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SOIL SURVEY OF IOWA CLARKE COUNTY

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Soil Survey Report No. 51
June, 1928
Ames, Iowa

SOIL SURVEY OF IOWA

Report No. 51—CLARKE COUNTY SOILS

By W. H. Stevenson and P. E. Brown with the assistance of A. M. O'Neal,
L. W. Forman and H. R. Meldrum



Fig. 1. Shelby loam topography in Clarke County, north of Murray.

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- 1 The Chemical Nature of the Organic Nitrogen in the Soil.*
- 2 Some Bacteriological Effects of Liming.*
- 3 Influences of Various Factors on the Decomposition of Soil Organic Matter.*
- 4 Bacterial Activities in Frozen Soils.*
- 5 Bacteriological Studies of Field Soils, I.*
- 6 Bacteriological Studies of Field Soils, II.*
- 7 Bacteria at Different Depths in Some Typical Iowa Soils.*
- 8 Amino Acid and Acid Amides as Source of Ammonia in Soils.*
- 9 Methods for the Bacteriological Examination of Soils.*
- 10 Bacteriological Studies of Field Soils, III.*

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CLARKE COUNTY SOILS*

By W. H. STEVENSON and P. E. BROWN, with the assistance of A. M. O'NEAL, L. W. FORMAN and H. R. MELDRUM

Clarke County is located in southern central Iowa in the second tier of counties north of Missouri, in the fifth tier east of the Missouri River and in the seventh tier west of the Mississippi River. It is entirely in the Southern Iowa loess soil area and almost one-half of the soils of the county are of loessial origin, the remainder being mainly derived from the underlying drift, exposed thru the action of erosion.

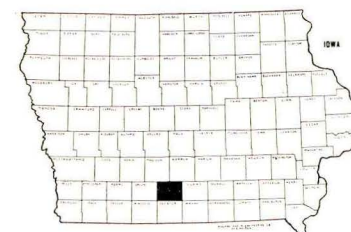


Fig. 2. Map showing the location of Clarke County.

The total area of the county is 428 square miles, or 273,920 acres. Of this area 263,177 acres, or 96 percent, is in farm land. The total number of farms is 1,519, and the average size of the farms is 173 acres. The farms are operated by 764 owners, 147 relative

renters, 517 renters and 91 both owning and renting. The following figures taken from the Iowa Yearbook of Agriculture for 1926 show the utilization of the farm land in the county:

| | |
|---|---------|
| Acreage in general farm crops..... | 132,909 |
| Acreage in farm buildings, public highways and feed lots..... | 11,041 |
| Acreage in pasture | 110,798 |
| Acreage in waste land not utilized for any purpose..... | 1,452 |
| Acreage in farm woodlots used for timber only..... | 3,198 |
| Acreage in farm lands lying idle..... | 794 |
| Acreage in crops not otherwise listed..... | 223 |

THE AGRICULTURE OF CLARKE COUNTY

The type of agriculture practiced at the present time in Clarke County consists mainly of a system of general farming, including the growing of grain and hay and the raising and feeding of cattle and hogs. Corn is the chief crop grown and other crops of less importance include oats, hay and wheat. The raising of hogs is the most important livestock industry. The raising and feeding of beef cattle is second in importance. Dairying is practiced to some extent, and sheep raising is a minor industry. There is very little grain farming, the great majority of the farmers combining grain production and livestock raising. Many of the farms are operated entirely on a livestock basis. It is generally recognized that the livestock, and the general systems of farming, permit more ready maintenance of soil fertility, which has led to a general tendency toward these systems. The farm income of the county is derived from the sale of hogs, beef cattle, dairy products and sheep and from the sale of surplus corn and other crops.

There is a considerable area in waste land, much of which might be reclaimed and made productive thru proper methods of treatment. It is impossible to make general recommendations for the reclamation of waste lands, as the causes of infertility are so variable. Later in this report, under the descriptions of

* See Soil Survey of Clarke County, Iowa, by A. M. O'Neal, of the Iowa Agricultural Experiment Station, and C. B. Boatwright, of the U. S. Department of Agriculture.

TABLE I. AVERAGE YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN CLARKE 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 crops |
|-------------------------------------|---------|--------------------------------------|--------------------------|-----------------------|---------------|----------------------|
| Corn..... | 61,028 | 23.2 | 35.5 | 2,166,494 | \$ 0.54 | \$1,169,906 |
| Oats..... | 28,838 | 10.9 | 29.0 | 838,271 | 0.35 | 293,394 |
| Winter wheat..... | 3,265 | 1.2 | 20.0 | 65,300 | 1.20 | 78,360 |
| Barley..... | 92 | .04 | 25.0 | 2,300 | 0.56 | 1,288 |
| Rye..... | 71 | .03 | 15.0 | 1,065 | 0.82 | 873 |
| Clover hay..... | 3,578 | 1.4 | 1.12 | 4,007 | 15.60 | 62,509 |
| Timothy hay..... | 1,087 | .41 | 0.51 | 556 | 12.25 | 6,811 |
| Timothy and clover hay (mixed)..... | 21,036 | 8.0 | 0.71 | 14,936 | 14.60 | 218,065 |
| Alfalfa hay..... | 151 | 0.06 | 2.20 | 332 | 19.50 | 6,474 |
| Wild hay..... | 46 | 0.02 | 0.73 | 34 | 12.50 | 425 |
| Soybeans..... | 92 | 0.04 | ..... | ..... | ..... | ..... |
| Potatoes..... | 16 | .005 | 94.0 | 1,504 | 1.70 | 2,556 |
| Timothy seed..... | 13,173 | 5.0 | 4.5 | 59,411 | 2.60 | 154,468 |
| Clover seed..... | 437 | .17 | .42 | 185 | 16.25 | 3,006 |
| Pasture..... | 110,798 | 42.1 | ..... | ..... | ..... | ..... |

* Iowa Yearbook of Agriculture, 1926.

individual soil types, special treatments will be suggested for use under particular soil conditions to make the soil more productive. In special cases for more or less abnormal conditions advice regarding treatment may be secured upon request from the Soils Section of the Iowa Agricultural Experiment Station.

THE CROPS GROWN IN CLARKE COUNTY

The general farm crops grown in Clarke County, in the order of their importance, are: corn, oats, hay, wheat, alfalfa, potatoes, barley and rye. The average yields and value of these crops are given in table I.

Corn is the principal crop, and it occupies 23.2 percent of the total farm land. Average yields per acre amount to 35.5 bushels. The varieties most commonly grown include Reid's Yellow Dent, Iowa Goldmine and Iowa Silvermine. When planting is delayed in the spring, Bloody Butcher and Ninety-Day White, both quick maturing varieties, are often used. Most of the corn is husked in the field, a small part being cut for ensilage and a small acreage being hogged down. When the corn is to be used for silage, soybeans are frequently drilled in at the time of planting. Rape is sometimes sown in the fields that are to be used for hogging down. Practically all the corn is used on the farms as feed for cattle, hogs and work stock.

Oats are the second crop of importance, being grown on 10.9 percent of the total farm land. Average yields per acre amount to 29 bushels. Iowa 103, Iowa 105, Iowar, Green Russian and Kherson are the principal varieties. About 10 percent of the oat crop is shipped thru the local elevators to outside markets, the remainder being utilized on the farms as feed for the work stock, cattle and hogs.

The third crop of importance is hay, which consists mainly of clover and timothy mixed. Hay is produced on 8.0 percent of the total farm land of the county, and average yields amount to 0.71 tons per acre. The value of the mixed hay crop is considerable. The clover and timothy is usually seeded with oats as a nurse crop. The first crop of clover is cut for hay, while the second is either harvested or pastured late and then turned under. The second year the clover

dies out and the timothy is grown for hay and seed. A considerable area is utilized for clover hay, amounting to 1.4 percent of the total farm land. Average yields amount to 1.12 tons per acre. In a number of cases clover is grown for seed, and the timothy crop, also, is frequently used for seed purposes. In 1926 over 13,000 acres were utilized for the production of timothy seed, and 437 acres were utilized for clover seed. There is a very small area of wild hay.

The wheat crop is fourth in importance, being grown on 1.2 percent of the total area. Average yields amount to 20 bushels per acre. Winter wheat is grown exclusively, and this crop constitutes the principal cash crop of the county, practically all of it being shipped out. The varieties most commonly grown are Turkey and Kanred.

Alfalfa, altho grown on a comparatively small acreage, constitutes a very valuable crop and could profitably be grown much more extensively than it is at present. Grimm and Northern Hardy are the varieties most commonly preferred. The spring seeding is considered preferable. The use of lime, to correct the acid condition of the soil, and the inoculation of the crop are essential for a good stand. Three cuttings are usually obtained, and average yields amount to 2.2 tons per acre.

Barley is of minor importance, being grown on a relatively small acreage. Average yields amount to 25 bushels per acre. Rye is likewise of minor importance, average yields amounting to 15 bushels per acre.

Soybeans are a new crop and are being grown more extensively each year. They are frequently seeded with the corn which is to be used for silage, and sometimes they are grown for seed. Sweet clover is grown to some extent and might profitably be grown much more extensively. Soybeans are particularly valuable for green manuring and pasture purposes. Sorghum and sudan grass are grown to a limited extent and utilized for forage.

Potatoes are grown on practically every farm to supply, in part, the needs of the farm. Average yields of 94 bushels per acre are reported. The potatoes produced are insufficient to supply the home demand. Many other vegetables are grown on the farms, but all are utilized for home consumption.

The production of fruit is not important, but small orchards are found on practically all farms. The varieties of apples grown include Jonathan, Grimes Golden, Winesap, Wealthy and Snow. In many seasons the yields of apples are not satisfactory, largely due to the fact that little care is taken of the fruit trees. Cherries are grown in all parts of the county, and plums, grapes, strawberries and raspberries are produced on a small scale. Watermelons and cantaloupes are grown on a few farms, but the trucking industry is not developed to any considerable extent.

THE LIVESTOCK INDUSTRY IN CLARKE COUNTY

The extent of the livestock industry in Clarke County is indicated by the following figures taken from the Iowa Monthly Crop Report for July 1, 1927, giving the January 1, 1927, estimates of the Bureau of Crop and Livestock Estimates of the U. S. Department of Agriculture:

| | |
|------------------|--------|
| Horses..... | 6,400 |
| Mules..... | 900 |
| Cattle, all..... | 30,000 |
| Hogs..... | 51,000 |
| Sheep..... | 8,700 |

The raising of hogs is the most important livestock industry and it provides a considerable part of the income on many of the farms. Practically every farm has some hogs and enough animals are slaughtered to supply the home demands and the local markets. The Poland China, Duroc Jersey, Chester White, and Hampshire are the most popular breeds. About half the animals are sold thru cooperative agencies. A few ship directly to outside commission men, and others sell to buyers. Omaha, Chicago, Kansas City and Des Moines are the principal outside markets.

The raising and feeding of beef cattle is an extremely important industry. The most popular breeds are the Shorthorn, Hereford and Angus. On many farms the animals are purebred, on the remainder they are mostly grades. About 75 percent of the beef cattle are raised on the farms, and the feeders are bought on the Omaha, St. Joseph and Kansas City markets and shipped in late in the fall. In the western part of the county about 10 percent of the cattle are sold thru cooperative livestock associations. The majority of the farmers, however, ship independently and dispose of their stock thru commission houses.

Dairying is generally a side-line, and the animals are mostly grade Shorthorns. A few farmers, however, have purebred Jersey or Holstein herds, and devote their entire attention to the production of cream and butter. The cream is sold either to the creamery at Osceola or to cream stations in the towns in the area and shipped to outside markets. Dairy cattle are kept on practically every farm in sufficient numbers to supply the home demand. The value of the dairy products of the county is considerable and has been increasing in recent years. Conditions are satisfactory for this industry, and it might advantageously be developed to a greater extent.

Sheep raising is of minor importance, and sheep are kept only on about 15 percent of the farms. Shropshires are the popular breed. Sheep do particularly well on the rougher sections where excellent pasturage is provided. About 50 percent of the animals are sold by the cooperative associations, the remainder being disposed of to buyers.

A few horses and mules are raised on the farms, the horses being mostly of the medium to heavy draft type. They are raised for supplying the work stock required on the farm.

The poultry industry is limited. There is considerable profit, however, in the sale of poultry products, and the income on many farms might be considerably increased thru the proper development of this industry.

THE FERTILITY SITUATION IN CLARKE COUNTY

In general the crop yields secured on the soils of Clarke County are fairly satisfactory, but much larger yields might be secured by the adoption of proper methods of soil treatment.

In some areas drainage is not as well established as it should be to make the soils most highly productive, and in such places the first treatment required is the installation of tile to carry away the excess moisture. There are areas in the Grundy silt loam on the loessial upland, and in the Bremer and Calhoun silt loams on the terraces, where drainage is not entirely satisfactory. The installation of tile would be of large value in such places.

All the soils in the county are acid in reaction, and applications of lime are

very necessary for the best growth of general farm crops, particularly of legumes. It is very important that these soils be tested for lime needs and that applications of lime be made where necessary, if the most satisfactory yields of general farm crops and especially of legumes are to be secured.

Some of the soils in the county are rather light in color and, therefore, not overly well supplied with organic matter and nitrogen. Others are dark in color and apparently much better supplied with these constituents. On the lighter colored, coarser textured types the use of fertilizing materials which supply organic matter is particularly necessary to provide for the most satisfactory crop yields, but even on those types which are apparently better supplied with organic matter, the use of fertilizing materials supplying organic matter and nitrogen is very desirable at regular intervals if the supply is to be kept up. Applications of farm manure are of large value on the light colored soils and large increases in the yields of general farm crops are secured from the use of farm manure, but even on the darker colored soils applications of farm manure have been found to bring about large crop increases. It is certainly one of the most valuable fertilizing materials that can be used. The use of leguminous crops as green manures will also be of value on many of the soils in Clarke County. Green manuring is particularly valuable on the lighter colored, coarser textured types in which the organic matter content is low. It will prove of value also, however, on some of the darker colored soils as a supplement to or as a substitute for farm manure. The thoro utilization of all crop residues also aids materially in building up and maintaining the supply of organic matter in the soil.

The soils of Clarke County are rather low in phosphorus content and it seems evident from the analyses that are given later in this report that applications of phosphorus fertilizers will be needed on these soils in the very near future. From experiments which have been carried out on some of the main soil types in this county and on some of the same types in adjacent counties, and from the experience of many farmers, it is certain that applications of phosphorus fertilizers will bring about profitable returns in many cases in this county at the present time. Superphosphate or rock phosphate may be used on many of the soils now with distinct value. In some cases the superphosphate is apparently somewhat preferable for use. This is particularly true of the lighter colored soils. However, on many of the soils rock phosphate will undoubtedly be quite as desirable. Farmers should test both superphosphate and rock phosphate on their own soils under their particular farm conditions in order to learn which material may be used with more profitable returns.

Tests have been carried out using complete commercial fertilizers on some of the soils of the county, and, while increased crop yields have resulted from the application of these fertilizing materials, the increases have been no larger than those brought about by the use of superphosphate or rock phosphate. It seems, therefore, that for general farm crops the phosphate fertilizers may be used with greater profit, inasmuch as the complete brands are more expensive and very much larger crop increases must be secured from their use if they are to prove as profitable as the phosphates. Where truck crops are to be grown, certain brands of complete commercial fertilizers may be used with

distinct profit. Tests of complete fertilizers should always be carried out for any crop, however, before extensive applications are made. In the case of general farm crops, the value of a complete fertilizer should be compared with superphosphate before applications are made to large areas, in order that the more profitable material may be used.

The use of commercial nitrogenous fertilizers cannot generally be recommended for the soils of this county at the present time. In small amounts, as top dressings, commercial nitrogen may bring about profitable returns. In general, however, nitrogen may be more cheaply supplied to the soils of the county by the use of leguminous crops as green manures, by the proper preservation and application of farm manure and by the thoro utilization of crop residues. Only with special crops, or as top dressings, does it seem probable that commercial nitrogenous materials may be used with profit.

Commercial potassium fertilizers may sometimes prove of value in the county, but in general the soils are very well supplied with potassium and additions should not be necessary. Farmers who are interested in such materials should test their value by applying them to small areas to determine whether or not profitable crop increases may be secured from their use.

Considerable erosion occurs in the county; the Shelby loam, the Lindley silt loam and the Clinton silt loam being particularly affected. Some areas in other types are also occasionally injured by the washing away of the surface soil or by the formation of gullies. Wherever this destructive action occurs some method for the prevention or control of erosion should be adopted.

THE GEOLOGY OF CLARKE COUNTY

The geological history of Clarke County is of little significance in connection with the study of the soils of the county, inasmuch as the native bedrock has been so deeply buried by the deposits of glacial drift and loess that there is no significant effect upon the soil conditions. In general, the soils have been formed from the glacial drift deposits and the subsequent loess deposit.

