# SOIL SURVEY OF IOWA

## POWESHIEK COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Farm Crops and Soils Section
Soils Subsection

Soil Survey Report No. 74

March, 1935

Ames, Iowa

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**Soil Survey Reports**

1 Bremer County
2 Pottawattamie County
3 Muscatine County
4 Webster County
5 Lee County
6 Sioux County
7 Van Buren County
8 Clinton County
9 Scott County
10 Ringgold County
11 Mitchell County
12 Clay County
13 Montgomery County
14 Black Hawk County
15 Henry County
16 Buena Vista County
17 Linn County
18 Wapello County
19 Wayne County
20 Hamilton County
21 Louisa County
22 Palo Alto County
23 Winnebago County
24 Polk County
25 Marshall County
26 Madison County
27 Adair County
28 Cedar County
29 Mahaska County
30 Fayette County
31 Wright County
32 Johnson County
33 Mills County
34 Boone County
35 Dubuque County
36 Emmet County
37 Dickinson County
38 Hardin County
39 Dallas County
40 Woodbury County
41 Page County
42 Jasper County
43 O'Brien County
44 Greene County
45 Des Moines County
46 Benton County
47 Grundy County
48 Floyd County
49 Worth County
50 Jefferson County
51 Clarke County
52 Winneshiek County
53 Appanoose County
54 Plymouth County
55 Harrison County
56 Delaware County
57 Jones County
58 Fremont County
59 Cherokee County
60 Carroll County
61 Howard County
62 Warren County
63 Chickasaw County
64 Kossuth County
65 Clayton County
66 Lyon County
67 Buchanan County
68 Union County
69 Pocahontas County
70 Butler County
71 Sac County
72 Calhoun County
73 Crawford County
74 Poweshiek County
75 Guthrie County
76 Hancock County
77 Washington County

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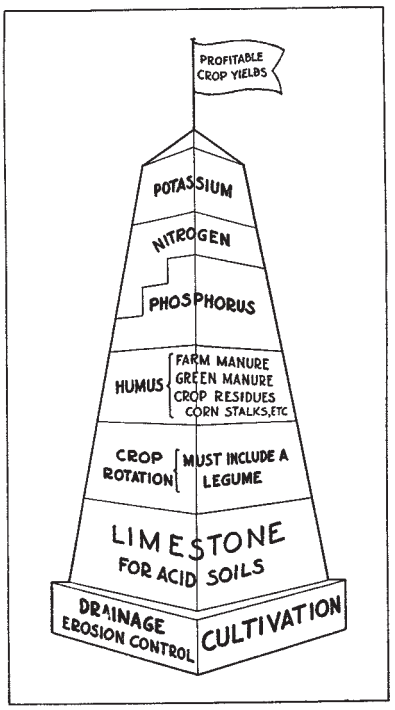
## Report No. 74—POWESHIEK COUNTY SOILS

By P. E. Brown, T. H. Benton, H. R. Meldrum and A. J. Englehorn




IOWA AGRICULTURAL
EXPERIMENT STATION
R. E. Buchanan, Director
Ames, Iowa

## CONTENTS

# POWESHIEK COUNTY SOILS[1]

By P. E. Brown, T. H. Benton, H. R. Meldrum and A. J. Englehorn

Poweshiek County is located in southeastern Iowa in the fourth tier of counties north of Missouri and in the fifth tier west of the Mississippi River. It is partly in the Mississippi loess and partly in the Southern Iowa loess soil areas and hence the soils are mainly of loessial origin, only small areas of drift soils being exposed where the loessial covering has been removed by erosion.

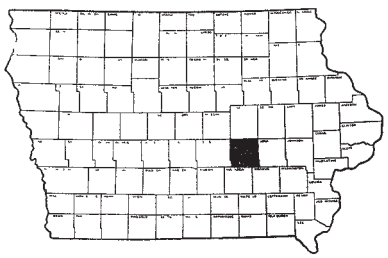


Fig. 1. Map showing location of Poweshiek County.

The total area of the county is 583 square miles or 373,120 acres. Of this area, 364,192 acres, or 97.6 percent, are in farm land. The total number of farms is 2,160 and the average size of the farms is 169 acres. Owners operate 59 percent of the total farm land and renters the remaining 41 percent.

The following figures taken from the Iowa Yearbook of Agriculture for 1932 show the utilization of the farm land of the county:

| | |
|---|---|
| Acreage in general farm crops | 232,286 |
| Acreage in farm buildings, public highways and feedlots | 15,446 |
| Acreage in pasture | 114,945 |
| Acreage in waste land not utilized for any purpose | 1,546 |
| Acreage in farm woodlots used for timber only | 2,636 |
| Acreage in crop land lying idle | 685 |
| Acreage in crops not otherwise listed | 108 |

## THE TYPE OF AGRICULTURE IN POWESHIEK COUNTY

The type of agriculture followed in Poweshiek County at present is mainly general farming, which includes the growing of corn, small grain crops and hay and the raising and feeding of livestock. Corn is the leading crop grown, and most of it is fed on the farms. Only the surplus is sold on the great majority of farms. Occasionally on tenant-operated farms more of the crops are sold, but the sale of corn to the local elevators and shipment out of the county probably amounts to less than one-eighth of the total produced. The small grain crops, chiefly oats, are largely fed to livestock and only a small portion of the crop is sold. Wheat is a minor cash crop, but it is grown to such a limited extent in the area that it is not of any particular importance. The hay crop is all utilized for feed. Hog raising and fattening is the chief livestock industry and provides the chief source of income on most farms. Dairying has recently developed into an important industry on some farms and is providing considerable income. The beef cattle industry is developed to some extent and sometimes serves as the chief source of income on the farm. Sheep are raised on the rougher areas and add to the farm income. The poultry industry is of importance, and the income from the sale of

[1] See Soil Survey of Poweshiek County, Iowa, by T. H. Benton of the Iowa Agricultural Experiment Station and A. E. Shearin of the U. S. Department of Agriculture. Field Operations of the Bureau of Chemistry and Soils Series 1929, Project 239 of the Iowa Agricultural Experiment Station.

poultry and poultry products adds much to the farm revenues. Fruit growing is practiced to some extent in the county, but there is little commercial production, most of the fruit being utilized for home consumption.

The acreage of waste land is considerable, and the adoption of proper methods of soil treatment would permit of the reclamation of much of this land. It is not possible to give general recommendations for the handling of waste land areas as the causes of unproductivity are so variable. Later in this report suggestions will be offered for the handling and treatment of the waste land in the various soil types. For more or less abnormal conditions, advice regarding desirable soil treatments for land may be obtained from the Soils Subsection of the Iowa Agricultural Experiment Station.

## GENERAL FARM CROPS GROWN IN POWESHIEK COUNTY

The general farm crops grown in Poweshiek County in the order of their importance are corn, oats, hay, alfalfa, timothy and clover seed, potatoes, barley, wheat, soybeans and rye. The acreage, yield and value of these crops are given in table 1.

TABLE 1. ACREAGE, YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN POWESHIEK COUNTY, IOWA*

| Crop | Acreage | Percentage of total farm land of county | Bushels or tons per acre | Total bushels or tons | Average price** | Total value of crops |
|---|---|---|---|---|---|---|
| Corn | 126,105 | 34.62 | 47.4 | 5,977,377 | $0.12 | $717,285 |
| Oats | 58,361 | 16.02 | 36.3 | 2,121,344 | 0.10 | 212,134 |
| Winter wheat | 464 | 0.12 | 16.7 | 7,753 | 0.33 | 2,558 |
| Spring wheat | 379 | 0.10 | 11.8 | 4,464 | 0.33 | 1,473 |
| Barley | 2,480 | 0.68 | 22.7 | 56,400 | 0.20 | 11,280 |
| Rye | 90 | 0.02 | 14.6 | 1,314 | 0.24 | 315 |
| Clover hay*** | 9,449 | 2.59 | 1.34 | 12,662 | 6.00 | 75,972 |
| Timothy hay | 8,461 | 2.32 | 1.30 | 10,999 | 4.50 | 49,495 |
| Clover and timothy hay (mixed)*** | 13,103 | 3.59 | 1.37 | 17,951 | 6.00 | 107,706 |
| Alfalfa | 2,470 | 0.67 | 2.54 | 6,274 | 8.00 | 50,192 |
| All other tame hay | 1,998 | 0.54 | 1.34 | 2,669 | 6.00 | 16,014 |
| Wild hay | 27 | 0.01 | 0.85 | 23 | 4.50 | 103 |
| Soybeans sown with other crops | 170 | 0.04 | .... | .... | .... | .... |
| Soybeans sown alone | 643 | 0.17 | .... | .... | .... | .... |
| Soybeans harvested for beans | 220 | 0.06 | 17.1 | 3,771 | 0.42 | 1,583 |
| Potatoes | 288 | 0.07 | 130.0 | 37,440 | 0.37 | 13,852 |
| Timothy seed | 5,593 | 1.53 | 5.6 | 31,209 | 0.95 | 29,648 |
| Clover seed*** | 1,761 | 0.48 | 0.95 | 1,675 | 6.00 | 10,050 |
| Sweet clover**** | 214 | 0.05 | .... | .... | .... | .... |

*Iowa Yearbook of Agriculture, 1932.
**Average state farm value Dec. 1, 1932, except timothy and alfalfa hay, and clover seed which are estimated.
***Sweet clover not included.
****All varieties for all purposes.

Corn is the most important crop both in acreage and value. In 1932 it was grown on 34.62 percent of the total farm land, and average yields amounted to 47.4 bushels per acre. The yields on the better soils under the most approved systems of soil management are often much higher than this average figure, while on the poorer soils and where improper management practices

are followed the yields are low. About 7 percent of the crop is hogged-down, and around 2 percent is used for silage. Most of the corn produced is fed on the farm, the surplus being sold, often in the county for feeding purposes. On some farms more of the crop is sold out of the county through the local elevators, but in general less than one-eighth of the crop is sold.

