of lime to these acid soils will mean the difference between a highly satisfactory and profitable crop and no crop at all. Farmers in Des Moines County should have their soils tested regularly for lime needs and apply lime before they make any attempt to grow a legume.

There is a deficiency in phosphorus in most of the soils in the county and the application of a phosphate fertilizer would undoubtedly be of value in

many cases. Experiments and some farm experience have indicated that large increases in crop yields may be secured by the proper application of acid phosphate or rock phosphate. In some instances the acid phosphate seems preferable while in other cases the rock phosphate may be quite as satisfactory. Tests of these two phosphates on individual soil types on the various farms of the county are urged.

The use of complete commercial fertilizers may be desirable in many cases on the soils of Des Moines County where truck crops are grown. For general farm crops, probably acid phosphate will prove quite as profitable as the complete fertilizer, or perhaps even more economically profitable because of the greater cost of the complete fertilizer. For truck crops, however, complete brands which are especially designed for certain crops may frequently be used with profit. Tests of these particular brands are recommended for the truck soils in the county. In some cases, nitrogenous fertilizers and potassium fertilizers may give large increases in the case of special crops and tests of these materials along with acid phosphate should be carried out to determine the response of the particular crops on the individual soil types.

In some cases the drainage conditions are not entirely satisfactory on individual soil types and when this is the case the type should be thoroly drained if satisfactory crop yields are to be secured. On the Grundy silty clay loam and the Marion silt loam on the uplands, drainage is not entirely satisfactory. On the Bremer soils on the terraces, drainage is almost certain to be poor and on some of the bottomland soils drainage is inadequate.

Erosion occurs to a limited extent in the county. One or two of the soil types show some effects of erosion, notably the Clinton silt loam and the Lindley silt loam on the loessial and drift uplands. Particularly in the case of the Lindley silt loam is the washing action of water evident and the formation of gullies noted. Where this destructive action occurs, some means of control or prevention should be adopted.

THE GEOLOGY OF DES MOINES COUNTY

The geological history of the county need not be considered in detail inasmuch as the earlier geological formations have no effect whatever upon the present soil conditions. The soils of the county are derived entirely from the loessial deposits and the earlier glacial deposits. The native rock materials underlying these deposits are so deeply buried that they have no effect whatever upon the characteristics of the soil.

During the glacial age, probably three great glaciers swept over the county, but there is very little evidence remaining of the first, the pre-Kansan. The second great glacier was known as the Kansan and the drift deposit underlying the loessial covering in the county is mainly derived from the debris left by this glacier. In its unweathered condition the Kansan till is a bluish-gray clay containing many boulders and pebbles. When weathered, the material becomes a red or reddish-brown in color gradually changing to a yellow. There is some evidence of a third glacier, the Illinoisan, but the

SOIL MAP OF DES MOINES COUNTY

Thomas D. Rice, Inspector, Northern Division. Soils Surveyed by T. H. Benton, in charge Iowa Agricultural Experiment Station and E. P. Lowe, U. S. Dept. of Agriculture.

U. S. DEPT. OF AGRICULTURE, BUREAU OF SOILS
Milton Whitney, Chief. Curtis F. Marbut, in charge Soil Survey

IOWA AGRICULTURAL EXPERIMENT STATION
C. F. Curtiss, Director W. H. Stevenson, in charge Soil Survey
P. E. Brown, Associate in Charge

LEGEND

Terrace Soils

- 12 — Bremer loam
- 193 — Bertrand silt loam
- 88 — Bremer silt loam
- 194 — Plainfield sand
- 97 — Plainfield fine sandy loam
- 81 — Jackson silt loam
- 40 — Buckner sandy loam
- 43 — Bremer silty clay loam
- 42 — Calhoun silt loam
- 101 — Davenport silty clay loam

Swamp and Bottomland Soils

- 53 — Riverwash
- 48 — Wabash silty clay loam
- 49 — Wabash loam
- 70 — Genesee very fine sandy loam
- 26 — Wabash silt loam
- 18 — Cass loam
- 51 — Cass silty clay loam
- 71 — Genesee silt loam
- 28 — Sarpy very fine sandy loam
- 195 — Ray silt loam
- 19 — (unlabeled)

Drift Soil

- 32 — Lindley silt loam

Loess Soils

- 64 — Grundy silt loam
- 80 — Clinton silt loam
- 120 — Tama silt loam
- 115 — Grundy silty clay loam
- 67 — (unlabeled)

Scale: 1 inch 2½ Miles

effect of this drift deposit is of little significance from the soil standpoint. In general the drift deposits covered the rock materials to a great depth, in some places as much as 175 feet of drift being found.

At a later date in geological history, following the glacial age, there was deposited, over the entire county, a layer of loess. This was a fine silt-like material which was deposited by the wind, climatic conditions being very different then than at present. In its unweathered condition, the loess is a yellow to light gray silt loam to silty clay loam. Weathering agents which have acted upon it since its deposition have caused it to lose its original lime content and the accumulation of plant materials has brought about a darkening in color. In depth this loess layer is quite variable, in many cases being rather thin. In some areas it may extend to a depth of 25 feet. The upland soils of the county are entirely derived from this loessial material with the exception of the Lindley loam, in which the subsoil has come from the Kansan drift deposit.

PHYSIOGRAPHY AND DRAINAGE

In topography Des Moines County is mainly gently undulating on the upland plain. This plain has a general slope to the southeast. The upland is divided into two parts by the valley of the Flint River which flows southeastward thru the center of the county. The areas between the streams are broad and flat except on the edge of the plain where the cutting action of many short tributary streams has brought about the formation of a somewhat rough to hilly topography. Near Mediapolis, Yarmouth and Middletown the tops of the broad divides are almost level and the drainage lines have not entered there. On the eastern edge of the plain there is a line of bluffs with a drop of 150 to 175 feet to the flat bottomland plain along the Mississippi River. In many places on these bluffs, the underlying limestone rock is exposed in perpendicular or overhanging edges on the higher parts of the bluff walls. Sometimes the bluffs are 5 to 25 feet in height where the limestone is exposed. The lower parts of the slopes, from the upland to the alluvial plain, are made up of drift and loess material, washed down from the uplands. Along the Skunk River on the south, the border of the upland plain is less abrupt and rough and there is a more gentle slope to the bottomlands. On both the south and east sides there are small ravines and gorges.

The areas of terrace land and first bottoms occurring along the rivers in the county are flat and bench-like, the terraces lying from 4 to 20 feet above overflow. The bottomlands are largely subject to overflow but all are suitable for cultivation. Many of the terrace and bottomland soils have been modified in character by the washing down of material from the uplands, forming colluvial coverings.

The drainage of the county is brought about by the Mississippi River with its larger tributaries, the Flint and Skunk Rivers which carry the greater parts of the surface drainage of the county. The broad area of bottomland soils extends in a belt about five miles in width, southward to near Burlington where it narrows down to one and one-fourth miles. Here the Flint

Fig. 3. Map Showing Natural Drainage System of Des Moines County.

River has cut thru the Mississippi flood plains. Numerous bayous, sloughs and lakes are found thruout the entire Mississippi River bottoms. The old bayous and sloughs are most numerous near the active river channel.

There is a levee roughly paralleling the river and located near the bank which extends from the northern county line to a point one-half mile north of the junction of the Flint and Mississippi Rivers. About 30,000 acres of bottomland soils are protected by this levee from overflow. Three pumping plants carry the drainage water from the enclosed levee district from reservoirs over the levee into the river. Large artificial drainage channels carry the water from the upland streams and from the lakes and sloughs to the reservoir. Many of the former lakes and sloughs are now thoroly drained and considerable areas of this black bottomland soil have been reclaimed.

South of Burlington where the Skunk River enters the Mississippi River bottoms, the bottomland plain is not protected by a levee and much of this land is overflowed regularly.

Skunk River with its small tributaries drains about one-sixth of the county. The valley of this river is narrow and V-shaped. There is a narrow, flat second bottomland adjacent to the valley. The principal tributaries are Spring Creek, Brush Creek and Long Creek. There are narrow strips of bottomland soils along all these streams.

The Flint River with its tributaries carries approximately two-fifths of the drainage of the county. In the upper part of the river, the flood plains are narrow and the valley walls are steep. Towards the south the valley widens out and there are narrow areas of terrace soils. On the south side, the valley wall is almost perpendicular and limestone rocks are exposed. The drainage in the extreme northern part of the county is largely carried northward into Louisa County. Several small creeks flowing thru deep narrow gorges carry the drainage of the eastern part of the county directly into the Mississippi River.

In general the drainage of the county is quite adequate, some of the streams or their tributaries extending into practically all parts of the upland. The accompanying map indicates the extent of the natural drainage system of the county.

There are two or three of the individual soil types which would be benefited by drainage but in general the soils are fairly well drained. The Grundy silty clay loam and the Marion silt loam on the loessial uplands, the Bremer soils and the Calhoun silt loam on the terraces and some of the Wabash types on the bottoms may be in need of drainage in some cases. In general, however, the drainage of areas of these types is easily accomplished by the installation of tile, outlets for the tile being readily available.

THE SOILS OF DES MOINES COUNTY

The soils of Des Moines County are grouped into four groups or classes according to their origin and location. These classes are drift soils, loess soils, terrace soils, and swamp and bottomland soils. Drift soils are those which have been formed by the material carried by glaciers and left on the surface of the land upon the retreat of the glacier. They are variable in composition and contain pebbles and frequently boulders. Loess soils are fine dustlike deposits made by the wind at some time when climatic conditions were very different than at present. Terrace soils are old bottomlands which have been raised above overflow by a decrease in the volume of the streams which deposited them or by depressions in the river channels. Swamp and bottomland soils are those occurring in low, poorly drained areas or along streams and many of them are subject to more or less frequent overflow. The extent and occurrence of these groups of soils in Des Moines County are given in table II.

Slightly over two-thirds or 67 percent of the total area of the county is

TABLE II. AREAS OF DIFFERENT GROUPS OF SOILS IN DES MOINES COUNTY

Soil Group	Acres	Percent
Drift soils	29,824	11.4
Loess soils	175,232	67.0
Terrace soils	8,704	3.2
Swamp and bottomland soils	48,000	18.4
Total	261,760	----

covered by the loessial soils. The one drift soil in the county covers 11.4 percent of the area. There is only 3.2 percent of terrace or second bottom soils in the county. Swamp and bottomland soils are developed quite extensively along the Mississippi River and the total area in this group of soils amounts to 18.4 percent of the county.

There are 26 individual soil types and these with the area of riverwash make a total of 27 soil areas. There is one drift soil, five loess soils, ten terrace types and eleven areas of swamp and bottomland soils including the area of riverwash. The various soil types are distinguished on the basis of certain definite characteristics which are described in a later section of this report. The names which have been given to the individual soil types are indicative of these characteristics. The occurrence of the individual soil types in the county is shown in table III.

The Lindley silt loam is the only drift soil and it is the third most extensive type. It is found on 11.4 percent of the total area. The Grundy silt loam is the most extensive individual soil type and the largest loess soil. It occurs on 31.1 percent of the total area. The Clinton silt loam is the second largest loess soil and the second most extensively developed type, covering 21.6 percent of the total area. The Tama silt loam is the third largest loess soil and the fifth most extensively developed type. It is found on 7.2 percent of the total area. The Grundy silty clay loam, the fourth largest loess soil, is the sixth most extensive type, covering 4.8 percent of the total area. The Marion silt loam is the smallest of the loess soils. It occurs on 2.3 percent of the total area.

The terrace soils are all limited in occurrence, the most extensively developed type, the Bremer loam, being found on only 0.9 percent of the total area. The remaining terrace soils cover less than one-half of a percent of the total area of the county.

The Wabash silty clay loam is the most extensively developed bottomland soil and it is the fourth largest type in the county. It covers 9.7 percent of the total area. The Wabash loam is the second largest bottomland soil but it is of minor importance, covering only 2.6 percent of the total area. The Genesee very fine sandy loam is the third bottomland type, covering 1.6 percent of the area. The Wabash silt loam covers 1.4 percent and the Cass loam, 1.2 percent of the county. The remaining bottomland soils are of very minor significance covering less than one-half of one percent of the total area.

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN DES MOINES COUNTY

Soil No.	Soil type	Acres	Percent of total area of county
	DRIFT SOILS		
32	Lindley silt loam	29,824	11.4
	LOESS SOILS		
64	Grundy silt loam	81,344	31.1
80	Clinton silt loam	56,512	21.6
120	Tama silt loam	18,816	7.2
115	Grundy silty clay loam	12,480	4.8
67	Marion silt loam	6,080	2.3
	TERRACE SOILS		
12	Bremer loam	2,432	0.9
193	Bertrand silt loam	1,152	0.4
88	Bremer silt loam	1,088	0.4
194	Plainfield sand	896	0.3
97	Plainfield fine sandy loam	896	0.3
81	Jackson silt loam	832	0.3
40	Buckner sandy loam	768	0.3
43	Bremer silty clay loam	320	0.1
42	Calhoun silt loam	192	0.1
101	Davenport silty clay loam	128	0.1
	SWAMP AND BOTTOMLAND SOILS		
48	Wabash silty clay loam	25,344	9.7
49	Wabash loam	6,720	2.6
70	Genesee very fine sandy loam	4,160	1.6
26	Wabash silt loam	3,840	1.4
18	Cass loam	3,264	1.2
51	Cass silty clay loam	1,216	0.5
71	Genesee silt loam	1,024	0.4
28	Sarpy very fine sandy loam	1,024	0.4
195	Ray silt loam	832	0.3
19	Cass sandy loam	512	0.2
53	Riverwash	64	0.1
	Total	261,760	----

There is a striking relationship between the individual soil types of the county and the topographic conditions. On the drift uplands the Lindley silt loam has a rough to rolling topography. On the loessial upland the Grundy soils are gently rolling to level in topography. The Marion silt loam is found on a rather level topographic plain and the Tama silt loam is found on the more rolling uplands. The Clinton silt loam occurs on the strongly rolling to rough or hilly areas.

On the terraces or second bottoms there are few topographic differences among the soil types. The Bremer soils, however, are generally found on the lower, level to depressed areas of second bottomland while the Plainfield, Jackson and Buckner soils occur on the higher terraces. These soils are older and some topographic features are occasionally developed on older terraces. The bottomland soils show no characteristic topographic features but they are all more or less level and cut only by old stream channels. They contain depressed areas showing the former occurrence of old sloughs, lakes or bayous.

THE FERTILITY IN DES MOINES COUNTY SOILS

Samples were taken for analysis from each soil type in the county. The area of riverwash was not sampled. The more extensive soil types were sampled in duplicate but only one sample was taken from each of the minor types. Samplings were all made with the utmost care that the samples should be representative of the particular type and that any variations due to previous treatments of the soil might be eliminated. Samples were taken at three depths, 0 to 6 2/3 inches, 6 2/3 to 20 inches and 20 to 40 inches, representing the surface soil, the subsurface soil and the subsoil respectively.

The samples were all analyzed for total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirement. The official methods were followed in the determination of the phosphorus, nitrogen and carbon and the Truog qualitative test was used in the determination of the limestone requirement. The figures given in the tables are the averages of the results of duplicate determinations on all samples of each type.

THE SURFACE SOILS

The results of the analyses of the surface soils are given in table IV. They are calculated on the basis of two million pounds of surface soil per acre.

TABLE IV. PLANT FOOD IN DES MOINES COUNTY, IOWA, SOILS

Pounds per acre of 2 million pounds of surface soil (0-6⅔″)

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
32	Lindley silt loam	633	1,880	24,525	------	4,000
	LOESS SOILS					
64	Grundy silt loam	1,037	3,683	46,688	------	8,000
80	Clinton silt loam	579	2,080	24,797	------	6,000
120	Tama silt loam	969	3,400	39,240	------	8,000
115	Grundy silty clay loam	1,441	4,720	58,860	------	2,000
67	Marion silt loam	942	2,720	33,790	------	8,000
	TERRACE SOILS					
12	Bremer loam	808	2,300	33,245	------	8,000
193	Bertrand silt loam	875	1,620	20,165	------	2,000
88	Bremer silt loam	1,185	3,720	41,956	------	8,000
194	Plainfield sand	431	260	5,177	------	6,000
97	Plainfield fine sandy loam	282	540	7,630	------	4,000
81	Jackson silt loam	929	2,080	25,342	------	6,000
40	Buckner sandy loam	915	1,580	21,800	------	6,000
43	Bremer silty clay loam	1,077	3,260	40,875	------	4,000
42	Calhoun silt loam	1,104	1,520	19,075	------	2,000
101	Davenport silty clay loam	1,118	3,700	40,602	------	8,000
	SWAMP AND BOTTOMLAND SOILS					
48	Wabash silty clay loam	1,064	3,920	47,687	------	6,000
49	Wabash loam	1,266	3,680	45,235	------	6,000
70	Genesee very fine sandy loam	875	1,300	16,895	------	500
26	Wabash silt loam	2,141	3,740	86,745	------	4,000
18	Cass loam	1,293	2,360	31,610	------	4,000
51	Cass silty clay loam	1,495	3,200	37,060	------	2,000
71	Genesee silt loam	983	1,840	23,707	------	500
28	Sarpy very fine sandy loam	1,239	1,480	23,435	------	1,000
195	Ray silt loam	983	1,600	25,070	------	500
19	Cass sandy loam	956	1,320	20,982	------	8,000

There is an extremely wide variation in the content of phosphorus in the various soil types in this county. The amount ranges from 282 pounds per acre in the Plainfield fine sandy loam up to 2,141 pounds in the Wabash silt loam. No relationship can be traced between the phosphorus content of the soils and the various soil groups. The drift soil, the Lindley silt loam, is quite low in phosphorus but it is the only drift soil in the county, and should not be compared with the average of the loess soils. Some of the terrace and bottomland soils are much higher in phosphorus than the loessial upland types, and the average of the bottomland soils would be somewhat higher. This might be expected inasmuch as crop production has been more extensive on the upland soils and there has been a greater removal of plant food constituents. The terrace soils are much lower in phosphorus on the average than the loessial uplands. This is particularly true of the Plainfield types which are very poorly supplied with all plant food constituents.

There are greater variations in the phosphorus content in the individual soil types than there are in the averages for the different soil groups. Certain relationships between the characteristics which serve to determine the soil series and the phosphorus content of the individual soils may be traced in these results. Thus the Grundy soils on the loessial uplands are better supplied than the other types. The Tama soils come next and the Marion and Clinton soils are the poorest in phosphorus. There is a relationship here to the topographic condition, to the color of the soil, and to the subsoil characteristics. All of these characteristics serve to distinguish the individual soil series. Similarly on the terraces, the Bremer, Calhoun and Davenport soils, on the average, are better supplied with phosphorus than the Plainfield, Jackson, Buckner and Bertrand soils. On the bottomlands the Wabash types are better supplied than the other soils. The Cass types are richer than the Genesee and Sarpy soils.

There are some interesting correlations among the individual soil types with regard to textural relationships. On the loessial uplands, the Grundy silty clay loam is richer than the Grundy silt loam. On the terraces the Bremer silt loam and silty clay loam are richer than the Bremer loam, there being little difference between the silt loam and silty clay loam. On the bottomlands the Wabash silt loam is higher than the loam. Both, however, contain more phosphorus than the silty clay loam. This would seem to indicate that the silty clay loam is probably somewhat abnormal as it will usually run much higher than the coarser textured types. The Cass silty clay loam is better supplied with phosphorus than the Cass loam, the Genesee silt loam is higher than the very fine sandy loam. The Cass sandy loam is lower than the loam or silty clay loam.

In general these results bear out previous conclusions which have seemed to show that soils which are more gently rolling to level in topography, blacker in color and with heavier textured subsoils and fine textured surface soils, are better supplied with phosphorus. Silty clay loams and clay loams are usually richer than the coarser textured soils. Silt loams are richer than loams and loams are better supplied than sandy loams and other sandy types.

It is apparent from these analyses that the content of phosphorus in the uplands and terrace soils of the county is very low in most cases. Most of the bottomland types are not rich in phosphorus. Only in one or two cases is there any large amount present. The application of phosphorus fertilizers to the soils of this county will obviously be needed in the very near future in order to secure the best crop growth on these soils.

The nitrogen content of the soils of the county is quite variable, almost as variable as the content of phosphorus. It ranges from 260 pounds per acre in the Plainfield sand up to 3,920 pounds in the Wabash silty clay loam. These are not the same types which were the lowest and highest respectively in phosphorus but it is interesting to note that they are of the same series.

There is no relation between the nitrogen content of the soils and the various soil groups. It does not even seem that the terrace and bottomland soils are any richer on the average than the loess soils on the upland. There is more variation in general in the nitrogen content of the individual soil types than in the averages of the types in different groups.

The same characteristics which have been noted as affecting the phosphorus content of the soil have an influence on the nitrogen supply. Thus the color of the soil, the topographic position and the characteristics of the subsoil play a part in determining the nitrogen content of the soil. The Grundy soils on the loessial upland are richer in nitrogen than the other types. The Tama soils come next and these are followed by the Marion and Clinton types. The Grundy soils are darker in color, more level in topography and have heavier subsoils than the other types.