At least twice during the glacial age, great ice sheets swept over the county and each upon its retreat left behind a vast deposit of glacial till. Little evidence remains of the earlier glaciation known as the pre-Kansan, except that there are occasionally layers of sand found between the beds of boulder clay in certain well-borings. These sand layers indicate the occurrence of some interval of time between the laying down of the pre-Kansan deposit and the deposition of the later Kansan.

The second glacier, known as the Kansan, passed over the entire area of the county, and the drift deposits are largely made up of the debris which was left by this glacier when it retreated. Originally the deposit of Kansan till, while rather variable in thickness, probably averaged around 125 feet in depth. The earlier topographic features of the county were completely obliterated by this glacier, the old valleys were filled and the old knolls and hills were cut away. The Kansan drift material in its unweathered condition is a bluish clay, containing many small boulders and a few large ones. Thru weathering, the upper layer of this clay is oxidized until the color changes to a red or reddish-brown. Where weathering has been less complete, a yellow color has developed. During the time which has elapsed since the loess covering was deposited over this drift

SOIL MAP OF CLARKE COUNTY, IOWA

Thomas D. Rice, Inspector, Northern Division. Soils Surveyed by
A. M. O'Neal of the Iowa Agricultural Experiment Station and
C. B. Boatwright of the U. S. Dept. of Agriculture

U. S. DEPT. OF AGRICULTURE, BUREAU OF SOILS
H. G. Knight, 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

Drift Soils

| | |
|----------------|----------------------|
| 79 | 32 |
| Shelby loam | Lindley silt loam |

Loess Soils

| | |
|---------------------|-------------------|
| 64 | 120 |
| Grundy silt loam | Tama silt loam |

| |
|----------------------|
| 80 |
| Clinton silt loam |

Terrace Soils

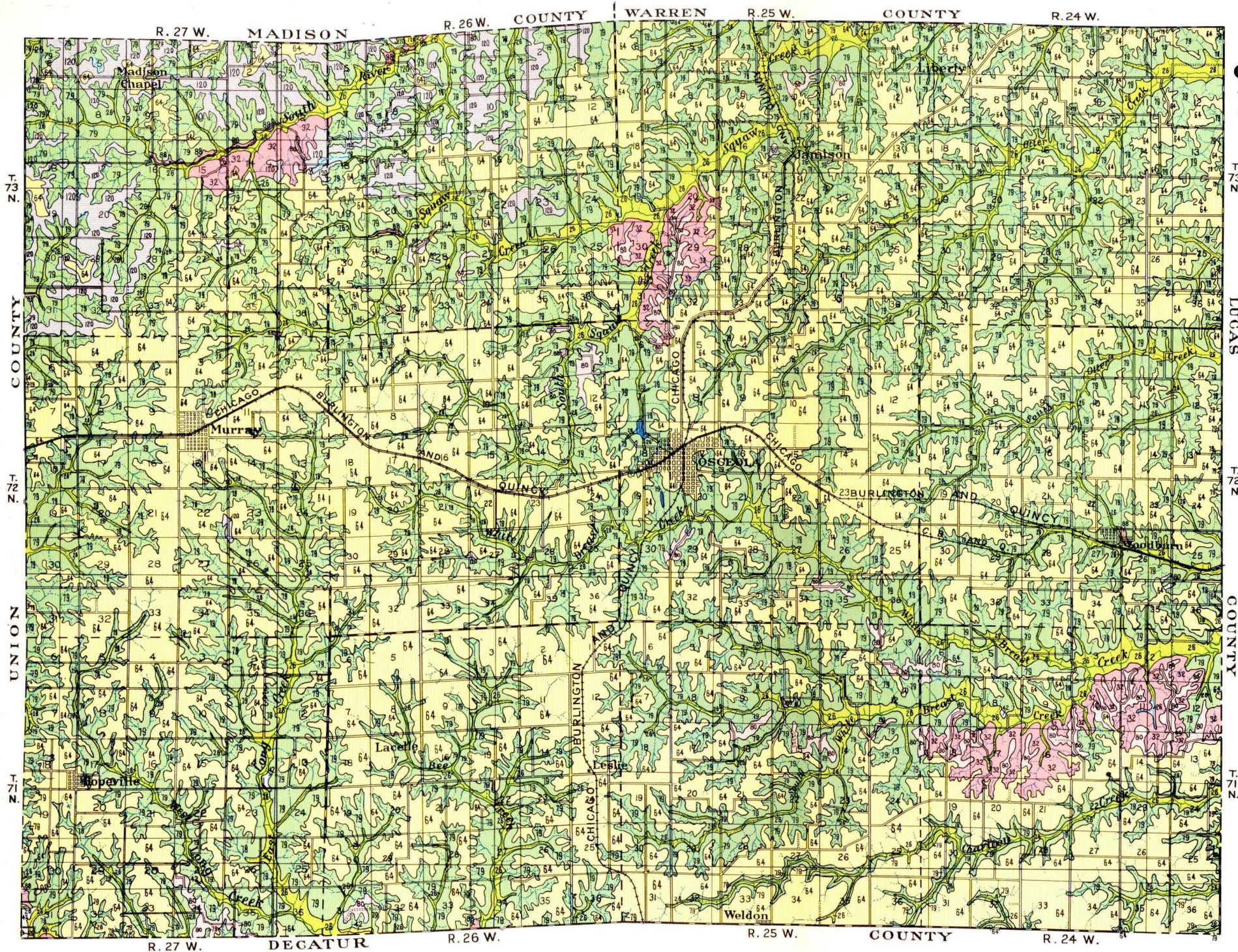
| | |
|---------------------|----------------------|
| 88 | 42 |
| Bremer silt loam | Calhoun silt loam |

Swamp and Bottomland Soils

| |
|---------------------|
| 26 |
| Wabash silt loam |

SCALE: 1 INCH TO 2 1/2 MILES

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material, there has been much washing away of the loessial material, and in many cases the underlying Kansan till is now exposed at the surface. The soils of the Shelby series are derived from the Kansan drift in areas where the loessial covering has been removed. The soils of the Lindley series are derived, in part, from the Kansan till and occur in areas where the loessial covering has been very largely, altho not entirely, removed.

At a later geological age, when climatic conditions were very different than those which prevail at present, a layer of fine silt-like material known as loess was laid down over the entire surface of the county. The deposit was undoubtedly uniform over the previous topographic features occurring in the county. The layer of loessial material probably averaged about 18 to 25 feet in thickness, being much thicker in the old valleys and thinner on the old hills. Since this deposition considerable erosion has washed away much of the loessial material. The depth of the deposit is now extremely variable, ranging from 1 to 18 feet. Unweathered, the loess is a yellow to light gray silt loam to silty clay loam. Thru the process of weathering and the accumulation of plant residues the color has changed and in much of the area the loess is now a dark brown to black. This is the characteristic color of the most important upland loess soil in the county, the Grundy. The color of the soils ranges, however, from the dark brown to black of the Grundy, and the similar dark color of the Tama, thru the lighter colored Putnam and Clinton series to the Marion series which are a light gray in color at the surface. All the upland soils of the county, except the Shelby, are derived in whole or in part from this loessial deposit. The Lindley soils are partly loessial in origin. The other series mentioned are entirely loessial.

There are many areas of terraces or second bottomlands and of first bottomland soils in the county. These are formed by the action of the various streams and are quite variable in character and depth. They generally consist of mixtures of drift and loess material carried by the streams from the uplands and deposited in layers of varying composition. These soils are mainly loessial in character. They are classified in the Bremer and Calhoun series on the terraces. The bottomland soil is the Wabash silt loam.

PHYSIOGRAPHY AND DRAINAGE

Originally the surface of Clarke County was a broad drift plain, but it has been modified and changed by the action of stream erosion until now the topography consists of irregular belts of rolling to strongly rolling or hilly land along the streams and drainageways, narrow strips of level bottomland soils bordering the streams and more or less level areas between the streams, which retain much of the original character of the surface plain. In the southern part of Green Bay and Franklin Townships the topography is generally level to gently undulating; the hills and slopes bordering Chariton Creek are gently rolling to moderately rolling, gradually merging with the broad, flat, inter-stream areas. Similar areas are found near Murray and north of Lacelle, altho here the transition from the level inter-stream areas to the strongly rolling to broken slopes to the streams is sometimes rather abrupt. In other parts of the county the broad upland areas are less extensive and somewhat irregular in shape, varying in width from one-half to one and a half miles. Thru the greater part of Madison and Washington Townships the upland inter-stream areas are

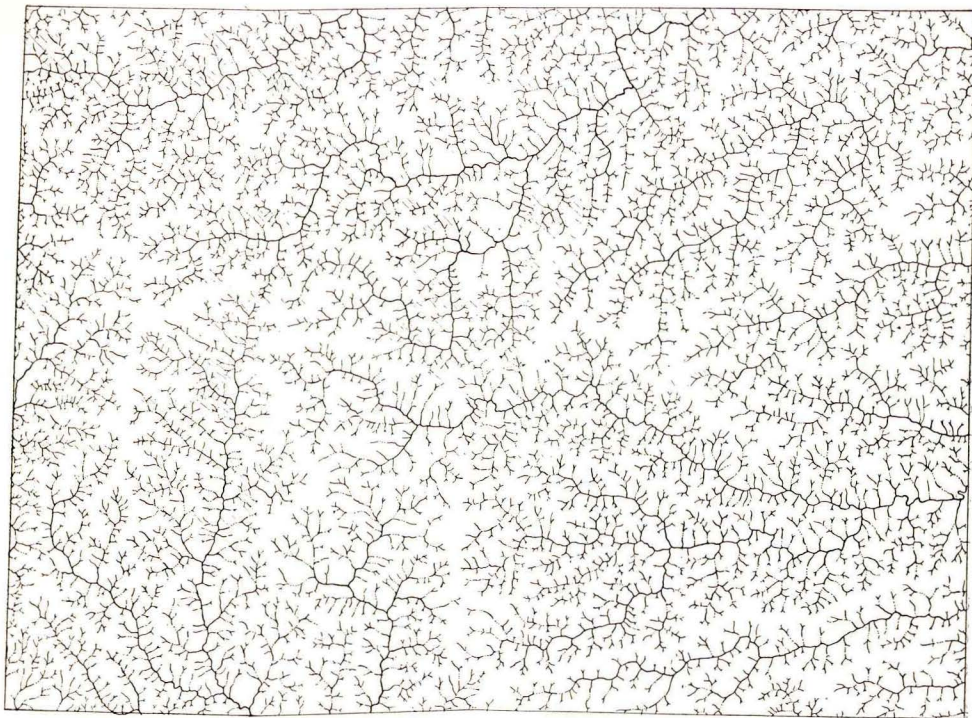


Fig. 3. Map showing the natural drainage of Clarke County.

less smooth; the topography varying from undulating to gently rolling. Here the level prairies merge gradually with the steep valley slopes.

Erosion has been more or less active along the various streams, and the topography varies from rolling to strongly rolling or hilly. The most striking topographic features are found along White Breast Creek in the northern part of Green Bay and Franklin Townships. The valleys are generally narrow and V-shaped and the slopes are rough and badly gullied. Narrow strips of bottomland soils are found along the rivers and larger creeks of the county. A few small more or less isolated areas along the streams are now above overflow and constitute the terrace soils.

The drainage of Clarke County is brought about by the tributaries of the Des Moines and Missouri Rivers. The area to the north and east of a line extending from Murray southeastward to Lacelle and Weldon drains into the Des Moines River, while the area to the southwest of this line drains into the Missouri River. The tributaries of the Des Moines River include South River, Squaw Creek, Otter Creek, White Breast Creek and Chariton Creek; all flowing in a northeasterly and easterly direction, draining almost 70 percent of the county. Except for Chariton Creek, the streams have all cut deep, narrow, V-shaped valleys thru the parent materials. The valley floors are from 75 to 150 feet below the level of the uplands. The valleys, as a rule, are narrow, and the streams are sluggish. The tributary drainageways are generally short, varying from one-half to one and one-half miles in length. The southwestern part of the county is drained by East and West Long Creek and Bee Creek, which flow in a southerly direction and finally join Grand River which flows into the Missouri.

In the rougher sections along the streams the water has gullied and eroded the slopes so that they are practically useless for anything but forest purposes.

The main streams and the intermittent drainageways provide adequate drainage for much of the county. The accompanying drainage map indicates the extensive drainage system. On some of the more level inter-stream upland areas drainage is not adequate, and in these places tiling is necessary. On the terrace areas drainage is needed. All the bottomland soils are subject to overflow.

THE SOILS OF CLARKE COUNTY

Clarke County soils are grouped into four classes according to origin and location, drift soils, loess soils, terrace soils, and swamp and bottomland soils. Drift soils are deposits left by the glaciers and they consist of material varying widely in composition, containing sand and some boulders. Loess soils are fine dust-like 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 stream which deposited them, or by a deepening of the river channel. Swamp and bottomland soils are those which occur in low-lying, poorly drained areas, or along streams which overflow frequently. The occurrence of these groups of soils in Clarke County is shown in table II.

Almost one-half of the total area of the county, 46.4 percent, is covered by the loess soils. The drift soils are only slightly less extensive, covering 44.1 percent of the total area. The terrace soils are developed to a very limited extent, covering only 0.2 percent of the county. There is a rather considerable area of bottomland soils, covering 9.3 percent of the area.

There are eight individual soil types, two drift soils, three loess types, two terrace soils and one bottomland soil. These various soils are distinguished on the basis of certain definite characteristics which are described in the appendix to this report. The type names which are given to the individual soils denote certain group characteristics which will be described later. The areas of the different soil types are given in table III.

The Shelby loam is the most extensively developed soil type in the county and the largest drift soil. It covers 42.2 percent of the total area. The Lindley silt loam, the second drift soil, is very minor in extent, covering only 1.9 percent of the county. The Grundy silt loam is the largest loess type and the second most extensively developed soil, covering 41.6 percent of the total area. The Tama silt loam, the second largest loess soil, is developed to a much less extent, covering only 3 percent of the total area. The Clinton silt loam is minor in extent, covering only 1.8 percent of the total area. There are two terrace types,

TABLE II. AREAS OF DIFFERENT GROUPS OF SOILS IN CLARKE COUNTY

| Soil group | Acres | Percent of total area of county |
|----------------------------------|---------|---------------------------------|
| Drift soils | 120,960 | 44.1 |
| Loess soils | 126,912 | 46.4 |
| Terrace soils | 640 | 0.2 |
| Swamp and bottomland soils | 25,408 | 9.3 |
| Total..... | 273,920 | 100.0 |

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN CLARKE COUNTY

| Soil No. | Soil type | Acres | Percent of total area of county |
|----------------------------|-------------------------|---------|---------------------------------|
| DRIFT SOILS | | | |
| 79 | Shelby loam | 115,712 | 42.2 |
| 32 | Lindley silt loam | 5,248 | 1.9 |
| LOESS SOILS | | | |
| 64 | Grundy silt loam | 113,984 | 41.6 |
| 120 | Tama silt loam | 8,064 | 3.0 |
| 80 | Clinton silt loam | 4,864 | 1.8 |
| TERRACE SOILS | | | |
| 88 | Bremer silt loam | 448 | 0.1 |
| 42 | Calhoun silt loam | 192 | 0.1 |
| SWAMP AND BOTTOMLAND SOILS | | | |
| 26 | Wabash silt loam | 25,408 | 9.3 |
| Total..... | | 273,920 | ..... |

the Bremer silt loam and the Calhoun silt loam. Both are developed to a very limited extent, covering only 0.1 percent of the total area each. The Wabash silt loam is the only bottomland soil and it is rather extensively developed, covering 9.3 percent of the total area.

The topographic features of the county are indicated quite definitely by the development of the various soil types on the upland. The Shelby and Lindley soils on the drift uplands are developed on the more strongly rolling to hilly or broken sections. On the loessial uplands the Grundy and Tama are developed on the more gently rolling to level areas, while the Clinton is found on the more rolling to rough areas. In some places the topography of the Clinton is strongly rolling to hilly or broken. The topographic features of the terrace and bottomland soils are not distinctive.

THE FERTILITY IN CLARKE COUNTY SOILS

Samples were taken from all the soil types in the county and analyzed to determine their plant food content. The more extensively developed types were sampled in triplicate, while the minor types were represented by only one sample. All samplings were made with the utmost care in order that they should be representative of the type and that any variations due to local conditions or special treatments should be eliminated. The samplings were made at three depths, 0 to 6 $\frac{1}{2}$ inches, 6 $\frac{2}{3}$ to 20 inches, and 20 to 40 inches, representing the surface soil, the subsurface soil and the subsoil respectively.

The total phosphorus, total nitrogen, total organic carbon, inorganic carbon and limestone requirements were determined in all the samples. The official methods were followed in the case of the nitrogen, phosphorus and carbon determinations, and the Truog qualitative test was used in the determination of the limestone requirement. The results given in the tables are the averages 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 2,000,000 pounds of surface soil per acre.