Oats are second in importance to corn, being grown in 1932 on 16.02 percent of the total farm land and producing an average yield of 36.3 bushels per acre. The yield of this crop varies widely on the different soils and under the varying management conditions on the farms. In some cases the yields are high, and in others low. The most popular varieties include Iowa 103, Iowa 105, Kherson and Early Champion. The oats crop is used mainly as feed for work stock on the farms, and only a small proportion of it is sold.

The hay crop is third in acreage and value. The chief hay crop is clover and timothy mixed, which in 1932 was grown on 3.59 percent of the total farm land. Average yields of that crop in 1932 were estimated at 1.37 tons per acre. Clover hay was grown in that year on 2.59 percent of the farm land and timothy hay on 2.32 percent. The average yields of these hay crops amounted to 1.34 tons and 1.30 tons per acre, respectively. Some clover is grown for seed, the crop being used for this purpose on 0.48 percent of the farm land in 1932. Some timothy is also produced for seed, the acreage utilized in this way in 1932 amounting to 1.53 percent of the total farm land. There is a small acreage of wild hay, but it is of little importance. The acreage in all other tame hay in addition to the red clover, timothy and mixed clover and timothy and alfalfa, amounted in 1932 to 1,998 acres, or 0.54 percent of the total farm land, and average yields were 1.34 tons per acre.

Alfalfa is grown on a limited acreage, but it is a very valuable crop and its use is increasing. In 1932 it was grown on 0.67 percent of the total farm land and average yields amounted to 2.54 tons per acre. When the soil is limed and the seed is inoculated, there is an excellent growth of this crop and it proves a distinctly profitable one.

Potatoes are grown on practically all farms but chiefly for home use. The average yield of this crop in 1932 was 130 bushels per acre. Some barley is grown, in 1932 being produced on 0.68 percent of the total farm land with average yields of 22.7 bushels per acre. A little winter wheat is grown and a still smaller acreage of spring wheat is reported. The yields were 16.7 and 11.8 bushels per acre, respectively, for these crops in 1932. There is a very limited production of rye. Soybeans are grown to some extent, being sown alone in 1932 on 0.17 percent of the total farm land and harvested for beans on 0.06 percent of the farm land. There was a still smaller acreage sown with other crops. Sweet clover is grown to a limited extent, chiefly for pasture purposes. Other minor crops are grown in the county, such as sorghum, sudan grass and various truck crops. Sweet corn is an important cash crop on a number of farms in the vicinity of Grinnell where there is a canning factory.

Tree and bush fruits do well in Poweshiek County but there is very little fruit grown commercially. Apples are the main tree fruit, and there are

many small orchards throughout the county. Frequently, however, the trees have been neglected, the production of fruit is low, and most of the product is utilized locally. A small surplus sometimes finds its way to the local markets. There are also a considerable number of peach, plum, cherry and pear trees on the farms, but the yields are not high. Grapes, blackberries, raspberries and strawberries are grown on many farms but serve mainly to meet the home demand.

## THE LIVESTOCK INDUSTRY IN POWESHIEK COUNTY

The livestock industry in Poweshiek County includes the raising and fattening of hogs, dairying, the raising and feeding of beef cattle, the raising of sheep and feeding of sheep shipped in, and the raising of some horses, largely for use on the farms.

The raising and fattening of hogs is the most important livestock industry. The 1930 census reported 139,376 hogs on the farms on April 1 of that year. The most popular breeds are the Poland China and Duroc Jersey. There are also some Hampshires, Chester Whites and Spotted Poland Chinas. In addition to the purebred herds many grades are raised. On many farms the income is derived largely from the sale of hogs on the Chicago markets. The raising of purebred hogs for breeding stock is practiced to some extent.

The beef cattle industry is second to hog raising and feeding in the area. In 1930 the census reported 45,899 head of cattle on the farms. There are some purebred herds in the county, chiefly Shorthorn, Aberdeen Angus, Hereford and Polled Hereford. The cattle shipped in for feeding are largely from the western ranges and bought on the Kansas City and Omaha markets. The fattened animals are sold mainly on the Chicago markets, in general through the cooperative livestock associations. Only a few farmers specialize in the production of breeding stock.

The dairy industry is developing to some extent and is proving very profitable. In 1930 the census reported 10,862 dairy cows on the farms. There are some purebred herds in the county, chiefly Holstein and Jerseys. Milk cows are kept on all farms to supply the home demand, but these animals are mostly grades. The milk and dairy products are sold locally and in nearby towns.

The sheep industry is of some importance, especially on the rougher lands. In 1930 there were from 4,000 to 10,000 sheep being fed and sold annually according to the census, with 19,450 sheep and lambs on the farms on April 1, 1930. The value of the wool produced was reported at $25,586 in 1929.

There is some raising of horses and mules in the county, many farmers raising a colt or two each season. In 1930 the census reported 11,048 horses and 962 mules in the county. The animals are raised mainly to provide workstock on the farms although there is some sale of horses. The Percheron is the most popular breed, followed by the Clydesdale and Shire.

Poultry provide an important source of income on most farms. In 1930 the census reported 304,717 chickens on the farms on April 1, and 263,374 were sold alive or dressed in 1929, valued at $234,403. Egg production amounted to 1,900,563 dozens in 1929, valued at $513,152.

## THE FERTILITY SITUATION IN POWESHIEK COUNTY

The yields of crops are usually satisfactory in Poweshiek County, but where poor soil management practices are followed and on some of the poorer soils, the production of crops is small, often far too small to prove economically profitable. It is certain that often the adoption of better methods of management of the land will bring about much larger crops *per acre* and hence more profitable crops.

Some areas are not adequately drained naturally, and in such areas tiling is necessary if the most satisfactory crop yields are to be obtained. The Grundy silt loam, the light colored phase of that type, the Grundy silty clay loam and the Muscatine silt loam, on the uplands all contain areas which are in need of artificial drainage. On the terraces the Bremer soils are poorly drained, and on the bottomlands the Wabash types are in need of drainage as well as protection from overflow if they are to be most successfully cropped. Thus while the natural drainage system of the county is fairly well developed there is need in many areas for better drainage if the best crops are to be grown.

The soils of the county are all acid in reaction and hence in need of lime if the yields of general farm crops are to be most satisfactory and if such legumes as sweet clover and alfalfa are to be grown at all.

All the soils in the county must be tested for acidity or lime requirements and lime must be added as needed if there is to be satisfactory crop growth. Such tests must be made regularly in the rotation, too, preferably preceding the growing of the legume crop, to insure the best growth of the legume, which is most sensitive to acidity. Beneficial effects are shown on the other crops as well as on the legumes, and the addition of lime is essential to the permanent fertility of the soils.

There is quite a difference in the supply of organic matter in the different soils of the county. Some of them are apparently fairly well supplied, while others are quite evidently somewhat deficient. Those types which are light in color show their lack of organic matter. Types like the Lindley, Clinton, Shelby, Jackson and Genesee are particularly in need of additions of fertilizing materials supplying organic matter at the present time. But many of the other types in the county such as the Tama, Grundy, Carrington, Waukesha and Judson will also respond in a large way to additions of organic matter, particularly farm manure. And on all the soils, the regular application of some materials supplying organic matter is quite necessary if the supply is to be kept up. The regular application of farm manure will bring about large crop increases, especially on the poorer soils, and the turning under of legumes as green manures will also prove of value, serving as a supplement to the farm manure or as a substitute for that material. The thorough utilization of all crop residues will also help to maintain the organic matter content of the soil. The soils of this county must be built up and kept up in organic matter by the proper use of farm manure, green manures and crop residues.

The phosphorus content of the soils is low. In no case is it sufficient to keep crops supplied for any long period. It seems certain that the applica-

tion of phosphorus fertilizers will be needed in the very near future, and it appears from the tests which have been carried out that the addition of rock phosphate or superphosphate might prove of large value now. It is not yet possible to say whether rock phosphate or superphosphate should be employed, as the results with the two fertilizers vary under individual farm conditions. Farmers are urged to test the effects of these two materials under their particular conditions and thus determine which can be used most advantageously and, in fact, whether or not phosphorus is needed. Simple tests may be carried out quite readily on the farm and provide the farmer with a definite basis upon which to plan his fertilizing operations.

The content of nitrogen in the soils varies quite as widely as does the supply of organic matter, and those soils which are low in organic matter are likewise low in nitrogen, while those which are dark in color and high in organic matter are well supplied with total nitrogen. Those types which are particularly in need of being built up in organic matter are also, therefore, in need of nitrogen. The application of farm manure and the turning under of crop residues will return to the land some of the nitrogen removed by the crops grown and will thus retard the losses of nitrogen which accompany, quite naturally, the growing of crops. Nitrogen is lost rapidly from land which is under cultivation, and regular return must be provided for, or the soil will become deficient. The use of legumes as green manures, being sure that the legumes are well inoculated, will increase and aid in maintaining the supply of nitrogen in the soil. This is the cheapest and best form of nitrogen, and when green manuring is properly practiced along with the use of farm manure and crop residues, there is no need for the addition of expensive commercial nitrogenous fertilizers.

The use of commercial potassium fertilizers is probably unnecessary usually on the soils of Poweshiek County. There is an abundant supply of total potassium in most of the soils, and if the availability processes are sufficiently rapid there should be enough supplied to meet the needs of crops. In some cases the use of a commercial potash carrier may be worth while. The only way to tell is to make a test on a small area and if the treatment proves beneficial then an application may be made to a larger area, with assurance of profit.

Complete commercial fertilizers may be of value on some of the soils in the county at the present time, but they cannot be recommended for general use. In the experiments which have been carried out with these materials, comparing their effect with that of superphosphate, the phosphate has usually given quite as large effects and as it is less expensive, its use would be preferable. There is no objection to the use of any commercial brand of complete fertilizer. It is merely a question of whether it will be profitable. At any rate, before any brand is applied at all extensively it should be tested on a small area and its effects determined.