On the terraces the Bremer and Davenport soils are richer in nitrogen than the other types. The Buckner, Calhoun and Bertrand types are more poorly supplied with nitrogen. The Jackson silt loam seems to be somewhat higher than some of the other types, contrary to the usual results on this soil. The Plainfield soils are the poorest. In general the relationships mentioned above hold true. Those soils which are darker in color, like the Bremer soils, level in topography and with heavier subsoils are higher in nitrogen. Again, on the bottomlands, the Wabash soils are richer than the other types. The Cass soils are better supplied than the Genesee and Sarpy and they are darker in color, altho they have a light or coarse textured subsoil in comparison with the Genesee which has a heavy subsoil. The relation shown here would seem to indicate the predominant effect of color over subsoil character.

In addition to those characteristics which serve to differentiate soil series, there are some interesting relations among the individual soil types based on textural differences. Thus the Grundy silty clay loam is richer in nitrogen than the silt loam. The Bremer silty clay loam and silt loam are higher than the loam. There is little difference between the silty clay loam and the silt loam. Ordinarily the silty clay loam would run a little higher than the silt loam. The Plainfield fine sandy loam is higher in nitrogen content than the Plainfield sand. The Wabash silty clay loam is higher than the loam or silt loam. The silt loam is a little bit richer than the loam. The Cass silty clay loam is very much higher than the loam or sandy loam and the loam

is better supplied than the sandy loam. The Genesee silt loam is richer in nitrogen than the very fine sandy loam. These comparisons show a very definite correlation between the texture of the soil and the content of nitrogen.

While most of the soils in the county are fairly well supplied with nitrogen, this element must not be overlooked in planning systems of permanent fertility. In the case of some of the soils like the Plainfield type there is an actual deficiency in nitrogen and the use of fertilizing materials supplying nitrogen is very necessary on these soils. In many other cases the application of nitrogen-containing fertilizers would prove of value.

The application of farm manure returns to the land considerable amounts of the nitrogen removed from the land by the crops. When farm manure is not available or when there are not sufficiently large amounts of this material to apply to the land, leguminous crops should be grown and turned under as green manure in the soil. By these means the nitrogen content of the soil may be maintained without the use of commercial nitrogenous fertilizers.

The total organic carbon content of the soils varies in very much the same way as the total nitrogen content. The amount present ranges from 5,177 pounds in the Plainfield sand to 86,745 pounds in the Wabash silt loam. Again it will be noted that the Plainfield soils are low in organic carbon and therefore low in organic matter and the Wabash soils are high. There is no relationship between the organic carbon content and the various soil groups. There are, however, certain relations to the soil series and to the individual soil types. The characteristics which determine the soil series and which have been mentioned earlier, all seem to play a part in determining the organic carbon content or the organic matter present in the soil. Again it will be seen that those soils, which are blacker in color, more level in topography and with heavier subsoils, are in general richer in organic matter. The Grundy soils on the loessial uplands are higher in organic matter than the other types. The Tama soils are better supplied than the Marion and Clinton types. On the terraces, the Bremer and Davenport soils are better supplied than the other terrace types. The Plainfield soils are the lowest. On the bottomlands, the Wabash types are the richest while the Cass soils are better supplied than the Sarpy and Genesee types.

The relationships between the organic matter content and the textural conditions in the soils are shown by some comparisons. Thus the Grundy silty clay loam is richer in carbon or organic matter than the silt loam. The Bremer silty clay loam and silt loam are better supplied than the Bremer loam. Again there is little difference between the silt loam and the silty clay loam. In many cases the silty clay loam would show a higher content. The Plainfield fine sandy loam is richer than the Plainfield sand. The Wabash silt loam is richer than the Wabash silty clay loam, which probably means that the latter type is somewhat abnormal as ordinarily it would show a higher content of organic matter than the silt loam. Both are higher than the Wabash loam. The Cass silty clay loam is higher than the Cass loam which in turn is better supplied than the Cass sandy loam. The Genesee silt loam is

richer in organic matter than the Genesee very fine sandy loam. It is apparent that in general there is a very close correlation between the texture of the soil and the content of organic matter. Heavy textured types like silty clay loams and clay loams are richer in nitrogen and organic carbon and usually also richer in phosphorus than the lighter textured soils. Soils which are black in color are higher in organic matter and nitrogen. Soils which are found on level to flat areas are likewise richer in these constituents. Finally those types which have heavy impervious subsoils are better supplied with these plant food elements than are the types which have more open and porous subsoils.

The relationship between the content of total nitrogen and organic carbon in soils indicates something regarding the fertility of the soil as the proportionate amounts of these two constituents shows roughly how much available plant food is being produced in the soil. In some of the soil types in Des Moines County, the relation between the nitrogen and carbon is such that there is definite evidence that the supply of available plant food is not being produced sufficiently rapidly for the best crop growth. This is particularly noted in the case of the Clinton silt loam, the Tama silt loam and the Marion silt loam on the loessial uplands. A number of the terrace types show this same condition, particularly the Bertrand silt loam, the Bremer silt loam, the Jackson silt loam, the Buckner sandy loam, the Calhoun silt loam and the Davenport silty clay loam. Some of the bottomland types are similarly in a condition where available plant food is not being produced properly. In all these soils the application of farm manure would be of particular value for stimulating the production of available plant food and its use is strongly urged.

While many of the soils in the county are fairly well supplied with organic matter, the addition of humus supplying materials is necessary at regular intervals in order to keep up the content in the soil. The application of farm manure is very desirable to aid in keeping up the supply of organic matter in the soil. Where farm manure is not available in sufficient amounts to supply all the land, the use of well inoculated leguminous crops, as green manures is very desirable. Crop residues should also be thoroly incorporated with the soils in this county to aid in maintaining the supply of organic matter.

None of the soils of the county show any content of inorganic carbon and all are acid in reaction. The acidity extends down thru the three-foot section in all the types. The amount of lime which is required by the various soil types in the county is indicated by the figures given in the table. These should not be considered definite, however, as there is a wide variation in the lime requirements of different soils and even in the requirements of the same soil type in different samples of the same soil or in different parts of the same field. The figures are merely indicative in showing the lime requirements of the various types.

It is apparent that the soils of the county are all acid in reaction and if the best growth of general farm crops, and particularly of legumes is to be secured, the soils should be tested and lime should be applied as needed.

THE SUBSURFACE SOILS AND SUBSOILS

The results of the analyses of the subsurface soils and subsoils are given in tables V and VI. They are calculated on the basis of 4,000,000 pounds of subsurface soil and 6,000,000 pounds of subsoil per acre.

The results given in these tables will not be considered in detail here inasmuch as the conclusions to be reached from their study are very much the same as those arrived at from a consideration of the analyses of the surface soils. Unless there is a large content of some plant food constituent or a very striking deficiency in certain elements, the analyses of the surface soils will indicate quite accurately the needs of the soils in the field. If the lower soil layers contain about the same amount of plant food constituents or only proportionately less, there will be little effect on the fertility needs of the surface soil.

It may merely be emphasized here that these analyses confirm the conclusions reached in the discussion of the results secured with the surface soils. Applications of phosphorus fertilizers will certainly be needed in the very near future and indeed it seems certain that they will be effective in many cases at the present time.

TABLE V. PLANT FOOD IN DES MOINES COUNTY, IOWA, SOILS

Pounds per acre of 4 million pounds of subsurface soil (6⅔″-20″)

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
32	Lindley silt loam	1,534	1,440	21,800	------	4,000
	LOESS SOILS					
64	Grundy silt loam	1,393	4,000	52,138	------	7,500
80	Clinton silt loam	1,050	2,000	17,440	------	6,000
120	Tama silt loam	1,480	4,760	56,680	------	8,000
115	Grundy silty clay loam	2,128	3,960	52,320	------	1,000
67	Marion silt loam	1,184	2,040	22,890	------	8,000
	TERRACE SOILS					
12	Bremer loam	834	1,560	19,620	------	6,000
193	Bertrand silt loam	1,642	1,640	19,620	------	2,000
88	Bremer silt loam	1,320	3,760	38,695	------	8,000
194	Painfield sand	996	280	6,540	------	4,000
97	Plainfield fine sandy loam	726	800	10,900	------	4,000
81	Jackson silt loam	1,372	1,840	18,530	------	8,000
40	Buckner sandy loam	1,372	2,640	35,325	------	6,000
43	Bremer silty clay loam	1,830	4,240	53,410	------	2,000
42	Calhoun silt loam	1,293	1,520	17,440	------	2,000
101	Davenport silty clay loam	1,454	5,240	52,865	------	8,000
	SWAMP AND BOTTOMLAND SOILS					
48	Wabash silty clay loam	1,724	3,920	50,685	------	2,000
49	Wabash loam	2,396	6,920	83,385	------	6,000
70	Genesee very fine sandy loam	1,696	3,960	35,970	------	500
26	Wabash silt loam	3,448	6,280	71,395	------	4,000
18	Cass loam	2,182	3,160	39,240	------	6,000
51	Cass silty clay loam	2,450	3,200	40,330	------	2,000
71	Genesee silt loam	1,778	2,800	40,875	------	500
28	Sarpy very fine sandy loam	2,046	2,440	38,150	------	1,000
195	Ray silt loam	2,558	6,480	77,935	------	1,000
19	Cass sandy loam	1,347	2,520	27,795	------	4,000

TABLE VI. PLANT FOOD IN DES MOINES COUNTY, IOWA, SOILS
Pounds per acre of 6 million pounds of subsoil (20″-40″)

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
32	Lindley silt loam	2,586	1,800	21,255	------	8,000
	LOESS SOILS					
64	Grundy silt loam	1,643	2,960	32,639	------	6,000
80	Clinton silt loam	2,544	1,920	16,350	------	8,000
120	Tama silt loam	1,614	3,480	35,970	------	5,000
115	Grundy silty clay loam	3,030	2,280	21,843	------	------
67	Marion silt loam	2,301	1,920	24,525	------	8,000
	TERRACE SOILS					
12	Bremer loam	1,010	2,160	22,890	------	4,000
193	Bertrand silt loam	2,463	2,640	25,342	------	4,000
88	Bremer silt loam	1,454	4,800	37,605	------	8,000
194	Plainfield sand	969	240	7,357	------	2,000
97	Plainfield fine sandy loam	1,212	840	11,450	------	4,000
81	Jackson silt loam	3,069	2,760	18,802	------	8,000
40	Buckner sandy loam	2,139	3,480	47,415	------	6,000
43	Bremer silt clay loam	1,899	3,720	49,050	------	1,000
42	Calhoun silt loam	2,544	1,560	14,715	------	8,000
101	Davenport silty clay loam	1,414	4,920	44,962	------	8,000
	SWAMP AND BOTTOMLAND SOILS					
48	Wabash silty clay loam	1,414	3,360	45,780	------	1,000
49	Wabash loam	2,220	5,280	56,407	------	6,000
70	Genesee very fine sandy loam	2,181	3,360	28,612	------	500
26	Wabash silt loam	3,756	7,680	101,370	------	1,000
18	Cass loam	1,697	1,560	23,707	------	5,000
51	Cass silty clay loam	3,675	2,880	45,780	------	1,000
71	Genesee silt loam	2,745	2,400	49,050	------	500
28	Sarpy very fine sandy loam	1,776	1,080	19,620	------	1,000
195	Ray silt loam	2,463	6,360	78,480	------	1,000
19	Cass sandy loam	1,980	960	16,350	------	2,000

The supply of organic matter and nitrogen is not overly high in some of the soils but in many types it is apparently quite adequate. In some cases these is a definite need for supplying some fertilizing material which contains nitrogen and organic matter to build up the supply of these constituents in the soil. Furthermore, in order to maintain the content of these plant foods in the soil, any system of management should include the application of farm manure, the turning under of all crop residues and the use of leguminous crops as green manures. These are the common and most profitable methods of keeping up the organic matter and nitrogen content of the soil.

In all the types there is a deficiency in lime and the tests indicate that the soils are strongly acid in reaction. Much evidence has been secured of the value of applying lime to acid soils and emphasis should be given here to the significance of testing the soils in the county and applying lime as it is needed if the best growth of farm crops and particularly of legumes is to be secured.

GREENHOUSE EXPERIMENTS

One greenhouse experiment was carried out on the Clinton silt loam from Des Moines County to determine the fertilizer needs and learn the value of the application of certain fertilizing materials. The experiments which were carried out on the Grundy silt loam from Louisa County and on the Clinton

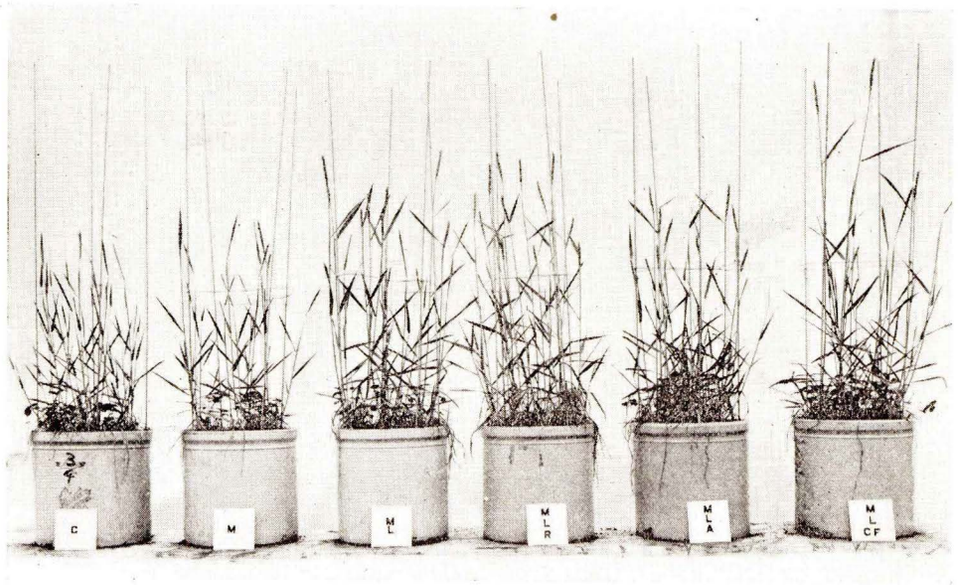

Fig. 4. Greenhouse Experiment on Clinton Silt Loam, Des Moines County.

silt loam, the Grundy silty clay loam and the Marion silt loam from Henry Country are also included. These soils are the same types as those occurring in Des Moines County and the results may, therefore, be considered to indicate quite definitely the effects from the same fertilizer treatments on the particular soils in Des Moines County.

The same fertilizers were tested in all the experiments and included manure, lime, rock phosphate, acid phosphate, and a complete commercial fertilizer. These materials were added in the amounts in which they are applied in the field and hence the results may be considered to indicate the fertilizer effects which may be secured on the farm.

Manure was added at the rate of 8 tons per acre, lime was applied in sufficient amounts to neutralize the acidity of the soil and supply 2 tons additional. Rock phosphate was added at the rate of 2,000 pounds per acre, acid phosphate at the rate of 200 pounds per acre, and a standard 2-8-2 complete commercial fertilizer at the rate of 300 pounds per acre. Wheat and clover were grown, the clover being seeded about one month after the wheat was up. In some of the tests only the wheat yields are given, the clover yields not being secured, and in other cases only the clover yields are given.

RESULTS ON CLINTON SILT LOAM

The results secured in the experiment on the Clinton silt loam from Des Moines County are given in table VII. The figures are the averages of the wheat grain harvested from the duplicate pots. The application of manure brought about a distinct increase in the yield of wheat. Lime in addition to manure gave a further increase in the wheat crop. The rock phosphate, acid phosphate and complete commercial fertilizer in addition to the manure

TABLE VII. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM
DES MOINES COUNTY

Pot No.	Treatment	Weight of wheat grain in grams
1	Check	6.0
2	Manure	8.4
3	Manure+lime	9.9
4	Manure+lime+rock phosphate	12.1
5	Manure+lime+acid phosphate	10.8
6	Manure+lime+complete commercial fertilizer	10.5

and lime all increased the yields, the rock phosphate giving the largest increase. The acid phosphate and complete fertilizer showed almost identical effects.

The value of the use of manure on this soil is very clearly indicated by the data. Lime is very necessary for the best growth of crops, its effect being most definitely shown on the legume crops in the rotation.

The use of a phosphate fertilizer is very desirable on the type. Whether or not rock phosphate or acid phosphate should be employed must be determined by special tests on individual soils. The complete commercial fertilizer did not give any greater effects than the acid phosphate and hence it cannot be recommended for general use.

RESULTS ON THE GRUNDY SILT LOAM FROM LOUISA COUNTY

The data secured from the experiment on the Grundy silt loam from Louisa County are shown in table VIII. Here the application of manure brought about a large increase in the yield of wheat and showed a definite gain in the case of clover. The application of lime did not show any large value in this experiment altho the yield on the manure and lime pots was not secured in the case of clover where the largest effects of the lime would be expected. The phosphates gave increased crop yields in the case of the clover but

Fig. 5. Clover on Clinton Silt Loam, Des Moines County.

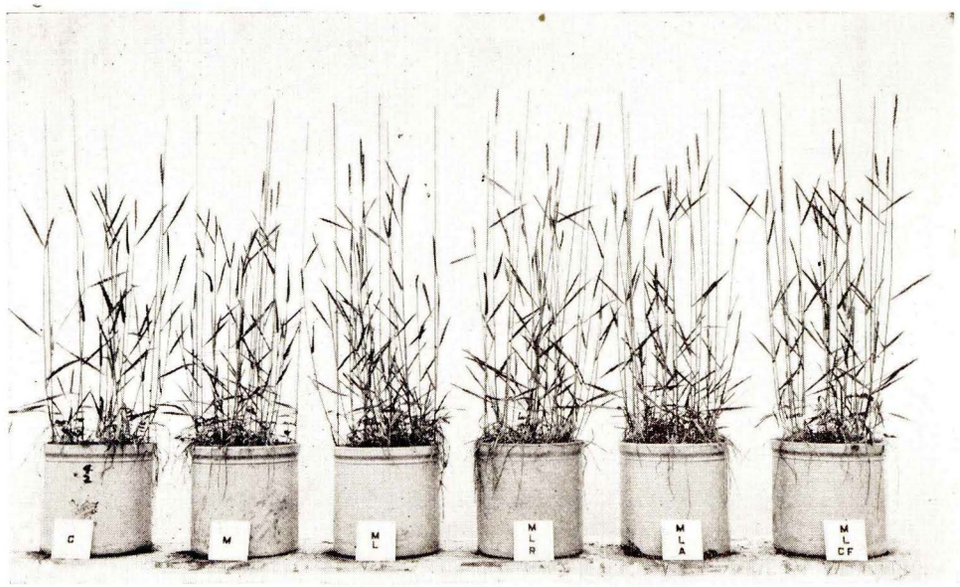

Fig. 6. Greenhouse Experiment on Grundy Silt Loam, Louisa County.

showed little effect on the wheat. The complete commercial fertilizer gave a large increase in the wheat yield and a slightly larger increase of clover than did the phosphates.

The results indicate that manure is a particularly valuable fertilizing material for the Grundy silt loam and profitable returns may always be expected from its use. When the soil is acid the application of lime is very desirable. While this particular test did not show any large effect of the lime, no great influence would be expected on wheat, as the greatest influence of lime is always shown on the legume crop. There are indications that phosphorus fertilizers either rock phosphate or acid phosphate may prove of value on this type. The complete commercial fertilizer showed up particularly well in this test. It is doubtful, however, if in general sufficiently greater returns would be secured from the use of a complete fertilizer over those brought about by a phosphate to warrant the use of the more expensive material.

TABLE VIII. GREENHOUSE EXPERIMENT, GRUNDY SILT LOAM
LOUISA COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	9.00	77.11
2	Manure	15.50	81.64
3	Manure+lime	15.00	-----
4	Manure+lime+rock phosphate	15.00	86.18
5	Manure+lime+acid phosphate	15.75	83.91
6	Manure+lime+complete commercial fertilizer	18.25	88.45

Fig. 7. Clover on Grundy Silt Loam, Louisa County.

RESULTS ON THE CLINTON SILT LOAM FROM HENRY COUNTY

The results secured on the Clinton silt loam from Henry County are given in table IX, only the yields of clover being secured. The application of manure increased the yield of clover on this soil, just as was noted in the experiment on the same type from Des Moines County. The application of lime along with the manure brought about a large increase in the yield. The rock phosphate had no beneficial effect but the acid phosphate gave a distinct increase. The complete fertilizer showed no increase.

These results serve to confirm the data given above in indicating that the Clinton silt loam will respond in a profitable way to the application of manure. to the use of lime to remedy acidity, and to the application of a phosphate fertilizer. It should be noted that in this test on clover, the acid phosphate showed up particularly well while the rock phosphate had no effect. In the earlier experiment on wheat, the rock phosphate had greater effect than the acid phosphate. These results would, therefore, serve to confirm the previous conclusion that tests of both rock phosphate and acid phosphate are desirable on this type. Apparently a complete commercial fertilizer would not be necessary nor as desirable for use on this soil as a phosphate.