There is considerable variation in the phosphorus content of the soils of the county, the amount present ranging from 484 pounds per acre in the Lindley silt loam up to 1293 pounds in the Bremer silt loam. There is little evidence of any relationship between the phosphorus content of the soils and the soil group; even the bottomland soils seem to be very little better supplied with this element than the upland types, altho it would be expected that the greater crop production and removal of plant food constituents would have depleted the upland soils to a greater extent, of their plant food constituents. The loess soils on the average, however, are somewhat better supplied than the drift types. This undoubtedly reflects the difference in the characteristics of the various soil types which are mapped in these two groups. The soils which occur on the drift uplands are naturally poorer in plant food constituents and lower in fertility than those found on the richer loessial uplands.

When the various individual soil types are compared, some interesting relationships are evidenced. Thus on the drift uplands the Shelby loam is much higher than the Lindley silt loam in phosphorus content. On the loessial upland the Tama is somewhat better supplied than the Grundy and the latter is richer in phosphorus than the Clinton silt loam. On the terraces the Bremer silt loam is richer than the Calhoun silt loam. Evidence is certainly supplied here of the effects of some of the characteristics which serve to distinguish the various soil series. The color of the surface soil, the topographic position, the character of the subsoil and the origin of the soils are all significant. The types like the Grundy, the Tama and the Bremer, which are darker in color, are richer in phosphorus than the lighter colored Clinton and Calhoun soils. The Shelby types are darker in color than the Lindley and are better supplied with phosphorus. The Grundy and Tama soils are more nearly level in topography and are richer in phosphorus than the Clinton which is distinctly rough in topography. The Shelby and Lindley soils on the drift uplands are rough in topography and low in phosphorus. Those types which are heavier in the subsoil are also somewhat better supplied with phosphorus.

TABLE IV. PLANT FOOD IN CLARKE COUNTY, IOWA, SOILS
Pounds per Acre of 2 Million Pounds of Surface Soil (0-6 $\frac{2}{3}$ ")

| Soil No. | Soil type | Total phosphorus | Total nitrogen | Total organic carbon | Total inorganic carbon | Limestone requirement |
|----------------------------|-------------------------|------------------|----------------|----------------------|------------------------|-----------------------|
| DRIFT SOILS | | | | | | |
| 79 | Shelby loam | 956 | 3,520 | 52,449 | ..... | 6,000 |
| 32 | Lindley silt loam | 484 | 1,440 | 21,472 | ..... | 5,000 |
| LOESS SOILS | | | | | | |
| 64 | Grundy silt loam | 978 | 3,387 | 52,764 | ..... | 4,667 |
| 120 | Tama silt loam | 1,050 | 4,320 | 48,048 | ..... | 4,000 |
| 80 | Clinton silt loam | 835 | 2,280 | 36,809 | ..... | 3,000 |
| TERRACE SOILS | | | | | | |
| 88 | Bremer silt loam | 1,293 | 4,200 | 65,994 | ..... | 4,000 |
| 42 | Calhoun silt loam | 835 | 3,160 | 42,793 | ..... | 2,000 |
| SWAMP AND BOTTOMLAND SOILS | | | | | | |
| 26 | Wabash silt loam | 713 | 3,400 | 46,635 | ..... | 4,000 |

The effect of texture on the phosphorus content which is usually indicated by such analyses is not shown by the results obtained in this county. Practically all of the types are silt loams and hence no comparisons on a texture basis are possible. It is generally observed that there is a very definite relationship between the texture of the soil and the content of plant food. Fine textured types are much better supplied with phosphorus than coarse textured soils. Silty clay loams are generally richer than silt loams, silt loams are better supplied than loams and loams are richer than sandy loams and sands.

In general the content of phosphorus in the various soils of Clarke County is rather low and it is apparent that phosphorus fertilizers will be needed on these soils in the very near future, even if they are not of value at the present time. Results of the experiments which have been carried out on these soils and which will be discussed later in this report, indicate that applications of certain phosphorus fertilizers will be of value on these soil types at the present time.

Considerable variation occurs in the nitrogen content of the various soils in this county, the amount present ranging from 1440 pounds in the Lindley silt loam up to 4,320 pounds in the Tama silt loam. Again there is little evidence of any relationship between the nitrogen in the soil and the various soil groups. The loessial upland types seem to be a little better supplied, however, than the drift upland soils; which is a reflection of the difference in characteristics of the types which are mapped in these two groups.

There is evidence, however, of a relationship between the nitrogen supply and the various soil series. The characteristics which serve to distinguish the soil series apparently have a rather definite effect on the nitrogen content. The color of the soils is of importance, those types which are darker in color are usually richer in nitrogen. The Shelby soils on the drift uplands are richer in nitrogen than the Lindley types. The Tama soils of the loessial upland are richer than the Grundy which in turn are better supplied with nitrogen than the Clinton soils. On the terraces the Bremer types are richer in nitrogen than the Calhoun soils. The topographic position is also of importance. The types which are level to flat in topography are better supplied with nitrogen than the rougher soils. The Shelby is better supplied than the Lindley and it is less rolling to rough in topography. The Grundy and Tama are better supplied than the Clinton on the loessial uplands, and they are more gently rolling to flat in topography, while the Clinton is rough to broken. The subsoil character is also of importance and the soils with heavier subsoils are richer in nitrogen.

Again no evidence is supplied of a relationship between nitrogen content and soil texture, inasmuch as the types mapped in the county are practically all silt loams. In general it has been found that soils which are fine textured, such as silty clay loams and clay loams, are richer in nitrogen than coarse textured types and undoubtedly the soils in this county are better supplied with plant food because of the fact that they are silt loams in texture rather than coarse textured sandy types.

While the supply of nitrogen in the soils of this county is not particularly low, it is not high and in most cases and especially on the lighter colored types, the application of nitrogenous fertilizing materials is very desirable. On all

the soils of the county, however, it is very necessary that some fertilizing material supplying nitrogen should be supplied regularly if the content is to be kept up. The use of leguminous crops as green manures is the best and cheapest means of increasing the nitrogen content of the soil, and green manuring is a valuable practice to be followed on many of the soils of the county. Altho a particularly desirable practice for grain farming conditions where farm manure is not available, it is also a very desirable practice under practically all farming conditions as an aid in maintaining and building up the nitrogen and organic matter content of the soil. The proper preservation and application of all the farm manure produced will aid considerably in keeping up the supply of nitrogen. The crop residues should be properly utilized, as they also aid in maintaining the nitrogen content of the soil.

The total content of organic carbon or organic matter in the soils of the county varies in much the same way as does the nitrogen, ranging from 21,472 pounds in the Lindley silt loam up to 65,994 pounds in the Bremer silt loam. Nearly the same relationships were noted in the case of the organic carbon content as were mentioned in the case of nitrogen. Little evidence of any relationship between the organic matter and the soil group is seen. The loessial soils are a little better supplied than the drift soils, which again may be interpreted to represent the difference in characteristics of the various soil types which are mapped in these groups. The differences among the soil series and types are more definitely shown; the same relationships being noted among the various series as was the case with nitrogen. The same factors evidently are of importance. Thus the color of the soil indicates very definitely the content of organic matter; dark colored soils are well supplied, while light colored types are more poorly supplied. The Shelby soils on the drift uplands are richer than the Lindley type and on the loessial uplands the Tama and Grundy are much better supplied than the Clinton. On the terraces the Bremer soils are richer than the Calhoun. There is also a relationship to topography; the types which are more level or gently rolling in topography are richer in organic matter than the more strongly rolling to rough soils. The Shelby is richer than the Lindley, the Grundy and Tama are richer than the Clinton, and this difference is undoubtedly partly an effect of topography. The subsoil conditions are also of importance; the types with heavier subsoils are richer in organic matter. The relationship to texture is not shown by these results, as the types are all silt loams with one exception.

While many of the soils of the county are apparently quite well supplied with organic matter, in some cases the supply is inadequate for the best crop yields. On the lighter colored soils, which are rougher in topography, the supply is inadequate for the best crop growth. On these types, the application of fertilizing materials supplying organic matter is very necessary, and on all the soils of the county the addition of such fertilizers will be of value at regular intervals in order to keep up the supply of organic matter. The application of farm manure is of large value on the light colored soils but it also brings about large increases on the darker colored types which are apparently better supplied with organic matter. The liberal use of organic matter on the soils of this county is strongly recommended. The practice of green manuring will undoubtedly

prove very profitable on many of the soils of the county. Green manure serves as a substitute for or as a supplement to farm manure and will bring about large crop increases in many cases. The utilization of crop residues will also aid materially in maintaining the supply of organic matter in this county.

No inorganic carbon is present in any of the soils of Clarke County. All the soils are acid in reaction, and the limestone requirements are rather high. The figures given in the table are merely indicative, however, of the lime needs of the soils of the county. There is a wide variation in the reaction, and lime requirements of soils, and even samples of the same types from different fields, may vary widely in lime requirement. It is necessary, therefore, to secure and test samples from any field before lime is applied. It is apparent from the figures given here, however, that the soils of the county are all strongly acid in reaction, and applications of lime are certainly necessary for the best growth of general farm crops and particularly of legumes.

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. It seems unnecessary to consider the analyses of these lower soil layers in detail inasmuch as the needs of the soil are indicated quite definitely by the analyses of the surface samples. There is no large content of any individual plant food constituent, nor is there any striking deficiency in any of the elements in the subsurface soils and subsoils. There will be little effect, therefore, upon the fertilizer needs of the surface soils by any content of fertilizing constituents in the lower soil layers.

In general these analyses confirm the conclusions drawn from the analyses of the surface soil. They show that the phosphorus content of the soils of the county is, in general, quite low. It is evident that phosphorus fertilizers will be of value on these soils in the very near future and may probably be used with profit in many cases at the present time.

The supply of organic matter and nitrogen in the soils is not high and must

TABLE V. PLANT FOOD IN CLARKE COUNTY, IOWA, SOILS
Pounds per Acre of 4 Million Pounds of Subsurface Soil (6 2/3"-20")

| Soil No. | Soil type | Total phosphorus | Total nitrogen | Total organic carbon | Total inorganic carbon | Limestone requirement |
|----------------------------|-------------------------|------------------|----------------|----------------------|------------------------|-----------------------|
| DRIFT SOILS | | | | | | |
| 79 | Shelby loam | 700 | 2,240 | 29,416 | ..... | 5,000 |
| 32 | Lindley silt loam | 914 | 2,080 | 21,706 | ..... | 8,000 |
| LOESS SOILS | | | | | | |
| 64 | Grundy silt loam | 1,337 | 4,533 | 62,801 | ..... | 2,667 |
| 120 | Tama silt loam | 1,884 | 5,840 | 70,681 | ..... | 4,000 |
| 80 | Clinton silt loam | 780 | 1,460 | 23,379 | ..... | 8,000 |
| TERRACE SOILS | | | | | | |
| 88 | Bremer silt loam | 1,158 | 2,960 | 42,341 | ..... | 5,000 |
| 42 | Calhoun silt loam | 1,185 | 2,000 | 35,074 | ..... | 6,000 |
| SWAMP AND BOTTOMLAND SOILS | | | | | | |
| 26 | Wabash silt loam | 1,750 | 6,880 | 96,424 | ..... | 5,000 |

TABLE VI. PLANT FOOD IN CLARKE 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 | | | | | | |
| 79 | Shelby loam | 929 | 2,040 | 24,872 | ..... | 3,000 |
| 32 | Lindley silt loam | 889 | 3,240 | 29,287 | ..... | 8,000 |
| LOESS SOILS | | | | | | |
| 64 | Grundy silt loam | 1,077 | 4,520 | 49,806 | ..... | 2,000 |
| 120 | Tama silt loam | 2,907 | 5,640 | 60,843 | ..... | 4,000 |
| 80 | Clinton silt loam | 2,463 | 1,080 | 28,634 | ..... | 8,000 |
| TERRACE SOILS | | | | | | |
| 88 | Bremer silt loam | 889 | 2,160 | 69,985 | ..... | 3,000 |
| 42 | Calhoun silt loam | 969 | 2,760 | 43,320 | ..... | 8,000 |
| SWAMP AND BOTTOMLAND SOILS | | | | | | |
| 26 | Wabash silt loam | 1,252 | 4,080 | 73,572 | ..... | 1,000 |

be maintained if the land is to remain productive. On some of the soil types it is desirable that the content of organic matter and nitrogen be increased at the present time in order to give the most satisfactory crop yields. By the proper utilization of farm manure, the turning under of leguminous crops as green manures and the thoro utilization of all crop residues, the soils of the county may be built up and kept up in organic matter and nitrogen.

The lower soil layers contain no lime; and all show a high lime requirement. All are acid in reaction, and, hence, the needs of the surface soil for applications of lime are emphasized by the acid conditions prevailing in the lower soil layers. It is very important that all the soils of the county be tested for lime needs and that the lime be supplied regularly in the rotation, to insure the best growth of legume crops and to keep the soils in the highest state of fertility.

GREENHOUSE EXPERIMENTS

Two greenhouse experiments were carried out on the Grundy silt loam and the Shelby loam, the two most extensively developed types in Clarke County, in order to determine the needs of the soils and to secure indications of the value of certain fertilizing materials when applied to these types. In addition, the results secured on the Grundy silt loam from Jefferson County, the Grundy silt loam from Wapello County, the Clinton silt loam from Wapello County, the Tama silt loam from Jasper County and the Shelby loam from Appanoose County are included. Inasmuch as these soil types are the same as those occurring in Clarke County, the results indicate quite accurately what may be expected from the same soil types in this county. The treatments used in these experiments included manure, lime, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. These materials were applied in the same amounts in which they are used in the field, and hence the results of the greenhouse tests may be considered quite definitely indicative of what may be expected in the field.

Manure was applied at the rate of 8 tons per acre, lime was added in sufficient amounts to neutralize the acidity of the soil. Rock phosphate was applied at

the rate of 2,000 pounds per acre, superphosphate the rate of 200 pounds per acre and the standard 2-8-2 complete commercial fertilizer at the rate of 300 pounds per acre. The muriate of potash was applied at the rate of 25 pounds per acre. Wheat and clover were grown in all the experiments, the clover being seeded after the wheat had been up about a month. In some of the tests only the yields of wheat are given, the clover yields not being secured.

THE RESULTS ON THE GRUNDY SILT LOAM FROM CLARKE COUNTY

The results secured in the greenhouse experiment on the Grundy silt loam from Clarke County are given in table VII. The application of the superphosphate increased the yield of wheat to a considerable extent and brought about a very large increase in the yield of clover. Limestone applied with the phosphate showed no effect on the wheat but gave a further gain in the clover crop. The application of manure increased the wheat yields to a considerable extent and also the clover yields, giving about the same effects on the latter crop as that occasioned by the lime and superphosphate. On the wheat the manure brought about somewhat larger effects than the superphosphate and lime. The addition of superphosphate with manure gave a further increase in the yield of wheat but showed no effect on the clover. The application of limestone with the superphosphate and manure gave a very large increase in the yield of wheat and showed a very pronounced effect on the yield of clover. The addition of potassium with the superphosphate, manure and limestone, the application being made in the form of muriate of potash, showed no effect on the wheat but brought about a considerable increase in the clover yields.

These results indicate quite definitely the beneficial effects of manure, lime and phosphorus on this soil type. The addition of manure proved of large value in increasing the yields of general farm crops. The soil is acid in reaction, and applications of lime are necessary for the best growth of general farm crops and especially of legumes. The use of a phosphate fertilizer would certainly be desirable on this soil. Additions of superphosphate seem to bring about very large crop increases. There are indications that the addition of muriate of potash might be of value in some cases. Tests of the use of this material under individual farm conditions should be carried out before any extensive applications are made. Farmers are urged to test the value of superphosphate and rock phosphate on these soils in order to determine the relative value of the two materials. Under field conditions the rock phosphate might prove just as profitable as the superphosphate. The indications from this experiment are that the addition of a phosphate fertilizer will prove distinctly profitable.

TABLE VII. GREENHOUSE EXPERIMENT, GRUNDY SILT LOAM, CLARKE COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---------|---|--------------------------------|---------------------------|
| 1 | Check | 15.2 | 18.5 |
| 2 | Superphosphate | 17.8 | 32.4 |
| 3 | Limestone+superphosphate | 17.3 | 35.9 |
| 4 | Manure | 18.7 | 35.8 |
| 5 | Manure+superphosphate | 19.0 | 33.6 |
| 6 | Manure+limestone+superphosphate | 24.2 | 39.7 |
| 7 | Manure+limestone+superphosphate+potassium | 19.8 | 42.2 |



Fig. 4. Clover on Grundy silt loam in greenhouse experiment, Clarke County.

RESULTS ON THE GRUNDY SILT LOAM FROM JEFFERSON COUNTY

The results secured on the Grundy silt loam from Jefferson County are given in table IX. The application of manure increased the yield of wheat in this experiment in a very pronounced way, and a considerable gain was also noted on the clover crop. Lime with the manure showed no effect on the wheat but brought about an increase in the yield of clover. The application of rock phosphate with manure and lime increased the yield of wheat and showed a gain also in the yield of clover. The superphosphate with the manure and lime increased the yield of wheat to a much larger extent than did the rock phosphate and brought about a much larger increase in the clover. The complete commercial fertilizer showed about the same effect as the superphosphate in the case of the wheat but had a smaller effect on the clover.