Considerable erosion occurs in Poweshiek County. Some of the soils have been seriously washed and even show gully formation. The Tama silt loam is frequently much affected by sheet erosion—the carrying away of the surface soil. The Shelby loam, the Lindley loam and silt loam, the Clinton silt

loam and the Carrington loam are all badly eroded in some areas and they are all subject to erosion if they are not properly farmed and managed. It is very desirable that methods be adopted to prevent the washing away of the surface soils and the development of gullies. Later in this report suggestions will be offered for the control or prevention of erosion, and from among the methods described, some one may be chosen which will be suitable for almost any farming conditions.

## THE GEOLOGY OF POWESHIEK COUNTY

The early geological history of Poweshiek County has little relation to the present-day soil conditions in the county, and hence it is not worth while to enter into a discussion of the conditions under which the bedrock underlying the county was laid down, or of the forces which operated upon these rock materials in the ages following their deposition. The soils of the county are derived entirely from the glacial and loessial deposits made in later geological ages, and these deposits were so deep that the native bedrock has been deeply buried.

At least two great glaciers invaded the county, during the glacial age and each, when the glacier melted, left on the surface of the land a vast deposit of so-called drift or till, made up of rock material gathered up by the glacier in its forward movement over the surface of the land and ground fine by the grinding action of the great mass of ice. Undoubtedly the original topographic features of the county were largely obliterated by the drift deposits; old valleys were filled and former knolls and hills were leveled. The depth of the drift deposits is variable.

The Kansan was the earliest glacier to pass over the county. It laid down a thick deposit of till, the depth varying widely in various sections, and ranging from a few feet to as much as a hundred feet in thickness. The original deposit was a blue boulder clay. Upon weathering, however, the color has changed to a bright yellow or deep reddish-brown. Pockets of sand and gravel occur in the deposit and often there are layers of sand and gravel under the drift deposit. Boulders are common in this drift material and often appear on the surface where the till is exposed. The soils of the Lindley and Shelby series are derived from this Kansan deposit, the former sometimes being partly formed from the later loessial covering.

At a later date geologically a second glacier entered the county, and left another deposit of glacial till. This glacier was known as the Iowan and the deposit as the Iowan drift. The deposit left by this glacier is a light yellow silty clay to sandy clay containing some gravel and boulders. It is variable in depth but is much thinner than the Kansan deposit. The Carrington loam is the only type which is derived from this drift material.

Still later geologically there was laid down over the entire surface of the county a deposit of wind-blown material known as loess. Apparently the deposition was made quite uniformly over the previous topographic features but there has been considerable movement of the silty material since it was laid down and the depth of the deposit is now quite variable, ranging from 20 to 30 feet in thickness in different areas. When unweathered, loess is an even-grained silty material, varying in color from a light grayish-brown to a yellowish-brown. The weathering processes and the accumulation of organic matter in the soil has changed the color to a buff color, or even a dark-brown to black in some areas. Under the prairie conditions there has been the largest accumulation of organic matter while under forested conditions the soils are lighter in color and much less productive. The Tama and Muscatine soils and the Grundy types are derived from the loessial material that developed under prairie conditions and they are, therefore, darker in color. The Clinton soils

are formed from the loess under forested conditions, and they are light in color. Where erosion has occurred to a very large extent and there is only a very thin layer of loess remaining or none at all, the Lindley soils are developed.

The terrace and bottomland soils of the county are partly of drift and partly of loessial origin. They are mainly derived from the loess material, however, in the sections of the county where the loessial soil predominates on the uplands. Where the Shelby, Carrington and Lindley soils are found on the uplands, there are admixtures of the loess and drift in the bottoms, and in some cases the soils are almost entirely made up of glacial till, but these areas are small and relatively of little importance, and many of them are included with the types which are typically loessial in origin.

## PHYSIOGRAPHY AND DRAINAGE

Poweshiek County is a part of an original plain that sloped gently to the east and south, but the surface is now broken by a number of nearly parallel

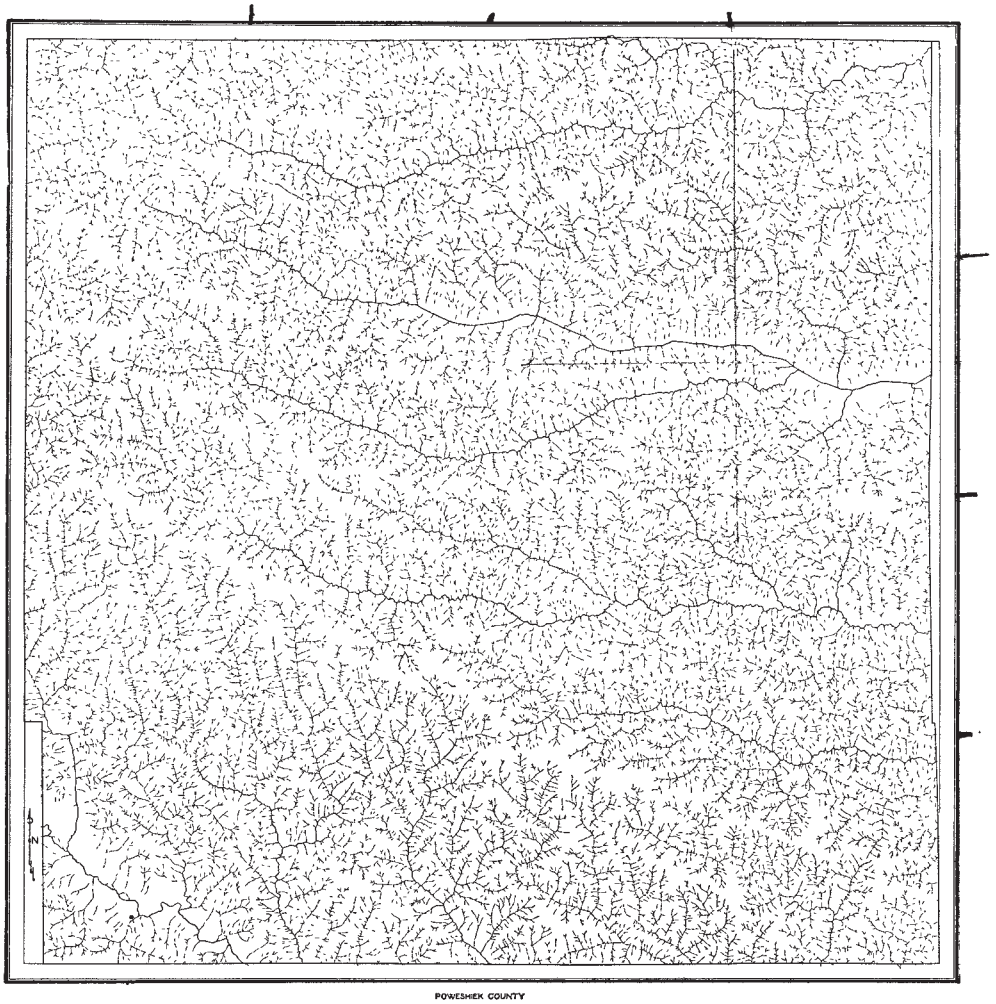



Fig. 2. Map showing the natural drainage of Poweshiek County.

stream valleys which are cut down from 50 to 150 feet below the level of the original plains. In the northeastern two-thirds of the county the stream flow is generally eastward but in the southwestern third the streams flow almost south. Between the stream valleys there are flat or gently rolling divides which are remnants of the original plain. Tributaries of the main streams and intermittent drainageways extend back into the uplands, producing a gently rolling surface topography. Uneroded remains of the plain, ranging from one-fourth to three-fourths of a mile in width occur on many of the interstream divides and extend for several miles along the tops of the divides. The longest of these plain divides extends for 15 miles between Grinnell and Montezuma, and is traversed by the Minneapolis and St. Louis Railroad. A number of small remnants of the plain occur, ranging in size from 60 to 640 acres. The southern slopes to the streams are short, irregular, rounded or in some places steep while on the northern sides the slopes are gradual and more or less regular up to the crest of the divide.

The main streams are gradually deepening their channels and the North Skunk River is down to bedrock in many places. Most of the stream valleys are narrow, but they are gradually being widened. They are subject to overflow. There are a few terrace or second bottomlands in the county, and these are developed mainly along the North Skunk River.

The drainage of the county is brought about by the North Skunk River, North Fork English River, Deep River, Bear Creek and their tributaries. These streams with their tributaries and the intermittent drainageways back into the uplands provide a rather complete drainage system for the county as is indicated in the accompanying drainage map. A few areas, however, of the heavier soils on the upland divides are not adequately drained. These types are level to flat in topography, and they have heavy, rather impervious subsoils and hence need artificial drainage. There are also minor areas of terrace soils which are in need of drainage, and the bottomland soils are likely to need drainage as well as protection from overflow.

## THE SOILS OF POWESHIEK COUNTY

The soils of Poweshiek County are grouped into four classes according to their origin and location. These are: drift, loess, terrace, and swamp and bottomland soils. Drift soils are formed from material carried by glaciers and left on the surface of the land after the melting of the glacier. They are variable in composition and contain pebbles and frequently boulders. Loess soils are fine dustlike deposits made by the wind at some time when climatic conditions were different from the present. Terrace soils are old bottomlands which have been raised above overflow by a decrease in volume of the streams which deposited them or by a deepening of the river channel. Swamp and bottomland soils are those occurring in low, poorly drained areas or along streams, and they are subject to more or less frequent overflow. The extent of the occurrence of the groups of soils in Poweshiek County is shown in Table 2.

TABLE 2. AREAS OF DIFFERENT GROUPS OF SOILS IN POWESHIEK COUNTY

| Soil groups | Acres | Percentage of total area of county |
|---|---|---|
| Drift soils | 49,408 | 13.3 |
| Loess soils | 260,096 | 69.6 |
| Terrace soils | 5,184 | 1.5 |
| Swamp and bottomland soils | 58,432 | 15.6 |
| Total | 373,120 | .... |

Drift soils cover 13.3 percent of the total area of the county. The greater portion of the area, however, is covered by the loess soils, 260,096 acres being in these soils, amounting to 69.6 percent of the total area of the county. The terrace soils are limited in extent, covering only 1.5 percent of the county. Swamp and bottomland soils are much more extensively developed, covering 15.6 percent of the total area.