RESULTS ON THE GRUNDY SILTY CLAY LOAM FROM HENRY COUNTY

The results secured on the Grundy silty clay loam from Henry County

TABLE IX. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM HENRY COUNTY

Pot No.	Treatment	Weight of clover in grams
1	Check	35.0
2	Manure	40.0
3	Manure+lime	56.0
4	Manure+lime+rock phosphate	49.0
5	Manure+lime+acid phosphate	63.0
6	Manure+lime+complete commercial fertilizer	56.0

TABLE X. GREENHOUSE EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY

Pot No.	Treatment	Weight of clover in grams
1	Check	40.0
2	Manure	53.0
3	Manure+lime	66.5
4	Manure+lime+rock phosphate	66.5
5	Manure+lime+acid phosphate	80.0
6	Manure+lime+complete commercial fertilizer	79.0

are given in table X, only the yields of clover being secured. Here the application of manure showed a very large effect on the clover crop. The use of lime with manure brought about a further increase in the crop yield. The rock phosphate had little influence but the acid phosphate and the complete commercial fertilizer gave very definite increases.

Apparently this soil will respond to the application of manure, lime, and a phosphate fertilizer. While the type is high in organic matter, black in color and apparently rich in fertility, the use of manure will often bring about large crop increases. The type is acid in reaction and the use of lime is very desirable for clover growing or for other legumes. The addition of a phosphate fertilizer is strongly urged. These results indicate the superiority of acid phosphate. Farmers are urged to test both materials on their own soils to determine which will be the more profitable. The complete commercial fertilizer did not give any larger effects than the acid phosphate and hence could not be recommended for general use.

RESULTS ON THE MARION SILT LOAM FROM HENRY COUNTY

The results secured on the Marion silt loam from Henry County are given in table XI. On this soil the application of manure gave a definite increase in the yield of wheat and more than doubled the yield of clover. The application of lime showed an increase on the wheat crop but had no effect on the clover. Ordinarily the use of lime on this soil will increase the growth of legumes. The application of rock phosphate showed no effect on the wheat but gave a very large increase in the clover. The acid phosphate had no effect on the wheat but the clover yield was increased to a very large extent, much greater than from the use of the rock phosphate. The complete commercial fertilizer gave a slight increase in the wheat yield and an

TABLE XI. GREENHOUSE EXPERIMENT, MARION SILT LOAM, HENRY COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	8.50	8.0
2	Manure	10.20	17.0
3	Manure+lime	11.85	12.0
4	Manure+lime+rock phosphate	11.45	25.0
5	Manure+lime+acid phosphate	11.10	39.0
6	Manure+lime+complete commercial fertilizer	12.22	36.0

increase in clover which was only slightly smaller than the increase brought about by the acid phosphate.

On this soil type it is apparent that the use of manure is very desirable. The soil is light in color and low in organic matter and a liberal application of manure is very necessary for improving the fertility conditions of the soil. If manure is not available, leguminous crops as green manures should be used, as it is important to build up the organic matter content of the soil. The type is acid in reaction and applications of lime will bring about considerable crop increases. In this test the wheat was increased and the clover was not. Ordinarily the reverse effect would be evidenced in the field. Legumes generally show a large increase while the grain crops frequently show no effect from the lime. The use of a phosphate fertilizer is very desirable on this type. This test indicates a superiority for acid phosphate, especially on clover, but the rock phosphate also brought about a large increase in clover. Apparently the use of one or the other of these phosphates may be expected to give profitable crop increases. The complete commercial fertilizer did not show as large an effect as the acid phosphate in the case of the clover and the difference was not great in the case of the wheat.

FIELD EXPERIMENTS

A field experiment has been started in Des Moines County but results have not been secured over a long enough period of years for the data to be of value at the present time. Tests are under way, however, in other counties adjacent to Des Moines County, on soil types which occur extensively in this county. The results secured on some of these fields will be presented here as they show quite clearly the effects of fertilizers which may be expected on the same soil types in this county. Experiments are included on the Grundy silt loam, on the Mount Pleasant field in Henry County, on the Grundy silt loam on the Agency field in Wapello County, on the Grundy silt loam and on the Marion silt loam on the West Point fields in Lee County, on the Clinton silt loam on the Princeton field in Scott County, and on the Grundy silty clay loam on the Mt. Union field in Henry County.

The field experiments have been carried out in the attempt to determine the value of various soil treatments and they are laid out on land which is representative of the individual soil type. The fields include 13 plots, each of which is 155′ 7″ by 28; or one-tenth of an acre in size. They are permanently located by the installation of corner stakes and precautions are taken to apply the fertilizer properly and to harvest the crops so that the results will be accurate.

The series of plots include tests under the livestock system of farming and under the grain system. In the former, manure is applied while in the latter, crop residues are employed. The other fertilizing materials tested include limestone, rock phosphate, acid phosphate and a complete commercial fertilizer. Manure is applied at the rate of eight tons per acre once in a four-year rotation. The crop residues treatment consists in plowing under the corn stalks which have been cut with a disc or stalk cutter and plowing under

at least the second crop of clover. Sometimes the first crop of clover is cut and allowed to remain on the land to be plowed under with the second. Lime is applied in sufficient amounts to neutralize the acidity of the soil and supply two tons additional. Rock phosphate is added at the rate of 2,000 pounds per acre once in a four-year rotation. Since 1923 the rock phosphate has been applied at the rate of 1,000 pounds once in four years. Acid phosphate is employed at the rate of 150 pounds per acre annually. Until 1923 the old standard 2-8-2 complete commercial fertilizer was employed, being applied at the rate of 300 pounds per acre annually. At the present time the new standard 2-12-2 is being used, application being made at the rate of 202 pounds per acre annually, thus applying the same amount of phosphorus as that contained in the 150 pounds of acid phosphate.

THE MOUNT PLEASANT FIELD

The results secured on the Grundy silt loam on the Mt. Pleasant field, series 100, are given in table XII. The application of manure has proven valuable on this soil as indicated by the increased crop yields secured. The beneficial effects of the manure are shown up particularly on the corn in 1920 and on the oats in 1926. Small increases were secured on these crops in other seasons. The application of lime along with the manure brought about crop increases which were very considerable in some years. The corn in 1917 showed a large increase due to the use of lime, and the same crop in 1920 was very materially increased. The oats in 1922 showed a very large effect from the lime. Smaller increases were secured in practically all years from the use of lime on this soil.

The application of rock phosphate gave definite increases in crops. There were large increases on the clover in 1919, on the corn in 1925, and on the oats in 1926. Acid phosphate likewise showed considerable influence on crop yields in all seasons and in all but one case brought about better results on crop growth than did the rock phosphate. The greater effect was particularly evidenced on the clover in 1919, on the corn in 1924, and on the oats in 1926. In some of the other seasons, the differences were not strikingly great but they were sufficiently definite to show the distinct superiority of the acid phosphate. The complete commercial fertilizer showed effects which were very similar to those brought about by the acid phosphate. In some cases the increases were somewhat larger while in other seasons the effects were less evident than those from the acid phosphate. On the average, it would seem that quite as large values may be secured from the use of the acid phosphate.

The crop residues showed little effect on the yields of the various crops. In a few instances small gains were noted. The application of lime along with the crop residues brought about increases in crop yields which in some cases were very distinct. This was true in the case of the oats in 1918 and the corn in 1920. In some of the other seasons the effects were shown but not so definitely. The rock phosphate and the acid phosphate brought about crop increases in practically all cases. In general the acid phosphate seemed to be somewhat more effective than the rock phosphate. The differences

TABLE XII. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY, MT. PLEASANT FIELD, SERIES 100

Plot No.	Treatment	1916 Corn bu. per A. (1)	1917 Corn bu. per A. (2)	1918 Oats bu. per A.	1919 Clover Tons per Acre: 1st crop	1919 Clover Tons per Acre: 2nd crop	1919 Clover Tons per Acre: Total	1920 Corn bu. per A. (3)	1921 Corn bu. per A. (4)	1922 Oats bu. per A. (5)	1923 Soy beans (6)	1924 Corn bu. per A.	1925 Corn bu. per A.	1926 Oats bu. per A. (7)
1	Check	27.4	36.0	72.3	2.22	1.65	3.87	34.5	54.3	35.9	------	50.7	41.2	20.5
2	Manure	22.2	37.5	75.1	2.29	1.50	3.79	57.0	56.7	39.8	------	54.0	35.9	30.4
3	Manure+lime	15.3	55.2	74.8	2.34	1.65	3.99	76.6	59.5	62.1	------	58.7	40.6	35.9
4	Manure+lime+rock phosphate	40.4	66.0	76.5	2.78	2.15	4.93	81.8	67.5	63.3	------	66.0	50.6	47.3
5	Manure+lime+acid phosphate	55.9	73.6	85.1	3.72	2.75	6.47	77.7	72.8	70.1	------	60.7	64.4	66.4
6	Manure+lime+complete commercial fertilizer	54.1	76.8	80.8	3.68	3.25	6.93	67.5	64.9	70.6	------	62.0	63.7	70.9
7	Check	47.9	60.1	76.5	2.20	2.20	4.40	65.6	60.7	56.1	------	54.0	54.1	40.2
8	Crop residues	41.7	50.8	81.3	2.30	------	------	67.5	65.7	54.5	------	52.0	55.0	40.6
9	Crop residues+lime	30.3	47.1	93.2	2.22	------	------	80.6	66.1	49.0	------	55.3	56.2	39.9
10	Crop residues+lime+rock phosphate	30.4	52.7	96.4	2.85	------	------	90.0	65.0	57.9	------	57.7	56.5	38.8
11	Crop residues+lime+acid phosphate	30.6	54.7	99.9	3.21	------	------	75.5	66.9	54.8	------	59.3	57.2	48.4
12	Crop residues+lime+complete commercial fertilizer	27.0	52.8	93.6	3.15	------	------	51.2	67.1	61.9	------	59.7	58.1	47.3
13	Check	21.1	48.3	72.3	2.18	2.00	4.18	45.0	59.1	42.3	------	50.0	52.8	30.6

1. Season wet, corn weedy but good quality.
2. Short season, early frost.
3. Cattle trampled plot 1.
4. Corn not uniform.
5. Three tons lime applied, oats thin and down. Smartweed bad in 11 and 12.
6. No records on account of weeds.
7. Low yield due to very dry season and considerable rust.

were not large in some seasons, but in one or two cases as with the clover in 1919, and the oats in 1926, the acid phosphate proved very much superior to the rock phosphate. In one or two cases the rock phosphate had more effect than the acid phosphate. The complete commercial fertilizer in general showed about the same effect as the acid phosphate, in some seasons showing a smaller effect and in other cases a greater effect.

In general it would seem from the results on this field that the Grundy silt loam will respond readily to applications of manure, lime, and a phosphate fertilizer. Acid phosphate rather than rock phosphate seems to be preferable for use with manure and lime. However, definite conclusions as to the relative value of the two materials cannot be drawn.

The results secured on the Grundy silt loam on the Mt. Pleasant field, Series 200, in Henry County, are given in table XIII. Here again the beneficial effects of manure are evidenced by increased crop yields secured in every season. In some cases very large increases were noted as on the oats in 1921, and on the clover in 1926. In all cases, however, the increases were definite. The application of lime along with manure increased the crop yields in practically all seasons. In some cases very large increases were noted as on the corn in 1924 and on the clover in 1926. The corn in 1920 also showed a large increase. The use of rock phosphate with the manure and lime gave large increases in some seasons, showing up particularly well on the oats in 1921, on the clover in 1922 and in 1926, and on the oats in 1925. In general, the

TABLE XIII. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY, MT. PLEASANT FIELD, SERIES 200

Plot No.	Treatment	1919 Corn bu. per A.	1920 Corn bu. per A.	1921 Oats bu. per A. (1)	1922 Clover tons per A. (2)	1923 Corn bu. per A.	1924 Corn bu. per A.	1925 Oats bu. per A.	1926 Clover tons per A. (3)
1	Check	55.7	48.1	36.9	1.6	61.3	49.3	50.9	0.10
2	Manure	66.3	51.2	46.9	1.9	77.3	58.0	55.0	0.60
3	Manure+lime	74.1	69.8	35.3	2.1	85.0	72.7	50.9	1.05
4	Manure+lime+rock phosphate	78.6	66.4	42.6	2.4	84.5	70.4	65.9	1.31
5	Manure+lime+acid phosphate	75.3	77.2	48.9	2.4	77.6	73.3	64.8	1.43
6	Manure+lime+complete commercial fertilizer	66.5	81.2	46.5	2.7	80.0	65.7	60.4	1.15
7	Check	50.6	64.0	33.7	2.1	58.3	44.3	47.1	0.52
8	Crop residues	65.3	75.5	43.1	2.3	64.6	35.3	47.6	0.52
9	Crop residues+lime	71.0	76.3	40.0	2.6	73.3	34.7	56.1	0.76
10	Crop residues+lime+rock phosphate	75.1	75.1	43.8	2.5	69.0	38.0	52.5	0.86
11	Crop residues+lime+acid phosphate	81.1	85.1	43.5	2.5	68.0	40.7	63.2	0.96
12	Crop residues+lime+complete commercial fertilizer	78.5	90.1	42.2	2.6	74.3	41.3	60.4	0.99
13	Check	65.8	64.1	31.1	1.7	60.3	39.3	43.8	0.39

1. Three tons lime applied, oats lodged in spots.
2. Two crops on all but crop residue plots.
3. Plots 7 to 13 were partly burned off in April. Check plots badly infested with weeds.

effects were less evident and in some seasons were not shown at all on the corn. The acid phosphate had a greater effect than the rock phosphate in some seasons, showing better results on the corn in 1920, on the oats in 1921, and on the clover in 1926. In other seasons the results brought about were slightly less or the same as those obtained when the rock phosphate was used. The complete commercial fertilizer had larger effects than the acid phosphate in one or two cases, notably on the corn in 1920 and on the clover in 1922. In most of the other seasons, however, the beneficial effects were less evident than those brought about by the acid phosphate.

The use of crop residues showed an effect on some of the crops grown but the influence was not great. The use of lime with the crop residues showed beneficial effects on most of the crops. The clover in 1922 and 1926 was increased very definitely. The corn was increased in 1923, and the oats in 1925. In the other seasons, the effects of the lime were small and not definite. The use of rock phosphate proved valuable on practically all of the crops grown. In some cases the increases were not large and in one or two instances no increases at all were noted. The acid phosphate showed larger effects than the rock phosphate in practically all seasons. The influence was much greater on the corn in 1920, on the oats in 1925, and on the clover in 1926. In the other seasons, the results were about the same or slightly less than those brought about by the rock phosphate. The complete commercial fertilizer brought about better results than the acid phosphate in one or two cases, but in general the differences were small and there was no evidence of a superiority of the commercial fertilizer over the acid phosphate.

It is apparent that the conclusions drawn from the data secured in series 100, on the Mt. Pleasant field, are borne out by these results. The beneficial effects of manure are very definitely shown. The value of lime is demonstrated by the increases in crop yields secured when it was used with manure or with crop residues. Applications of phosphate fertilizers are clearly shown to be valuable, in some cases acid phosphate proving more desirable when used with lime and manure and also when applied with the crop residues and lime. In some instances rock phosphate seemed to be quite as beneficial as the acid phosphate. The use of a complete commercial fertilizer did not seem to be any more effective than the use of acid phosphate.

THE AGENCY FIELD

The data secured from the field experiment on the Grundy silt loam on the Agency field in Wapello County are given in table XIV. The beneficial effect of manure on this soil is evidenced by the increases in crops which were noted in practically all seasons. The best results were obtained on the oats in 1919, on the hay in 1921 and 1922, and on the oats in 1925. The use of lime with manure brought about crop increases in practically all seasons. The beneficial effects of the lime were evidenced particularly on the hay crops but large increases were also noted on the corn and oats. Rock phosphate with manure and lime increased the crop yields in every season. The hay crops were particularly benefited by the rock phosphate and considerable

TABLE XIV. FIELD EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY, AGENCY FIELD

Plot No.	Treatment	1918 Corn bu. per A. (1)	1919 Oats bu. per A.	1920 Winter wheat bu. per A. (2)	1921 Clover and timothy tons per A. (3)	1922 Timothy tons per A. (4)	1923 Corn bu. per A.	1924 Corn bu. per A.	1925 Oats bu. per A.	1926 Winter wheat bu. per A. (5)
1	Check	63.5	44.9	22.7	1.92	2.00	72.7	46.4	66.2	21.7
2	Manure	64.5	62.2	31.5	2.09	2.20	71.8	51.9	70.8	19.0
3	Manure+lime	66.8	58.3	36.7	2.20	2.25	79.2	52.2	73.8	21.8
4	Manure+lime+rock phosphate	68.8	63.6	38.7	2.52	2.30	86.8	54.0	80.6	35.3
5	Manure+lime+acid phosphate	70.0	66.6	40.0	2.39	2.80	85.4	60.2	77.9	38.9
6	Manure+lime+complete commercial fertilizer	66.0	65.6	34.7	2.52	2.50	83.0	55.4	77.3	30.7
7	Check	59.3	54.5	------	1.82	2.30	69.7	43.3	67.8	14.7
8	Crop residues	58.5	49.0	31.4	1.81	2.20	66.3	43.7	66.4	18.7
9	Crop residues+lime	61.3	59.5	43.8	2.02	2.40	71.3	50.7	72.1	18.6
10	Crop residues+lime+rock phosphate	61.8	61.2	36.4	2.33	2.65	73.1	54.9	75.9	26.0
11	Crop residues+lime+acid phosphate	63.5	61.2	36.3	2.19	2.75	80.7	55.5	74.6	------
12	Crop residues+lime+complete commercial fertilizer	62.5	63.6	35.6	2.17	2.65	70.4	54.4	78.4	------
13	Check	52.5	52.0	22.8	1.56	2.40	63.9	42.7	58.5	------

1. Corn damaged slightly by hail in July and dry weather in August.
2. Sample No. 7 lost in transit; wheat down badly. Light dressing of manure to all plots by mistake in winter of 1920. Lime applied in November.
3. Pastured after first crop.
4. Pastured after first crop.
5. Wet weather prevented seeding of plots 11, 12, 13.

increases were secured on the wheat in 1926, on the oats in 1919, and on the corn in 1923. Acid phosphate brought better results than the rock phosphate in practically all seasons. There were no strikingly large differences, however, except in the case of the hay crop in 1922. In 1921 the rock phosphate gave a slightly larger increase in yield, and similarly in 1925 on the oats and in 1923 on the corn, but in none of these cases was the difference very significant. The complete commercial fertilizer generally showed somewhat smaller effects than the acid phosphate. Only on the hay crop in 1921 was there any greater increase from the commercial fertilizer. In some cases the rock phosphate gave larger increases than did the complete commercial fertilizer.

The crop residues showed little effect on the various crops grown. Lime, used with the crop residues brought about increased crop yields in practically every season. Only in the case of the wheat in 1926 was there no increase from the use of lime. In some seasons, and on some crops the beneficial effects were quite definite. This was particularly true of the hay crops in 1921 and in 1922. The application of rock phosphate gave increases in crop yields in practically every year. In some instances the increases

were very definite, as on the hay crops in 1921 and 1922 and on the wheat crop in 1926. The acid phosphate showed larger effects than the rock phosphate in several seasons. It had a smaller effect than the rock, however, on the clover in 1921, on the oats in 1925, and practically the same effect on the oats in 1919, and on the wheat in 1920. The complete commercial fertilizer gave very similar increases to those brought about by the use of acid phosphate. In 1923 the complete fertilizer showed no effect on the corn.

The results secured on the Grundy silt loam in this field confirm those obtained on the same soil type on the Mt. Pleasant field. They indicate the value of application of manure to the soil and the beneficial effect of applying lime when the soil is acid. The use of a phosphate fertilizer is certainly very desirable on this type, either with manure and lime under the livestock system of farming or with crop residues and lime under the grain system.

THE WEST POINT FIELD

The results secured on the Grundy silt loam on the West Point field No. 1, series 1, in Lee County are given in table XV. Here again the application of manure brought about considerable increases in crop yields in most seasons. The most beneficial effects of the manure were evidenced on the corn in 1922,

TABLE XV. FIELD EXPERIMENT, GRUNDY SILT LOAM, LEE COUNTY, WEST POINT FIELD NO. I, SERIES I

Plot No.	Treatment	1918 Corn bu. per A. [1]	1919 Oats bu. per A.	1920 Clover and timothy tons per A.	1921 Corn bu. per A. [2]	1922 Corn bu. per A.	1923 Oats bu. per A. [3]	1924 Clover tons per A. [4]	1925 Corn bu. per A.	1926 Corn bu. per A. [5]
1	Check	58.4	44.2	1.87	64.0	80.2	56.0	0.25	46.7	31.5
2	Manure	59.7	41.5	1.87	68.3	93.3	57.5	0.42	62.7	46.6
3	Manure+lime	58.0	43.5	2.89	72.5	98.1	61.3	1.08	61.7	47.1
4	Manure+lime+rock phosphate	56.5	43.5	3.06	63.5	97.7	62.9	1.09	61.5	46.9
5	Manure+lime+acid phosphate	56.0	61.9	3.12	70.0	94.6	71.5	1.24	63.0	37.6
6	Manure+lime+complete commercial fertilizer	57.7	50.3	3.74	72.5	96.1	75.0	1.28	64.2	34.2
7	Check	54.8	37.4	2.38	67.5	83.3	61.3	0.36	46.2	24.6
8	Crop residues	55.4	36.0	2.72	66.0	80.7	56.1	0.51	48.2	28.4
9	Crop residues+lime	55.4	43.5	3.14	70.1	88.2	64.5	0.88	50.2	27.8
10	Crop residues+lime+rock phosphate	58.0	43.5	3.23	67.9	87.3	61.3	0.94	55.7	31.9
11	Crop residues+lime+acid phosphate	60.5	46.2	2.63	68.1	84.0	66.3	0.92	54.2	28.9
12	Crop residues+lime+complete commercial fertilizer	56.0	43.5	3.57	62.3	87.8	59.5	0.91	55.0	24.5
13	Check	58.0	47.6	2.38	54.4	77.2	39.1	0.30	47.0	27.2

1. Crops on all plots injured by hot winds.
2. Corn down badly due to storms in September.
3. Two tons lime April 11.
4. Low yields due to very dry season.
5. Wireworms did considerable damage, also wet weather damaged some corn.