These results indicate that the application of manure will be of considerable value on this type. The addition of lime will prove profitable from the standpoint of increasing the legume crop. The use of a phosphate fertilizer seems to be distinctly profitable. Superphosphate showed up somewhat better than rock phosphate in this experiment, producing larger effects both on the wheat and on the clover. The complete commercial fertilizer had no larger effects than did the superphosphate, hence, it does not seem to be as desirable for use.

RESULTS ON THE SHELBY LOAM FROM CLARKE COUNTY

The data secured in the greenhouse experiment on the Shelby loam from Clarke County are given in table VIII, only the yields of wheat being recorded.

TABLE VIII. GREENHOUSE EXPERIMENT, SHELBY LOAM, CLARKE COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams |
|---------|---|--------------------------------|
| 1 | Check | 6.4 |
| 2 | Superphosphate | 7.8 |
| 3 | Limestone+superphosphate | 7.7 |
| 4 | Manure | 10.5 |
| 5 | Manure+superphosphate | 10.4 |
| 6 | Manure+limestone+superphosphate | 10.6 |
| 7 | Manure+limestone+superphosphate+potassium | 10.9 |

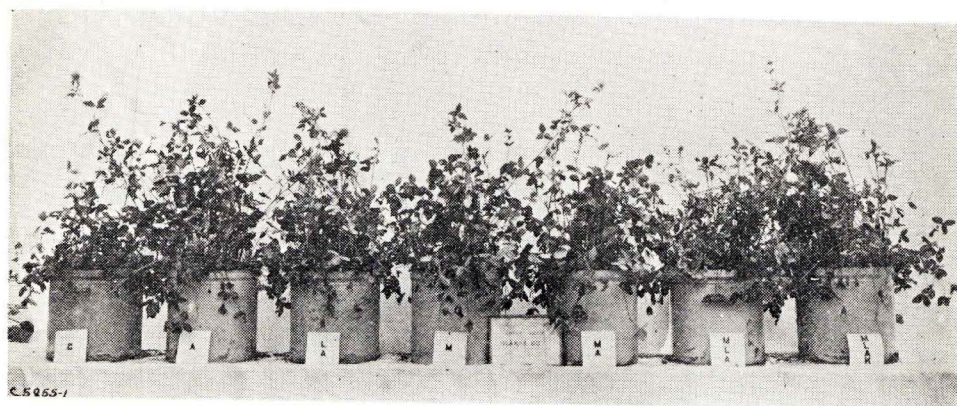


Fig. 5. Clover on Shelby loam in greenhouse experiment, Clarke County.

The application of superphosphate increased the wheat yields considerably. Lime with the superphosphate had no further effect on the wheat. Manure alone brought about a much larger increase than that occasioned by the lime and superphosphate. The addition of superphosphate with the manure showed practically no effect on the yield of wheat, and the further addition of limestone with the manure and phosphate had no effect. The inclusion of the muriate of potash with the treatment showed little effect on the crop yield.

The results of this experiment indicate quite definitely the beneficial value of manure when applied to this soil. It is undoubtedly the most desirable fertilizer that can be applied to this type. The soil is generally acid in reaction and applications of lime would be of value, especially for the growth of legumes. The use of a phosphate fertilizer would certainly prove of value on this type, and tests of superphosphate under field conditions are recommended. Probably the use of a potassium fertilizer would not prove profitable on this soil.

RESULTS ON THE GRUNDY SILT LOAM FROM WAPELLO COUNTY

The results secured on the Grundy silt loam from Wapello County are given in table X. Manure showed a slight effect on the clover in this experiment but had no influence on the wheat. Lime with the manure proved of value on both crops, a distinct increase being obtained in the case of the clover. The rock phosphate increased the wheat yields considerably, and the clover yield was also increased to a large extent by the use of this material. The superphosphate had practically no effect on the wheat. The clover crop, however, was increased to a very much larger extent than by the use of the rock phosphate. The com-

TABLE IX. GREENHOUSE EXPERIMENT, GRUNDY SILT LOAM, JEFFERSON COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---------|---|--------------------------------|---------------------------|
| 1 | Check | 8.8 | 27.4 |
| 2 | Manure | 10.5 | 32.7 |
| 3 | Manure+limestone | 10.7 | 35.0 |
| 4 | Manure+limestone+rock phosphate | 11.6 | 38.5 |
| 5 | Manure+limestone+superphosphate | 12.7 | 43.0 |
| 6 | Manure+limestone+complete commercial fertilizer | 12.2 | 40.2 |

TABLE X. GREENHOUSE EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---------|---|--------------------------------|---------------------------|
| 1 | Check | 18.1 | 33.0 |
| 2 | Manure | 17.8 | 34.0 |
| 3 | Manure+limestone | 18.4 | 37.0 |
| 4 | Manure+limestone+rock phosphate | 24.4 | 48.0 |
| 5 | Manure+limestone+superphosphate | 18.2 | 55.0 |
| 6 | Manure+limestone+complete commercial fertilizer | 21.1 | 38.0 |

plete commercial fertilizer increased the wheat yields to a less extent than did the rock phosphate. The effect on the clover was small; superphosphate and rock phosphate both showing up much better on this crop.

These results very largely confirm those secured on the same soil type in Clarke and Jefferson Counties and indicate the value of manure, lime and a phosphate fertilizer when applied to this soil. In some cases rock phosphate may be just as satisfactory as superphosphate, while in other instances the superphosphate will give larger returns. Tests of the two materials under individual farm conditions will indicate which will be the most desirable for use.

RESULTS ON THE CLINTON SILT LOAM FROM WAPELLO COUNTY

The results secured on the Clinton silt loam from Wapello County are given in table XI. Manure brought about a distinct influence on both the wheat and clover crops. The application of lime with the manure gave an increase in the wheat. Owing to an abnormal condition in the case of the clover crop the yield was not secured. The rock phosphate showed a small effect on the wheat and a small effect likewise on the clover. The superphosphate gave a distinct increase in the wheat yield and the effect on the clover was definite. The complete commercial fertilizer increased the wheat yield somewhat less than the superphosphate but the opposite was true with the clover. In that case the commercial fertilizer showed the largest effect of any of the materials employed.

These results indicate that this soil type will respond to applications of manure, lime and a phosphorus fertilizer. It would seem from this test that superphosphate may be slightly preferable to the rock phosphate. The differences, however, are not very large, and definite conclusions are hardly permissible. The complete commercial fertilizer gave slightly better results than the phosphates, but the differences were not large enough to warrant the use of the more expensive material.

RESULTS ON THE TAMA SILT LOAM FROM JASPER COUNTY

The results secured on the Tama silt loam from Jasper County are given in

TABLE XI. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM, WAPELLO COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---------|---|--------------------------------|---------------------------|
| 1 | Check | 17.39 | 38.0 |
| 2 | Manure | 18.69 | 44.0 |
| 3 | Manure+limestone | 19.27 | ..... |
| 4 | Manure+limestone+rock phosphate | 20.46 | 47.0 |
| 5 | Manure+limestone+superphosphate | 23.38 | 49.0 |
| 6 | Manure+limestone+complete commercial fertilizer | 21.89 | 52.0 |

TABLE XII. GREENHOUSE EXPERIMENT, TAMA SILT LOAM, JASPER COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---------|---|--------------------------------|---------------------------|
| 1 | Check | 7.6 | 11.0 |
| 2 | Manure | 9.4 | 21.8 |
| 3 | Manure+limestone | 10.9 | 22.7 |
| 4 | Manure+limestone+rock phosphate | 11.2 | 23.2 |
| 5 | Manure+limestone+superphosphate | 11.5 | 26.1 |
| 6 | Manure+limestone+complete commercial fertilizer | 11.7 | 28.3 |

table XII. The application of manure brought about a distinct increase in the yields of both the wheat and the clover, the latter crop being almost doubled by the manure treatment. Lime with the manure had an additional effect on both crops, showing a gain on the wheat as well as on the clover. The rock phosphate showed a small effect on the wheat and similarly a small effect on the clover. Superphosphate brought about a larger effect on the wheat than did the rock phosphate but it had a very much larger influence on the yield of clover. The complete commercial fertilizer gave about the same increase on the wheat as that occasioned by the superphosphate but it had less effect on the clover, showing up about the same as the rock phosphate in the case of the latter crop.

It appears from these results that this soil will respond very definitely to applications of manure, lime and a phosphate fertilizer. The value of applications of manure is very definitely shown by these data. Large increases in crop yields are secured from an application of manure. The type is acid in reaction, and without lime the yields of general farm crops will not be entirely satisfactory; hence, applications of lime are very desirable. Superphosphate seemed to give a somewhat larger effect on the crops in this test than did the rock phosphate, but definite conclusions should not be drawn from one experiment. It is evident, however, that one or the other of these fertilizers should be employed on this soil, and profitable results may be secured from the application. The complete commercial fertilizer had less effect than the superphosphate on the clover crop and only a very slightly larger effect on the wheat, hence it would not seem that a complete fertilizer would be as profitable for use as superphosphate on this soil.

RESULTS ON THE SHELBY LOAM FROM APPANOOSE COUNTY

The results secured on the Shelby loam from Appanoose County are given in table XIII. The superphosphate brought about a considerable increase in the yield of wheat and a very large increase in the yield of clover. Lime with the superphosphate showed some effect on the wheat but practically none on the clover. Ordinarily, however, the addition of lime would show its most pronounced effect on the legume crop of the rotation. The addition of manure increased the yield of wheat to a very large extent over the check and also increased the yield of clover considerably. In fact the manure alone brought about a larger effect on both crops than that occasioned by the addition of superphosphate and limestone. The application of superphosphate with manure gave distinct increases in both the yields of wheat and clover. Limestone applied with the manure and superphosphate showed a further gain on the wheat but

TABLE XIII. GREENHOUSE EXPERIMENT, SHELBY LOAM, APPANOOSE COUNTY

| Pot No. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---------|---|--------------------------------|---------------------------|
| 1 | Check | 4.3 | 2.8 |
| 2 | Superphosphate | 6.1 | 30.5 |
| 3 | Limestone+superphosphate | 7.6 | 30.6 |
| 4 | Manure | 7.5 | 40.5 |
| 5 | Manure+superphosphate | 8.0 | 43.6 |
| 6 | Manure+limestone+superphosphate | 8.6 | 43.4 |
| 7 | Manure+limestone+superphosphate+potassium | 9.4 | 43.0 |

practically no effect on the clover. Muriate of potash applied with the manure, limestone and superphosphate gave a distinct increase in the yield of wheat but showed no effect on the clover.

It is apparent from these results that manure is a particularly valuable fertilizer for application to this soil and liberal additions of manure should be made regularly to this type. The type is usually acid in reaction, and additions of lime are very necessary for the best growth of general farm crops, particularly of legumes. Ordinarily the legume crop will be increased to a very large extent thru the use of lime. The use of a phosphate fertilizer would seem to be very desirable to bring about very large crop increases. Under field conditions the addition of rock phosphate might be just as profitable as the use of superphosphate, and tests of both phosphates under individual farm conditions are recommended. There are indications of the value of applications of muriate of potash to this type, but tests should be carried out in the field before any extensive applications of potash fertilizers are made.

FIELD EXPERIMENTS

No field experiments are located in Clarke County, but experiments have been under way for a number of years in counties in the same soil area. These experiments are located on the same soil types as those which occur extensively in this county. The results secured will be given here, as they indicate quite definitely the fertilizer effects to be expected on the same soil types in Clarke County. Tests on the Grundy silt loam on the Agency Field, in Wapello County; on the Grundy silt loam on the Mt. Pleasant Field, Series 100, in Henry County; on the Mt. Pleasant Field, Series 200, in Henry County; on the Tama silt loam on the Hudson Field, Series II, in Black Hawk County; and on the Clinton silt loam on the Princeton Field, Series I, in Scott County, are given here.

These field experiments are carried out to determine the value of certain soil treatments. They are laid out on land which is thoroly representative of the particular soil type. The fields include 13 plots 155' 7" x 28', or one-tenth of an acre in size. They are permanently located by the installation of corner stakes, and all precautions to secure accurate results are taken in the application of fertilizers and in the harvesting of the crops.

The experiments are carried out under both the livestock and grain systems of farming. In the former, manure is applied as the basic treatment, while, in the latter, crop residues are employed. The other fertilizer materials tested include limestone, superphosphate, rock phosphate and a complete commercial fertilizer.

Manure is applied at the rate of 8 tons per acre once in a four-year rotation.

The crop residue treatment consists of the plowing under of corn stalks, which have been cut with a disc or stalk cutter, and the plowing under of 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 amounts sufficient to neutralize the acidity of the soil. Rock phosphate is added at the rate of 2000 pounds per acre once in four years. Since 1925, rock phosphate has been employed at the rate of 1000 pounds per acre once in four years. Superphosphate is added at the rate of 150 pounds per acre annually or three years out of the four of the regular four-year rotation. Until 1923, the old standard 2-8-2 complete commercial fertilizer was used, applications being made at the rate of 300 pounds per acre annually. Since 1923, the new standard 2-12-2 brand is being employed, applications being made at the rate of 202 pounds per acre annually; thus the same amount of phosphorus as that contained in the 150 pounds of superphosphate is applied.

THE AGENCY FIELD

The data secured in the field experiment on the Grundy silt loam on the Agency Field, in Wapello County, are given in table XIV. The beneficial effects of manure on this soil are evidenced by the increased crop yields secured in practically all seasons. The largest increases were shown in the oats in 1919, in the hay in 1921 and 1922, in the oats in 1925 and in the clover in 1927. The use of lime with the manure brought about crop increases in practically all seasons. The beneficial effects of the lime were most evident on the hay crop, but large increases were also shown on the corn and oats.

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

| Plot No. | Treatment | (1) 1918 Corn bu. per A. | 1919 Oats bu. per A. | (2) 1920 Winter wheat bu. per A. | (3) 1921 Clover and Timothy tons per A. | (4) 1922 Timothy tons per A. | 1923 Corn bu. per A. | 1924 Corn bu. per A. | 1925 Oats bu. per A. | (5) 1926 Winter wheat bu. per A. | (6) 1927 Clover tons per A. |
|----------|--|-----------------------------|-------------------------|--|---|------------------------------------|-------------------------|-------------------------|-------------------------|--|--------------------------------|
| 1 | Check | 63.5 | 44.9 | 22.7 | 1.92 | 2.00 | 72.7 | 46.4 | 66.2 | 21.7 | 1.28 |
| 2 | Manure | 64.5 | 62.2 | 31.5 | 2.09 | 2.20 | 71.8 | 51.9 | 70.8 | 19.0 | 1.96 |
| 3 | Manure+lime | 66.8 | 58.3 | 36.7 | 2.20 | 2.25 | 79.2 | 52.2 | 73.8 | 21.8 | 2.28 |
| 4 | Manure+lime+rock phosphate | 68.8 | 63.6 | 38.7 | 2.52 | 2.30 | 86.8 | 54.0 | 80.6 | 35.3 | 2.14 |
| 5 | Manure+lime+super- phosphate | 70.0 | 66.6 | 40.0 | 2.39 | 2.80 | 85.4 | 60.2 | 77.9 | 38.9 | 2.05 |
| 6 | Manure+lime+complete commercial fertilizer | 66.0 | 65.6 | 34.7 | 2.52 | 2.50 | 83.0 | 55.4 | 77.3 | 30.7 | 2.47 |
| 7 | Check | 59.3 | 54.5 | ..... | 1.82 | 2.30 | 69.7 | 43.3 | 67.8 | 14.7 | 1.29 |
| 8 | Crop residues | 58.5 | 49.0 | 31.4 | 1.81 | 2.20 | 66.3 | 43.7 | 66.4 | 18.7 | 1.28 |
| 9 | Crop residues+lime | 61.3 | 59.5 | 43.8 | 2.02 | 2.40 | 71.3 | 50.7 | 72.1 | 18.6 | 1.69 |
| 10 | Crop residues+lime+ rock phosphate | 61.8 | 61.2 | 36.4 | 2.33 | 2.65 | 73.1 | 54.9 | 75.9 | 26.0 | 2.14 |
| 11 | Crop residues+lime+ superphosphate | 63.5 | 61.2 | 36.3 | 2.19 | 2.75 | 80.7 | 55.5 | 74.6 | ..... | 2.26 |
| 12 | Crop residues+lime+ complete commercial fertilizer | 62.5 | 63.6 | 35.6 | 2.17 | 2.65 | 70.4 | 54.4 | 78.4 | ..... | 2.14 |
| 13 | Check | 52.5 | 52.0 | 22.8 | 1.56 | 2.40 | 63.9 | 42.7 | 58.5 | ..... | 0.91 |

- (1) Corn damaged slightly by hail in July and by dry weather in August.
(2) Sample No. 7 lost in transit; wheat badly down. 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 and 13.
(6) Mostly timothy.