There are 17 individual soil types in the county, and these with the light colored phase of the Grundy silt loam and the colluvial phase of the Wabash silt loam make a total of 19 separate soil areas. There are 4 drift soils, 6 loess types, 5 terrace soils and 4 bottomland soils. The various soil types are distinguished on the basis of certain definite characteristics which are described in the appendix to this report. The names of the soils indicate the characteristics. The areas covered by the various soils are shown in table 3.

The Tama silt loam is by far the largest individual soil type in the county and the largest loess soil. It covers more than half of the total area, 52.6 percent. The Clinton silt loam is the second largest loess soil and the fourth type in the county, covering 7.4 percent of the area. The Muscatine silt loam is the third loess soil and the fifth type in the county, covering 6.9 percent of the area. The Grundy silt loam is much smaller, covering only 2.3 percent of the county. The Grundy silty clay loam and the light colored phase of the Grundy silt loam are very small, covering 0.3 and 0.1 percent of the county, respectively. The Shelby loam is the largest drift soil and the third largest type in the county. It covers 8.1 percent of the county. The Carrington loam is the second drift type, covering 3.7 percent of the county. The Lindley silt loam

is the third drift soil, covering one percent of the area. The Lindley loam is small in extent, covering 0.5 percent of the total area. The Waukesha silt loam is the largest of the terrace soils, covering 0.9 percent of the county. The Judson silt loam and the Bremer silt loam each cover 0.2 percent of the total area. The Bremer silty clay loam and the Jackson silt loam each cover 0.1 percent of the county. The Wabash silt loam is the largest of the bottomland soils, and the second largest type in the county, covering 8.8 percent of the total area. The colluvial phase of the Wabash silt loam is the second largest bottomland type, covering 6.1 percent of the county. The Wabash silty clay

TABLE 3. AREAS OF DIFFERENT SOIL TYPES IN POWESHIEK COUNTY

| Soil legend on map | Soil no. | Soil type | Acres | Percentage of total area of county |
|---|---|---|---|---|
| | | DRIFT SOILS | | |
| S | 79 | Shelby loam | 30,080 | 8.1 |
| C | 1 | Carrington loam | 13,824 | 3.7 |
| Ls | 32 | Lindley silt loam | 3,776 | 1.0 |
| L | 65 | Lindley loam | 1,728 | 0.5 |
| | | LOESS SOILS | | |
| Ts | 120 | Tama silt loam | 196,160 | 52.6 |
| Cs | 80 | Clinton silt loam | 27,840 | 7.4 |
| Ms | 30 | Muscatine silt loam | 25,728 | 6.9 |
| G | 64 | Grundy silt loam | 8,768 | 2.3 |
| Gs | 115 | Grundy silty clay loam | 1,024 | 0.3 |
| G | 260 | Grundy silt loam (light colored phase) | 576 | 0.1 |
| | | TERRACE SOILS | | |
| Wt | 75 | Waukesha silt loam | 3,328 | 0.9 |
| Js | 131 | Judson silt loam | 832 | 0.2 |
| Bl | 88 | Bremer silt loam | 640 | 0.2 |
| Bs | 43 | Bremer silty clay loam | 256 | 0.1 |
| J | 81 | Jackson silt loam | 128 | 0.1 |
| | | SWAMP AND BOTTOMLAND SOILS | | |
| Wm | 26 | Wabash silt loam | 32,960 | 8.8 |
| Wm | 26a | Wabash silt loam (colluvial phase) | 22,976 | 6.1 |
| Wa | 48 | Wabash silty clay loam | 2,304 | 0.6 |
| Gl | 71 | Genesee silt loam | 192 | 0.1 |
| | | Total | 373,120 | .... |

loam covers 0.6 percent of the area, and the Genesee silt loam is small in extent, covering 0.1 percent of the county.

The upland soils of the county vary widely in topography, depending upon the origin and character of the soil. The Shelby loam and the Lindley types on the drift uplands are rolling to steep, while the Carrington loam is gently rolling, the Clinton silt loam is rolling to rough; the Muscatine and Grundy soils are level to almost flat in topography. There is little in the way of topographic features on the terraces, but the Bremer soils occur on the level to depressed terrace areas, while the Waukesha, Judson and Jackson types are found on the higher terraces. There are no topographic features in the bottomlands.

## THE FERTILITY IN POWESHIEK COUNTY SOILS

Samples were taken for analysis from each of the soil types mapped in the county. The more extensive types were sampled in triplicate, while only one sample was taken of the minor types. The samplings were all made with the

greatest care so that the samples would be entirely representative of the types and that there would not be any abnormal condition in the samples owing to previous treatments of the area or to peculiarities of the soil in the particular location. The samples were taken at three depths, 0–6⅔ inches, 6⅔–20 inches, and 20–40 inches, representing the surface soil, the subsurface soil and the subsoil, respectively.

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

## The Surface Soils

The results of the analyses of the surface soils are given in table 4. They are calculated on the basis of 2 million pounds of surface soil per acre.

The phosphorus content of the soils is quite variable ranging from 592 pounds per acre in the Genesee silt loam up to 1,724 pounds per acre in the Bremer silty clay loam. There is little evidence of any relationship between the phosphorus content of the soils and the different soil groups, although the loess soils are better supplied on the average than the drift soils and the bottomland soils are richer than the upland types as might be expected owing to the fact that there has been less crop growth on the bottomlands and hence a smaller removal

TABLE 4. PLANT FOOD IN POWESHIEK COUNTY, IOWA, SOILS
Pounds per acre of 2 million pounds of surface soil (0–6⅔")

| Soil no. | Soil type | Total phosphorus | Total nitrogen | Total organic carbon | Total inorganic carbon | Limestone requirement |
|---|---|---|---|---|---|---|
| | DRIFT SOILS | | | | | |
| 79 | Shelby loam | 781 | 2,960 | 30,760 | .... | 6,000 |
| 1 | Carrington loam | 1,339 | 4,300 | 48,131 | .... | 4,500 |
| 32 | Lindley silt loam | 633 | 1,480 | 16,143 | .... | 8,000 |
| 65 | Lindley loam | 646 | 1,360 | 17,343 | .... | 8,000 |
| | LOESS SOILS | | | | | |
| 120 | Tama silt loam | 1,337 | 4,013 | 44,495 | .... | 6,000 |
| 80 | Clinton silt loam | 686 | 1,400 | 12,598 | .... | 5,000 |
| 30 | Muscatine silt loam | 1,454 | 5,240 | 64,111 | .... | 7,000 |
| 64 | Grundy silt loam | 1,427 | 4,920 | 59,394 | .... | 6,000 |
| 115 | Grundy silty clay loam | 1,245 | 4,180 | 51,594 | .... | 5,500 |
| 260 | Grundy silt loam (light colored phase) | 673 | 2,360 | 25,224 | .... | 4,000 |
| | TERRACE SOILS | | | | | |
| 75 | Waukesha silt loam | 1,441 | 4,400 | 46,359 | .... | 5,000 |
| 131 | Judson silt loam | 1,360 | 4,560 | 51,294 | .... | 5,000 |
| 88 | Bremer silt loam | 1,118 | 4,240 | 52,276 | .... | 5,000 |
| 43 | Bremer silty clay loam | 1,724 | 8,000 | 92,036 | .... | 4,000 |
| 81 | Jackson silt loam | 660 | 2,680 | 24,733 | .... | 3,000 |
| | SWAMP AND BOTTOMLAND SOILS | | | | | |
| 26 | Wabash silt loam | 1,495 | 4,960 | 53,176 | .... | 4,000 |
| 26a | Wabash silt loam (colluvial phase) | 1,400 | 4,600 | 47,913 | .... | 4,000 |
| 48 | Wabash silty clay loam | 1,427 | 4,240 | 52,876 | .... | 4,000 |
| 71 | Genesee silt loam | 592 | 1,960 | 22,170 | .... | 3,000 |

of plant food constituents. The difference between the drift and loess soils is probably largely a reflection of the soil series characteristics rather than any fundamental difference between the drift and loess soils.

The results indicate that those characteristics which serve to distinguish soil series have an effect upon the phosphorus content of the soils. Thus the color of the surface soil, the topography, the origin of the soil and the characteristics of the subsoil, all of which are significant in the soil series separation, influence the phosphorus supply. In the drift group, the Carrington loam is the richest of the soils in phosphorus, the Shelby soil is second and the Lindley soils are the poorest. This is a direct reflection of the lighter color of the Lindley soils, the rougher topography and the forested origin. The Shelby soils are poorer than the Carrington because of the coarser subsoil and the fact that the soil is derived from older material, Kansan drift. On the loess uplands the Muscatine soils are the richest, followed in order by the Grundy, Tama and Clinton types. Again the color of the soil has an effect as is indicated by the fact that the Clinton soil is the lightest in color and the lowest in phosphorus. The Tama soil is lower than the Grundy and Muscatine and this is due to the more rolling topography and different subsoil condition. There is little difference between the Muscatine and the Grundy as would be expected. The Grundy silty clay loam is lower than the silt loam, but the difference is not significant. On the terraces the Bremer soils are the richest in phosphorus and they are the blackest in color and the more nearly flat to depressed in topography. The Jackson soil is the lowest in phosphorus, and it is the lightest in color. There is little difference between the Waukesha and the Judson. On the bottomlands, the Genesee soil is the lowest in phosphorus, and it is the lightest in color.

The effects of the texture of the surface soil show up in some cases although there are not many soils mapped where the surface soils are different and the soils are of the same series. The Lindley silt loam is about the same as the loam, while ordinarily the silt loams are higher than the loams. The Grundy silty clay loam is lower than the Grundy silt loam which is contrary to the usual results. The Bremer silty clay loam is higher than the silt loam. The Wabash silty clay loam is lower than the silt loam which is higher than the colluvial phase of that type. The results do not bear out the usual conclusions that the finer the texture of the soil, the higher the plant food content, except in the case of the Bremer silty clay loam, but the differences in most cases are not large, and it may be concluded that some other factor has masked the effect of the texture. It may generally be expected that coarse textured types will be lower in plant food than fine textured types of the same series.