1925 and 1926. The other crops were also increased to a considerable extent, in the main, by the use of the manure. Lime with manure brought about appreciable increases in crop yields in most cases. The largest effect of the lime, as would be expected, was evidenced on the clover and timothy in 1920 and on the clover in 1924. Considerable increases were secured, however, on some of the other crops in the rotation. The application of rock phosphate did not show any large effect on the crops grown on this field. Only in the case of the clover and timothy in 1920 was there any considerable increase in the yields. In several seasons no increases at all were noted. The acid phosphate with manure and lime brought about very noticeable crop increases in several seasons. The oats in 1919, the clover and timothy in 1920, the oats in 1923, and the clover in 1924, were all increased very appreciably by the application of the acid phosphate. In one or two cases the acid phosphate apparently did not prove valuable from the standpoint of crop increases. The yield in 1926 should not be considered significant as the crops in that season were materially injured. In general the acid phosphate increased the crop yields to a marked extent. The complete commercial fertilizer showed slightly greater effect than the acid phosphate in several cases, particularly in 1920 on the clover and timothy. In many cases, however, it did not bring about as large increases in crops as did the acid phosphate.

The crop residues brought about slight crop increases in several cases but the effects were not large. Applications of lime with the residues increased the crop yields to an appreciable extent in several seasons. The effect on the clover and timothy in 1920 and on the clover in 1924 was particularly noticeable. Yields of corn and oats were considerably increased by the use of lime. The application of rock phosphate with the crop residues and lime increased the yields in most seasons but the increases were not large in any case. The acid phosphate with the crop residues and lime had slightly larger effects than the rock phosphate, but in several cases did not show any more beneficial effect than did the rock. The complete commercial fertilizer gave about the same results as the acid phosphate in most cases. In one or two cases there was a greater effect as on the clover and timothy in 1920 and on the corn in 1922 but in several other cases there was a less beneficial effect from the complete fertilizer.

These results bear out, in a very striking way, the results secured on the same soil type on the Mt. Pleasant and Agency fields. Apparently the Grundy silt loam will respond very profitably to applications of manure, lime and a phosphate fertilizer. Acid phosphate in some cases seems to be preferable but rock phosphate often is quite as good.

THE WEST POINT FIELD NO. II

The results secured on the Marion silt loam on the West Point field No. II, series I in Lee County are given in table XVI. The application of manure to this soil type brought about very striking crop increases in most seasons. In 1922, the yield of clover and timothy was more than doubled. In several

TABLE XVI. FIELD EXPERIMENT, MARION SILT LOAM, LEE COUNTY, WEST POINT FIELD NO. II, SERIES I

Plot No.	Treatment	1918 Oats bu. per A. (1)	1919 Clover tons per A.	1920 Corn bu. per A. (2)	1921 Oats bu. per A. (3)	1922 Clover and timothy tons per A. (4)	1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Clover tons per A.	1926 Corn bu. per A.
1	Check	46.7	1.45	24.5	27.7	1.20	43.4	38.8	1.08	37.3
2	Manure	55.2	1.59	43.0	28.7	2.70	62.6	66.4	1.57	56.0
3	Manure+lime	55.2	1.87	37.2	28.7	2.80	62.4	66.8	1.73	60.2
4	Manure+lime+rock phosphate	51.3	1.91	45.5	38.4	3.00	68.5	66.4	1.92	53.1
5	Manure+lime+acid phosphate	55.2	2.60	41.5	42.9	3.60	69.3	76.6	2.03	52.9
6	Manure+lime+complete commercial fertilizer	55.2	2.85	46.5	46.6	3.60	69.8	86.4	2.01	58.6
7	Check	38.2	1.63	33.5	32.5	1.60	49.6	40.3	1.02	41.1
8	Crop residues	34.0	1.50	27.0	27.4	1.70	46.9	41.0	1.26	36.2
9	Crop residues+lime	38.2	1.55	30.5	30.2	1.90	48.0	41.0	1.35	30.4
10	Crop residues+lime+rock phosphate	36.1	2.07	32.0	35.0	2.60	48.5	54.4	1.41	25.6
11	Crop residues+lime+acid phosphate	38.2	2.68	30.5	24.4	3.20	54.9	56.9	1.45	28.5
12	Crop residues+lime+complete commercial fertilizer	51.3	2.73	27.0	42.3	2.90	56.4	53.0	1.72	38.4
13	Check	34.0	1.65	25.5	27.4	2.40	51.7	35.2	1.20	36.8

1. Four tons lime November 1917.
2. Wet spring made crop poor.
3. Three tons lime September. Plots 3 and 11 low yields due to injury to samples.
4. Stand of clover irregular.

cases the yields of oats were almost doubled and in one or two instances this was true with the corn. On all the crops there was a very beneficial effect from the manure. The use of lime with manure brought about small but definite increases in the crops in practically all seasons. The application of rock phosphate with the manure and lime brought about increases in crop yields in practically all cases. Sometimes very considerable increases were secured as in the case of the clover and timothy in 1922, the clover in 1925, the corn in 1920 and the oats in 1921. In most other seasons increases were secured. The crop was poor and irregular in 1926, hence the yields in that season should not be considered of significance. Acid phosphate with manure and lime brought about much larger increases than the rock phosphate in several cases. The larger beneficial effects were evidenced on the clover in 1919, on the clover and timothy in 1922, on the oats in 1924 and on the clover in 1925. In most of the other seasons there was a slightly larger effect from the acid phosphate. The complete commercial fertilizer gave a somewhat greater effect than the acid phosphate in one or two cases but the differences, with the exception of the oats in 1924, were not large enough to be of great significance. In most cases the increases were very similar to those brought about by the acid phosphate.

Very little influence of the crop residues was evidenced on the different crops grown on this soil. Only in the case of the clover in 1925 was there any evidence of a beneficial effect which was significant. The use of lime with the crop residues increased the crop yields in practically every season, in some cases very considerable increases being secured. The application of rock phosphate with the crop residues and lime gave considerable increases in the yield of clover in 1919, in the clover and timothy in 1922, and in the oats in 1924. In several other seasons definite increases in yields were secured. The acid phosphate brought about much greater results than the rock phosphate on the clover in 1919 and on the clover and timothy in 1922. In several other seasons larger effects from rock phosphate were evidenced and only in one case was the yield lower with the acid phosphate and this is explained because of an injury to the samples of oats taken on that plot. The complete commercial fertilizer showed somewhat larger effects than the acid phosphate in several seasons. The oats in 1918, the clover in 1925, and the corn in 1926 were increased considerably more by the complete fertilizer than by the acid phosphate, but in three or four seasons the acid phosphate proved somewhat superior.

These results indicate that the Marion silt loam will respond in a very profitable way to applications of manure, lime and a phosphate fertilizer. The addition of liberal amounts of manure to this type which is light in color and low in organic matter is very desirable for the best growth of crops. Large increases in yields of general farm crops will follow the use of manure on this soil. Where manure is not available in sufficient amounts leguminous green manures should be employed and would certainly bring about profitable crop increases. The application of lime is necessary as the soil is acid and there will be very favorable results on the legume crops of the rotation and generally also on other farm crops. Rock phosphate and acid phosphate both brought about crop increases, the acid phosphate seeming to be somewhat superior in most cases. The complete commercial fertilizer at times gave somewhat larger effects than the acid phosphate particularly with the crop residues and lime under the grain system of farming. With manure and lime, the acid phosphate seems preferable because it brought about quite as large increases and it is less expensive for application.

THE PRINCETON FIELD

The results secured on the Clinton silt loam on the Princeton field, series I, in Scott County are given in table XVII. The application of manure increased the crop yields on this soil in practically all seasons. In some cases very considerable increases were secured, as for example on the wheat in 1925, and on the clover in 1926. The corn in 1923 was also very largely increased and the clover in 1922 showed a gain. The use of lime with manure increased still further the yields of crops on this soil, the beneficial effects being particularly evidenced on the clover in 1922 and 1926. Increases in the yields of corn, wheat and oats were also secured in practically

TABLE XVII. FIELD EXPERIMENT, CLINTON SILT LOAM, SCOTT COUNTY, PRINCETON FIELD, SERIES I

Plot No.	Treatment	1918 Winter wheat bu. per A. (1)	1919 Corn bu. per A. (2)	1920 Corn bu. per A. (3)	1921 Oats bu. per A.	1922 Clover tons per A. (4)	1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Winter wheat bu. per A. (5)	1926 Clover tons per A.
1	Check	40.7	69.3	61.8	27.7	1.41	54.0	65.8	13.6	0.96
2	Manure	37.4	67.6	68.3	28.4	1.93	63.2	64.8	22.6	1.57
3	Manure+lime	43.0	68.2	70.6	32.1	2.13	70.2	65.3	27.5	2.06
4	Manure+lime+rock phosphate	47.4	67.8	73.5	31.9	2.25	72.5	63.1	32.1	2.08
5	Manure+lime+acid phosphate	45.2	64.0	70.8	35.1	2.29	73.2	75.1	31.8	2.31
6	Manure+lime+complete commercial fertilizer	37.3	68.4	73.0	36.4	2.34	68.1	71.9	32.4	2.15
7	Check	31.7	57.0	57.5	24.4	1.60	53.0	62.2	16.9	0.73
8	Crop residues	------	52.6	58.6	29.6	1.47	55.2	66.4	15.5	0.72
9	Crop residues+lime	31.7	62.4	67.3	29.7	2.14	61.8	65.6	23.8	1.35
10	Crop residues+lime+rock phosphate	35.0	64.1	68.7	29.8	2.28	65.0	63.4	26.7	2.06
11	Crop residues+lime+acid phosphate	31.7	66.6	61.5	31.1	2.18	68.0	75.1	27.1	2.03
12	Crop residues+lime+complete commercial fertilizer	36.2	65.2	69.5	30.8	------	70.1	73.5	28.3	2.25
13	Check	28.2	59.3	59.5	25.5	------	58.6	54.4	17.5	0.98

1. Three tons lime applied August, 1917. Yield on plot 8 error.
2. Clover poor and plowed up.
3. Plot 11 many missing hills, low yields.
4. Yields on plots 13 and 14 lost due to error.
5. Stand of wheat very thin due to extreme dry spring.

every season, in some cases the yields on these grain crops being surprisingly large.

The addition of rock phosphate with the manure and lime increased the yields of crops in most seasons. The gains, however, were not generally large. The acid phosphate with the manure and lime gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of the acid phosphate were no greater or less than those brought about by the use of rock phosphate. The clover in 1926 and the oats in 1924 showed the largest effects from the addition of the acid phosphate. The complete commercial fertilizer with the manure and lime gave somewhat greater effects than the acid phosphate in some seasons, but in others the beneficial influence was less and in no case was there any considerable gain from the use of the complete fertilizer over that induced by the addition of acid phosphate.

The crop residues had little effect on the various crops grown, bringing about slight increases in some seasons. Lime with the residues increased the crop yields in a very noticeable way on the clover in 1922 and 1926. Very considerable gains were also brought about on the corn in 1919, 1920 and 1923. Rock phosphate with the crop residues and lime increased the

crop yields in all but one season. In the case of the clover crop the increases were very definite. With the other crops grown smaller but definite increases were secured. Acid phosphate with the crop residues and lime showed larger effects than the rock phosphate in some seasons, particularly on the oats in 1924 and on the same crop in 1921. In several seasons, however, there were smaller effects from the acid phosphate than from the rock phosphate. The complete commercial fertilizer gave larger increases than the rock phosphate and acid phosphate in several cases, particularly on the clover in 1926. In most seasons, however, there was very little difference between the effects of this material and the influence of the phosphates.

These data indicate the very large beneficial effects on the Clinton silt loam from the application of manure, lime and a phosphate fertilizer. Large increases in all general farm crops may be secured from the use of manure. The type is acid in reaction and the application of lime is very desirable. Either rock phosphate or acid phosphate may be applied with profit on this soil. Beneficial effects from these materials are secured with manure and lime under the livestock system of farming and with crop residues and lime under the grain system. In some cases the acid phosphate seems to be preferable for use but in other instances rock phosphate gives quite as good returns.

THE MT. UNION FIELD

The results secured on the Grundy silty clay loam on the Mt. Union field on series I in Henry County, are given in table XVIII. The application of manure to this soil type brought about increased crop yields in every season in spite of the fact that the soil is dark in color and apparently well supplied with organic matter. In some cases the effects of the manure were particularly large, for example, on the corn in 1923 and on the corn in 1920. In all cases, however, the increases were very definite. The use of lime with manure gave small increases on the various crops grown on this field, in every season. No large effects were noted, however, on the various grain crops grown. Rock phosphate with the manure and lime increased the yields of crops slightly in most seasons. In one or two years, no beneficial effects were noted. Acid phosphate with the manure and lime brought about distinct crop increases in all but one season. In some cases the gains were very definite and in general the effects were much greater than those brought about by the rock phosphate. The complete commercial fertilizer with the manure and lime had about the same effect as the acid phosphate in most cases, showing up slightly better in one or two seasons and being slightly less effective in several other seasons.

The crop residues exerted little effect on the yields of the various crops grown. Lime with the crop residues brought about increases in the yields of crops in several seasons. In no cases, however, were the increases large. Rock phosphate with the crop residues and lime showed small effects on the various crops grown. Only in one or two cases were the increases very definite. Acid phosphate with the crop residues and lime had a much

TABLE XVIII. FIELD EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY, MT. UNION FIELD, SERIES I

Plot No.	Treatment	1918 Corn bu. per A. (1)	1919 Winter wheat bu. per A. (2)	1920 Corn bu. per A. (3)	1921 Oats bu. per A. (4)	1922 Winter wheat bu. per A.	1923 Corn bu. per A. (5)	1924 Corn bu. per A. (6)	1925 Oats bu. per A. (7)	1926 Clover tons per A.
1	Check	57.2	8.3	45.0	25.4	21.3	45.3	23.4	35.1	Pastured
2	Manure	61.3	11.8	52.0	27.7	22.0	65.0	27.5	36.8	"
3	Manure+lime	62.0	12.0	52.5	27.0	22.1	65.6	35.7	37.6	"
4	Manure+lime+rock phosphate	63.1	11.3	47.0	31.7	23.4	68.3	34.7	41.1	"
5	Manure+lime+acid phosphate	65.5	13.1	49.0	35.1	28.5	66.9	37.3	45.5	"
6	Manure+lime+complete commercial fertilizer	59.4	12.2	50.0	42.1	27.7	67.4	30.7	40.8	"
7	Check	57.4	10.2	44.0	37.0	21.0	34.9	22.1	30.2	"
8	Crop residues	54.1	9.8	48.5	32.6	24.4	38.4	22.7	27.5	"
9	Crop residues+lime	56.9	8.9	47.5	33.9	21.7	39.7	21.3	29.8	"
10	Crop residues+lime+rock phosphate	58.9	10.9	47.5	30.3	25.2	40.2	20.0	34.6	"
11	Crop residues+lime+acid phosphate	61.8	10.7	44.5	38.5	29.5	59.4	25.5	37.3	"
12	Crop residues+lime+complete commercial fertilizer	61.0	10.5	46.5	36.0	27.8	44.2	29.9	35.9	"
13	Check	59.0	11.3	49.0	34.5	22.4	36.2	22.7	29.8	"

1. Plots 8-9-10-11 damaged by excessive rain at planting. No lime until 1922.
2. Wheat poor quality.
3. Poor stand, wet spring.
4. Clover poor, plowed under and wheat planted.
5. Corn fired due to hot winds. Some down.
6. Early frost damaged corn considerably.
7. Frost in April damaged oat plants resulting in a thin stand.

larger effect than did the rock phosphate in practically every season. The complete commercial fertilizer showed slightly larger effects than the acid phosphate in one or two cases, but in general had an influence very similar to that of acid phosphate.

The results secured on the same soil type on series II in the Mt. Union field in Henry County are given in table XIX. Again the beneficial effect of manure on the Grundy silty clay loam is evidenced by these data. In every case large crop increases were secured from the use of manure. Beneficial effects are shown even more definitely in this series than in series I. Very large crop increases may generally be expected from the application of manure to this type, probably because of the stimulation in the production of available plant food brought about by the manure. The application of lime with manure gave small crop increases in most seasons, just as was noted in the case of series I. Rock phosphate with the manure and lime increased the crop yields in most seasons, showing very definite effects on the clover in 1923 and on the oats in 1922. In most of the other seasons the increases were much smaller but quite definite. In several cases the acid phosphate with the manure and lime showed better results than did the rock phosphate. The beneficial effect on the clover in 1919 and on the corn in 1925 was much greater. In several other seasons the rock phosphate seemed to give quite as satisfactory results. The complete commercial fertilizer showed slightly greater effects than the acid phosphate in one or two cases but in general its influence was less definite than that brought about by the acid phosphate.

The crop residues showed very little effect on the crops grown, bringing about slight increases only in one or two seasons. Lime with the crop residues increased the crop yields to a small extent in several seasons. Rock phosphate with the crop residues and lime brought about large crop increases in some cases. The clover in 1919 and 1923 and the oats in 1922 were increased considerably. Acid phosphate with the crop residues and lime showed very similar increases to those brought about by the rock phosphate. In one or two cases it had somewhat greater effects but in others was even less effective. The complete commercial fertilizer gave less effects than the phosphate in some cases, and in other instances was slightly preferable. The differences, however, were not large enough to be very distinctive.

From the results secured on the two series on the Mt. Union field on the

TABLE XIX. FIELD EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY, MT. UNION FIELD, SERIES II

Plot No.	Treatment	1918 Oats bu. per A. (1)	1919 Clover tons per A. (2)	1920 Corn bu. per A.	1921 Corn bu. per A. (3)	1922 Oats bu. per A. (4)	1923 Clover tons per A. (5)	1924 Corn bu. per A. (6)	1925 Corn bu. per A.	1926 Oats bu. per A.
1	Check	65.8	2.28	78.5	64.8	52.1	1.27	54.1	71.5	43.3
2	Manure	72.1	3.22	91.3	76.0	67.2	1.79	49.9	80.1	50.8
3	Manure+lime	74.2	2.65	92.0	71.1	68.1	1.91	49.1	80.1	49.7
4	Manure+lime+rock phosphate	74.2	2.89	95.3	79.1	80.8	2.47	52.5	87.5	53.7
5	Manure+lime+acid phosphate	72.1	3.33	99.0	79.1	75.9	2.36	51.4	93.0	57.1
6	Manure+lime+complete commercial fertilizer	78.5	3.07	98.5	82.0	72.6	2.34	48.8	88.0	54.9
7	Check	65.8	2.30	86.8	62.9	69.0	2.33	39.2	70.5	43.3
8	Crop residues	63.7	2.24	85.3	58.3	57.5	1.59	40.3	76.0	46.6
9	Crop residues+lime	61.6	1.90	79.2	60.3	55.7	1.72	37.9	73.5	38.3
10	Crop residues+lime+rock phosphate	65.8	3.34	80.7	68.6	71.5	2.15	33.8	76.5	45.0
11	Crop residues+lime+acid phosphate	65.8	2.98	86.3	70.1	55.5	2.14	34.9	77.0	52.8
12	Crop residues+lime+complete commercial fertilizer	65.8	2.57	86.9	64.8	60.3	1.88	45.6	80.0	53.0
13	Check	61.6	1.76	85.0	59.7	59.7	1.18	37.3	69.5	40.1

1. Soil basic and no lime applied till 1922.
2. Yield on plot 2 too high.
3. Stand not uniform, many missing hills—especially on No. 5. Yield corrected for missing hills.
4. Plot 11 sample injured by mice and yield inaccurate.
5. Spots on 12 and 13 where clover was poor.
6. Early frost damaged corn to some extent.

Grundy silty clay loam, it is apparent that this soil type responds to applications of manure and considerable increases in the yields of various general farm crops may be secured by its use. The type is acid in reaction and applications of lime will be of value, particularly on the legume in the rotation. The use of a phosphate fertilizer is very desirable. In some cases acid phosphate seems to give much greater effect while in other instances rock phosphate is preferable.

THE NEEDS OF DES MOINES COUNTY SOILS AS INDICATED BY LABORATORY, GREENHOUSE AND FIELD TESTS

The general treatments which are desirable for the soils of Des Moines County have been indicated by the results presented earlier in this report in connection with the laboratory, greenhouse and field experiments. Soils which are more or less abnormal will require special treatment. These will be mentioned later under the discussion of individual soil types. Certain general recommendations can be given, however, as they are applicable to the more extensive soil types in the county. These recommendations are based not only on the experimental work carried out on the main soil types which occur in this county but they are based on the experience of many farmers. No suggestions are offered which have not been proven to be of value by practical experience and any of the treatments recommended may be put into effect on any soil in the county.