The rock phosphate with the manure and lime increased the crop yields in every season, in some cases very large effects being noted. The hay crop was particularly benefited by the rock phosphate, and considerable increases were secured on the oats in 1919, on the corn in 1923 and on the wheat in 1926. The superphosphate showed larger effects 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 and 1923 the rock phosphate gave a slightly larger effect on the corn and in 1925 on the oats. The complete commercial fertilizer generally showed somewhat smaller effects than the superphosphate. Only on the hay crop in 1921 and on the clover in 1927 was there any greater effect from the complete fertilizers. In some cases the rock phosphate gave larger increases than did the complete fertilizer.

The crop residues showed little effects on the various crops grown. Lime with the residues brought about increased crop yields in practically every season. Only with the wheat in 1926 was there no increase from the use of lime. In some seasons and on certain crops the beneficial effects were quite definite. This was particularly true of the hay crops in 1921 and in 1922 and of the clover crop in 1927.

The application of rock phosphate gave increases in crop yields in practically every season. In some instances the increases were very definite as on the hay crop in 1921, 1922 and 1927, and on the wheat in 1926. The superphosphate showed larger effects than the rock phosphate in several seasons, but had a smaller effect than the rock phosphate, however, on the clover in 1921 and 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 similar increases to those brought about by the superphosphate. Only in one case was there a striking difference. On the corn in 1923 the complete fertilizer showed no effect.

These results indicate the large value of applications of manure to the Grundy silt loam. Liberal amounts of this fertilizing material should certainly be used on this soil, and large increases in the yields of general farm crops will be secured from its application. The value of lime is definitely shown by the increased yields secured. The soil should be tested for acidity, and lime should be applied as needed, in order to secure the best yields of general farm crops. The use of a phosphate fertilizer is 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 results sometimes show a superior value for rock phosphate, while in other instances the superphosphate proved more effective. The complete commercial fertilizer did not bring about any greater crop increases than those occasioned by the superphosphate and hence would be less desirable for general use.

THE MOUNT PLEASANT FIELD

The results secured on the Grundy silt loam on the Mount Pleasant Field, Series 100, in Henry County, are given in table XV. The application of manure has proved of value on this soil, as is indicated by the increased crop yields secured in most seasons. The beneficial effects of the manure were particularly apparent 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

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

| Plot No. | Treatment | 1919 Clover tons per acre | | | 1918 Oats bu. per A. | (2) 1917 Corn bu. per A. | 1919 Clover tons per acre | | | (3) 1920 Corn bu. per A. | (4) 1921 Corn bu. per A. | (5) 1922 Oats bu. per A. | (6) 1923 Soy-beans | 1924 Corn bu. per A. | 1925 Corn bu. per A. | (7) 1926 Oats bu. per A. | (8) 1927 Clover tons per A. |
|----------|---|---------------------------|-------------|-------|-------------------------|-----------------------------|------------------------------|-------------|-------|-----------------------------|-----------------------------|-----------------------------|--------------------|-------------------------|-------------------------|-----------------------------|--------------------------------|
| | | First crop | Second crop | Total | | | First crop | Second crop | Total | | | | | | | | |
| 1 | Check | 2.22 | 1.65 | 3.87 | 72.3 | 36.0 | 2.22 | 1.65 | 3.87 | 34.5 | 54.3 | 35.9 | ..... | 50.7 | 41.2 | 20.5 | 0.05 |
| 2 | Manure | 2.29 | 1.50 | 3.79 | 75.1 | 37.5 | 2.29 | 1.50 | 3.79 | 57.0 | 56.7 | 39.8 | ..... | 54.0 | 35.9 | 30.4 | 0.40 |
| 3 | Manure+lime | 2.34 | 1.65 | 3.99 | 74.8 | 55.2 | 2.34 | 1.65 | 3.99 | 76.6 | 59.5 | 62.1 | ..... | 58.7 | 40.6 | 35.9 | 0.64 |
| 4 | Manure+lime+rock phosphate | 2.78 | 2.15 | 4.93 | 76.5 | 66.0 | 2.78 | 2.15 | 4.93 | 81.8 | 67.5 | 63.3 | ..... | 66.0 | 50.6 | 47.3 | 1.46 |
| 5 | Manure+lime+superphosphate | 3.72 | 3.25 | 6.47 | 85.1 | 73.6 | 3.72 | 3.25 | 6.47 | 77.7 | 72.8 | 70.1 | ..... | 60.7 | 64.4 | 66.4 | 1.56 |
| 6 | Manure+lime+complete commercial fertilizer | 3.68 | 3.25 | 6.93 | 80.8 | 76.8 | 3.68 | 3.25 | 6.93 | 67.5 | 64.9 | 70.6 | ..... | 62.0 | 63.7 | 70.9 | 1.31 |
| 7 | Check | 2.20 | 2.20 | 4.40 | 76.5 | 60.1 | 2.20 | 2.20 | 4.40 | 65.6 | 60.7 | 56.1 | ..... | 54.0 | 54.1 | 40.2 | 0.51 |
| 8 | Crop residues | 2.30 | ..... | ..... | 81.3 | 50.8 | 2.30 | ..... | ..... | 67.5 | 65.7 | 54.5 | ..... | 52.0 | 55.0 | 40.6 | 0.89 |
| 9 | Crop residues+lime | 2.22 | ..... | ..... | 93.2 | 47.1 | 2.22 | ..... | ..... | 80.6 | 66.1 | 49.0 | ..... | 55.3 | 56.2 | 39.9 | 0.67 |
| 10 | Crop residues+lime+rock phosphate | 2.85 | ..... | ..... | 96.4 | 52.7 | 2.85 | ..... | ..... | 90.0 | 65.0 | 57.9 | ..... | 57.7 | 56.5 | 38.8 | 1.09 |
| 11 | Crop residues+lime+superphosphate | 3.21 | ..... | ..... | 99.9 | 54.7 | 3.21 | ..... | ..... | 75.5 | 66.9 | 54.8 | ..... | 59.3 | 57.2 | 48.4 | 1.43 |
| 12 | Crop residues+lime+complete commercial fertilizer | 3.15 | ..... | ..... | 93.6 | 52.8 | 3.15 | ..... | ..... | 51.2 | 67.1 | 61.9 | ..... | 59.7 | 58.1 | 47.3 | 1.28 |
| 13 | Check | 2.18 | 2.00 | 4.18 | 72.3 | 48.3 | 2.18 | 2.00 | 4.18 | 45.0 | 59.1 | 42.3 | ..... | 50.0 | 52.8 | 30.6 | 0.35 |

- (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 plots 11 and 12.
 (6) No record on account of weeds.
 (7) Low yield due to very dry season and considerable rust.
 (8) Very poor stand on check plots.

manure brought about crop increases which were considerable in some years. The corn in 1917 and 1920 showed large increases due to the use of lime. The oats in 1922 showed a very large effect from the lime. Small increases were secured in practically all seasons from the use of lime on this soil.

The application of rock phosphate gave distinct increases in crops in all cases and in some instances very large effects were secured. This was true of the clover in 1919, the corn in 1925, the oats in 1926 and the clover in 1927. The superphosphate likewise showed a large influence on crop yields in all seasons and in all but one case gave a larger influence on crop growth than did the rock phosphate. A greater effect was evident on the clover in 1919, on the corn in 1924 and on the oats in 1926. In some of the other seasons the increases were not strikingly great but were sufficiently definite to show a distinct superiority for the superphosphate. The complete commercial fertilizer showed similar effects to those brought about by the superphosphate. In some cases the increases were somewhat larger while in other seasons the effects were less evident than from the superphosphate. On the average it would seem that quite as large increases may be secured from the use of superphosphate.

The crop residues showed no large 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 distinct increases in crop yields. This was true of the oats in 1919, the corn in 1920 and the clover in 1927. In other seasons beneficial effects were shown but not so definitely. The rock phosphate and the superphosphate brought about crop increases in practically all cases. In general, the superphosphate seemed to be somewhat more effective than the rock phosphate. The differences were small in some seasons, but with the clover in 1919, the oats in 1926 and the clover in 1927 the superphosphate proved much superior to the rock phosphate. In one or two cases the rock phosphate had more effect than the superphosphate. The complete commercial fertilizer generally showed about the same effect as the superphosphate.

The results secured on the Grundy silt loam on the Mount Pleasant Field, Series 200, are given in table XVI. Here, again, the beneficial effects of manure were evident by the increased crop yields secured every season. Large increases were noted on the oats in 1921, on the clover in 1926 and on the corn in 1927. The application of lime along with the manure increased the crop yields in nearly all seasons. In some cases considerable increases were secured, as, for example, on the corn in 1920 and 1924, on the clover in 1926 and on the corn in 1927.

The use of rock phosphate with the manure and lime gave increases in some seasons, showing up particularly well on the oats in 1921 and 1925, on the clover in 1922 and 1926 and on the corn in 1927. Usually the effects were less evident and in some seasons were not shown at all on the corn. The superphosphate had a greater effect than the rock phosphate in some seasons, showing up very much better on the corn in 1920, on the oats in 1921 and on the clover in 1926. In some other seasons the effects were slightly less or the same as those brought about by the rock phosphate. The complete commercial fertilizer had larger effects than the superphosphate 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 effects were less evident than those brought about by the superphosphate.

TABLE XVI. 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. | (1) 1921 Oats bu. per A. | (2) 1922 Clover tons per A. | 1923 Corn bu. per A. | 1924 Corn bu. per A. | 1925 Oats bu. per A. | (3) 1926 Clover tons per A. | 1927 Corn bu. per A. |
|----------|--|-------------------------|-------------------------|-----------------------------|--------------------------------|-------------------------|-------------------------|-------------------------|--------------------------------|-------------------------|
| 1 | Check | 55.7 | 48.1 | 36.9 | 1.6 | 61.3 | 49.3 | 50.9 | 0.10 | 33.8 |
| 2 | Manure | 66.3 | 51.2 | 46.9 | 1.9 | 77.3 | 58.0 | 55.0 | 0.60 | 44.4 |
| 3 | Manure+lime | 74.1 | 69.8 | 35.3 | 2.1 | 85.0 | 72.7 | 50.9 | 1.05 | 60.0 |
| 4 | Manure+lime+rock phosphate | 78.6 | 66.4 | 42.6 | 2.4 | 84.5 | 70.4 | 65.9 | 1.31 | 76.9 |
| 5 | Manure+lime+super- phosphate | 75.3 | 77.2 | 48.9 | 2.4 | 77.6 | 73.3 | 64.8 | 1.43 | 76.6 |
| 6 | Manure+lime+complete commercial fertilizer | 66.5 | 81.2 | 46.5 | 2.7 | 80.0 | 65.7 | 60.4 | 1.15 | 65.0 |
| 7 | Check | 50.6 | 64.0 | 33.7 | 2.1 | 58.3 | 44.3 | 47.1 | 0.52 | 40.6 |
| 8 | Crop residues | 65.3 | 75.5 | 43.1 | 2.3 | 64.6 | 35.3 | 47.6 | 0.52 | 47.5 |
| 9 | Crop residues+lime | 71.0 | 76.3 | 40.0 | 2.6 | 73.3 | 34.7 | 56.1 | 0.76 | 67.5 |
| 10 | Crop residues+lime+ rock phosphate | 75.1 | 75.1 | 43.8 | 2.5 | 69.0 | 38.0 | 52.5 | 0.86 | 59.7 |
| 11 | Crop residues+lime+ superphosphate | 81.1 | 85.1 | 43.5 | 2.5 | 68.0 | 40.7 | 63.2 | 0.96 | 53.8 |
| 12 | Crop residues+lime+ complete commercial fertilizer | 78.5 | 90.1 | 42.2 | 2.6 | 74.3 | 41.3 | 60.4 | 0.99 | 47.2 |
| 13 | Check | 65.8 | 64.1 | 31.1 | 1.7 | 60.3 | 39.3 | 43.8 | 0.39 | 33.1 |

(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.

The influence of the crop residues on crop growth was not great. The use of lime along 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, and the corn in 1927 showed a large effect from the use of lime. In other seasons the effects of the lime were small and not definite.

The use of rock phosphate proved of value 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 secured. The superphosphate 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 effects were about the same or slightly less than those brought about by the rock phosphate. The complete commercial fertilizer showed a larger effect than the superphosphate 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 superphosphate.

The results secured in the two experiments on the Mount Pleasant Field on the Grundy silt loam, confirm those secured on the same soil type on the Agency Field. They show definitely the beneficial effect of applications of manure to this soil and the large increases in yields of general farm crops which may be secured from the application of this fertilizer. The value of lime is very definitely indicated in these results, and the desirability of testing the soil and applying the lime, which is shown to be necessary according to the test, is evident. The use of a phosphate fertilizer is strongly recommended on this soil. In some



Fig. 6. Pasture experiment on Shelby loam, Murray field.

cases the superphosphate proved more profitable while in other instances the rock phosphate seemed to give quite as large effects. Tests of both materials under individual farm conditions are urged. The use of the complete commercial fertilizer did not seem to be any more effective than the use of superphosphate, hence would be less desirable.

THE HUDSON FIELD

The results secured on the Tama silt loam on the Hudson Field, Series II, in Black Hawk County, are given in table XVII. The beneficial effect of applications of manure on this soil type is evidenced by the increased crop yields secured in every season. In some cases large increases were obtained, as, for example, on the oats in 1919, on the corn in 1920, on the oats in 1922, on the oats in 1924, on the timothy in 1926 and on the corn in 1927. In every case manure brought about very profitable increases in the yields of general farm crops grown. The application of lime with the manure increased the yields still more in every season, the beneficial effects being particularly evident on the clover and timothy in 1925. Appreciable crop increases were also secured, however, on the corn and oats grown in the other seasons.

The application of rock phosphate with the manure and lime increased the yields of crops in most seasons. The beneficial effects were particularly evident on the oats in 1919, on the corn in 1920, on the oats in 1924 and on the timothy in 1926. The superphosphate applied with the manure and lime showed slightly larger effects than the rock phosphate in one or two cases, but, in general, the differences between the yields secured with the two phosphates were slight. Only with the clover and timothy in 1925 and the corn in 1927 was there any great difference in favor of the superphosphate. The complete commercial fertilizer had a larger effect than the phosphates in one or two seasons but in many seasons

TABLE XVII. FIELD EXPERIMENT, TAMA SILT LOAM, BLACK HAWK COUNTY, HUDSON FIELD, SERIES II

| Plot No. | Treatment | (1) 1918 Corn bu. per A. | 1919 Oats bu. per A. | (2) 1920 Oats bu. per A. | (3) 1921 Corn bu. per A. | (4) 1922 Oats bu. per A. | (5) 1923 Corn bu. per A. | 1924 Oats bu. per A. | 1925 Clover and Timothy tons per A. | (6) 1926 Timothy tons per A. | 1927 Corn bu. per A. |
|----------|--|-----------------------------|-------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------|---|------------------------------------|-------------------------|
| 1 | Check | 45.8 | 47.6 | 53.2 | ..... | 44.8 | 54.0 | 40.3 | 1.43 | 0.88 | 45.7 |
| 2 | Manure | 49.3 | 54.7 | 62.8 | ..... | 53.1 | 59.6 | 50.6 | 1.64 | 1.16 | 64.3 |
| 3 | Manure+lime | 54.4 | 59.2 | 67.4 | ..... | 59.6 | 65.2 | 52.2 | 2.03 | 1.21 | 71.2 |
| 4 | Manure+lime+rock phosphate | 56.5 | 64.9 | 73.3 | ..... | 58.1 | 61.4 | 63.4 | 2.02 | 1.55 | 66.3 |
| 5 | Manure+lime+super- phosphate | 57.4 | 62.2 | 73.3 | ..... | 53.2 | 59.6 | 63.7 | 2.25 | 1.61 | 76.3 |
| 6 | Manure+lime+complete commercial fertilizer | 58.5 | 57.5 | 72.4 | ..... | 62.2 | 68.4 | 60.0 | 2.09 | 1.64 | 75.6 |
| 7 | Check | 56.9 | 62.2 | 44.0 | ..... | 41.4 | 54.8 | 50.6 | 1.84 | 1.21 | 57.8 |
| 8 | Crop residues | 54.7 | 62.2 | 65.2 | ..... | 49.0 | 53.1 | 49.5 | 1.69 | 1.22 | 66.3 |
| 9 | Crop residues+lime | 57.9 | 64.6 | 71.3 | ..... | 62.4 | 66.7 | 57.7 | 2.27 | 1.66 | 70.5 |
| 10 | Crop residues+lime+ rock phosphate | 62.8 | 58.1 | 74.9 | ..... | 59.6 | 65.7 | 66.4 | 2.32 | 1.70 | 74.1 |
| 11 | Crop residues+lime+ superphosphate | 55.6 | 55.8 | 74.9 | ..... | 64.4 | 62.8 | 60.9 | 2.36 | 1.79 | 70.2 |
| 12 | Crop residues+lime+ complete commercial fertilizer | 52.5 | 57.5 | 74.1 | ..... | 71.3 | 62.8 | 61.5 | 2.52 | 2.03 | 55.9 |
| 13 | Check | 54.5 | 57.0 | 71.3 | ..... | 59.7 | 50.2 | 48.7 | 1.94 | 1.43 | 55.4 |

- (1) Four tons of lime. Hail damaged corn.
(2) Yield on plot 7 evidently an error.
(3) Corn cut and put in silo.
(4) Not very ripe when cut.
(5) Dry season.
(6) High yields on crop residue series due to lower ground and more moisture.

showed a smaller beneficial influence than did the superphosphate. The oats in 1922 were increased considerably by the complete commercial fertilizer. The corn in 1923 showed a larger effect from the complete fertilizer than from the phosphate. In several seasons the differences were slight.