It is apparent that the phosphorus content of the soils is low, and phosphorus fertilizers will certainly be needed on these soils in the near future, even if they are not of value at present. The experiments which have been carried out on many of these types and the experiences of farmers who have tried them, show that phosphorus fertilizers may be used with profit in most cases now. Tests of rock phosphate and superphosphate are certainly very desirable.

The nitrogen content of the soils varies widely, ranging from 1,360 pounds per acre in the Lindley loam up to 8,000 pounds per acre in the Bremer silty clay loam, which is the same type that was the highest in phosphorus. Again

there is little evidence of any relationship between the soil group and the content of nitrogen. The loess soils are richer, on the average, than the drift soils, and the bottomland soils are higher than the upland soils as would be anticipated. But the differences are not large and probably represent more of a difference in the characteristics of the soil series mapped in the soil groups rather than any real comparison between groups.

The data indicate that there is a relation between the nitrogen content and the characteristics of the soil series mapped. Thus the Lindley soils on the drift uplands are the lowest in nitrogen, and they are the lightest in color and the roughest in topography. The Shelby soil is lower than the Carrington, and it is of a different and older origin and has a coarser subsoil. The Muscatine and Grundy soils on the loessial uplands are the richest in nitrogen, and they are the darkest in color and heaviest in subsoil character. The Clinton soil is the lowest in nitrogen and the lightest in color. The Tama soil is lower in nitrogen than the Muscatine and Grundy soils, and it is more rolling in topography. There is little difference in the nitrogen supply in the Muscatine and Grundy soils although the Muscatine is a little richer, probably because of the origin of the loess material, which is of Mississippi loess origin while the Grundy silt loam is of Southern Iowa loess origin. On the terraces the Bremer soils are the richest in nitrogen, and they are the blackest in color and the more nearly flat to depressed in topography. The Jackson soil is the lowest in nitrogen, and it is the lightest in color. The Judson soil is a little higher than the Waukesha probably due to the difference in the subsoil character. On the bottoms the Wabash soils are richer in nitrogen than the Genesee soil owing to the blacker color of the Wabash types.

There is some evidence of the effect of texture on the nitrogen content of soils but the results are not very extensive nor definite. The Lindley silt loam is higher than the Lindley loam, and the Bremer silty clay loam is richer in nitrogen than the Bremer silt loam. The Grundy silt loam, however, is higher than the Grundy silty clay loam and the Wabash silty clay loam is lower than the silt loam, both of which are contrary to the usual situation. In general it is found that soils which are coarse in texture are lower in nitrogen than those which are fine textured. Silty clay loams are richer than silt loams, silt loams are higher in nitrogen than loams, and loams are better supplied than sandy loams or sands.

The supply of nitrogen in the soils of the county is not high. It is necessary, therefore, on some soils that fertilizing materials supplying nitrogen be applied at the present time, and on all of them the regular addition of such fertilizers will be needed to keep up the supply. The lighter colored soils will respond in a very large way to such applications, and the darker soils will also give some response. Farm manure is the best material to supply to land to aid in maintaining the nitrogen content, as it returns some of the nitrogen taken out of the soil by the crops grown. Crop residues when turned under also help to keep up the content of nitrogen. But to increase the supply and to meet the need of the soils low in this constituent, the use of legumes as green manures is the cheapest and best method of supplying nitrogen. Nitrogen

is taken from the atmosphere by inoculated legumes, and when they are plowed down they enrich the soil in this constituent.

The total organic carbon content of the soils varies considerably, ranging from 12,598 pounds per acre in the Clinton silt loam up to 92,036 pounds per acre in the Bremer silty clay loam. Again there is little evidence of any relation between the organic carbon and the soil groups. The loess soils on the average are higher than the drift soils, and the bottomland soils are higher than the upland types as might be expected. As previously noted, however, it seems that the differences are more likely due to the particular characteristics of the series mapped rather than to the relationships between the soil groups.

There are very definite differences between the soil types and the soil series within the various soil groups just as was noted in the case of the nitrogen content. The factors which determine the series influence the content of organic carbon. The soils of the Lindley series are the lightest in color and the lowest in content of organic carbon. The Shelby soils are lower than the Carrington in the drift group, and they are coarser in the subsoil. The Muscatine and Grundy types are the darkest in color of the loess soils, and they are the richest in carbon. They also have the heaviest subsoils and are the most nearly level to flat in topography. The Clinton soil is the lightest in color, the roughest in topography and the lowest in organic carbon content. The Tama soil is more rolling in topography than the Grundy and Muscatine soils, and it is lower in organic carbon. On the terraces the Bremer soils are the highest in organic carbon and they are the blackest in color and the most nearly flat to depressed types. The Jackson soil is the lightest in color and it is the lowest in carbon. The Judson soil is a little higher than the Waukesha because of its subsoil conditions, and its origin mainly. On the bottoms the Genesee soil is the lowest in organic carbon, and it is the lightest in color.

There are some indications of texture effects, the Bremer silty clay loam being higher than the silt loam in organic carbon content. But the Grundy silty clay loam is lower than the silt loam, the Wabash silty clay loam is lower than the silt loam and the Lindley loam is higher than the silt loam all of which is contrary to the usual situation. In general the finer-textured soils are richer in organic carbon than the coarse-textured soils and silty clay loams are usually richer than silt loams, silt loams are higher than loams, and the latter are higher than sandy loams or sands.

Some of the Poweshiek County soils are fairly well supplied with organic matter, but others are low in this constituent and need the application of fertilizing materials supplying organic matter. All the types, however, must receive regular additions of organic matter if the supply is to be kept up, as organic matter disappears rapidly from soils under cultivation. Farm manure supplies valuable organic matter as well as plant food, and it is the most desirable material for building up and keeping up the organic matter in soils. The use of crop residues also aids materially in maintaining the organic matter content of soils. But these two materials are usually insufficient to permit complete maintenance of the organic matter content. To supplement them legumes must be used as green manures. Green manuring has a double value in that

it also provides plant food nitrogen, and its use is especially desirable on the poorer lighter colored soils. It will be desirable also in most cases as a supplement to farm manure or as a substitute for it. The organic matter content of soils may be built up and kept up by the proper use of farm manure and crop residues, supplemented with the turning under of legumes as green manures.

There is no inorganic carbon content in any of the soils of the county and hence the types are all acid in reaction and in need of additions of limestone. The figures given in the table indicate the lime requirements of the different soils, but they should not be considered to show the exact requirements of all soils of the same type in the field. Soils vary so widely in lime needs that it is necessary to test the soil in every field before lime is applied. In this way the proper amount may be used. It is evident, however, from the table that all the soils of the county are strongly acid in reaction and must be limed for the best growth of all crops and especially legumes.

## The Subsurface Soils and Subsoils

The data obtained in the analyses of the subsurface soils and subsoils are shown in tables 5 and 6. They are calculated on the basis of 4 million pounds of subsurface soil per acre and 6 million pounds of subsoil per acre. It does not seem necessary to consider these analyses in detail as the needs of the soils are shown very definitely by the results of the analyses of the surface soils. Unless there is a very large amount or a big deficiency of some constituent in the subsoil, there will be little effect upon the needs of the surface soils by the constituents present in the subsoils. The analyses do not show any large

TABLE 5. PLANT FOOD IN POWESHIEK COUNTY, IOWA, SOILS
Pounds per acre of 4 million pounds of subsurface soil (6⅔"–20")

| Soil no. | Soil type | Total phosphorus | Total nitrogen | Total organic carbon | Total inorganic carbon | Limestone requirement |
|---|---|---|---|---|---|---|
| | DRIFT SOILS | | | | | |
| 79 | Shelby loam | 1,239 | 2,640 | 33,651 | .... | 6,000 |
| 1 | Carrington loam | 1,979 | 5,170 | 62,338 | .... | 6,000 |
| 32 | Lindley silt loam | 862 | 1,120 | 11,017 | .... | 8,000 |
| 65 | Lindley loam | 1,050 | 1,440 | 16,525 | .... | 8,000 |
| | LOESS SOILS | | | | | |
| 120 | Tama silt loam | 2,416 | 6,320 | 73,483 | .... | 6,000 |
| 80 | Clinton silt loam | 1,912 | 1,600 | 15,271 | .... | 6,000 |
| 30 | Muscatine silt loam | 2,342 | 7,680 | 96,208 | .... | 7,000 |
| 64 | Grundy silt loam | 1,938 | 5,200 | 65,393 | .... | 7,000 |
| 115 | Grundy silty clay loam | 1,710 | 4,960 | 67,792 | .... | 5,000 |
| 260 | Grundy silt loam (light colored phase) | 1,131 | 2,720 | 29,669 | .... | 4,000 |
| | TERRACE SOILS | | | | | |
| 75 | Waukesha silt loam | 2,504 | 6,400 | 71,220 | .... | 5,000 |
| 131 | Judson silt loam | 2,854 | 8,320 | 107,607 | .... | 4,000 |
| 88 | Bremer silt loam | 2,262 | 7,040 | 45,568 | .... | 4,000 |
| 43 | Bremer silty clay loam | 2,882 | 10,800 | 147,421 | .... | 2,000 |
| 81 | Jackson silt loam | 1,185 | 4,560 | 51,976 | .... | 3,000 |
| | SWAMP AND BOTTOMLAND SOILS | | | | | |
| 26 | Wabash silt loam | 3,016 | 8,000 | 98,826 | .... | 4,000 |
| 26a | Wabash silt loam (colluvial phase) | 3,124 | 11,360 | 126,805 | .... | 5,000 |
| 48 | Wabash silty clay loam | 2,370 | 6,080 | 82,082 | .... | 4,000 |
| 71 | Genesee silt loam | 1,131 | 3,760 | 40,632 | .... | 3,000 |