LIMING

All the soils of Des Moines County are acid in reaction and therefore, in need of lime. The data given earlier in this report have indicated roughly the limestone requirements of the various soil types. As has been noted, however, these figures merely indicate the lime needs of the various soils. There is a wide variation in the lime requirement of soil and even in the same type differences in lime requirement will be noted. Frequently there will be a wide divergence in the lime required for different fields and even for different parts of the same field. It is essential, therefore, that every soil or the soil in every field be tested for lime requirement if the proper application of lime is to be made to the particular area. Farmers may test their own soils for acidity but they will usually find it more satisfactory to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge.

It is well known that the best growth of farm crops, particularly of legumes, is dependent to a very large extent on the reaction of the soil. If the type is acid, the best crops will not be secured until applications of lime have been made. It is very important, therefore, that the soils of the county be tested for lime needs and that the amount required be applied, if crop growth is to be satisfactory. Furthermore, tests of the soil should be made at regular intervals, at least once in the rotation, to provide for the keeping up of the proper supply of lime in the soil.

In many of the experiments discussed earlier in this report, very striking crop increases have been secured from the application of lime to the various soil types found in the county. The beneficial effects have been evidenced on the Grundy silt loam, the Clinton silt loam, the Marion silt loam, and the Grundy silty clay loam, the leading upland types in the county. Large increases would also be secured on practically all of the other soil types in the county. Farm experiences with lime have indicated large beneficial effects from this material on the yields of general farm crops. Further information pertaining to the use of lime on soils, losses by leaching, and other points connected with liming, are presented in Extension Bulletin 105 of the Iowa Agricultural Extension Service. This bulletin also contains a list of the companies prepared to furnish limestone for agricultural use.

MANURING

Most of the soils of Des Moines County are fairly well supplied with organic matter but some of the important types are rather light in color and, therefore, lacking in humus. One or two of the types are strikingly deficient in organic matter. On all the soils of the county it is very necessary that some fertilizing materials supplying organic matter be added at regular intervals if the content of the soil is to be kept up. With some of the types the application of organic matter at the present time would be very desirable. Those soils which are light in color and coarse in texture are particularly in need of organic matter.

The application of farm manure to soils is the cheapest and best means of building up and keeping up the supply of organic matter. Large crop increases are brought about from the use of this material on practically all soils. The evidence presented earlier in this report indicates large beneficial effects from the application of manure to some of the more extensive soil types in this county. Even those soils which are high in organic matter and dark in color respond readily to applications of manure, and on the lighter colored soils and especially on the coarser textured types, beneficial effects are particularly noticed. Increases noted in this report on the Grundy silt loam, the Marion silt loam, the Clinton silt loam, and the Grundy silty clay loam show very definitely the beneficial effects on these types. On many of the other soils in the county and particularly on some of the sandy types, very much greater results would be secured.

The proper utilization of all crop residues is of importance because it aids in keeping up the supply of organic matter in the soil. Frequently crop residues are burned and when this occurs there is an actual loss of valuable fertilizing constituents. On the livestock farm the residues may be used for feed or bedding and returned to the land with the manure. On the grain farm they may be stored and allowed to decompose partially before being applied, or they may be applied directly to the land.

In many cases there is an inadequate production of manure on the farm to supply the needs of all the soils, and in such cases leguminous crops should be used as green manures. On grain farms, green manuring is a very

important practice as a substitute for the use of farm manure. Legumes should be utilized as green manuring crops because of the fact that when well inoculated they utilize nitrogen from the atmosphere and hence when turned under in the soil they increase the content of that plant food constituent as well as adding organic matter to the soil. Hence they have a double value. There are undoubtedly many cases in Des Moines County where the use of leguminous crops as green manures would have very beneficial effects. This would be particularly true on some of the light colored, coarse textured soils which are most in need of organic matter.

In some areas where trucking is practiced, green manuring is already an established practice in the county. In general, however, legumes are not grown for that purpose. Rye is a common crop used in this way. It undoubtedly exerts beneficial effects on the soil from the standpoint of the incorporation of organic matter but it does not add nitrogen.

THE USE OF COMMERCIAL FERTILIZERS

The soils of Des Moines County are rather poorly supplied with phosphorus and some of the types are very low in this constituent. In no case was there any large content of phosphorus in any of the soils. It is evident, therefore, that the use of a phosphate fertilizer will be needed on the soils of this county in the very near future. The greenhouse and field experiments show, however, that the application of a phosphate fertilizer might prove valuable in many cases at the present time. Considerable increases in crop yields have been noted in these experiments from the use of rock phosphate or acid phosphate.

It is not possible as yet to draw a definite conclusion regarding the relative value of acid phosphate and rock phosphate for application to the soils of this county. In many of the tests, acid phosphate seemed to be somewhat more effective but in other instances rock phosphate showed up almost as well. While acid phosphate is somewhat more expensive than rock phosphate, it is applied in smaller amounts and supplies the element phosphorus in an immediately available form and hence may have quicker effects in increasing crop yields. Acid phosphate is usually added at the rate of 150 to 200 pounds per acre annually. On the other hand, rock phosphate is applied at the rate of one ton per acre once in a four-year rotation. It is less expensive but the phosphorus present is only slowly changed into an available form and hence it may have a much slower effect on crop yields.

It is urged that farmers test both of these phosphates on their own soils and thus determine for their particular conditions whether or not the use of a phosphate fertilizer will prove profitable and which material is preferable. Simple tests may be carried out quite readily on any farm. Many farmers at the present time are conducting such tests on their farms. Directions which may be followed in carrying out similar experiments are given in Circular 97 of the Iowa Agricultural Experiment Station.

The soils of Des Moines County are in general fairly well supplied with nitrogen, but in a few cases there is a scarcity of this element. Applications

of some fertilizing material supplying nitrogen must be made to the soils of the county at regular intervals if the supply of the element is to be kept up. On many of the types, however, the addition of some material supplying nitrogen would be of value at the present time.

On the livestock farms the proper preservation and application of all the farm manure produced will aid materially in keeping up the supply of nitrogen in the soil. The proper utilization of crop residues aids also in keeping up the nitrogen in the soil as there is thus a considerable return to the soil of the element removed by the crops grown. The use of leguminous crops as green manures is very important on the livestock farm as a means of supplementing the nitrogen returned in the farm manure. It is a particularly important practice, however, on the grain farm. When the legumes are well inoculated, they take a large part of their nitrogen from the atmosphere and hence when the crop is turned under in the soil there may be a considerable addition of nitrogen to the land.

The use of commercial nitrogenous fertilizers cannot be recommended in this county for general farm crops inasmuch as the nitrogen content of the soil may be more economically maintained by the proper use of leguminous green manure, farm manure, and crop residues. Applications of nitrogenous fertilizers may be of value, however, for special crops, such as truck crops and garden crops.

From the results of earlier analyses it would seem that the soils of the county are very well supplied with potassium and it would not be expected, therefore, that commercial potassium fertilizers would prove of much value. If the proper conditions are maintained in the soil for the changing of the potassium into an available form, crops should be well supplied with this element for many years to come. There is some evidence, however, that occasionally potassium fertilizers may prove profitable for use in connection with the growing of some general farm crops. Tests should be carried out on small areas before a potassium fertilizer is applied extensively. For special crops such as truck crops and garden crops, the use of potassium fertilizers may frequently be very desirable and very profitable effects may be secured from their application.

Complete commercial fertilizers have been compared with acid phosphate and rock phosphate in the experiments discussed earlier in this report and from the data secured in these tests it would not seem that the complete commercial fertilizers would be as desirable for use as the phosphates, at least for the growing of general farm crops. Potassium is hardly likely to be needed on many of the soils and the nitrogen content may be more cheaply supplied by the use of a leguminous green manure crop. Hence the value of the complete commercial fertilizer lies mainly in its phosphorus content. It might be expected, therefore, that acid phosphate would often give greater economic returns than a complete fertilizer because it is less expensive. For the growing of special crops such as truck crops and garden crops, however, the use of complete commercial fertilizers is frequently very desirable. Special brands which have been prepared for use in connection with in-

dividual crops are quite generally used and profitable returns on truck crops are secured. Tests on small areas to determine the value of commercial fertilizers for general farm crops are recommended, comparing them with acid phosphate, before they are used on any extensive scale. If they give profitable effects then they may be used on large areas with the assurance of profit.

DRAINAGE

The natural drainage system of Des Moines County is very well developed as has been shown earlier in this report. The map which was given shows that the streams and their tributaries and the intermittent drainageways extend into practically all parts of the county. There are some individual soil types, however, which are inadequately drained and would respond to tiling. The Grundy silty clay loam and the Marion silt loam on the uplands are, in many cases, not as well drained as they should be and the installation of tile would be of value. On the terraces, the Bremer, Calhoun and Davenport soils are in need of drainage while the Wabash types on the bottoms may also be poorly drained. In most of these cases, the soils are not only level in topography but have heavy, impervious subsoils, and hence the lack of drainage would naturally be expected.

The need of tiling out certain areas in these soil types may be indicated by the occurrence of small unproductive areas. In many cases, the lack of drainage is evidenced only by poor crop yields in certain seasons. It is certain, however, that if the soil is too wet, satisfactory crop yields cannot be secured. The first treatment needed for such land is the installation of tile. The operation of tiling may be somewhat expensive but the results secured always warrant the outlay. Other fertilizer treatments will have little value on land which is not properly drained. Much experimental data and considerable farm experience have demonstrated definitely the benefits from tiling out wet land. Farmers in Des Moines County should see that their land is adequately tiled if they wish to secure the best results.

THE ROTATION OF CROPS

While it is quite generally recognized that the continuous growing of any one crop is undesirable from the standpoint of the fertility of the soil, there are still some farmers who because of its large money value grow the same crop, year after year, on the same land. When this practice is followed, yields decrease very rapidly, and a time soon comes when the growing of the crop becomes unprofitable. When crops are rotated, the yields do not decrease so rapidly and may be increased if proper additional soil treatments are made. If the rotation includes crops which have less money value, the total income from all the crops grown in the rotation over a period of years will be much greater than where one crop is grown continuously. Furthermore, for the permanent fertility of the land, the rotation of crops is absolutely essential. Continuous cropping very quickly lowers the natural fertility of the soil.

There are a number of rotations which are being used successfully in various parts of the state and the following are given as examples of some of these rotations. No one rotation can be considered suitable for all conditions but from among these rotations some one may be chosen which will undoubtedly fit in with any particular farm conditions.

1. SIX-YEAR ROTATION

First year —Corn.
Second year—Corn.
Third year —Wheat or oats (with clover, or clover and grass).
Fourth year—Clover, or clover and grass.
Fifth year —Wheat (with clover), or grass and clover.
Sixth year —Clover, or clover and grass.
(This rotation may be reduced to a five-year rotation by cutting out either the second or sixth year and to a four-year rotation by omitting the fifth and sixth years.)

2. FOUR OR FIVE-YEAR ROTATION

First year —Corn.
Second year—Corn.
Third year —Wheat or oats (with clover or with clover and timothy).
Fourth year—Clover (If timothy was seeded with the clover the preceding year, the rotation may be extended to five years. The last crop will consist principally of timothy).

3. FOUR-YEAR ROTATION WITH ALFALFA

First year —Corn.
Second year—Oats.
Third year —Clover.
Fourth year—Wheat.
Fifth year —Alfalfa (The crop may remain on the land five years. This field should then be used for the four year rotation outlined above and the alfalfa shifted to one of the fields which previously was in the four-year system).

4. FOUR-YEAR ROTATIONS

First year —Wheat (with clover).
Second year—Corn.
Third year —Oats (with clover).
Fourth year—Clover.

First year —Corn.
Second year—Wheat or oats (with clover).
Third year —Clover.
Fourth year—Wheat (with clover).

First year —Wheat (with clover).
Second year—Clover.
Third year —Corn.
Fourth year—Oats (with clover).

5. THREE-YEAR ROTATIONS

First year —Corn.
Second year—Oats or wheat (with clover seeded in the grain).
Third year —Clover (In grain farming, only the grain and clover seed should be sold; most of the crop residues such as corn stover and straw should be plowed under. The clover may be clipped and left on the land to be returned to the soil and only the seed taken from the second crop).

First year —Corn.
Second year—Oats or wheat (with sweet clover).
Third year —Sweet clover (The clover may be mixed clovers and used largely as pasture and green manure).
(This may be changed to a two-year rotation by plowing the sweet clover under the following spring for corn.)

First year —Wheat (with clover).
Second year—Corn.
Third year —Cowpeas or soybeans.

THE PREVENTION OF EROSION

Erosion is the carrying away of the surface soil by the free movement of water over the surface of the land, known as sheet erosion or the washing away of the soil with the formation of gullies, gulches or ravines.

Erosion occurs to a limited extent in Des Moines County affecting a few of the individual soil types. The Lindley silt loam on the drift upland is particularly injured. The Clinton silt loam on the loessial upland is likewise eroded to a considerable extent in many areas. Much of the surface soil has been washed away from these types and occasionally deep gullies are formed. Some of the other types in the county are eroded in some cases but the washing action has not been serious except in the two soils mentioned.

Various methods are followed for the control and prevention of erosion in Iowa. These methods differ somewhat depending upon the type of erosion. Erosion occurring due to "dead furrows" may be controlled by "plowing in," by "staking in," or by the use of earth dams.

Small gullies may be filled by the "staking in" operation, by the use of straw dams, earth dams, Christopher or Dickey dams, Adams dams, stone dams, rubbish dams, woven wire dams, concrete dams. They may be prevented from occurring by thoro drainage or by the use of sod strips. Large gullies are similarly filled or prevented from occurring. Erosion in bottomlands is prevented by straightening the streams, by tiling and by planting trees up the drainage channels. Hillside erosion is controlled by the use of organic matter, by growing cover crops, by contour discing, by terracing, by deep plowing and by the use of sod strips.**

INDIVIDUAL SOIL TYPES IN DES MOINES COUNTY*

There are 26 individual soil types in Des Moines County and these with the area of riverwash make a total of 27 separate soil areas. These are divided into four groups according to their origin and location. These groups are the drift soils, the loess soils, the terrace soils and the swamp and bottomland soils.

DRIFT SOILS

There is only one drift soil in the county, the Lindley silt loam. It is the third largest soil type in the county, covering 11.4 percent of the total area.

LINDLEY SILT LOAM (32)

This soil occurs along the steeper hill slopes adjacent to the stream bottoms and in deeper gullies where stream action has cut through the loess into the underlying glacial till. Extensive developments of the type are found in continuous strips along the slopes and bluffs adjacent to the bottomlands of the Mississippi River, Flint River, Skunk River, and Yellow Spring Creek.

**See Bulletin 183, Soil Erosion in Iowa, Iowa Agricultural Experiment Station. Extension Service Bulletins 93, 94, 95, 96. Agricultural Extension Service, I. S. C.

*The description of individual soil types given in this section of the report very closely follow those in the Bureau of Soils report.

The surface soil of the Lindley silt loam is a light yellowish-brown or grayish-brown silt loam containing much fine sand and extending to a depth of six inches. Below this point there is yellowish-brown gritty silty clay, containing some coarse sand, pebbles and boulders. The surface soil varies in depth and texture in different areas. In some places there is a thin covering of the silt loam or a coarse loam while in other places, the drift material ranging in texture from a sandy to gravelly clay is exposed. The silt loam texture predominates, however. Included with the type are small areas of a grayish-brown or black residual clay loam overlying limestone, since these areas were too small to be mapped separately.

In topography the Lindley silt loam is steep to rough. Drainage is good. The type is more or less eroded, deep gullies occurring rather commonly.

Most of the soil is covered with a forest growth consistly mainly of oak, ash, hickory, walnut, red haw and underbrush. Only a small part of the type is under cultivation. Most of it is non-agricultural and supports only poor pasturage. The lower slopes adjacent to the bottomlands are cropped and fairly good yields of general farm crops are grown. In these locations, the soil is darker than typical ranging from a brown to a dark brown in color. On areas which can be cultivated the soil will respond to applications of manure, the addition of lime and the use of a phosphate fertilizer.

LOESS SOILS

There are five loess soils in the county classified in the Grundy, Clinton, Tama and Marion series. Together they cover 66.9 percent of the total area.

GRUNDY SILT LOAM (64)

The Grundy silt loam is the largest individual soil type as well as the most extensive loess soil. It covers 31.1 percent of the total area. It is found on the uplands in all parts of the county, occurring most extensively in the northwestern part. The largest development of the type is in Washington Township, Yellow Spring Township, Franklin Township, Danville Township and Union Township. There are large individual areas of the type in these townships, covering the more or less level to gently rolling upland.

The surface soil of the Grundy silt loam is a dark brown to almost black friable silt loam, extending to a depth of 14 inches. The subsoil from 14 to 26 inches consists of a silty clay loam, brown to dark brown in color with some gray mottlings in the lower section. Below this point there is an abrupt change to a heavy, tenacious silty clay, the color becoming somewhat lighter at the lower depths. The lower subsoil is mottled with gray, yellowish-brown and rusty brown iron stains. The surface soil has a grayish cast in many cases when dry.

In topography the Grundy silt loam is gently undulating to undulating. The natural drainage of the soil is fair. Because of the heavy texture of the subsoil, however, drainage of the soil in the more level areas is often inadequate and increased production of general farm crops frequently follows the installation of tile.

In some of the flatter areas at the heads of the gentle draws there are areas of a black silty clay loam which really should be mapped as Grundy silty clay loam but they are included with the silt loam because they are too small to show on the map. In areas, where the Grundy silt loam occurs adjacent to the gray Marion silt loam there is a broad area where one type grades into the other. Here it has been difficult to establish definite soil boundaries and these are located more or less arbitrarily. Thruout the Grundy silt loam there are flat, depressed areas where there is a subsurface layer of a gray silt. The soil in these areas should really be mapped as the Edina silt loam but they are too small to show on the map and hence they have been included with the type. Occasionally where the Grundy silt loam adjoins the heavier level areas of the Grundy silty clay loam, there is a gradual change in texture from the one type to the other, and the boundaries have been located more or less arbitrarily.

Practically all of the type is under cultivation, general farm crops being grown. In normal seasons corn yields 40 to 65 bushels per acre, averaging between 45 and 50 bushels. In many cases the yields will go as high as 70 to 90 bushels, in individual cases when conditions are very favorable. Oats yield 30 to 60 bushels per acre, and timothy and clover hay, the chief hay crop, from 1 to 3 tons per acre. Some timothy is grown for seed. Winter wheat is raised occasionally. Small quantities of alfalfa, millet and barley are also grown.

The Grundy silt loam is naturally a productive soil and, in most cases, crop yields are quite satisfactory. It has been shown, however, in the experimental results given earlier in this report, that applications of fertilizing materials will increase the yields of crops grown on this soil very materially. The type will respond profitably to applications of farm manure and liberal amounts of this material should be applied. Where farm manure is not available in sufficient amounts, the turning under of leguminous crops as green manures might be very desirable in many cases. The type is acid in reaction and the application of lime will stimulate the growth of legumes and bring about greater production of other general farm crops. The use of a phosphate fertilizer is also desirable on this soil. The experiments given earlier indicate that acid phosphate or rock phosphate may bring about large crop increases. In some cases, acid phosphate seemed to be more effective but in other cases, rock phosphate was quite as good. Tests of the two phosphates on individual farms are recommended. Complete commercial fertilizers are probably not as desirable for use on this soil as acid phosphate. While increased crop yields were secured in the tests, the increases were not sufficiently large to warrant the greater cost of the material. Any commercial fertilizer may be tested on a small scale, however, in comparison with acid phosphate and if profitable crop yields are secured the material may be applied more extensively.

CLINTON SILT LOAM (80)

The Clinton silt loam is the second largest soil type, covering 21.6 percent of the total area. It is developed extensively, occurring along

all of the larger drainageways and back along their deep, gully-like tributaries, occupying the bluffs and ridges and in many cases extending well down the slopes to the exposures of drift material or limestone rock. Large areas occur along Flint River, Skunk River, the Mississippi River bluffs and on the narrow ridges between the numerous creeks. The largest individual area is found along the Mississippi River bluff, beginning just south of Burlington and extending northward in a strip one-fourth of a mile to three miles in width to the Louisa County line. The various areas of the type are irregular in shape and follow the bluffs along the various streams and tributaries.

The surface soil of the Clinton silt loam is a smooth floury silt loam, yellowish-brown or grayish-brown in color, extending to a depth of 10 inches. At this point the subsoil is a deeper yellowish-brown silty clay loam to silty clay, grading at 20 inches into a buff or yellowish-brown impervious silty clay to clay with faint gray mottlings and dark brown iron stains in the lower part. The surface soil is brownish in appearance when wet and grayish-brown when dry. The subsoil is very tenacious when moist.

In topography, the Clinton silt loam is gently rolling to hilly. Along some of the steeper slopes the areas of the type are frequently badly eroded and there are many gullies. Occasionally the surface soil is nearly all removed, and only a thin covering of from one to three inches of the material remains. The soil is very susceptible to erosion and frequently gullying starts following a single heavy rain and in a short time deep gullies may be formed. The type is adequately drained and in places the drainage is excessive.