The crop residues had little effect on the various crops grown; the beneficial effects being evident only in one or two cases. Lime with the crop residues increased the crop yields in every season, bringing about pronounced gains in the case of clover and timothy in 1925 and the timothy in 1926. In several seasons the oats and corn were increased to a very large extent by the use of lime, the effect being the greatest on the oats in 1922 and on the corn in 1923 and 1927.

The rock phosphate with the crop residues and lime brought about increases in crop yields in most seasons. In general, the gains were small but in several seasons they were quite definite. The superphosphate with the crop residues and lime showed slightly larger effects than the rock phosphate in one or two cases, but generally the yields secured were very similar to those obtained on the rock phosphate plots. The complete commercial fertilizer with the crop residues and lime had larger effects than the phosphates in several cases. Pronounced gains were secured on the oats in 1922, on the clover and timothy in 1925, and on the timothy in 1926. In several other seasons the complete fertilizer showed no greater influence on the yields than did the phosphates.

These results indicate very definitely the effect of applications of manure, lime, and a phosphate fertilizer to the Tama silt loam. The value of manure

is shown particularly well in these data, very large increases in crop yields being secured by the application of this material. The use of lime along with manure is apparently very valuable, increases in the yields of general farm crops being obtained in every case. The addition of a phosphate fertilizer seems to be of value on this type, rock phosphate and superphosphate both bring about pronounced increases in the yields of general farm crops. In some cases the superphosphate seemed to be somewhat preferable for use, but usually the yields with the two materials were very similar. Definite conclusions regarding the value of the two phosphates cannot, therefore, be drawn. Tests on individual farms are recommended. The use of a complete commercial fertilizer does not seem to be as desirable as the application of a phosphate. While increases in crop yields are secured in many cases, the increases are not sufficiently large to warrant the cost of the complete fertilizer.

THE PRINCETON FIELD

The results secured on the Clinton silt loam on the Princeton Field, Series I, in Scott County, are given in table XVIII. The application of manure increased the crop yields on this soil in nearly every season. In some cases considerable increases were secured, as, for example, on the wheat in 1925, on the corn in 1923 and 1927 and on the clover in 1922 and 1926. The use of lime with manure increased still further the yields of crops on this soil. The beneficial effects were particularly evident on the clover in 1922 and 1926 and on the corn in 1927. Increases in the yields of wheat, oats and corn were also secured in practically every season. In some cases the effects on these same crops were sur-

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

| Plot No. | Treatment | (1) 1918 Winter wheat bu. per A. | (2) 1919 Corn bu. per A. | (3) 1920 Corn bu. per A. | 1921 Oats bu. per A. | (4) 1922 Clover tons per A. | 1923 Corn bu. per A. | 1924 Oats bu. per A. | (5) 1925 Winter wheat bu. per A. | 1926 Clover tons per A. | 1927 Corn bu. per A. |
|----------|--|--|-----------------------------|-----------------------------|-------------------------|--------------------------------|-------------------------|-------------------------|--|----------------------------|-------------------------|
| 1 | Check | 40.7 | 69.3 | 61.8 | 27.7 | 1.41 | 54.0 | 65.8 | 13.6 | 0.96 | 67.8 |
| 2 | Manure | 37.4 | 67.6 | 68.3 | 28.4 | 1.93 | 63.2 | 64.8 | 22.6 | 1.57 | 79.7 |
| 3 | Manure+lime | 43.0 | 68.2 | 70.6 | 32.1 | 2.13 | 70.2 | 65.3 | 27.5 | 2.06 | 97.3 |
| 4 | Manure+lime+rock phosphate | 47.4 | 67.8 | 73.5 | 31.9 | 2.25 | 72.5 | 63.1 | 32.1 | 2.08 | 96.4 |
| 5 | Manure+lime+super- phosphate | 45.2 | 64.0 | 70.8 | 35.1 | 2.29 | 73.2 | 75.1 | 31.8 | 2.31 | 86.9 |
| 6 | Manure+lime+complete commercial fertilizer | 37.3 | 68.4 | 73.0 | 36.4 | 2.34 | 68.1 | 71.9 | 32.4 | 2.15 | 89.8 |
| 7 | Check | 31.7 | 57.0 | 57.5 | 24.4 | 1.60 | 53.0 | 62.2 | 16.9 | 0.73 | 59.7 |
| 8 | Crop residues | ..... | 52.6 | 58.6 | 29.6 | 1.47 | 55.2 | 66.4 | 15.5 | 0.72 | 57.4 |
| 9 | Crop residues+lime | 31.7 | 62.4 | 67.3 | 29.7 | 2.14 | 61.8 | 65.6 | 23.8 | 1.35 | 78.4 |
| 10 | Crop residues+lime+ rock phosphate | 35.0 | 64.1 | 68.7 | 29.8 | 2.28 | 65.0 | 63.4 | 26.7 | 2.06 | 81.3 |
| 11 | Crop residues+lime+ superphosphate | 31.7 | 66.6 | 61.5 | 31.1 | 2.18 | 68.0 | 75.1 | 27.1 | 2.03 | 89.0 |
| 12 | Crop residues+lime+ complete commercial fertilizer | 36.2 | 65.2 | 69.5 | 30.8 | ..... | 70.1 | 73.5 | 28.3 | 2.25 | 83.8 |
| 13 | Check | 28.2 | 59.3 | 59.5 | 25.5 | ..... | 58.6 | 54.4 | 17.5 | 0.98 | 64.0 |

- (1) Three tons lime applied August, 1917. Yield on plot 8 an 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 extremely dry spring.

prisingly 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 superphosphate with the manure and lime gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of the superphosphate were no greater than those brought about by the rock phosphate. The oats in 1924 and the clover in 1926 showed the largest effects from the addition of the superphosphate. The complete commercial fertilizer with the manure and lime gave somewhat greater effects than the superphosphate in most seasons, but in other cases the beneficial influence was less and in no case was there any considerable gain from the use of the complete fertilizer over that brought about by the addition of the superphosphate.

The crop residues showed little effect on the various crops grown, bringing about slight increases only in some seasons. Lime with the residues increased the crop yields in a very noticeable way in most seasons. The largest beneficial effect was shown on the clover in 1922 and 1926, and on the corn in 1919, 1920 and 1923.

The 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. On the other crops grown, smaller increases were secured. The corn, in 1927, however, showed a very large gain from the application. The largest beneficial effects of the lime were shown on the clover in 1922 and 1926 and on the corn in 1919, 1920, 1923 and 1927.

The 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. On the other crops grown smaller increases were secured. The superphosphate with the crop residues and lime showed larger effects than the rock phosphate in some seasons. This was particularly true on the oats in 1921 and 1924 and on the corn in 1927. In several seasons, however, there were smaller effects from the superphosphate than from the rock phosphate. The complete commercial fertilizer gave larger increases than did the rock phosphate and superphosphate in several cases. This was noted particularly on the clover in 1926. In most seasons, however, there was little difference between the effect of this material and the phosphate.

These data indicate that the application of manure is particularly desirable on the Clinton silt loam, and large increases in the yields of general farm crops may be secured from its use. The type is acid in reaction and the application of lime is very desirable. Legume crops will be particularly benefited by the use of lime on this type, but considerable gains in the yields of other general farm crops will follow its application. Beneficial effects from the use of superphosphate or rock phosphate were secured in this experiment, both under the livestock system of farming, with manure and lime, and under the grain system of farming, with crop residues and lime. In some cases the superphosphate seemed to be preferable, but in other cases rock phosphate gave just as good results. Definite conclusions regarding the relative value of these two fertilizers for this soil type cannot, therefore, be reached. Tests of the two phosphates under individual farm conditions are very desirable. The complete commercial fertilizer did not give any better results in this test than did the superphosphate,

hence the use of a complete fertilizer on this soil is probably not as desirable as the application of a phosphate, inasmuch as the complete fertilizer is much more expensive to apply.

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

Some general recommendations regarding the needs of the soils of Clarke County are given here. The results secured in the laboratory, greenhouse and field experiments, which have just been discussed, indicate in a general way the fertilizing treatments that would be desirable for use on the soils of this county. The suggestions offered here are based not only on the experimental work which has been carried out on the main soil types occurring in this county and other counties but are also based on the experience of many farmers. Only suggestions that have been proved valuable by practical experience are offered, and the treatments recommended may be put into effect on any of the soils of the county. Abnormal soils require special treatments which will be discussed later under the descriptions of the individual soil types. The recommendations given here refer, in general, to the normal soils of the county.

LIMING

Tests of the individual soil types occurring in the county have shown that the soils are all distinctly acid in reaction and in need of lime. The figures given in this report indicate roughly the lime requirements of the various soil types. They should not be considered, however, to definitely show the actual lime needs of all the soils of the various types. Soils vary widely in lime requirement, and even soils of the same type in different fields will show different lime requirements. It is essential, therefore, that the soils from every field be tested for lime requirement, if the proper application is to be made to that 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 where it will be tested free of charge.

It is well known that the best growth of general farm crops and particularly of legumes will not be obtained on a soil which is acid in reaction. On such types it is particularly important that lime be applied, to insure the most satisfactory crop yields. In many cases the addition of lime may mean the difference between a satisfactory crop or no crop at all. In the experiments discussed earlier in this report, striking crop increases were secured from the application of lime to some of the main soil types occurring in the county. The beneficial effects were shown on the Grundy silt loam, on the Tama silt loam, on the Clinton silt loam and on the Shelby loam. Large increases in crop yields may undoubtedly be obtained on the other types occurring in the county. Farm experience with the use of lime has indicated that it will bring about large increases in the yields of general farm crops and its use has proved distinctly profitable.

It should be emphasized, therefore, that all the soils of this county should be tested for lime needs at regular intervals and that lime be applied as shown to be necessary according to the tests. One application of lime will not be sufficient for all time and the soils should be tested at least once in the rotation, preceding the growing of a legume crop, in order that there may be a proper supply

of lime to provide for the best growth of the legume. Beneficial effects from the application of the lime will also be shown on the succeeding grain crops of the rotation.

Further information pertaining to the use of lime on soils, loss of lime by leaching and other points connected with liming may be found in Extension Service Bulletin 105 of the Iowa Agricultural Extension Service.

MANURING

While the more extensive upland types in Clarke County are fairly well supplied with organic matter, at least those types which occur on the more gently rolling to level areas of upland, there are many cases in the county where there is an inadequate supply of organic matter and there is need for the application of some fertilizing material supplying this essential constituent. On the Shelby loam and the Lindley silt loam on the drift upland the supply of organic matter is low and it is particularly necessary that organic matter be applied to these soils. On the Clinton silt loam on the loessial uplands the content of organic matter is low, as is indicated by the light color of the soil, and the use of organic matter on this type is particularly necessary. On all the soils of the county, however, the addition of some fertilizing material supplying organic matter is essential, if the content of this constituent is to be kept up.

Farm manure is the best means of increasing and maintaining the supply of organic matter in the soil. Large increases in crop yields are secured on practically all the soils of the county from the application of manure. The experiments reported earlier have indicated the increases in crop yields which may be secured from the addition of manure to some of the types occurring extensively in the county. Increases were noted on the Grundy silt loam, the Tama silt loam, the Clinton silt loam and the Shelby loam. The other soil types in the county would undoubtedly respond just as well to the use of manure and in some cases even greater crop increases would be secured. The liberal application of farm manure to all the soils of the county is very desirable, and farmers should see to it that all the manure produced on the farm is applied to the land regularly.

The proper utilization of all crop residues aids materially in keeping up the supply of organic matter in soils. On the livestock farm the residues may be used for feed or bedding and then returned to the land as 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. On the grain farm where little or no farm manure is produced, some other means of supplying organic matter to the soils must be resorted to. The turning under of leguminous crops as green manures is the most important and valuable means of building up and maintaining the organic matter in the soils of such farms. On the livestock farms green manuring would also be of value to supplement the use of farm manure. When leguminous crops are used as green manures, they not only add organic matter to the soils but also supply nitrogen which is secured from the atmosphere when legumes are well inoculated. There are many cases in Clarke County where the use of leguminous crops as green manures would have large beneficial effects. Green manuring is of particularly large value on the

lighter colored types which show a greater deficiency in organic matter. The practice should not be followed blindly or carelessly, however, as undesirable results may be secured if the decomposition of the green material does not proceed properly. Farmers in this county should build up and maintain the supply of organic matter in their soils thru the proper use of farm manure, leguminous green manures and crop residues.

THE USE OF COMMERCIAL FERTILIZERS

The analyses of Clarke County soils which have been discussed previously indicated that the supply of phosphorus is rather low. It is evident, therefore, that the supply of phosphorus is inadequate to provide for crop growth over any long period of years. The use of phosphate fertilizers will certainly be necessary on these soils in the near future and may be of value in many instances at the present time. The greenhouse and field experiments which have been discussed show that phosphate fertilizers will often prove distinctly profitable on the soils of this county at the present time.

Considerable increases in crop yields have been secured by the application of rock phosphate or superphosphate to the more important types in this county. It is impossible at the present time to say whether rock phosphate or superphosphate will prove more profitable for use under the general farm conditions occurring in this county. In many of the tests superphosphate has seemed to be more effective, but in other instances rock phosphate has shown up quite as well. The superphosphate is more expensive than the rock phosphate but is applied in smaller amounts and provides the element phosphorus in an immediately available form. It may, therefore, have a much quicker effect in increasing crop yields. This is particularly true on the lighter colored soils which are more poorly supplied with organic matter. On these types the use of superphosphate is very desirable. On the other hand, rock phosphate, while applied in large amounts, is less expensive and the phosphorus is more slowly changed into an available form. It will, therefore, in general, have a much slower effect and the beneficial influence of the application of rock phosphate may not be evident until the second or third year after it has been applied. Frequently, however, the rock phosphate brings about very profitable increases in crop yields, especially on soils which are well supplied with organic matter.

It is recommended that farmers test both phosphates on their own soils to determine for their particular conditions which of the fertilizers will prove more profitable for use on their farms. Simple tests may be readily carried out on any farm, and many farmers are conducting such tests at the present time. Directions for carrying out such experiments are given in Circular 97 of the Iowa Agricultural Experiment Station.

Some of the soil types developed in Clarke County are fairly well supplied with nitrogen, but others, which are lighter in color, are inclined to be rather deficient in this constituent. Applications of some fertilizing material to supply nitrogen should be made to the light colored soils at the present time to provide for the best crop growth. On all the soils of the county, however, fertilizing materials supplying nitrogen must be added regularly to keep up the supply of this element. Soils constantly lose nitrogen thru removal by crop growth and losses in drainage water; and, even if the content is adequate at the present

time, it will not remain so and additions of nitrogenous fertilizing materials must be made.

The use of leguminous crops as green manures is the most desirable means of building up and maintaining the supply of nitrogen in the land. Green manures also provide organic matter in which the light colored soils are deficient, thus they have a double value on such soils. They are also of large value on the darker colored soils in that they aid in maintaining the supply of organic matter and nitrogen.

Proper applications of farm manure will also aid in maintaining the supply of nitrogen on the soils of the county, and on the livestock farms the proper use of farm manure is the best means of keeping up the content of this constituent. The utilization of crop residues will return to the land some of the nitrogen removed by the crops. It is very important that all crop residues be properly utilized on the farm, in order to aid in maintaining the supply of nitrogen.

If the farm manure is properly utilized, crop residues are all returned to the land and leguminous crops are turned under as green manures, it will probably be unnecessary to use commercial nitrogenous fertilizers on these soils to build up and maintain the nitrogen content. Commercial nitrogen cannot be recommended for general use in the county at the present time. Such fertilizers may be used in small amounts as top dressings for certain crops and may bring about profitable returns. For truck crops or garden crops nitrogenous fertilizers are frequently of considerable value. They should not be used, however, for general farm crops until tests have been carried out on a small area and their value proven.

Commercial potassium fertilizers are probably not necessary for use on the soils of this county at the present time. Analyses which have been made of these soils have indicated a large content of potash and unless there is an inadequate production of available potassium to keep crops supplied, the use of potassium fertilizers will not prove profitable. Occasionally the addition of a potassium carrier has been found to bring about profitable returns on some general farm crops. Tests should always be carried out, however, on small areas, before a potassium fertilizer is applied extensively, and thus the value of the fertilizer may be determined before any large application is made. For special crops such as truck crops and garden crops, potassium fertilizers may be distinctly profitable.