TABLE 6. PLANT FOOD IN POWESHIEK 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 | 1,737 | 2,400 | 29,697 | .... | 8,000 |
| 1 | Carrington loam | 2,262 | 3,840 | 43,686 | .... | 4,000 |
| 32 | Lindley silt loam | 1,171 | 1,440 | 16,362 | .... | 8,000 |
| 65 | Lindley loam | 1,857 | 1,440 | 17,570 | .... | 8,000 |
| | LOESS SOILS | | | | | |
| 120 | Tama silt loam | 2,895 | 4,920 | 58,875 | .... | 6,000 |
| 80 | Clinton silt loam | 3,069 | 2,160 | 18,161 | .... | 6,000 |
| 30 | Muscatine silt loam | 2,706 | 5,280 | 60,375 | .... | 6,000 |
| 64 | Grundy silt loam | 2,058 | 4,920 | 60,293 | .... | 7,000 |
| 115 | Grundy silty clay loam | 1,595 | 4,140 | 46,999 | .... | 3,000 |
| 260 | Grundy silt loam (light light colored phase) | 1,657 | 3,480 | 36,569 | .... | 4,000 |
| | TERRACE SOILS | | | | | |
| 75 | Waukesha silt loam | 3,432 | 7,320 | 76,165 | .... | 6,000 |
| 131 | Judson silt loam | 3,717 | 9,720 | 137,113 | .... | 4,000 |
| 88 | Bremer silt loam | 2,787 | 7,680 | 96,617 | .... | 4,000 |
| 43 | Bremer silty clay loam | 3,636 | 4,440 | 69,620 | .... | 1,000 |
| 81 | Jackson silt loam | 2,362 | 2,760 | 26,588 | .... | 4,000 |
| | SWAMP AND BOTTOMLAND SOILS | | | | | |
| 26 | Wabash silt loam | 3,393 | 6,840 | 104,062 | .... | 4,000 |
| 26a | Wabash silt loam (colluvial phase) | 4,566 | 15,600 | 198,225 | .... | 4,000 |
| 48 | Wabash silty clay loam | 2,424 | 3,600 | 51,703 | .... | 4,000 |
| 71 | Genesee silt loam | 1,657 | 5,640 | 75,346 | .... | 2,000 |

amounts of plant food present nor do they show any great lack. Hence the conclusions drawn from the data obtained in the analyses of the surface soils, regarding the needs of the various soils are largely confirmed by the results of the tests of the lower soil layers.

It is apparent that phosphorus will be needed on these soils in the near future, for the supply is inadequate for any large number of crops. The organic matter and nitrogen content of some of the soils is low, and additions of fertilizing materials supplying these constituents are needed now and will be required on all the soils if the supply is to be kept up. The proper use of farm manure, crop residues and green manure will permit of the increase and maintenance of these constituents in the soils.

All of the soils are acid in reaction and in need of lime. There is acidity down through the lower soil layers, and hence it is important, not only that the soils be tested for lime needs now and that limestone be applied as necessary, but tests must be made at regular intervals preceding the legume crop of the rotation if the conditions are to be kept right in the soil for the best legume growth.

## GREENHOUSE EXPERIMENTS

Two greenhouse experiments were carried out on the Tama silt loam and the Clinton silt loam, two of the most important types in the county, to determine something of the needs of the soils and of the value of the application of certain fertilizers.

Fig. 3. Clover on Tama silt loam.

The treatments included manure, limestone, superphosphate and muriate of potash. These materials were applied in the same amounts in which they are used in practice, and hence the results may be considered to show very accurately what may be expected from the same treatments in the field. Farm manure was applied at the rate of 8 tons per acre, limestone was added in sufficient amounts to neutralize the acidity of the soil, superphosphate was applied at the rate of 200 pounds per acre and muriate of potash at the rate of 25 pounds per acre. Wheat and clover were seeded in the pots, the clover being planted when the wheat was up.

### Results on the Tama Silt Loam

The data obtained in the experiment on the Tama silt loam are given in table 7. Manure increased the yields of both crops, the effects on the clover being very large. Limestone with manure had a beneficial effect on the wheat, but

TABLE 7. GREENHOUSE EXPERIMENT, TAMA SILT LOAM, POWESHIEK COUNTY

| Pot no. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---|---|---|---|
| 1 | Check | 11.3 | 54.0 |
| 2 | Manure | 14.0 | 79.6 |
| 3 | Manure+limestone | 15.6 | 74.8 |
| 4 | Superphosphate | 13.4 | 68.4 |
| 5 | Manure+superphosphate | 15.1 | 84.8 |
| 6 | Limestone+superphosphate | 14.7 | 78.7 |
| 7 | Manure+limestone+superphosphate | 14.1 | 92.0 |
| 8 | Manure+limestone+superphosphate+muriate of potash | 15.4 | 95.0 |

contrary to the usual results, showed no effect on the clover. Superphosphate alone had less effect than manure on both crops, but did increase them appreciably. Manure and superphosphate together gave a larger effect on both the wheat and clover than did either material alone, showing a particularly large effect on the clover. Limestone and superphosphate had less effect than manure and superphosphate but showed an increase over superphosphate alone. Manure, limestone and superphosphate had no greater effect on the wheat than manure and superphosphate without limestone but did give a definite increase in the clover. Muriate of potash with manure, limestone and super-

phosphate showed a beneficial effect on both crops, having a particularly large effect on the clover.

### Results on the Clinton Silt Loam

The results obtained in the experiment on the Clinton silt loam are shown in table 8. Manure increased the yields of both the wheat and clover to a considerable extent, showing especially large effects on the clover. Manure and limestone showed a greater effect on both crops than manure alone, the effect being considerable on the clover. Superphosphate alone had less effect than manure, showing no gain at all in the wheat crop and only a small increase in the clover. Manure and superphosphate together had no greater effect on the wheat than

TABLE 8. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM
POWESHIEK COUNTY

| Pot no. | Treatment | Weight of wheat grain in grams | Weight of clover in grams |
|---|---|---|---|
| 1 | Check | 6.7 | 53.6 |
| 2 | Manure | 7.7 | 62.6 |
| 3 | Manure+limestone | 8.2 | 69.4 |
| 4 | Superphosphate | 6.4 | 58.8 |
| 5 | Manure+superphosphate | 7.4 | 69.4 |
| 6 | Limestone+superphosphate | 7.1 | 73.8 |
| 7 | Manure+limestone+superphosphate | 7.7 | 78.0 |
| 8 | Manure+limestone+superphosphate+muriate of potash | 7.9 | 82.5 |

manure alone, but there was a definite gain in the yield of the clover. Limestone and superphosphate had a greater effect on both crops than superphosphate alone, and a greater effect than manure and superphosphate on the clover. There was less effect on the wheat. Manure, limestone and superphosphate showed greater effects than manure and superphosphate or limestone and superphosphate on both crops. Muriate of potash with manure, limestone and superphosphate showed slight beneficial effects on both the wheat and clover.

## FIELD EXPERIMENTS

No field experiments are under way in Poweshiek County, but tests are being carried out in adjacent counties on the same soil types as occur in this county, and the results obtained over a period of years in these tests certainly may be considered to indicate quite definitely the fertilizer effects which may be expected from the same treatments on the soils of this county. Tests on the Tama silt loam on the Newton Field in Jasper County and on the West Branch

Fig. 4. Clover on Clinton silt loam.

Field in Cedar County, on the Clinton silt loam on the Princeton Field in Scott County, on the Muscatine silt loam on the Bluegrass Field in Scott County and on the Letts Field in Muscatine County, on the Grundy silt loam on the Cedar Field in Mahaska County, on the Libertyville Field in Jefferson County and on the Agency Field in Wapello County, on the Grundy silty clay loam on the Mt. Union Field in Henry County and on the Shelby loam on the Millerton Field in Wayne County are included here.

These field experiments are all laid out on land which is thoroughly representative of the soil types and they include 9 or 13 plots which are 155 feet 7 inches by 28 feet, or one-tenth of an acre in size. They are permanently located by the installation of corner stakes, and all precautions are taken in the application of fertilizers and in the obtaining of results, to insure their accuracy.

The experiments are carried out under the livestock and grain systems of farming, manure being applied as the basic treatment in the former system and crop residues used instead of manure in the grain system. The fertilizing materials tested include limestone, superphosphate, rock phosphate, a complete commercial fertilizer and muriate of potash. The manure is applied at the rate of 8 tons per acre once in the 4-year rotation. The crop residue treatment consists of the plowing down of the cornstalks which have been cut with a disc or stalk cutter in the spring after having been winter pastured. Sometimes the second crop of clover is plowed under, but usually it is used for seed, hay or pasture, and only the residues are turned under. Limestone is applied in amounts sufficient to neutralize the acidity of the soil. Rock phosphate is added at the rate of 500 pounds per acre once in the 4-year rotation. Until 1923 this material was applied at the rate of 2,000 pounds per acre once in 4 years and from 1923 to 1932 at the rate of 1000 pounds per acre. Superphosphate is added at the rate of 120 pounds per acre of the 20 percent material three times in the 4-year rotation. Until 1923 the 16 percent superphosphate was used at the rate of 200 pounds per acre annually. In 1929 the 20 percent material was first employed. Between 1923 and 1929 there was an application of 150 pounds of the 16 percent superphosphate per acre 3 years out of 4 in the rotation. Until 1923 the old standard 2-8-2 complete commercial fertilizer was used, being applied at the rate of 300 pounds per acre annually. From 1923 to 1929 a standard 2-12-2 brand was used, the application being made at the rate of 200 pounds per acre annually, thus suplying the same amount of phosphorus as that contained in the superphosphate. Since 1929 a 2-12-6 complete fertilizer has been used on Tama and Grundy soils, a 2-16-2 on the Muscatine silt loam and the Grundy silty clay loam and a 4-16-4 on the Clinton and Shelby types, all being applied in equivalent amounts of phosphorus to that supplied in the superphosphate. Muriate of potash is applied at the rate of 50 pounds per acre 3 years out of 4 in the 4-year rotation.

### The Newton Field

The results obtained in the field experiment on the Tama silt loam on the Newton field in Jasper County are shown in table 9. The use of farm manure on this soil showed a beneficial effect in practically all seasons. The largest influence appeared on the clover in 1923 and 1927 and on the oats in 1930.