Where the Clinton silt loam occurs adjacent to the lighter colored Marion silt loam on the flat upland areas between streams, there is a gradual change from the one type to the other in many areas. The establishment of boundary lines between the two types is frequently made rather arbitrarily.

Most of the type has been cleared and is now used for general farming. The original tree growth was largely hickory, red, black, scarlet, white and burr oak, walnut, maple, pine and hazel brush. On the areas which are timbered at present the growth is scattered and mostly small in size. These areas are used for pasture purposes.

On the cultivated areas, general farm crops are grown. Corn yields from 25 to 45 bushels per acre, oats, 20 to 40 bushels per acre, hay, one to 2½ tons. Clover and timothy mixed is the chief hay crop grown. Wheat is grown to some extent, yielding 15 to 30 bushels per acre. Some rye is grown. On this type there is some commercial production of tree fruits, mainly apples and small fruits. Peaches, plums, pears and cherries do well. Raspberries, blackberries and strawberries are grown in considerable quantities near Burlington. Sweet corn, tomatoes, cucumbers, onions, cabbage and other vegetables are produced in the vicinity of Burlington and are sold at the canning factories and at the city markets.

The Clinton silt loam will respond in a very large way to applications of fertilizing materials. Farm manure is particularly valuable for use on this soil, inasmuch as the type is rather low in organic matter. If farm manure

is not available for use, legume crops should be turned under as green manures. The type is acid and applications of lime are very necessary for the best growth of general farm crops, and particularly of legumes. The application of a phosphate fertilizer would be very desirable on this soil when general farm crops are to be grown, either acid phosphate or rock phosphate being applied. Acid phosphate seems to be somewhat preferable for use but in some cases rock phosphate gives very good results. Tests of both fertilizers are recommended.

For fruit crops and for the various truck crops which are grown in some areas, the application of certain complete commercial fertilizers is very desirable. The particular brands of fertilizers which are made up for the crops to be grown should be selected. In many cases very large crop increases in truck crops are secured from the use of complete commercial fertilizers. For general farm crops acid phosphate will probably prove quite as satisfactory. Tests of complete commercial fertilizers may be carried out, however, in comparison with acid phosphate and if better results are secured, then the complete fertilizer may be employed.

TAMA SILT LOAM (120)

The Tama silt loam is the third largest loess soil and the fifth most extensively developed type, covering 7.2 percent of the total area. It is quite generally developed, occurring at the heads of most of the smaller drainageways. It is found on the slopes separating the more level Grundy silt loam uplands from the lighter-colored, forested and more eroded hillsides adjacent to the streams. Here it occurs in many narrow, continuous strips. It is most extensively developed in the northwestern part of the county, altho there are a number of rather large individual areas in the southern part of the county in Concordia and Union Townships. The areas in the northwestern part are most extensive in Washington and Pleasant Grove Townships. Some rather considerable areas are also found in Danville Township.

The surface soil of the Tama silt loam is a dark brown friable silt loam, grading at 14 inches into a yellowish-brown silty clay loam. At 22 inches, the subsoil is somewhat heavier in texture, becoming a silty clay, yellowish-brown in color. Occasionally below 30 inches there are faint yellowish-brown mottlings and iron stains.

In topography the Tama silt loam is gently rolling to rolling. It is well drained as a whole. In some areas where it occurs adjacent to the Grundy silt loam, and the topography is more gently undulating, there is a gradual transition from one type to the other and the boundary lines are quite arbitrarily located. Drainage here is not satisfactory. Occasionally erosion occurs and on the steeper slopes the surface soil may vary from 2 to 6 inches in depth. In a few isolated spots, the lighter colored silty clay loam subsoil is exposed.

The type is largely cultivated, about 70 percent being in cultivated crops. The remainder is utilized for pasture. General farm crops are grown and the yields of these crops are very much the same as those secured on the Grundy

silt loam. Corn will average from 45 to 50 bushels. Oats, from 40 to 50 bushels and hay from 1 to 3 tons per acre.

While the Tama silt loam is normally a productive type, it will respond readily to applications of farm manure, lime, and a phosphate fertilizer. The use of manure is particularly beneficial and many experiments have shown large increases in the yields of general farm crops brought about by this material. The type is acid in reaction and lime applications will be of benefit to the growth of legumes and will also bring about increases in the yields of general farm crops. Rock phosphate and acid phosphate have both been used to advantage on this type, in some cases the acid phosphate seeming somewhat preferable while in other cases the rock phosphate showed up about as well. Complete commercial fertilizers may be used on this type but it would not seem from the experimental data available, that they will be as economically profitable as the use of acid phosphate.

GRUNDY SILTY CLAY LOAM (115)

The Grundy silty clay loam is the fourth largest loess soil and the sixth most extensive soil type. It covers 4.8 percent of the total area of the county. It occurs on the high, flat upland areas between the streams where the land is not so well drained. There are numerous irregular shaped bodies, ranging from 50 acres to several sections in extent. The type is found mainly in the western half of the county. The largest developments occur around Danville, west of Yarmouth, along the county line and near Mediapolis. Numerous small areas are found scattered thruout the Grundy silt loam on the uplands.

In topography the Grundy silty clay loam is level to nearly level. The natural drainage is poor owing to the level topography and the impervious condition of the subsoil. Tiling is very necessary on this soil to make it most satisfactorily productive.

All of the type is under cultivation, general farm crops being grown. When well drained, corn yields 40 to 70 bushels per acre, with an average yield of about 50 bushels. Oats yield from 40 to 60 bushels per acre. Clover alone and clover and timothy hay yield from 1½ to 3½ tons per acre.

The Grundy silty clay loam needs drainage first of all in order that it may be made more satisfactorily productive. Proper cultivation is also necessary. It is important in cultivating the type that it be handled under the proper moisture conditions. Plowed and cultivated when too wet it may bake and clod and will remain in poor physical condition for a long period. In dry weather cracks frequently form on the surface of the soil. While the soil is high in organic matter, the application of farm manure seems to be of value. Small amounts of manure will stimulate the production of available plant food and improve the physical condition of the soil. The manure should not be applied on the type preceding the growing of a small grain crop as it is liable to increase the danger of lodging. Small amounts at other points in the rotation, however are of value.

The type is acid in reaction and will respond to the application of lime if

legumes are to be grown. In a number of experiments the use of a phosphate fertilizer has been found to prove valuable on the soil. Acid phosphate and rock phosphate have been tested in these experiments and in some cases the acid phosphate has proven preferable. In other cases, however, rock phosphate has been quite as satisfactory.

MARION SILT LOAM (67)

The Marion silt loam is a minor type covering only 2.3 percent of the total area. It is found in numerous small irregular shaped bodies on the flat areas of upland between the streams, occurring adjacent to the Clinton silt loam on the slopes to the streams. The type is developed in all parts of the county in association with the Clinton silt loam. There are no very large individual areas but it is most extensively developed in Flint River Township and in Union Township.

The surface soil of the Marion silt loam is a grayish brown to whitish-gray smooth silt loam, extending to a depth of 10 inches. At this point there is a light gray or white, floury compact silt layer, 5 to 8 inches in thickness, sometimes faintly mottled with brown. Below this silt layer, the subsoil consists of a light brown or grayish-brown plastic silty clay to clay, mottled with gray and yellowish-brown. The mottlings increase in the lower depths and occasionally iron stains are noticed. At about 40 inches there is a more friable lighter brown silty clay or clay loam. Sometimes this lighter area occurs at a depth of 30 inches. The subsoil is very tough and impervious.

In topography the Marion silt loam is level to flat. The natural drainage is poor owing to the topographic position and to the impervious nature of the subsoil. Tiling the type is very necessary in order that satisfactory crop yields may be secured.

All of the type is under cultivation corn, oats, wheat, timothy, rye and millet being the chief crops grown. The yields of these crops are slightly lower on the average than those secured on the Clinton silt loam. The soil will be benefited very materially by applications of farm manure and large increases in general farm crops are secured with liberal use of this material. If manure is not available for application to the type, then legume crops should be turned under as green manures. The soil is particularly in need of organic matter. The application of lime would be valuable, as the soil is acid in reaction. This would be particularly true if legumes are grown. The use of a phosphate fertilizer will increase crop yields on this soil. Acid phosphate would probably be preferable for use as the organic matter content of the soil is low. When the soil is built up in organic matter then rock phosphate might be used with equal effectiveness. When properly drained and with the addition of organic matter in the form of farm manure, the use of lime, and the application of a phosphate fertilizer, crop yields on this soil type are quite satisfactory.

TERRACE SOILS

There are ten terrace types classified in the Bremer, Bertrand, Plainfield, Jackson, Buckner, Calhoun, and Davenport series. They are all minor in extent, the total acreage in the terrace soils amounting to only 3.3 percent of the county.

BREMER LOAM (12)

The Bremer loam is the most extensively developed of the terrace types, occurring on 0.9 percent of the total area. It is found mainly in three areas, occurring northeast of Snider and one and three miles northeast of Kingston. There are also a number of small areas of the type. It occurs on the flat terraces from 6 to 14 feet above the Mississippi bottomlands.

The surface soil of the Bremer loam consists of 12 inches of a dark brown loam, varying somewhat in texture from a sandy loam to a heavy silt loam. The prevailing texture, however, is a loam. The upper subsoil is a chocolate brown or a dark reddish-brown friable silty clay loam with some gray and reddish or yellowish-brown mottlings. Below 20 inches, the subsoil is a heavy silty clay to clay loam, light reddish or pinkish-brown in color, highly mottled with yellowish-brown and gray. The lower subsoil shows numerous brown iron stains and contains some coarse sand and pebbles.

In sections of 33 and 34 of Union Township and in Section 19 of Tama Township, there are small areas which are mapped as Bremer loam which vary somewhat from the typical soil. In these areas there is a lighter subsoil, a yellowish-brown sandy clay having no evidence of the reddish tint which occurs in the typical subsoil. In the area south of Starrs Cave on the east side of Flint River the soil below the 24 inch depth is underlaid by limestone while that on the west side of the river rests on sandy clay.

The type is all in cultivation and the principal crops grown are corn, wheat, oats, corn and timothy. Potatoes are also grown on this soil. Yields of these crops are generally quite satisfactory, in normal seasons. The type will respond, however, to small applications of farm manure, to the use of lime for the best growth of legumes and to the application of phosphorus fertilizers. Liberal amounts of farm manure are not recommended for this soil, as it is black in color and fairly well supplied with organic matter. The use of small amounts, however, will aid in the production of available plant food and hence will bring about profitable increases in crop yields. The use of a phosphate fertilizer will prove very desirable on the soil, either rock phosphate or acid phosphate being used. In many places, acid phosphate may be preferable but there are probably areas where rock phosphate would show quite as profitable returns.

BERTRAND SILT LOAM (193)

The Bertrand silt loam is a minor type, covering only 0.4 percent of the total area. The most extensive areas are found along the bluffs near Burlington, extending in narrow strips northward as far as Snider. Small areas are also found at Kingston and three miles west of Spring Grove.

The surface soil of the Bertrand silt loam is a friable light yellowish silt loam to a depth of ten inches. Below that point, the subsoil is a light yellowish-brown silty clay loam, slightly heavier than the surface soil. From 30 to 36 inches, the subsoil is a yellowish brown silty clay, mottled with

grayish-brown. In some places, the type is lighter in texture in the surface soil ranging from a very fine sandy loam to a loam. These variations are usually found on areas of the type adjacent to the bluffs where there has been considerable wash from the higher uplands down over the terraces.

In topography the type varies from flat to gently undulating. Natural drainage is adequate. All of the soil is in cultivation and general farm crops are grown.

Crop yields are very much the same as those secured on the Bremer soils and are in general very satisfactory. The type will respond, however, to the applications of farm manure, the use of lime to remedy acidity, and the application of a phosphate fertilizer.

BREMER SILT LOAM (88)

The Bremer silt loam is a minor terrace type, covering 0.4 percent of the total area. It is found on the second bottomlands along the streams of the county, being most extensively developed along Flint River. There are three small areas northwest of Augusta along the Skunk River, two on Brush Creek, one on Long Creek, northeast of Augusta, one at Kingston and several small areas along Yellow Spring Creek and Cedar Fork of Flint River.

The Bremer silt loam is a dark brown, friable silt loam, extending to a depth of 10 inches. Below that point the subsoil is a brown silty clay loam with faint gray or yellowish-brown mottlings. At 20 to 26 inches, it becomes a yellowish-brown or brown silty clay, mottled with gray and yellowish-brown.

There is some variation in the surface soil. Occasionally it approaches a silty clay loam and is somewhat darker in color. There are some areas where a lighter colored material has been washed over the surface from the adjacent uplands.

In topography, the Bremer silt loam is flat and drainage is frequently not entirely adequate. The type occurs two to ten feet above overflow but owing to the flat topography and the heavy character of the subsoil tiling is frequently very necessary.

The soil is all in cultivation and general farm crops are grown. The yields of these crops are ordinarily quite satisfactory. The type will respond, however, to a small application of manure, the use of lime and the application of a phosphate fertilizer. Large amounts of manure are not needed as the soil is fairly well supplied with organic matter. Small applications, however, will stimulate the growth of crops to a very large extent. The use of lime is needed for the very best growth of legumes and a phosphate fertilizer, either acid phosphate or rock phosphate will prove profitable for use on the type.

PLAINFIELD SAND (194)

The Plainfield sand is a minor type, covering only 0.3 percent of the total area. It occurs in a number of small areas, the largest being found in the vicinity of Spring Grove. Small areas occur northeast of

Kingston near Mullahy and west of Timber Lake. In the areas near Spring Grove, the soil is 15 to 20 feet above the bottomland while in the smaller areas the type is only 6 to 10 feet above the bottomland.

The surface soil of the Plainfield sand is a yellowish-brown, loose to medium sand, extending to a depth of 18 inches. Below that point, the subsoil is a lighter yellowish-brown, loose, incoherent uniform sand. Small quantities of coarse gravel are occasionally found in the surface soil. The type is level in topography and drainage is good to excessive.

All of the soil is in cultivation and on most of the areas general farm crops are grown. Corn yields about 20 bushels, wheat, about 12 to 15 bushels, and other crops give similarly low yields. In the area near Spring Grove, trucking is carried on quite extensively and onions, asparagus, melons, celery and sweet corn are grown.

This type is particularly in need of organic matter to make it more productive and the liberal use of farm manure is very desirable. Large increases in the yields of general farm crops will follow the use of this material and for trucking the turning under of considerable amounts of manure is very desirable. When farm manure is not available the use of leguminous crops as green manure should be practiced in order to build up the organic matter supply in the soil and thus reduce the danger of crop injury in dry seasons. The type is acid in reaction and should be limed for the best growth of legumes. The use of a phosphate fertilizer would prove of large value when general farm crops are grown. Where trucking is practiced the application of special commercial fertilizers made up to favor the growth of the individual crops, should be employed. Profitable returns may be secured from the use of the proper complete commercial fertilizers.

PLAINFIELD FINE SANDY LOAM (97)

The Plainfield fine sandy loam is a minor type, covering only 0.3 percent of the total area. It is found in a number of small areas, usually associated with the Plainfield sand. There are several areas associated with this latter type in the vicinity of Spring Grove. Five small areas are found northeast of Snider.

The surface soil of the Plainfield fine sandy loam is a light brown to brown fine sandy loam, underlaid at 16 inches by a lighter brown, loose fine sandy loam to very fine sandy loam. In the areas near Snider, the subsoil contains much coarse material and the surface soil varies from a fine sandy loam to a sandy loam.

In topography the type is flat to gently undulating and drainage is good to excessive. The soil is inclined to be drouthy. It is all cultivated and general farm crops are grown except on the areas near Spring Grove where trucking is practiced. The same crops are grown on this soil as on the Plainfield sand.

The needs of this soil are very much the same as those noted in the case of the Plainfield sand and include the liberal application of farm manure or the turning under of leguminous crops as green manures, the application of

lime to remedy the acid condition, the use of a phosphate fertilizer for general farm crops, and the application of a complete commercial fertilizer for such truck crops as may be grown. Large increases in crop yields may be secured on this type by the proper application of these fertilizing materials.

JACKSON SILT LOAM (81)

The Jackson silt loam is a minor terrace type, covering only 0.3 percent of the total area. It is found on the flat terraces 12 to 20 feet above the bottomlands and occurs in numerous small areas along the Skunk River and Flint River. Small, disconnected strips of the type are found along the Skunk River beginning just east of Augusta and following the course of the river to the county line. More extensive developments of the type are found beginning about one half mile north of Burlington and extending northeastward. There are several small isolated areas along the Flint River.

The Jackson silt loam to a depth of 8 inches is a dark yellowish-brown or grayish-brown floury silt loam, passing into a yellowish-brown light silty clay loam, mottled with gray and showing some yellowish-brown and iron stains. The subsoil becomes heavier with depth and, at 16 inches, grades into a silty clay loam to clay loam, light brown to brown in color and strongly mottled with light yellow and some gray. There are numerous iron stains in the lower subsoil. Occasionally in the areas adjacent to the slopes of the uplands the surface layer is modified by a mixture of fine material which has been washed down from the bluffs.

Most of the Jackson silt loam is under cultivation, general farm crops being grown. Corn yields 35 to 50 bushels per acre, oats, 30 to 45 bushels and wheat, 18 to 35 bushels.

The type will respond to applications of organic matter in the form of farm manure. Leguminous crops should be used as green manures to supplement the application of farm manure or as a substitute for that material. The type is acid and additions of lime are desirable for the best growth of legumes. The application of a phosphate fertilizer will be of value.

BUCKNER SANDY LOAM (40)

The Buckner sandy loam is a minor terrace type, covering 0.3 percent of the total area. It occurs in several small areas, the largest being found northeast of Kingston and northeast of Snider. There is a small area just east of Prairie Grove along the Flint River.

The surface soil of the Buckner sandy loam consists of a dark brown sandy loam, extending to a depth of 24 inches. At this point the subsoil is a dark reddish-brown or chocolate-brown sandy loam to loamy medium to coarse sand. In some areas where the type occurs in depressions, the surface soil is a somewhat heavier sandy loam to loam and the subsoil is a clayey sandy loam.

The topography of the Buckner sandy loam is level to flat. Drainage is good because of the sandy character of the soil. Practically all of it is under cultivation, and general farm crops are grown. Good yields are secured in favorable seasons but the crops are apt to suffer in periods of drought.

The use of farm manure is very desirable on this soil and liberal applications should be made. This will reduce the danger of injury to the crops from drought and also increase the fertility of the soil. Leguminous crops should be used as green manures when farm manure is not available for use in sufficient amounts. The type is acid and would respond to lime especially for the best growth of legumes. The application of a phosphate fertilizer would undoubtedly prove of value.

BREMER SILTY CLAY LOAM (43)

The Bremer silty clay loam is a minor type, covering only 0.1 percent of the total area. It is found in several small disconnected areas occurring along the Flint River, especially in Flint River Township. Other bodies associated with the Bremer silt loam are found southeast and northeast of Kingston.

The Bremer silty clay loam is a heavy silty clay loam, extending to a depth of 20 inches, the texture becoming somewhat heavier at the lower depths. The subsoil is a dark brown to black clay, usually mottled with brown or gray and containing iron stains below 30 inches. In some areas the black, unmottled clay extends to a depth of 36 inches.

The type occurs in depressions and poorly drained areas on the flat terraces. The natural drainage is poor. The installation of tile and in some cases the use of open ditches is necessary for the best drainage of the soil. General farm crops are grown on the soil and when it is thoroly drained, fairly satisfactory crop yields are secured.

Small amounts of manure added to the type, especially when it is newly drained, will be of value. Manure should not be added to the soil, however, preceding the growing of small grain crops. The type is acid and the use of lime will be of value when legumes are to be grown. The application of a phosphate fertilizer, either acid phosphate or rock phosphate, would prove very profitable.

CALHOUN SILT LOAM (42)

The Calhoun silt loam is a minor type, covering only 0.1 percent of the total area. It occurs in four small areas, the largest being found north of Burlington, where Flint River joins the Mississippi River. Two bodies are found along Flint River northwest of West Burlington and one area occurs in the southwest corner of the county, where the Skunk River enters the county.

The surface soil of the Calhoun silt loam is a smooth light grayish-brown silt loam extending to a depth of 10 inches. At this point there is a layer 6 to 8 inches in thickness of a whitish gray floury silt loam, mottled faintly with brown. Below this silt layer, the subsoil is a yellowish-brown silty clay mottled with gray and yellow and brown. Rusty brown iron stains occur thruout the subsoil. In some small areas, the subsoil contains considerable fine gravelly material, but usually it is very stiff and impervious. In topography the type is flat and due to this fact and the heavy subsoil, natural drainage is poor.

All of the soil is now in cultivation, general farm crops being grown.

The yields are about the same as those secured on the Jackson silt loam. When the type is well drained, improved conditions for crop yields are secured. Applications of farm manure are very desirable on this soil as it is low in organic matter. Large increases in crop yields will follow the use of this material. Leguminous crops should be used as green manure when farm manure is not available. The type is acid and will respond to the use of lime when legumes are to be grown. The use of a phosphate fertilizer is to be recommended and considerable increases in crop yields may be secured by the application of acid phosphate or rock phosphate.