Complete commercial fertilizers are much more expensive than the phosphates and hence they must bring about much larger increases in crop yields if their application is to prove profitable. The value of complete fertilizers lies mainly in their phosphorus content and it would seem, therefore, that superphosphate or rock phosphate would probably prove more desirable for use. In the experiments discussed earlier in this report the complete commercial fertilizer which was tested did not bring about any larger crop increases than the phosphates and hence would not give nearly as profitable returns. The general use of complete fertilizers on the soils of the county cannot be recommended at the present time. Special brands which have been prepared for use with individual truck crops may prove profitable, but, for general farm crops, complete commercial fertilizers should not be used until tests comparing them with super-

phosphate have been carried out on small areas. If profitable results are secured from the application, then the complete fertilizer may be applied to extensive areas with the assurance of profit.

DRAINAGE

As noted earlier in this report, the natural drainage system of Clarke County is fairly well developed. The map given has indicated that the major streams, tributaries, and intermittent drainageways extend into practically all parts of the county. There are some areas, however, in individual soil types where the drainage is not entirely adequate, and in such areas the installation of tile would be very desirable. In the Grundy silt loam on the loessial uplands there are areas where tiling would be of considerable value, and the Bremer and Calhoun soils on the terraces would also be benefited considerably by artificial drainage. The bottomland types are poorly drained but, in general, these bottomland soils first need protection from overflow. When this is accomplished, adequate drainage may be readily brought about.

Wherever soils are too wet, satisfactory crop yields will not be secured regularly, and in wet seasons very unsatisfactory yields will be obtained. The first treatment needed for such land is the installation of tile. The cost of tiling may be considerable, but the results secured always warrant the outlay. The addition of any fertilizer will be of little value on land which is not properly drained. Much evidence from experimental data and farm experience, shows definitely the value of tiling out land which is too wet. Farmers should see to it that any areas on their farms which are not properly drained, are tiled if they would secure the most satisfactory crop yields.

THE ROTATION OF CROPS

The practice of growing one crop continuously on the same land leads very quickly to a reduction in the fertility of the soil, and crop yields will rapidly decrease until finally the crop will become unprofitable. The value of adopting a proper rotation of crops is generally recognized. Experiments have indicated clearly that the total value of all the crops grown in a good rotation over a period of years is much greater than the value of any crop grown under a continuous cropping system over the same period of time. This is due to the fact that while in a rotation certain crops are included which have less actual money value, the yields of the crops of the higher money value when grown continuously are so rapidly reduced that the value of the crops when totaled over a number of years is less than the value of crops grown in the rotation. Farmers should not be deluded into thinking that they can grow one crop continuously on their land and derive a greater profit because of the larger money value from that particular crop. Their soils will quickly be reduced in fertility and crop yields will very rapidly decline.

No special rotation experiments have been carried out in Clarke County, but a number of rotations are being used successfully in various parts of the state. From among those given here, some rotation may be chosen which will fit in with almost any farm condition. Farmers in this county should see to it that a good rotation is adopted on their farms, since it is one of the fundamental practices necessary for the maintenance of fertility in their soils and for the

continuous production of satisfactory crop yields. Almost any rotation may be followed with value provided it includes a legume and the crop of particular money value.

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 for 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 under the sweet clover 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 by the washing away of the soil with the formation of gullies, gulches or ravines.



Fig. 7. Erosion proves very serious in Clarke County.

Erosion occurs to a considerable extent in Clarke County, particularly in the Shelby loam and the Lindley silt loam on the drift uplands. The Clinton silt loam on the loessial uplands is also much eroded and gullied. All these types are badly washed by the erosive action of water, and in all cases some means of prevention or control of this destructive action should be taken.

Various methods are followed for the control and prevention of erosion in Iowa. These methods differ somewhat depending upon the type of erosion. Erosion 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, or 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 clover crops, by contour discing, by terracing, by deep plowing and by the use of sod strips.*

INDIVIDUAL SOIL TYPES IN CLARKE COUNTY**

There are eight individual soil types in Clarke County, and these are divided into four groups, drift soils, loess soils, terrace soils, and swamp and bottomland soils.

DRIFT SOILS

The two drift soils in the county are classified in the Shelby and Lindley series. Together they cover 44.1 percent of the total area.

* See Bul. 183, Soil Erosion in Iowa. Iowa Agricultural Experiment Station and Extension Service Bulletins 93, 94, 95, 96, of the Agricultural Extension Service, Iowa State College.

** The descriptions given in this section very closely follow those in the Bureau of Soils Report.

SHELBY LOAM (79)

The Shelby loam is the largest individual drift soil and the largest soil type in the county, covering 42.2 percent of the total area. It is extensively developed in all parts of the county along the streams and drainageways, occupying a position intermediate between the level Grundy silt loam of the interstream areas and the soils of the bottoms.

The surface soil of the Shelby loam consists of a brown to dark brown mellow loam, extending to a depth of 8 to 10 inches. The subsoil is a yellowish-brown moderately gritty silty clay mottled with gray and rusty brown, grading at 24 to 30 inches into a mottled yellowish-brown, grayish-brown and gray heavy silty clay containing some gravel. Occasionally some lime-bearing material is found in the lower subsoil. There is considerable variation in the texture of the surface soil. On the upper parts of the slopes much silt is present, and the type often approaches a silt loam. In the lower positions there is a higher sand content. In some places the entire surface covering has been removed and the underlying glacial drift parent material is exposed.

In topography the Shelby loam varies from rolling to strongly rolling. The slopes are eroded and often badly gullied. Drainage is excessive.

The greater part of the Shelby loam, owing to its rough topography, is unsuited to the growing of cultivated crops. Bluegrass does very well on the type, and the land makes excellent pasture. Many of the slopes are in forest, consisting mostly of oak, hickory, elm and maples with here and there some hazel. On the more gently rolling areas of the type general farm crops are grown. Corn is the chief crop and oats and hay are also produced. The yields of these general farm crops are somewhat lower than those secured on the adjacent Grundy silt loam. The soil is well adapted to the production of apples and small fruits. Apple orchards are found on many farms and the fruit is excellent.

The most serious problem involved in the handling of the Shelby loam is erosion. The rougher sections should certainly be left in pasture and are most



Fig. 8. Gullying occurs frequently in Clarke County.

valuable when used for that purpose. Much of the land can be reclaimed, and damage from erosion can be reduced thru the adoption of proper methods of control. Many suggestions have been offered in other publications regarding means which may be employed to reduce erosion occurring under such conditions as are found in this soil. The type is rather poorly supplied with organic matter, and liberal applications of farm manure are very desirable. The turning under of leguminous crops as green manures would also have considerable value on this soil. The proper utilization of crop residues would aid in maintaining the supply of organic matter. The type is acid in reaction, and applications of lime are necessary for the most satisfactory growth of legumes and general farm crops.

The use of a phosphate fertilizer is also very desirable, and tests of superphosphate and rock phosphate are strongly recommended. On the poorer areas of the type the superphosphate would undoubtedly give better returns at the present time until the soil is built up somewhat in fertility and especially in organic matter. When the content of organic matter has been increased, however, the use of rock phosphate may be quite as profitable for building up and maintaining the supply of phosphorus necessary for the best crop yields. The use of complete commercial fertilizers would probably not be as desirable on this type as the use of a phosphate, and tests on individual areas should be carried out with any complete brand before it is applied extensively. The use of a phosphate fertilizer, along with manure and lime, would undoubtedly prove of large value on this soil, as has been indicated by the experimental results discussed earlier in this report.

LINDLEY SILT LOAM (32)

The Lindley silt loam is the second largest drift soil and the fifth most extensively developed type, covering 1.9 percent of the total area. It occurs in three rather extensive areas in the county, the largest being found in the southwestern part, mainly in Franklin Township along the slopes along White Breast Creek. A second area, less extensively developed, is found in the southwestern corner of Fremont Township, extending over into Osceola Township along South Squaw Creek. The third area is developed in Madison Township along South River.

The surface soil of the Lindley silt loam is a light brown to grayish-brown silt loam extending to a depth of 6 to 10 inches and containing a considerable amount of very fine sand. The subsoil is a yellowish-brown silty clay loam grading at 20 to 24 inches into a mottled yellowish-brown, reddish-brown and gray, gritty, compact, heavy clay, generally containing a considerable amount of gravel and coarse sand. Like the Shelby loam there are many variations in the surface soil of the Lindley silt loam. The upper two-thirds of the slopes are predominately a silt loam, while on the lower parts of the slopes, which have been modified considerably by the wash from the upland, the soil approaches a loose textured loam or fine sandy loam. In the more densely forested areas the upper layer of the soil to a depth of 2 or 3 inches has a darker color, due to the accumulation of leaf mold. Included with the Lindley silt loam there are small areas of the Shelby loam which were too small and intricately associated to show separately on the map.

In topography the Lindley silt loam varies from strongly rolling to rough and hilly. The slopes are badly eroded and gullied and in many places the entire surface soil has been removed. Drainage is excessive.

Practically all of the Lindley silt loam is still in forest. The tree growth consists mainly of oak, hickory, elm and ash. Bluegrass grows well on the type and affords excellent pasturage. Because of its rough, eroded topography this type should undoubtedly be used mainly for pasture purposes, and the maintenance of good pasturage on this soil is very desirable. Only in a very few cases would it be desirable to cultivate this soil. In such cases the addition of farm manure or leguminous green manure crops to build up the supply of organic matter would be particularly desirable, as the type is low in organic matter and light in color. It is acid in reaction, and the use of lime would be necessary. The application of a phosphate fertilizer would undoubtedly be of value for general farm crops, and the addition of superphosphate would certainly bring about profitable crop increases. After the soil has been built up in organic matter and made somewhat more fertile, the use of rock phosphate would probably prove just as desirable as superphosphate in maintaining the supply of the element phosphorus. If ever cultivated, the chief problem in connection with the management of the Lindley silt loam will be protection from erosion. In all cases some means to prevent or control this destructive action must be followed, if proper crop yields are to be secured.

LOESS SOILS

There are three loess types in the county and they are classified in the Grundy, Tama and Clinton series. Together they cover 46.4 percent of the total area.

GRUNDY SILT LOAM (64)

The Grundy silt loam is the most extensively developed loess soil and the second largest type, covering 41.6 percent of the total area. It is developed in all parts of the county, being found on the more level to gently undulating interstream areas on the uplands. It occurs, mostly, as connected strips, varying from one-half to two miles in width. The greatest development of the type is found in the vicinity of Lacelle and Murray and extending to the east and south thru Troy, Ward and Knox Townships. The type is also quite extensively developed in the southeastern townships, particularly Franklin and Green Bay, and rather extensive areas of the type occur to the north and east of Osceola.

The surface soil of the Grundy silt loam consists of a dark brown to very dark brown mellow silt loam 12 to 16 inches in depth. The subsoil is a dark grayish-brown silty clay loam mottled with iron stains and grading at 22 to 24 inches into a mottled bluish-gray, rusty brown, yellowish-brown and grayish-brown, heavy, impervious silty clay to clay. At the lower depths the heavy clay becomes a bluish-gray in color and is sometimes locally known as hard pan. Iron concretions are abundant, and orange colored blotches occur in the lower subsoil.

The type varies to some extent in the different areas. In the northwestern part of the county, where the Grundy joins the Tama silt loam, a few areas resemble the true Tama, in that the upper subsoil is a yellowish-brown in color

instead of dark grayish-brown. In the southern part of Green Bay and Franklin Townships, in the northern sections of Knox Township and in the southwestern part of Ward Township north of Lacelle, are extensive flats in which the surface soil is deeper and slightly darker and the subsoil is a grayish-brown grading at 22 to 24 inches into a mottled dark gray, rusty brown and grayish-brown, containing many iron concretions. In an area two miles north of Osceola, the dark brown surface soil is underlaid at 14 to 16 inches by a light gray to brownish-gray layer from 2 to 6 inches thick. These areas, had they been of sufficient size, would have been mapped as the Edina silt loam. Owing to their small extent they have been included with this type. Part way down some of the more gentle slopes are small areas where a very thin surface soil rests directly on a heavy impervious clay. Such areas are locally known as push soils, due to the fact that the plow will not penetrate the impervious subsoil but passes over the surface pushing the thin soil aside. In many places in the northwestern corner of the county the boundary lines between the Grundy silt loam and the Tama silt loam have been rather arbitrarily placed, as the transition from one type to the other is quite gradual.

In topography the Grundy silt loam varies from level to gently undulating; in most cases the flat areas extend up to the stream approaches without appreciable change in surface topography. The drainage of the type varies from moderately good to poor. Thruout the greater part of the area natural drainage is adequate except in abnormal seasons. On some of the more extensive flat areas the drainage is rather poor, and frequently crops suffer from an excess of moisture. The installation of tile is particularly necessary in such locations, and wherever the type is poorly drained, tiling should be practiced.

Practically all of the soil is under cultivation or in pasture. The only tree growth consists of a few willows along old fence rows and wind breaks of evergreen, maple and cottonwood that have been set out around the farm buildings. Corn, oats and hay are the chief crops. Corn is grown most extensively, with average yields of 25 to 60 bushels per acre. Frequently, however, much larger yields are obtained under the most satisfactory conditions. Oats are second in importance, and yield from 35 to 60 bushels per acre. Wheat is grown to some extent, yielding 15 to 25 bushels. Barley is produced on some farms and yields 25 to 30 bushels per acre. There is a small area in rye which yields 18 to 20 bushels per acre. The hay crop consists mostly of clover and timothy and yields from 1½ to 2 tons per acre. Some clover is grown alone and some timothy is grown alone, largely for seed. In some cases soybeans are planted with the corn where the crop is to be used for silage. Some of the corn is hogged down and some is used for silage. Practically all of the crop is utilized on the farm and only in the occasional season is there a surplus for sale outside of the county. Wheat is the principal cash crop and practically all of it is shipped out of the area. The oats are partly utilized on the farm, a portion of the crop being sold to the elevators and shipped out. Some sorgho (sweet sorghum) is grown on the type, usually, however, as a catch crop. Gardens are maintained on all farms, and vegetables are grown to help supply the home demand. Small fruits are grown for local consumption; some apple orchards are maintained and the yields are fair.

The Grundy silt loam is considered the most valuable agricultural type in the county. It is probably as productive in all cases as any of the other soils. The Tama silt loam is the only type in the county which will yield as satisfactory crops without special methods of soil treatments. The Grundy silt loam is naturally a productive soil. Where drainage is adequate satisfactory crop yields may be secured, and in certain areas tiling is all that is necessary to bring about considerable increases in crops. Large gains in the yields of general farm crops may be secured, however, thru proper methods of treatment on this soil type.

While the content of organic matter is adequate, the application of farm manure has been found to be of large value on this soil. Considerable increases in the yields of crops are secured from the proper application of farm manure. The addition of this fertilizing material to the Grundy silt loam is strongly recommended. The use of leguminous crops as green manures would also be of value, especially where the supply of farm manure is limited. The turning under of crop residues is also a desirable aid in maintaining the supply of organic matter.

The type is acid in reaction, and applications of lime are very necessary for the best growth of legume crops. Large increases in the yields of general farm crops will also often follow the addition of lime. Farmers should see to it that their soils are tested for lime needs and that lime is applied where necessary, if they would secure the best crop yields on this soil type.

There is no large supply of phosphorus in this soil, and additions of phosphate fertilizers are very necessary for securing more satisfactory crop yields. The application of superphosphate or rock phosphate is strongly recommended on this soil. Whether superphosphate is preferable to rock phosphate has not yet been definitely determined. In some cases superphosphate seems to be more desirable for use, but in other instances the rock phosphate gives quite as large crop increases. Tests of the two phosphate fertilizers under individual farm conditions are recommended. The use of a complete commercial fertilizer on the Grundy silt loam may be desirable in some cases. In general, however, a phosphate fertilizer would probably bring about quite as large crop increases and prove, therefore, more economical.

The experiments discussed earlier in this report indicate definitely the beneficial effects from the application of manure, lime and a phosphate fertilizer to this soil. While, in general, the yields of farm crops may be satisfactory on this type, farmers may be confident that very much larger crop yields may be secured thru proper methods of fertilization with these materials.

TAMA SILT LOAM (120)

The Tama silt loam is the second largest loess soil and the fourth most extensively developed type. It covers 3.0 percent of the total area. The Tama silt loam is developed almost exclusively in the northwestern townships, particularly in Madison and Washington Townships. There is one small area in Troy Township south of Murray. The largest developments of the type are in Sections 19, 20 and 29 of Madison Township and along the northern sections of the same township. There is also a rather extensive development of the type thru the central sections of Washington Township.