TABLE 9. FIELD EXPERIMENT, TAMA SILT LOAM, JASPER COUNTY NEWTON FIELD,* SERIES I

| Plot no. | Treatment | 1923 red clover tons per A. | 1924 corn bu. per A. | 1925 corn bu. per A. (1) | 1926 oats bu. per A. | 1927 red clover tons per A. | 1928 corn bu. per A. | 1929 corn bu. per A. | 1930 oats bu. per A. | 1931 corn bu. per A. | 1932 corn bu. per A. | 1933 oats bu. per A. (2) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 1.28 | 58.5 | 52.5 | 57.9 | 1.13 | 69.4 | 57.3 | 46.5 | 59.4 | 69.3 | 33.9 |
| 2 | Manure | 1.36 | 59.8 | 51.7 | 56.8 | 1.37 | 75.9 | 64.0 | 58.4 | 67.3 | 73.7 | 39.2 |
| 3 | Manure+limestone | 1.35 | 61.7 | 55.5 | 56.8 | 1.44 | 81.7 | 66.9 | 61.2 | 72.1 | 79.8 | 42.3 |
| 4 | Manure+limestone+rock phosphate | 1.45 | 66.0 | 57.9 | 62.6 | 1.79 | 79.2 | 64.8 | 67.5 | 69.7 | 76.5 | 42.3 |
| 5 | Check | 1.42 | 57.8 | 53.3 | 49.4 | 1.27 | 69.3 | 56.5 | 46.8 | 61.7 | 71.2 | 33.9 |
| 6 | Manure+limestone+superphosphate | 1.32 | 66.3 | 58.9 | 67.3 | 1.79 | 78.2 | 67.7 | 69.2 | 68.7 | 72.4 | 49.9 |
| 7 | Manure+limestone+superphosphate+ muriate of potash | 1.35 | 65.9 | 58.7 | 63.3 | 1.81 | 78.2 | 68.3 | 63.9 | 70.3 | 78.1 | 50.3 |
| 8 | Manure+limestone+complete commercial fertilizer | 1.34 | 66.1 | 53.6 | 76.9 | 1.72 | 81.2 | 67.2 | 77.7 | 72.7 | 73.8 | 46.5 |
| 9 | Check | 1.20 | 56.0 | 49.6 | 51.9 | 1.20 | 73.4 | 59.7 | 45.7 | 58.2 | 65.1 | 28.7 |

(1) Plots 8 and 9 damaged considerably by hail.
(2) Hot dry weather in June and July reduced yields.
*The Newton Field was established in the fall of 1922 on the H. S. Martin farm, northeast of Newton in Jasper County. It is located in the SE ¼ of the NE ¼ of Section 30, T. 80 N and R. 18 W in Kellogg Township.

The corn was also increased considerably in the different seasons. The largest influence appeared on the clover in 1923 and 1927 and on the oats in 1930. The corn was also increased considerably in the different seasons. Limestone with manure had some effect on the various crops grown, showing up the best on the clover in 1927. The corn and oats crops were also increased to some extent in all but one season.

Rock phosphate with manure and limestone increased the crops in most seasons. The largest effects appeared on the clover in 1923 and 1927 and on the oats in 1926. Superphosphate with manure and limestone had a greater effect than rock phosphate in some cases, as for example, on the oats in 1926, 1930 and 1933 and on the corn in 1929, but in the other seasons the effects were slightly smaller or just the same as from rock phosphate. Muriate of potash with manure, limestone and superphosphate showed little or no beneficial effects on any of the crops grown. Only in one or two cases were there any effects at all. Complete commercial fertilizer with manure and limestone had about the same effect as superphosphate, showing up a little better in some cases, as on the corn in 1928 and 1931 and on the oats in 1930, but in most instances the differences were not large enough to be significant.

### The West Branch Field

The data obtained in the field experiment on the Tama silt loam on the West Branch Field in Cedar County are given in table 10. Manure increased the yields of the crops grown on this field in all but one season. The greatest effects were shown on the clover in 1922 and 1930, on the oats in 1925 and 1929 and on the corn in 1927 and 1928. Limestone with manure increased the crop yields in all but two seasons. The clover in 1922 and 1930 showed large increases as would be expected. Gains were also obtained, however, on most of the oats and corn crops.

Rock phosphate with manure and limestone had a beneficial effect on the

crops grown in most years. The benefits were particularly evident on the oats in 1925. In several cases, however, no increases were obtained. Superphosphate with manure and limestone frequently had a much greater effect than rock phosphate. The clover in 1922, the oats in 1925 and the corn in 1923, 1928 and 1931 were all increased more by superphosphate than by rock phosphate. Muriate of potash with manure, limestone and superphosphate had a beneficial effect on the crops in one or two cases, notably on the clover in 1922 and the corn in 1927. In the other seasons, however, there was little or no effect from muriate. Complete commercial fertilizer with manure and limestone usually had about the same effect as superphosphate. No great differences between the effects of the two materials were evident.

### The Princeton Field

The data obtained in the field experiment on the Clinton silt loam on the Princeton Field in Scott County are given in table 11. Manure increased the crop yields on this soil in nearly every season. Considerable increases were sometimes obtained as for example on the wheat in 1925, on the corn in 1923,

TABLE 10. FIELD EXPERIMENT, TAMA SILT LOAM, CEDAR COUNTY WEST BRANCH FIELD,* SERIES I

| Plot no. | Treatment | 1922 clover tons per A. | 1923 corn bu. per A. | 1924 corn bu. per A. | 1925 oats bu. per A. | 1926 timothy and clover T. per A. (1) | 1927 corn bu. per A. | 1928 corn bu. per A. | 1929 oats bu. per A. | 1930 clover tons per A. | 1931 corn bu. per A. (2) | 1932 corn bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 2.20 | 61.3 | 29.5 | 62.1 | ... | 49.7 | 69.9 | 60.0 | 1.97 | 102.1 | 86.7 |
| 2 | Manure | 2.40 | 65.3 | 32.0 | 73.2 | ... | 59.9 | 75.7 | 72.6 | 2.80 | 100.3 | 90.0 |
| 3 | Manure+limestone | 2.50 | 66.9 | 34.7 | 77.0 | ... | 60.2 | 73.6 | 76.0 | 2.92 | 96.6 | 90.8 |
| 4 | Manure+limestone+rock phosphate | 2.50 | 64.8 | 32.3 | 89.0 | ... | 61.9 | 71.7 | 76.0 | 2.57 | 97.5 | 95.5 |
| 5 | Check | 2.10 | 64.5 | 32.1 | 63.2 | ... | 47.0 | 58.6 | 62.4 | 1.88 | 90.2 | 77.9 |
| 6 | Manure+limestone+superphosphate | 2.90 | 81.3 | 37.5 | 100.7 | ... | 63.9 | 76.1 | 75.0 | 2.95 | 101.0 | 94.4 |
| 7 | Manure+limestone+superphosphate +muriate of potash | 3.00 | 71.4 | 36.3 | 98.0 | ... | 66.8 | 74.3 | 87.3 | 2.26 | 97.9 | 91.0 |
| 8 | Manure+limestone+complete commercial fertilizer | 2.70 | 70.6 | 37.3 | 93.4 | ... | 68.2 | 82.1 | 80.6 | 2.58 | 98.1 | 93.1 |
| 9 | Check | 2.10 | 65.3 | 28.6 | 67.2 | ... | 56.5 | 66.9 | 56.8 | 1.62 | 89.3 | 84.8 |

(1) Field was pastured; no results taken.
(2) Sheep lay on plots 1 and 2 when pasturing field.
Field discontinued in 1933 on account of economy program.
*The West Branch Field was started in the spring of 1922 on the farm of Paul Pownall, southeast of West Branch, in Cedar County. It is located in the SW ¼ of the NE ¼ of Section 16, T. 79 N. and R. 4 W. in Springdale Township.

1927, 1928, 1932 and 1933 and on the clover in 1922 and 1926. Limestone with manure increased still further the yields of crops. The beneficial effects were particularly evident on the clover in 1922, 1926 and 1931, and on the corn in 1927 and 1933. Increases in the yields of wheat and oats were also obtained in most cases and in the yields of corn in the other seasons.

Rock phosphate with manure and limestone increased the yields of crops in most seasons. The gains, however, generally were not large. Superphosphate with manure and limestone gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of superphosphate were not any greater than those brought about by rock phosphate. The oats in 1924, the clover in 1926 and the corn in 1932 showed the largest effects from