DAVENPORT SILTY CLAY LOAM (101)

The Davenport silty clay loam is a minor type, covering only 0.1 percent of the total area. There is one area of the type, just north of the city of Burlington.

The surface soil of the Davenport silty clay loam is a dark brown to chocolate-brown heavy, tenacious silty clay loam to clay loam, extending to a depth of 6 inches. The subsoil is a plastic chocolate-brown silty clay or clay becoming gradually lighter in color at the lower depths. At 18 inches it changes to a lighter reddish-brown clay, mottled with gray and yellowish-brown in the lower part. The lower subsoil generally gives a reaction for lime when tested with acid. The soil is underlaid with limestone rock which is usually well below the three foot section, but in some places it occurs within 12 inches of the surface. Drainage is poor, owing to the flat topography and the heavy character of the soil.

General farm crops are grown on the type, and the yields are very much the same as those secured on the Grundy silty clay loam. The type is in need of drainage to be made more productive. Small applications of farm manure would be of value to stimulate the production of available plant food. The use of lime to remedy the acidity in the surface soil would be of value when legumes are to be grown. The application of a phosphate fertilizer would bring about considerable crop increases.

SWAMP AND BOTTOMLAND SOILS

There are 10 areas of swamp and bottomland soils in the county and these with the area of riverwash make 11 soil areas. Together they cover 18.3 percent of the total area of the county.

WABASH SILTY CLAY LOAM (48)

The Wabash silty clay loam is the largest bottomland soil in the county and the fourth most extensively developed type. It covers 9.7 percent of the total area. It is found principally in the Mississippi River bottoms altho there are a few strips along the heads of the smaller creeks in the northwestern part of the county. These areas and the areas south of Spring Grove are subject to overflow. All the type north of Burlington to the county line, except small areas near the city is protected by the levee which keeps out the flood waters. The extensive development of the type along the river is particularly evidenced in the northeastern part of the county.

The surface soil of the Wabash silty clay loam is a black, tenacious silty clay loam to clay loam, extending to a depth of six to eight inches. At that point, the soil is a black stiff clay or silty clay sometimes faintly mottled with gray and brown to a depth of 18 to 24 inches. The lower subsoil is a dark brown or grayish-brown impervious clay mottled with yellowish-brown and gray, containing iron stains. In some places the dark brown or black clay extends thru the 3-foot section with faint gray or brown mottlings. occurring only in the lower part. Occasionally coarse sand and small pebbles are found on the surface and in the subsurface soil.

In topography the Wabash silty clay loam is level to flat. It is cut by a network of old sloughs and channels along the river, extending back one to one and one-half miles toward the bluffs. There were many shallow lakes formerly scattered over the area and most of these have been drained.

In the old depressed areas and poorly drained sloughs, the soil varies from the typical in that the surface soil is inclined to be marshy and there is a growth of rushes, sedges and water grasses. The subsoil in these areas is a gray to drab silty clay mottled with gray and iron stains in the lower depths. Occasionally there is some calcareous material in the lower subsoil. Deposits of so called alkali appear on the surface of the soil on the edges of these areas, in hot dry weather. Sometimes thin layers of peat and muck, 1 to 3 inches in depth cover the surface. These depressed poorly drained areas are found mainly north and northeast of Snider, in old disconnected sloughs near the river.

Small areas of riverwash and pure sand along the banks of the river are also included with the Wabash silty clay loam, because they are too small to show separately on the map. There are also patches of the Cass and Sarpy fine sandy loams which cannot be mapped separately because of their small extent. These are found on the islands of the river.

About three-fourths of the type is under cultivation, general farm crops being grown. Corn yields 60 to 90 bushels per acre in favorable seasons when the soil is well drained. Wheat frequently yields from 20 to 42 bushels per acre, oats, 40 to 60 bushels and hay, 1½ to 3 tons per acre. Some wild hay is grown on the poorly drained areas. Some truck crops are grown. The areas not under cultivation are used for pasture purposes. The land outside the levee on the islands is completely covered in periods of high water. A few areas on the islands have been cleared and are farmed. The low depressed slough areas are non-agricultural until drained.

This type is chiefly in need of drainage to be made more productive. When thoroly drained, care should be taken to plow and cultivate the soil under proper moisture conditions to avoid baking and cracking. Small amounts of farm manure will stimulate the production of available plant food on this soil. Large amounts should not be used, and manure should not be applied preceding the growing of small grain crops. Applications of lime would be valuable when legumes are to be grown. The use of a phosphate fertilizer either acid phosphate or rock phosphate would prove very desirable on the type.

WABASH LOAM (49)

The Wabash loam is the second largest bottomland soil, covering 2.6 percent of the total area. It occurs along Spring Creek, Brush Creek and Long Creek and in considerable areas along the Flint River and in the Mississippi River bottoms. Other developments of the type are also found along the creeks which flow northward into Louisa County. There are a number of other areas of the type but the largest development is in the northeastern part of the county.

The surface soil of the Wabash loam to a depth of 20 inches is a dark brown to black friable loam, containing considerable very fine sand. The subsoil is a yellowish-brown to dark brown silty clay loam, mottled with yellowish-brown and gray. In the areas near Huron, the subsoil is a heavy loam, only slightly heavier than the surface soil, and in places it has a reddish cast. Along the smaller streams and tributaries, the darker colored heavier clay loam subsoil predominates. In the northeastern part of the county, in the Mississippi River bottoms, the soil is lighter in texture both in the surface soil and in the subsoil. Here the boundary lines between this type and the Cass loam have been fixed rather arbitrarily as there is gradual change from one type to the other. In the areas along the Flint River, the soil is characteristically lighter in texture.

The areas of the type along the Flint River and in the Mississippi River bottoms are practically all under cultivation, general farm crops being grown. Yields are very much the same as on the other Wabash types and are quite satisfactory in normal seasons. The areas along the smaller streams and their tributaries are largely pastured.

When cultivated, this soil will respond to applications of farm manure in small amounts to stimulate the production of available plant food. The type is acid and lime will prove of value for increasing the growth of legumes. The application of a phosphate fertilizer would be very desirable.

GENESEE VERY FINE SANDY LOAM (70)

The Genesee very fine sandy loam is the third largest bottomland soil, covering 1.6 percent of the total area. There are a number of small areas of the type along the Skunk River and Flint River, but it is developed most extensively in narrow strips along the shorter tributary streams which cut thru the light colored Clinton soils on the uplands.

The surface soil of the Genesee very fine sandy loam consists of 18 inches of a light yellowish-brown to brown very fine sandy loam. The subsoil is a lighter brown to brown very fine sandy loam to silt loam. In the various areas of the type, there are spots of light colored sand.

The areas along the smaller streams are largely subject to overflow and the bodies of the type along Flint River and Skunk River are frequently flooded. These latter areas are cropped mostly to corn, which yields 25 to 55 bushels per acre.

The smaller areas of the type along the minor streams are used for pasture purposes. When the areas are cultivated they will respond to liberal applications of farm manure. Lime should be added to remedy the acid condition which prevails in the soil and the application of a phosphate fertilizer would be very desirable.

WABASH SILT LOAM (26)

The Wabash silt loam is the fourth most extensive bottomland soil, covering 1.4 percent of the total area. It is found mainly along the smaller creeks and their tributaries in the Grundy silt loam upland plain. In the western part of the county there are continuous strips along the upper courses of Cedar Creek and Flint River. Small areas, 10 to 30 acres in size are found along the lower part of the river. Two of the larger areas lie southwest of Spring Grove. Narrow strips occur along Skunk River. There are few scattered areas in the Mississippi River bottoms north of Burlington and several in the vicinity of Huron.

The surface soil of the Wabash silt loam is a dark brown heavy silt loam, 18 inches in depth. This is underlaid by a dark brown or brown tenacious silty clay loam mottled with yellowish-brown and light gray. Where the type occurs near the heads of small tributary streams, there is considerable material washed on it from the adjacent uplands. Hence it is somewhat variable in character. Along Spring Creek and Brush Creek it is a rather light colored silt loam mixed with the typical darker silt loam.

The type is of minor importance but most of it is under cultivation. The narrower strips along the smaller streams are utilized for pasture. General farm crops are grown on the cultivated areas and in favorable seasons very good crop yields are secured. The type will respond to applications of farm manure, the use of lime to remedy acid conditions and the application of a phosphate fertilizer.

CASS LOAM (18)

The Cass loam is a minor type, covering only 1.2 percent of the total area. It is found mainly in the Mississippi River bottoms. There are three small areas, 10 to 40 acres in size, east of Spring Grove. A number of small areas are scattered among the sloughs along the river, in the northeastern part of the county. Other areas are found north and east of Huron near the county line. The largest individual area occurs north of Snider.

The surface soil of the Cass loam is a dark brown to black friable heavy loam, from 10 to 15 inches in depth. This is underlaid by a light brown to brown loamy sand, mottled with faint gray and yellowish-brown. Iron stains occur in the lower part of the subsoil and there is considerable coarse material and very fine sand. There are some variations in the texture of the subsoil. In some places it is a light brown loam, slightly lighter than the surface soil while in other areas, below 30 inches the subsoil is a fine to very fine loose sand. In topography the Cass loam is flat but drainage is good. The type is protected from overflow by the levee.

The soil is practically all in cultivation, a small portion being forested and used for pasture. Corn, oats, wheat and hay are the chief crops. Corn yields 35 to 60 bushels, oats, 30 to 55 bushles, wheat, 18 to 35 bushels and hay,

about 1½ to 2 tons per acre. Some areas are utilized for alfalfa and rye.

The type is naturally productive and in good seasons very satisfactory crop yields are secured. The application of farm manure would be valuable in increasing the yield of general farm crops. The use of lime would aid in securing the best growth of legumes. The addition of a phosphate fertilizer would be profitable.

CASS SILTY CLAY LOAM (51)

The Cass silty clay loam is a minor type covering only 0.5 percent of the total area. It is found only in the Mississippi River bottoms, on ridges adjacent to the main channel between the sloughs and old channels, or on the tops of the banks. The largest area of the type is found just northeast of the pumping station on Tama Slough. There are several other smaller bodies in this vicinity. A few narrow strips along sloughs near the river are found southeast of Kingston. Other small bodies occur ½ mile south of Concordia School and on the county line east of Iowa Lake. Many patches of the type too small to map have been included with the Wabash silty clay loam.

The surface soil of the Cass silty clay loam is a dark brown to black silty clay to clay loam, extending to a depth of about 8 inches. At this point it passes into a dark brown to brown silty clay, showing gray and yellowish-brown mottlings. At about 24 inches the subsoil is a brown heavy loam mottled with gray and yellowish-brown. Many variations occur in the upper subsoil. In places it is a reddish-brown silty clay, mottled with brown or reddish-brown. Below 26 to 28 inches it is a sandy clay or clayey sand grayish-brown in color, mottled with gray, reddish brown and iron stains. In other places the lower subsoil may be a yellowish or reddish-brown sand or sandy loam.

Less than half of the type is under cultivation, the remainder being covered with a growth of bass wood, elm, cottonwood, sycamore, oak and maple, and used for pasture. The type is protected from overflow by the levee. Drainage, however, is restricted because of the heavy surface soil. When brought under cultivation and used for general farm crops, the soil should, first of all, be adequately drained. It will then respond to small amounts of farm manure to stimulate the production of available plant food. Large applications of manure are not needed. The type is acid and additions of lime will be valuable for the growing of legumes. The use of a phosphate fertilizer would undoubtedly prove profitable.

GENESEE SILT LOAM (71)

The Genesee silt loam is a minor type, covering only 0.4 percent of the total area. It occurs in a few isolated areas northwest of Augusta in the Skunk River bottoms, and along the bluff road north of Burlington in the Mississippi River bottoms. The largest area is south of Spring Grove along the Skunk River.

The surface soil of the Genesee silt loam is a light brown heavy silt loam, containing much fine sand. At 12 inches, the subsoil is a friable light brown to brown silty clay loam. In some areas, the subsoil has about the same

texture as the surface soil but is somewhat lighter in color. The type is all subject to overflow except north of Burlington where the levee protects it.

The Genesee silt loam is largely utilized for general farm crops and corn and oats are grown principally. Corn yields from 30 to 55 bushels per acre. The type will respond in a very large way to applications of farm manure as it is low in organic matter. It is acid in reaction and lime should be applied. The use of a phosphate fertilizer is very desirable.

SARPY VERY FINE SANDY LOAM (28)

The Sarpy very fine sandy loam is a minor type in the county, covering only 0.4 percent of the total area. It is found in small irregular shaped strips, lying from 6 to 15 feet above the stream channel. Most of it is in the Mississippi River bottoms and it is protected from overflow by the levee. The largest area is found north of Burlington along Flint River. Another area occurs southeast of Spring Grove. Small areas are found just north of the pumping plant near Tama Slough, southeast of Huron, near Gates Lake, near the mouth of Yellow Spring Creek, and near Snider.

The surface soil of the Sarpy very fine sandy loam is a light brown to brown very fine sandy loam, containing considerable silt and some gravel. At 18 inches it becomes a lighter brown very fine sandy loam. There are many variations in the type and patches of sand and also of heavier soil ranging from a silt loam and very fine sand to fine sand in texture are scattered over the areas. Because of their small size they cannot be shown separately on the map. The area southeast of Spring Grove is a sandy loam to sand. The area near Snider is a pure, medium sand.

The Sarpy very fine sandy loam is largely under cultivation, corn being the chief crop grown. It yields from 25 to 50 bushels per acre, depending upon seasonal conditions. Potatoes, celery and other truck crops are occasionally grown on the soil with success. The type will respond favorably to the application of farm manure, particularly for the growing of truck crops. The soil is acid in reaction and will respond to liming in order to secure the best growth of legumes. It should receive a phosphate fertilizer for the best yields of general field crops and the use of complete commercial fertilizers will be valuable when truck crops are grown.

RAY SILT LOAM (195)

The Ray silt loam is a minor type, covering only 0.3 percent of the total area. It occurs only in the northeastern corner of the county in the Mississippi River bottoms. There are small areas in the vicinity of Kingston and Snider. The largest area is one-half mile south of Huron.

The surface soil of the Ray silt loam is a light yellowish-brown heavy silt loam, 12 inches in depth. The subsoil is a black, tenacious silty clay or clay containing much drift and frequently some coarse sand. Faint gray mottlings occur in the lower subsoil, becoming more extensive with depth. The surface soil may contain some coarse materials but usually it is a rather uniform silt. It has been developed from the material washed down from the light colored Clinton and Lindley soils on the hill tops and spread out over the black

alluvial clay of the bottomlands. In many cases after the heavy rains, thin layers of material newly washed down from the uplands are deposited over the type. The topography is level to flat and drainage is poor.

The Ray silt loam is used mostly for general farm crops or for pasture. The yields are much the same as those secured on the Genesee silt loam. This type needs to be protected from the flood waters from the uplands and the deepening and straightening of the stream channels from the uplands would very largely stop the flooding of this type. When cultivated, the soil will respond to applications of farm manure, it should be limed to remedy the acid conditions and the use of a phosphate fertilizer is very desirable.

CASS SANDY LOAM (19)

The Cass sandy loam is a minor type, covering only 0.2 percent of the total area. It is developed mainly in the Mississippi River bottoms, one to two miles north of Huron. There are a few scattered areas between Huron and Kingston along the Skunk River.

The surface soil of the Cass sandy loam is a dark brown sandy loam, extending to a depth of 12 inches. At this point it passes into a loose brown sandy loam to fine sandy loam, grading at 30 inches into a light yellowish-brown sandy loam. There is considerable coarse sand and gravel thruout the soil section. In topography, the Cass sandy loam is nearly flat. Some areas are found in strips which are slightly ridged or raised above the adjacent soil. Most of the type is protected from overflow by the levee.

General farm crops such as corn, wheat, oats and rye, are grown on this soil and all are apt to suffer in periods of dry weather. The chief need of the soil to bring about better crop yields is for the incorporation of liberal amounts of farm manure to build up the organic matter supply and reduce the danger of injury in drouthy periods. The type is acid and will respond to liming for the best growth of legumes. The application of a phosphate fertilizer would be of value.

RIVERWASH (53)

There is a small area of riverwash in the county, covering 0.1 percent of the total area. It has been mapped along the Mississippi River in the extreme northeastern corner of the county. The material consists of the recently deposited sediments from the stream and cannot be considered as a soil. It is made up of a mixture of coarse and fine materials and may be a sandbar or a mucky sand. The areas are worked over at every period of high water and are subject to change in size, shape and composition. The material has little agricultural value. A few trees, mostly willows, are scattered along the more permanent areas and occasionally there is a thin growth of grass on some of the better areas.

APPENDIX

THE SOIL SURVEY OF IOWA

What soils need to make them highly productive and to keep them so, and how their needs may be supplied, are problems which are met constantly on the farm today.

To enable every farmer to solve these problems for his local conditions, a complete survey and study of the soils of the state has been undertaken, the results of which will be published in a series of county reports. This work includes a detailed survey of the soils of each county, following which all the soil types, streams, roads, railroads, etc., are accurately located on a soil map. This portion of the work is being carried on in cooperation with the Bureau of Soils of the United States Department of Agriculture.

Samples of soils are taken and examined mechanically and chemically to determine their character and composition and to learn their needs. Pot experiments with these samples are conducted in the greenhouse to ascertain the value of the use of manure, fertilizers, lime and other materials on the various soils. These pot tests are followed in many cases by field experiments to check the results secured in the greenhouse. The meagerness of the funds available for such work has limited the extent of these field studies and tests have not been possible in each county surveyed. Fairly complete results have been secured, however, on the main types in the large soil areas.

Following the survey, systems of soil management which should be adopted in the various counties and on the different soils are worked out, old methods of treatment

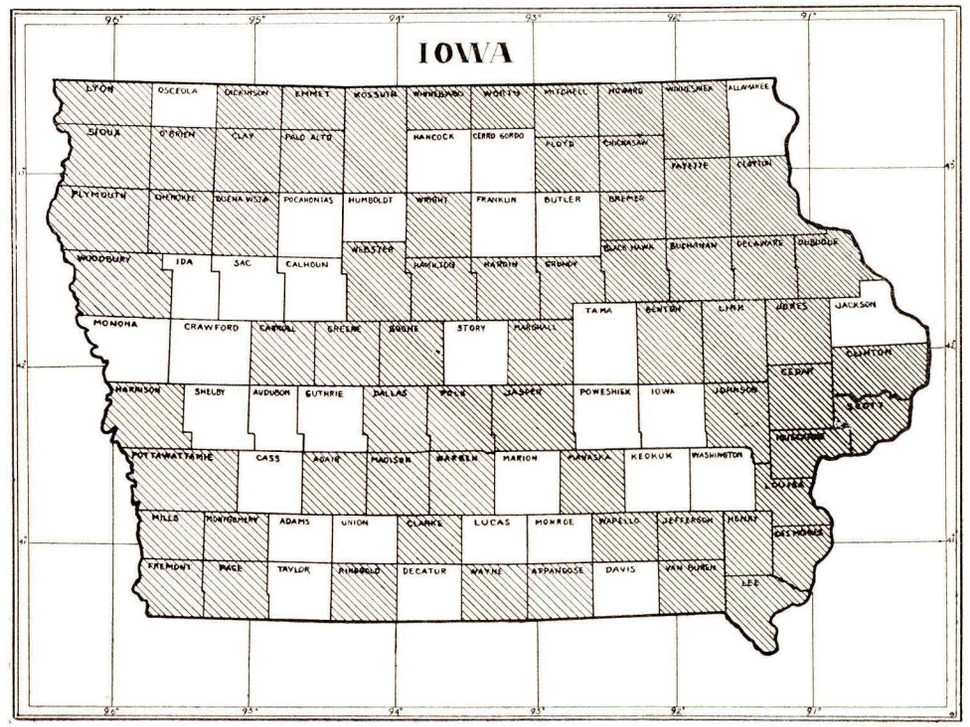

Fig. 8. Map of Iowa showing the counties surveyed

are emphasized as necessary or their discontinuance advised, and new methods of proven value are suggested.

PLANT FOOD IN SOILS

Fifteen different chemical elements are essential for plant food, but many of these occur so extensively in soils and are used in such small quantities that there is practically no danger of their ever running out. Such, for example, is the case with iron and aluminum, past experience showing that the amount of these elements in the soil remains practically constant.

Furthermore, there can never be a shortage in the elements which come primarily from the air, such as carbon and oxygen, for the supply of these in the atmosphere is practically inexhaustible. The same is true of nitrogen, which is now known to be taken directly from the atmosphere by well-inoculated legumes and by certain microscopic organisms. Hence, altho many crops are unable to secure nitrogen from the air and are forced to draw on the soil supply, it is possible by the proper and frequent growing of well-inoculated legumes and their use as green manures, to store up sufficient of this element to supply all the needs of succeeding non-legumes.

THE "SOIL DERIVED" ELEMENTS

Phosphorus, potassium, calcium and sulfur, known as "soil derived" elements, may frequently be lacking in soils, and then a fertilizing material carrying the necessary element must be used. Phosphorus is the element most likely to be deficient in all soils. This is especially true of Iowa soils. Potassium frequently is lacking in peats and swampy soils, but normal soils in Iowa and elsewhere are usually well supplied with this element. Calcium may be low in soils which have borne a heavy growth of a legume, especially alfalfa; but a shortage of this element is very unlikely. It seems possible from recent tests that sulfur may be lacking in many soils, for applications of sulfur fertilizers have proved of value in some cases. However, little is known as yet regarding the relation of this element to soil fertility. If later studies show its importance for plant growth and its deficiency in soils, sulfur fertilizers may come to be considered of much value.