The surface soil of the Tama silt loam is a dark brown mellow silt loam ex-

tending to a depth of 14 to 16 inches. The subsoil is a yellowish-brown, friable, compact silty clay loam becoming somewhat heavier with depth. Faint mottlings of gray and iron stains are common in the lower subsoil.

There is some variation in the type as it occurs in the county. Near the boundaries of the Grundy silt loam strips are often found where the yellowish-brown silty clay loam grades at 32 to 34 inches into a mottled, yellowish-brown, gray, and rusty brown silty clay, containing numerous iron concretions. These areas represent transitional areas between the Grundy silt loam and the Tama, and in many cases the boundary lines have been rather arbitrarily placed. In some places where the surface soil has been washed away to some extent, the color ranges from brown to grayish-brown. Such areas were too small to show on the map.

In topography the Tama silt loam varies from gently rolling to rolling and drainage is quite adequate.

The type is practically all in cultivation, and corn is the most important crop grown; average yields amounting to 25 to 60 bushels per acre. Oats are grown extensively and yield 35 to 55 bushels per acre. Some wheat is grown, yielding 15 to 25 bushels per acre. The hay crop is second in importance to corn and yields 1 to 2 tons per acre. Wheat is the principal cash crop. Some barley and rye are grown for feed. Rape is sometimes seeded in the corn, and some sorghum is grown as a catch crop. Apples and small fruits do well on this type but are not grown on a commercial scale.

The Tama silt loam is naturally quite productive, and yields of general farm crops are fairly satisfactory. The adoption of proper methods of treatment would, however, bring about large increases in the yields of general farm crops. The application of manure to this soil would be of particular value, and large increases in crop yields will follow its use. The turning under of leguminous crops as green manures would also prove profitable in building up and maintaining the supply of organic matter and nitrogen in this soil. The type is acid in reaction, and applications of lime are very necessary for the best growth of general farm crops and particularly of legumes.

The use of a phosphate fertilizer would undoubtedly be of value on this type, and tests of superphosphate and rock phosphate are strongly recommended. The experiments discussed earlier in this report indicated large value from the application of a phosphate fertilizer to this soil, but the tests thus far carried out have not shown definitely whether superphosphate or rock phosphate will prove more profitable. Farmers are urged to test these two phosphorus carriers on small areas on their own farms, to determine which will be the more profitable for use. It is apparent, however, that one of these phosphorus fertilizers, when used with manure and lime, will certainly bring large increases in the yields of general farm crops.

CLINTON SILT LOAM (80)

The Clinton silt loam is the third largest loess soil in the county, covering 1.8 percent of the total area. It occurs on the tops of ridges thruout the rougher sections of the county. The most extensive areas occur in the southwest quarter of the county along White Breast Creek and north of Osceola in Osceola and Fremont Townships along the south side of Squaw Creek. Other smaller bodies

are found in the extreme southwestern part of the county along East and West Long Creek.

The surface soil of the Clinton silt loam is a gray, pale grayish-yellow to grayish-brown, mellow silt loam extending to a depth of 8 to 14 inches. The subsoil is a pale yellowish-brown silty clay loam faintly mottled with light gray, grading at 20 to 24 inches into a mottled yellowish-brown, brown and grayish-brown heavy compact silty clay. Iron stains and concretions are common in the lower subsoil. When dry the surface of this soil has a whitish color, a floury texture and is brown to slightly grayish-brown in color when wet. In topography the type varies from level to gently rolling and drainage is good.

Only a few areas of the Clinton silt loam are in cultivation. The narrow ridges are practically all in forest and support a tree growth consisting mostly of oak and some hickory. Bluegrass makes an excellent growth, and the type provides good pasture. Corn is the chief crop grown on the cultivated areas; oats and hay are also produced. Yields of these crops are lower than those secured on the adjacent Grundy silt loam.

The type is subject to erosion and on the rougher sections it should undoubtedly be left in bluegrass and used for pasture. When cultivated the soil will respond in a very large way to applications of farm manure and to the turning under of leguminous crops as green manures. It is very important that the supply of organic matter in this soil be built up thru the use of these fertilizing materials in order to make it most satisfactorily productive. It is acid in reaction, and applications of lime are very necessary for the best growth of legumes, and lime will also bring about large increases in the yields of general farm crops. The use of a phosphate fertilizer is very desirable on this soil, and tests of superphosphate are recommended. When the soil has been built up in fertility and organic matter content, rock phosphate may then be used to supply the needed phosphorus. The tests reported earlier have indicated large value on this soil from the application of a phosphate fertilizer along with manure and lime. Farmers may be sure that treatment of this type with these fertilizers will bring about very profitable crop increases.

TERRACE SOILS

The two terrace types in the county are classified in the Bremer and Calhoun series. Together they cover only 0.2 percent of the total area.

BREMER SILT LOAM (88)

The Bremer silt loam is a minor type in the county, covering only 0.1 percent of the total area. It is developed on the terraces and occupies a position 6 to 16 feet above the normal level of the streams and 2 to 6 feet above the first bottoms. The largest areas, which are comparatively small and disconnected, are found along South River. Less extensive areas occur along Squaw Creek, White Breast Creek and Bee Creek.

The surface soil of the Bremer silt loam is a dark brown to almost black mellow silt loam 10 to 14 inches in depth. The subsoil is a dark grayish-brown to dark gray heavy silty clay loam to silty clay, mottled with rusty brown in the lower depth. There is some variation in the type in the different areas. Narrow strips along the outer edges of the terraces where the colluvial material has

accumulated have a lighter colored soil and a gray to dark gray subsoil. Such bodies, had they been of sufficient size, would have been mapped as the Judson silt loam. However, they were too small to separate on the map. In the extreme southwest corner along the Decatur County line the soil resembles the Waukesha silt loam. The greater part of the area, however, as developed in Clarke County, is Bremer. This variation from the typical Bremer, resembling the Waukesha, has been included with the Bremer silt loam.

In topography the soil is level to gently sloping. Drainage is good, the heavy subsoil condition rather restricting the natural drainage of the type.

Practically all of the Bremer silt loam is in cultivation or pasture. Corn is the chief crop, and yields of 35 to 55 bushels per acre are secured. Hay, oats, wheat and rye are also grown. The yields of hay amount to 1½ to 2 tons per acre. Other crops grown yield very much the same as the Grundy silt loam on the uplands.

In general, the Bremer silt loam is apt to be in need of artificial drainage. Tiling is very necessary in many cases to remove the excess moisture. The type is high in organic matter content, and small amounts of farm manure will prove of value in stimulating the production of available plant food. This is especially true on newly drained areas. The type is acid in reaction, and applications of lime are very necessary for the best growth of legumes. Lime will also bring about considerable increases in the yields of general farm crops. The use of a phosphate fertilizer is desirable on this soil, and tests of superphosphate and rock phosphate are strongly recommended. There is evidence that one or the other of these phosphates may be used with distinct profit on this soil.

CALHOUN SILT LOAM (42)

The Calhoun silt loam is a minor type in the county, covering 0.1 percent of the total area. It is largely developed in the southwestern corner, several small areas being found in Doyle Township. The largest area is found in the extreme southwestern corner on the county line. A small area occurs in Sections 10, 11, 14 and 15 of Ward Township. There is another area in Section 8 of Franklin Township.

The surface soil of the Calhoun silt loam consists of a light brown to brownish-gray floury silt loam extending to a depth of 8 to 14 inches where there is a light gray layer having a very floury texture. This in turn grades at 20 to 24 inches into a mottled bluish-gray, rusty brown and yellowish-brown heavy compact silty clay, containing some iron concretions.

There are a few variations from the typical soil. The area in the extreme southwestern corner of the county has a slightly darker surface and a thicker gray layer. Along the Union County line the brownish-gray surface soil grades at 12 to 15 inches into a heavy compact subsoil with only slight indications of the gray layer. A small area located in Sections 22 and 34 in Doyle Township has a brown to dark brown surface soil and had it been more extensively developed it would have been separated as the Chariton silt loam. Other small bodies of the type, too small to show on the map, have been included with the upland soils, especially where they occur bordering the upland slopes where the surface soil has a darker color.

In topography the Calhoun silt loam is level to very gently sloping. It oc-

cupies a position 6 to 10 feet above the normal water level of the streams and 2 to 4 feet above the first bottoms. Drainage is rather poor.

Practically all of the soil is under cultivation, and corn, wheat, oats, clover and timothy are the principal crops grown. Corn yields 30 to 50 bushels per acre, wheat 15 to 35 bushels, oats 30 to 49 bushels and hay 1 to 2 tons. Yields of general farm crops on this type are somewhat lower than those secured on the better upland soils of the Grundy and Tama series.

The type is poorly drained and tiling is the first treatment needed in most cases to make it more satisfactorily productive. The application of farm manure would be of large value on this soil, and liberal applications of this material are recommended. The turning under of leguminous crops as green manures would also prove profitable. The soil is acid, and the application of lime is necessary for the best growth of legumes. Lime would also undoubtedly bring about considerable increases in the yields of other farm crops. The use of a phosphate fertilizer is very desirable on this soil, and tests of superphosphate and rock phosphate are recommended. At the present time the use of superphosphate would probably be preferable but when the soil has been built up somewhat in fertility and organic matter content, the use of rock phosphate would probably be quite as desirable. Tests of both materials under individual farm conditions are recommended.

SWAMP AND BOTTOMLAND SOILS

There is one swamp and bottomland soil mapped as the Wabash silt loam. It covers 9.3 percent of the total area.

WABASH SILT LOAM (26)

The Wabash silt loam is developed in all parts of the county along the streams and in many of the minor drainageways. The largest development of the type is along Squaw Creek, White Breast Creek, East Long Creek, Otter Creek and South River. The type is developed in all cases in narrow strips along the streams and drainageways.

The surface soil of the Wabash silt loam is a dark brown to almost black compact friable silt loam 12 to 15 inches in depth. The subsoil is a dark grayish-brown to dark brown heavy silt loam grading at 20 to 24 inches into a heavy grayish-brown to dark slate colored silty clay loam to clay, containing mottlings of gray to yellowish-gray. There are many variations in the soil. In many places the dark brown to black color extends to a depth of 3 feet without appreciable change. In other sections the dark colored surface soil is underlaid at 15 to 18 inches by a brownish-gray heavy silt loam. Included with the type are small areas of a silty clay loam which were too small to be separated on the map. Along some of the smaller tributary streams the narrow bottoms are somewhat variable in texture in the surface soil, ranging from a fine sandy loam to a silt loam with the loam predominating. Because of their small extent they have been included with the Wabash silt loam.

The type is developed on the bottoms along the streams and is subject to overflow. It usually occupies a position from 2 to 5 feet above the normal water level. Drainage varies from poor to moderately good. The surface is level to gently sloping.

The greater part of the type, about 70 percent, is in cultivation; the rest is in its natural state and used for pasture. A few of the areas are forested with oak, hickory, ash, cottonwood, soft maple and willow. On the cultivated areas corn is most extensively grown, and average yields in good seasons amount to 40 to 60 bushels per acre. Hay and oats are also grown and make very good returns.

Land of this type to be properly cultivated must be protected from overflow, otherwise crops will suffer in periods of heavy rainfall. Adequate drainage should also be provided. The use of farm manure would be desirable. The type is acid and lime should be applied. The addition of a phosphate fertilizer would undoubtedly be of value. Tests of superphosphate and rock phosphate are recommended.

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 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

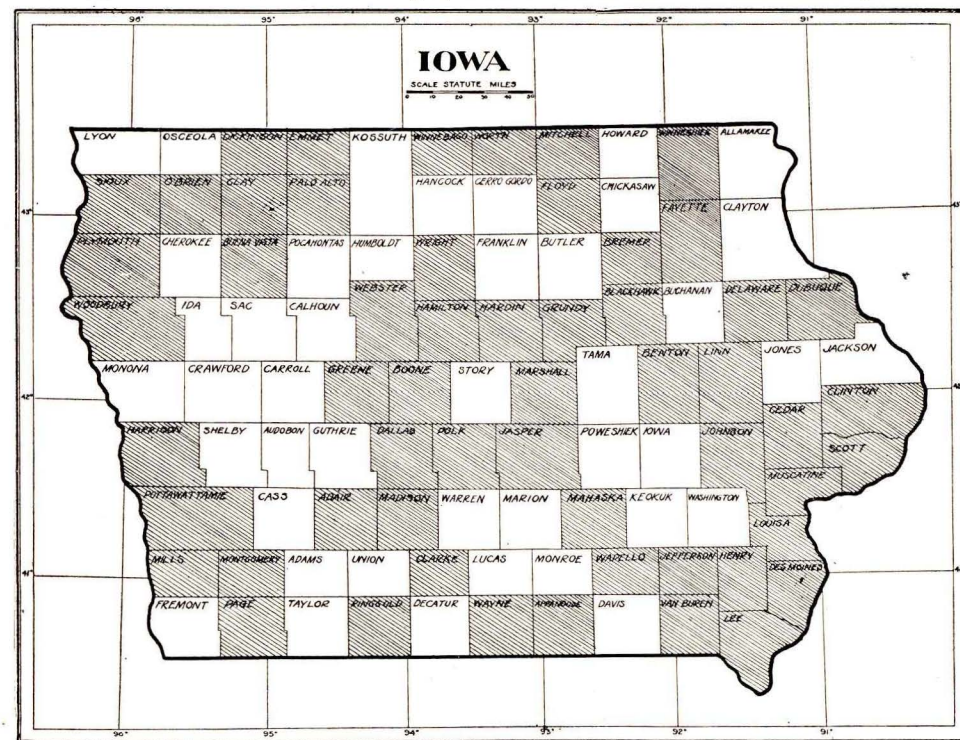


Fig. 9. Map of Iowa showing the counties surveyed.

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 solution 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 rapidly enough, plants will suffer for proper food.

Bacteria and molds are the agents which bring about the change of insoluble, unavailable material into 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 superphosphate, and potassium at 6 cents, the cost in muriate of potash.

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

TABLE I. PLANT FOOD IN CROPS AND VALUE
Calculating Nitrogen (N) at 16c (Sodium Nitrate (NaNO₃)), 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 | Phos-phorus | Potas-sium | Nitro-gen | Phos-phorus | Potas-sium | |
| 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 |
| Oats, 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 |

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 percent of the corn and 35 to 40 percent 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 the production, by bacteria, of available plant food.

Proper system 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 of 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 is a third explanation of the value of rotations. It is claimed 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 proper rotation the time between two different crops of the same plant is long enough to allow the "toxic" substances 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 reasons 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 portion 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 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 superphosphate 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 and the production of acids in the decomposition processes constantly occurring in soils. Iowa soils are no exception 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 the 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 areas 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. The various areas are shown in the map, fig. 10.

With the exception of the northeastern part of the state, the whole surface of Iowa was in ages past overrun by 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 of "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 the 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 soils 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, to-

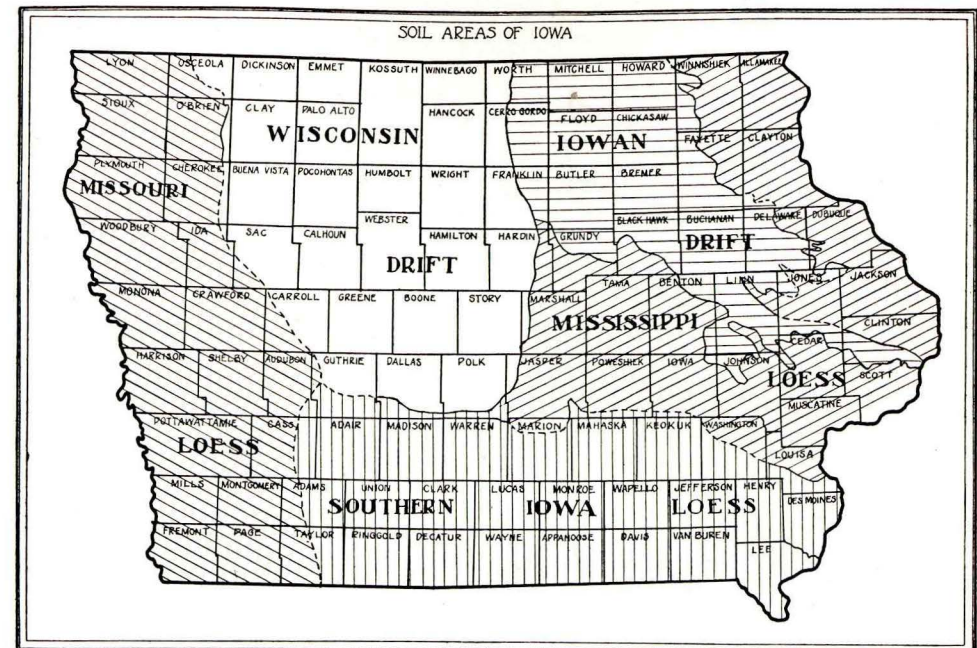


Fig. 10. Map showing principal soil areas in Iowa.

pography, 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 or 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. |

* 25mm equals 1 in. † Bureau of Soils Handbook.

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 silt.

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.

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.