AVAILABLE AND UNAVAILABLE PLANT FOOD

Frequently a soil analysis shows the presence of such abundance of the essential plant foods that the conclusion might be drawn that crops should be properly supplied for an indefinite period. However, applications of a fertilizer containing one of the elements present in such large quantities in the soil may bring about an appreciable and even profitable increase in crops.

The explanation of this peculiar state of affairs lies in the fact that all the plant food shown by analysis to be present in soils is not in a usable form; it is said to be **unavailable.** Plants cannot take up food unless it is in solution; hence **available** plant food is that which is in solution. Analyses show not only this soluble or available portion, but also the very much larger insoluble or unavailable part. The total amount of plant food in the soil may, therefore, be abundant for numerous crops, but if it is not made available fast enough, plants will suffer for proper food.

Bacteria and molds are the agents which bring about the change of insoluble, unavailable material into an available form. If conditions in the soil are satisfactory for their vigorous growth and sufficient total plant food is present, these organisms will bring about the production of enough soluble material to support good crop growth.

REMOVAL OF PLANT FOOD BY CROPS

The decrease of plant food in the soil is the direct result of removal by crops, altho there is often some loss by leaching also. A study of the amounts of nitrogen, phosphorus, and potassium removed by some of the common farm crops will show how rapidly these elements are used up under average farming conditions.

The amounts of these elements in various farm crops are given in table I. The amount of calcium and sulfur in the crops is not included, as it is only recently that the removal of these elements has been considered important enough to warrant analyses.

The figures in the table show also the value of the three elements contained in the different crops, calculated from the market value of fertilizers containing them. Thus the value of nitrogen is figured at 16 cents per pound, the cost of the element in nitrate of soda; phosphorus at 12 cents, the cost in acid phosphate, and potassium at 6 cents, the cost in muriate of potash.

TABLE I. PLANT FOOD IN CROPS AND VALUE

Calculating Nitrogen (N) at 16c (Sodium Nitrate ($NaNO_3$)), Phosphorus (P) at 12c (Acid Phosphate), and Potassium (K) at 6c (Potassium Chloride (KCl))

Crop	Yield	Plant food, lbs.			Value of Plant Food			Total value of plant food
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	
Corn, grain	75 bu.	75	12.75	14	$12.00	$1.52	$0.84	$14.37
Corn, stover	2.25 T.	36	4.5	39	5.76	0.54	2.34	8.64
Corn, crop		111	17.25	53	17.76	2.07	3.18	23.01
Wheat, grain	30 bu.	42.6	7.2	7.8	6.81	0.86	0.46	8.13
Wheat, straw	1.5 T.	15	2.4	27	2.40	0.28	1.62	4.30
Wheat, crop		57.6	9.6	34.8	9.21	1.14	2.08	12.43
Oats, grain	50 bu.	33	5.5	8	5.28	0.66	0.48	6.42
Barley, straw	1.25 T.	15.5	2.5	26	2.48	0.30	1.56	8.28
Oats, crop		48.5	8	34	7.76	0.96	2.04	14.70
Barley, grain	30 bu.	23	5	5.5	3.68	0.60	0.33	4.61
Barley, straw	0.75 T.	9.5	1	13	1.52	0.12	0.78	2.42
Barley, crop		32.5	6	18.5	5.20	0.72	1.11	7.03
Rye, grain	30 bu.	29.4	6	7.8	4.70	0.72	0.46	5.88
Rye, straw	1.5 T.	12	3	21	1.92	0.36	1.26	3.54
Rye, crop		41.4	9	28.8	6.62	1.08	1.72	9.42
Potatoes	300 bu.	63	12.7	90	10.08	1.25	5.40	17.00
Alfalfa, hay	6 T.	300	27	144	48.00	3.24	8.64	59.88
Timothy, hay	3 T.	72	9	67.5	11.52	1.08	3.95	16.55
Clover, hay	3 T.	120	15	90	19.20	1.80	5.40	16.40

It is evident from the table that the continuous growth of any common farm crop without returning these three important elements will lead finally to a shortage of plant food in the soil. The nitrogen supply is drawn on the most heavily by all the crops, but in the case of alfalfa and clover only a small part should be taken from the soil. If these legumes are inoculated as they should be, they will take most of their nitrogen from the atmosphere. The figures are therefore entirely too high for the nitrogen taken from the soil by these two crops, but the loss of nitrogen from the soil by removal in non-leguminous crops is considerable. The phosphorus and potassium in the soil are also rapidly reduced by the growth of ordinary crops. While the nitrogen supply may be kept up by the use of leguminous green manure crops, phosphorus and potassium must be supplied by the use of expensive commercial fertilizers.

The cash value of the plant food removed from soils by the growth and sale of various crops is considerable. Even where the grain alone is sold and the crop residues are returned to the soil, there is a large loss of fertility, and if the entire crop is removed and no return made, the loss is almost doubled. It is evident, therefore, that in calculating the actual income from the sale of farm crops, the value of the plant food removed from the soil should be subtracted from the proceeds at least in the case of constituents which must be replaced at the present time.

Of course, if the crops procured are fed on the farm and the manure carefully preserved and used, a large part of the valuable matter in the crops will be returned to the soil. This is the case in livestock and dairy farming where the products sold contain only a portion of the valuable elements of plant food removed from the soil. In grain farming, however, green manure crops and commercial fertilizers must be depended upon to supply plant food deficiencies in the soil. It should be mentioned that the proper use of crop residues in this latter system of farming reduces considerably plant food loss.

REMOVAL FROM IOWA SOILS

It has been conservatively estimated that the plant food taken from Iowa soils and shipped out of the state in grain amounts to about $30,000,000 annually. This calculation is based on the estimate of the secretary of the Western Grain Dealers' Association that 20 per cent of the corn and 35 to 40 per cent of the oats produced in the state is shipped off the farms.

This loss of fertility is unevenly distributed over the state, varying as farmers do more or less livestock and dairy farming or grain farming. In grain farming, where no manure is produced and the entire grain crop is sold, the soil may very quickly become deficient in certain necessary plant foods. Eventually, however, all soils are depleted in essential food materials, whatever system of farming is followed.

PERMANENT FERTILITY IN IOWA SOILS

The preliminary study of Iowa soils, already reported, revealed the fact that there is not an inexhaustible supply of nitrogen, phosphorus and potassium in the soils of the state. Potassium was found in much larger amounts than the other two elements, and it was concluded, therefore, that attention should be centered at the present time on nitrogen and phosphorus. In spite of the fact that Iowa soils are still comparatively fertile and crops are still large there is abundant evidence at hand to prove that the best possible yields of certain crops are not being obtained in many cases because of the lack of necessary plant foods or because of the lack of proper conditions in the soil for the growth of plants and production, by bacteria, of available plant food.

Proper systems of farming will insure the production of satisfactory crops and the maintenance of permanent fertility and the adoption of such systems should not be delayed until the crop yields are much lower, for then it will involve a long, tedious and very expensive fight to bring the soil back to a fertile condition. If proper methods are put into operation while comparatively large amounts of certain plant foods are still present in the soil, it is relatively easy to keep them abundant and attention may be centered on other elements likely to be limiting factors in crop production.

Soils may be kept permanently fertile by adopting certain practices which will be summarized here.

CULTIVATION AND DRAINAGE

Cultivation and drainage are two of the most important farm operations in keeping the soil in a favorable condition for crop production, largely because they help control the moisture in the soil.

The moisture in soils is one of the most important factors governing crop production. If the soil is too dry, plants suffer for lack of water necessary to bring them their food and also for lack of available plant food. Bacterial activities are so restricted in dry soils that the production of available plant food practically ceases. If too much moisture is present, plants likewise refuse to grow properly because of the exclusion of air from the soil and the absence of available food. Decay is checked in the absence of air, all beneficial bacterial action is limited and humus, or organic matter, containing plant food constituents in an unavailable form, accumulates. The infertility of low-lying, swampy soils is a good illustration of the action of excessive moisture in restricting plant growth by stopping aeration and limiting beneficial decay processes.

While the amount of moisture in the soil depends very largely on the rainfall, any excess of water may be removed from the soil by drainage and the amount of water present in the soil may be conserved during the periods of drouth by thoro cultivation or the maintaining of a good mulch. The need for drainage is determined partly by the nature of the soil, but more particularly by the subsoil. If the subsoil is a heavy, tight clay, a surface clay loam will be rather readily affected by excessive rainfall. On the other hand, if the surface soil is sandy, a heavy subsoil will be of advantage in preventing the rapid drying out of the soil and also in checking losses of valuable matter by leaching.

THE ROTATION OF CROPS

Experience has shown many times that the continuous growth of one crop takes the fertility out of a soil much more rapidly than a rotation of crops. One of the most important farm practices, therefore, from the standpoint of soil fertility, is the rotation of crops on a basis suited to the soil, climatic, farm and market conditions. The choice of crops is so large that no difficulty should be experienced in selecting those suitable for all conditions.

There are several explanations of the value of rotations. One is that crops in their growth produce certain substances called "toxic" which are injurious to the same crop, but have no effect on certain other crops. In a proper rotation the time between two different crops of the same plant is long enough to allow the "toxic" substance to be disposed of in the soil or made harmless. This theory has not been commonly accepted, chiefly because of the lack of confirmatory evidence. It seems extremely doubtful if the amounts of these "toxic" substances could be large enough to bring about the effects evidenced in continuous cropping.

But, whatever the reason for the bad effects of continuous cropping, it is evident that for all good systems of farming some definite rotation should be adopted, and that rotations should always contain a legume, because of the value of such crops to the soil. In no other way can the humus and nitrogen content of soils be kept up so cheaply and satisfactorily as by the use of legumes, either as regular or "catch" crops in the rotation.

MANURING

There must always be enough humus, or organic matter, and nitrogen in the soil if satisfactory crops are to be secured. Humus not only keeps the soil in the best physical condition for crop growth, but it supplies a considerable amount of nitrogen. An abundance of humus may always be considered a reliable indication of the presence of much nitrogen. This nitrogen does not occur in a form available for plants, but with proper physical conditions in the soil, the nonusable nitrogen in the animal and vegetable matter which makes up the humus, is made usable by numerous bacteria and changed into soluble and available nitrates.

The humus, or organic matter, also encourages the activities of many other bacteria which produce carbon dioxide and various acids which dissolve and make available the insoluble phosphorus and potassium in the soil.

Three materials may be used to supply the organic matter and nitrogen of soils. These are farm manure, crop residues and green manure, the first two being much more common.

By using all the crop residues, all the manure produced on the farm, and giving well-inoculated legumes a place in the rotation for green manure crops, no artificial means of maintaining the humus and nitrogen content of soils need be resorted to.

THE USE OF PHOSPHORUS

Iowa soils are not abundantly supplied with phosphorus. Moreover, it is possible by the use of manures, green manures, crop residues, straw, stover, etc., to return to the soil the entire amount of that element removed by crops. Crop residues, stover and straw merely return a portion of the phosphorus removed, and while their use is important in checking the loss of the element, they cannot stop it. Green manuring adds no phosphorus that was not used in the growth of the green manure crop. Farm manure returns part of the phosphorus removed by crops which are fed on the farm, but not all of it. While, therefore, immediate scarcity of phosphorus in Iowa soils cannot be positively shown, analyses and results of experiments show that in the more or less distant future, phosphorus must be applied or crops will suffer for a lack of this element. Furthermore, there are indications that its use at present would prove profitable in some instances.

Phosphorus may be applied to soils in three commercial forms, bone meal, acid phosphate and rock phosphate. Bone meal cannot be used generally, because of its extremely limited production, so the choice rests between rock phosphate and acid phosphate. Experiments are now under way to show which is more economical for farmers in the state. Many tests must be conducted on a large variety of soil types, under widely differing conditions, and thru a rather long period of years. It is at present impossible to make these experiments as complete as desirable, owing to small appropriations for such work, but the results secured from the tests now in progress will be published from time to time in the different county reports.

Until such definite advice can be given for individual soil types, it is urged that farmers who are interested make comparisons of rock phosphate and acid phosphate on their own farms. In this way they can determine at first hand the relative value of the two materials. Information and suggestions regarding the carrying out of such tests may be secured upon application to the Soils Section.

LIMING

Practically all crops grow better on a soil which contains lime, or in other words, on one which is not acid. As soils become acid, crops grow smaller, bacterial activities are reduced and the soil becomes infertile. Crops are differently affected by acidity in the soil; some refuse to grow at all; others grow but poorly. Only in a very few instances can a satisfactory crop be secured in the absence of lime. Therefore, the addition of lime to soils in which it is lacking is an important principle in permanent soil fertility. All soils gradually become acid because of the losses of lime and other basic materials thru leaching the production of acids in the decomposition process constantly occurring in soils. Iowa soils are no exceptions to the general rule, as was shown by the tests of many representative soils reported in Bulletin No. 151 of this station. Particularly are the soils in the Iowan drift, Mississippi loess and Southern Iowa loess areas likely to be acid.

All Iowa soils should therefore be tested for acidity before a crop is seeded, particularly when legumes, such as alfalfa or red clover, are to be grown. Any farmer may test his own soil and determine its need of lime, according to simple directions in bulletin No. 151, referred to above.

As to the amount of lime needed for acid soils as a general rule sufficient should be applied to neutralize the acidity in the surface soil and then an additional amount of one or two tons per acre.

SOIL AREAS IN IOWA

There are five large soil divisions in Iowa, the Wisconsin drift, the Iowan drift, the Missouri loess, the Mississippi loess and the Southern Iowa loess. These five divisions of the soils of the state are based on the geological forces which brought about the formation of the various soil areas.

With the exception of the northeastern part of the state, the whole surface of Iowa was in ages past overrun by the great continental ice sheets. These great masses of ice moved slowly over the land, crushing and grinding the rocks beneath and carrying along with them the material which they accumulated in their progress. Five ice sheets invaded Iowa at different geological eras, coming from different directions and carrying therefore, different rock material with them.

The deposit, or sheet, of earth debris left after the ice of such glaciers melts is called "glacial till" or "drift" and is easily distinguished by the fact that it is usually a rather stiff clay containing pebbles of all sorts as well as large boulders or "nigger heads." Two of these drift areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift was laid down at a much earlier period and is somewhat poorer in plant food than the Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

The drift deposits in the remainder of the state have been covered by so-called loess soils, vast accumulations of dust-like materials which settled out of the air during a period of geological time when climatic conditions were very different than at present. These loess soils are very porous in spite of their fine texture and they rarely contain large pebbles or stones. They present a strong contrast to the drift soils, which are somewhat heavy in texture and filled with pebbles and stone. The three loess areas in the state, the Missouri, the Mississippi and the Southern Iowa, are distinguished by differences in texture and appearance, and they vary considerably in value for farming purposes. In some sections the loess is very deep, while in other places the underlying leached till or drift is very close to the surface. The fertility of these soils and their needs are greatly influenced, therefore, by their depth.

It will be seen that the soils of the state may be roughly divided into two classes, drift soils and loess soils, and that further division may then be made into various drift and loess soils because of differences in period of formation, characteristics and general composition. More accurate information demands, however, that further divisions be made. The different drift and loess areas contain large numbers of soil types which vary among themselves, and each of these should receive special attention.

THE SOIL SURVEY BY COUNTIES

It is apparent that a general survey of the soils of the state can give only a very general idea of soil conditions. Soils vary so widely in character and composition, depending on many other factors than their source, that definite knowledge concerning their needs can be secured only by thoro and complete study of them in place in small areas. Climatic conditions, topography, depth and character of soil, chemical and mechanical composition and all other factors affecting crop production must be considered.

This is what is accomplished by the soil survey of the state by counties, and hence the needs of individual soils and proper systems of management may be worked out in much greater detail and be much more complete than would be possible by merely considering the large areas separated on the basis of their geological origin. In other words, while the unit in the general survey is the geological history of the soil area, in the soil survey by counties or any other small area, the unit is the soil type.

GENERAL SOIL CHARACTERISTICS

Soil types possess more or less definite characteristics which may be determined largely in the field, altho some laboratory study is necessary for final disposition. Usually the line of separation between adjoining soil types is quite distinct and it is a simple matter to locate the type boundaries. In some cases, however, there is a graduation from one type to another and then the boundaries may be fixed only with great difficulty. The error introduced into soil survey work from this source is very small and need cause little concern.

The factors which must be taken into account in establishing soil types have been well enumerated by the Illinois Experiment Station in its Soil Report No. 1.
They are:

1. The geological origin of the soil, whether residual, glacial, loessial, alluvial, colluvial or cumulose.

2. The topography or lay of the land.
3. The structure or depth and character of the surface, subsurface and subsoil.
4. The physical and mechanical composition of different strata composing the soil, as the percentages of gravel, sand, silt, clay and organic matter which they contain.
5. The texture of porosity, granulation, friability, plasticity, etc.
6. The color of the strata.
7. The natural drainage.
8. The agricultural value based upon its natural productiveness.
9. Native vegetation.
10. The ultimate chemical composition and reaction.

The common soil constituents may be given as follows:†

Organic matter	All partially destroyed or decomposed vegetable and animal material.
Inorganic matter	Stones—over 32 mm.* Gravel—32—2.0 mm. Very coarse sand—2.0—1.0 mm. Coarse sand—1.0—0.5 mm. Medium sand—0.5—0.25 mm. Fine sand—0.25—0.10 mm. Very fine sand—0.10—0.05 mm. Silt—0.05—0.00 mm.

SOILS GROUPED BY TYPES

The general groups of soils by types are indicated thus by the Bureau of Soils.

Peats—Consisting of 35 percent or more of organic matter, sometimes mixed with more or less sand or soil.

Peaty Loams—15 to 35 percent organic matter mixed with much sand and silt and a little clay.

Mucks—25 to 35 percent of partly decomposed organic matter mixed with much clay and some silt.

Clays—Soils with more than 30 percent clay, usually mixed with much silt; always more than 50 percent silt and clay.

Silty Clay Loams—20 to 30 percent clay and more than 50 percent silt.

Clay Loams—20 to 30 percent clay and less than 50 percent silt and some sand.

Silt Loams—20 percent clay and more than 50 percent silt mixed with some sand.

Loams—Less than 20 percent clay and less than 50 percent silt and from 30 to 50 percent sand.

Sandy Clays—20 percent silt and small amounts of clay up to 30 percent.

Fine Sandy Loams—More than 50 percent fine sand and very fine sand mixed with less than 25 percent very coarse sand, coarse sand and medium sand, much silt and a little clay; silt and clay 20 to 50 percent.

Sandy Loams—More than 25 percent very coarse, coarse and medium sand; silt and clay 20 to 50 percent.

Very Fine Sand—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.

Fine Sand—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.

Sand—More than 25 percent very coarse, coarse and medium sand, less than 50 percent fine sand, less than 20 percent silt and clay.

Coarse Sand—More than 25 percent very coarse, coarse and medium sand, less than 50 percent of other grades, less than 20 percent silt and clay.

Gravelly Loams—25 to 50 percent very coarse sand and much sand and some silt.

Gravels—More than 50 percent very coarse sand.

Stony Loams—A large number of stones over one inch in diameter.

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*25mm equals 1 in. †Bureau of Soils Field Book.

METHODS USED IN THE SOIL SURVEY

It may be of some interest to state briefly the methods which are followed in the field in surveying the soils.

As has been indicated the completed map is intended to show the accurate location and boundaries, not only of all soil types but also of the streams, roads, railroads, etc.

The first step, therefore, is the choice of an accurate base map and any official map of the county may be chosen for this purpose. Such maps are always checked to correspond correctly with the land survey. The location of every stream, road and railroad on the map is likewise carefully verified and corrections are frequently necessary. When an accurate base map is not available the field party must first prepare one.

The section is the unit area by which each county is surveyed and mapped. The distances in the roads are determined by an odometer attached to the vehicle, and in the field by pacing, which is done with accuracy. The directions of the streams, roads, railroads, etc., are determined by the use of the compass and the plane table. The character of the soil types is ascertained in the section by the use of the auger, an instrument for sampling both the surface soil and the subsoil. The boundaries of each type are then ascertained accurately in the section and indicated on the map. Many samplings are frequently necessary, and individual sections may contain several soil types and require much time for mapping. In other cases, the entire section may contain only one soil type, which fact is readily ascertained, and in that case the mapping may proceed rapidly.

When one section is completed, the party passes to the next section and the location of all soil types, streams, etc., in that section is then checked with their location in the adjoining area just mapped. Careful attention is paid to the topographic features of the area, or the "lay of the land," for the character of the soils is found to correspond very closely to the conditions under which they occur.

The field party is composed of two men, and all observations, measurements and soil type boundaries are compared and checked by each man.

The determinations of soil types are verified also by inspection and by consultation with those in charge of the work at the Bureau of Soils and at the Iowa Agricultural Experiment Station. When the entire county is completed, all the section maps of field sheets are assembled and any variations or questionable boundaries are verified by further observations of the particular area.

The completed map, therefore, shows as accurately as possible all soils and soil boundaries, and it constitutes also an exact map of the county.