TABLE 11. FIELD EXPERIMENT, CLINTON SILT LOAM, SCOTT COUNTY, PRINCETON FIELD,* SERIES I

| Plot no. | Treatment | 1918 w. wheat bu. per A. (1) | 1919 corn bu. per A. | 1920 corn bu. per A. (2) | 1921 oats bu. per A. | 1922 clover tons per A. (3) | 1923 corn bu. per A. | 1924 oats bu. per A. | 1925 w. wheat bu. per A. (4) | 1926 clover tons per A. | 1927 corn bu. per A. | 1928 corn bu. per A. | 1929 oats bu. per A. (5) | 1930 w. wheat bu. per A. | 1931 red clover tons per A. | 1932 corn bu. per A. | 1933 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 | 64.6 | 46.5 | 15.3 | 0.96 | 97.9 | 78.1 |
| 2 | Manure | 37.4 | 67.6 | 68.3 | 28.4 | 1.93 | 63.2 | 64.8 | 22.6 | 1.57 | 79.7 | 72.7 | 74.9 | 23.2 | 1.02 | 108.9 | 89.4 |
| 3 | Manure+limestone | 43.0 | 68.2 | 70.6 | 32.1 | 2.13 | 70.2 | 65.3 | 27.5 | 2.06 | 97.3 | 74.2 | 70.2 | 26.9 | 1.87 | 113.0 | 96.9 |
| 4 | Manure+limestone+rock phosphate | 47.4 | 67.8 | 73.5 | 31.9 | 2.25 | 72.5 | 63.1 | 32.1 | 2.08 | 96.4 | 76.4 | 71.3 | 27.7 | 1.98 | 113.3 | 96.7 |
| 5 | Manure+limestone+superphosphate | 45.2 | 64.0 | 70.8 | 35.1 | 2.29 | 73.2 | 75.1 | 31.8 | 2.31 | 86.9 | 79.2 | 69.2 | 30.0 | 1.98 | 117.4 | 96.7 |
| 6 | Manure+limestone+complete commercial fertilizer | 37.3 | 68.4 | 73.0 | 36.4 | 2.34 | 68.1 | 71.9 | 32.4 | 2.15 | 89.8 | 80.7 | 75.0 | 31.1 | 2.32 | 111.3 | 98.9 |
| 7 | Check | 31.7 | 57.0 | 57.5 | 24.4 | 1.60 | 53.0 | 62.2 | 16.9 | 0.73 | 59.7 | 50.3 | 39.7 | 17.3 | 0.87 | 95.9 | 66.2 |
| 8 | Crop residues | ... | 52.6 | 58.6 | 29.6 | 1.47 | 55.2 | 66.4 | 15.5 | 0.72 | 57.4 | 52.2 | 44.3 | 17.5 | 0.92 | 94.9 | 73.7 |
| 9 | Crop residues+limestone | 31.7 | 62.4 | 67.3 | 29.7 | 2.14 | 61.8 | 65.6 | 23.8 | 1.35 | 78.4 | 66.6 | 60.1 | 24.0 | 1.59 | 103.2 | 87.2 |
| 10 | Crop residues+limestone+rock phosphate | 35.0 | 64.1 | 68.7 | 29.8 | 2.28 | 65.0 | 63.4 | 26.7 | 2.06 | 81.3 | 69.8 | 56.8 | 28.3 | 1.60 | 97.2 | 82.7 |
| 11 | Crop residues+limestone+superphosphate | 31.7 | 66.6 | 61.5 | 31.1 | 2.18 | 68.0 | 75.1 | 27.1 | 2.03 | 89.0 | 74.4 | 41.9 | 30.6 | 2.08 | 100.6 | 80.4 |
| 12 | Crop residues+limestone+complete commercial fertilizer | 36.2 | 65.2 | 69.5 | 30.8 | ... | 70.1 | 73.5 | 28.3 | 2.25 | 83.8 | 74.5 | 68.1 | 31.2 | 2.25 | 104.7 | 85.8 |
| 13 | Check | 28.2 | 59.3 | 59.5 | 25.5 | ... | 58.6 | 54.4 | 17.5 | 0.98 | 64.0 | 54.4 | 52.1 | 19.0 | 1.05 | 92.5 | 77.8 |

(1) Three tons limestone applied August, 1917. Yield on plot 8 an error.
(2) Plot 11 many missing hills, low yields.
(3) Yields on plots 13 and 14 lost due to error.
(4) Stand of wheat very thin due to extremely dry spring.
(5) Oats down badly on plots 3, 4, 5, 10, 11 and 12.

*The Princeton Field was established in the fall of 1917 on the Kroeger Bros. farm, near Princeton in Scott County. It is located in the northwest corner of the SW ¼ of the NE ¼ of Section 10, T. 79 N, R. 5 E. in Princeton Township.

superphosphate. Complete commercial fertilizer with manure and limestone gave somewhat greater effects than 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 complete fertilizer over that brought about by superphosphate.

Crop residues had little effect on the various crops grown, bringing about only slight increases in some seasons. Limestone with crop residues increased the yields in most seasons. The largest beneficial effects were shown on the clover in 1922, 1926 and 1931 and on the corn in 1919, 1920, 1923, 1932 and 1933.

Rock phosphate with residues and limestone increased the crop yields in most years. In the case of the clover crop the increases were quite evident. On the other crops the increases were smaller. Superphosphate with residues and limestone showed larger effects than rock phosphate in some seasons. This was particularly true on the oats in 1921 and 1924, on the clover in 1931 and on the corn in 1927, 1928 and 1932. In several seasons, however, there were smaller effects from superphosphate. Complete commercial fertilizer with residues and limestone sometimes gave larger increases than did phosphates. This was noted particularly on the clover in 1926 and 1931 and on the corn in 1932. In most years, however, there was little difference between the effects of this material and of the phosphates.

### The Bluegrass Field

The data obtained on the Muscatine silt loam on the Bluegrass Field in Scott County are given in table 12. Manure increased the crop yields in all but two seasons. Some very large effects were noted from the manure, as on the clover in 1920 and 1924, on the oats in 1929 and 1931 and on the corn in 1922 and 1933. Limestone with manure increased the crop yields in all seasons, the largest effects appearing on the clover in 1920 and 1924, on the oats in 1923 and 1927 and on the corn in 1921, 1922, 1925, 1928 and 1933.

Rock phosphate applied with manure and limestone brought about increases in crop yields in some seasons. The clover in 1924 was greatly benefited. The corn was increased in 1925. In the other seasons there was little or no effect from rock phosphate. Superphosphate with manure and limestone showed slightly larger effects than rock phosphate in one or two seasons, especially on the wheat in 1919, but in most seasons there was little difference in the yields obtained with superphosphate over those obtained with rock phosphate. Complete commercial fertilizer with manure and limestone showed somewhat larger effects than superphosphate in some seasons, particularly on the clover in 1924, on the oats in 1923, 1927 and 1929 and on the corn in 1925, 1926 and 1930 but in the other seasons there was no larger increase from complete fertilizer than was obtained when superphosphate was applied.

Crop residues showed little or no effect on the crops grown in most seasons. An increase was obtained in the clover in 1924 and slight increases in some of the other years. Limestone with residues had a beneficial effect on the crops

TABLE 12. FIELD EXPERIMENT, MUSCATINE SILT LOAM, SCOTT COUNTY, BLUEGRASS FIELD,* SERIES I

| Plot no. | Treatment | 1918 corn bu. per A. (1) | 1919 spring wheat bu. per A. (2) | 1920 clover tons per A. (3) | 1921 corn bu. per A. | 1922 corn bu. per A. | 1923 oats bu. per A. | 1924 clover tons per A. | 1925 corn bu. per A. | 1926 corn bu. per A. | 1927 oats bu. per A. | 1928 corn bu. per A. | 1929 oats bu. per A. | 1930 corn bu. per A. | 1931 oats bu. per A. | 1932 corn bu. per A. (4) | 1933 corn bu. per A. (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 74.1 | 11.5 | 1.57 | 54.7 | 62.9 | 27.2 | 1.62 | 85.2 | 63.2 | 56.2 | 66.9 | 49.9 | 61.2 | 48.5 | 81.6 | 42.2 |
| 2 | Manure | 75.2 | 12.4 | 1.92 | 57.8 | 68.8 | 30.6 | 1.71 | 87.0 | 61.3 | 55.7 | 70.2 | 59.0 | 68.3 | 62.4 | 81.8 | 49.5 |
| 3 | Manure+limestone | 77.0 | 13.3 | 2.37 | 66.1 | 74.1 | 47.6 | 1.81 | 95.2 | 68.6 | 65.3 | 81.4 | 61.4 | 72.8 | 63.0 | 81.0 | 54.6 |
| 4 | Manure+limestone+rock phosphate | 73.3 | 13.1 | 2.35 | 67.5 | 72.5 | 46.4 | 2.30 | 100.0 | 65.3 | 64.0 | 80.8 | 64.6 | 70.2 | 68.6 | 74.0 | 53.6 |
| 5 | Manure+limestone+superphosphate | 71.4 | 18.9 | 2.37 | 63.5 | 74.1 | 45.3 | 2.30 | 98.2 | 66.5 | 53.3 | 77.0 | 62.4 | 73.3 | 70.0 | 74.4 | 51.5 |
| 6 | Manure+limestone+complete commercial fertilizer | 73.2 | 14.4 | 2.35 | 64.0 | 73.4 | 49.8 | 2.44 | 101.5 | 67.7 | 69.7 | 79.8 | 67.0 | 73.6 | 70.4 | 77.8 | 53.8 |
| 7 | Check | 71.6 | 11.3 | 2.22 | 56.5 | 70.6 | 41.8 | 1.44 | 82.5 | 56.3 | 62.9 | 60.9 | 46.5 | 59.8 | 52.0 | 76.0 | 44.2 |
| 8 | Crop residues | 69.6 | 9.6 | 2.05 | 59.2 | 66.9 | 39.7 | 1.54 | 82.7 | 51.7 | 58.2 | 61.6 | 47.7 | 57.4 | 45.0 | 72.6 | 42.4 |
| 9 | Crop residues+limestone | 66.9 | 11.6 | 2.25 | 60.8 | 70.4 | 46.4 | 1.69 | 92.7 | 63.0 | 62.0 | 74.8 | 55.5 | 66.9 | 56.8 | 73.0 | 46.2 |
| 10 | Crop residues+limestone+rock phosphate | 73.8 | 13.9 | 2.35 | 66.7 | 73.8 | 45.3 | 2.17 | 97.5 | 64.8 | 68.4 | 79.7 | 60.1 | 73.4 | 61.5 | 75.6 | 50.1 |
| 11 | Crop residues+limestone+superphosphate | 65.6 | 15.0 | 2.37 | 63.2 | 66.9 | 47.6 | 2.26 | 97.0 | 62.6 | 70.9 | 78.2 | 53.4 | 70.7 | 54.5 | 73.1 | 47.2 |
| 12 | Crop residues+limestone+complete commercial fertilizer | 62.9 | 15.0 | 2.35 | 64.8 | 70.1 | 48.7 | 2.29 | 98.2 | 62.9 | 66.4 | 75.7 | 60.1 | 73.3 | 57.0 | 76.3 | 45.6 |
| 13 | Check | 66.9 | 7.6 | 2.17 | 61.3 | 64.3 | 30.6 | 1.45 | 84.5 | 56.1 | 46.4 | 64.3 | 51.0 | 63.9 | 45.4 | 79.7 | 44.3 |

(1) Limestone applied 3½ tons per acre in May. Growth of smartweed reduced crop on plots 11 and 12.
(2) Crop injured by blight.
(3) Limestone applied in fall.
(4) Fertilized corn further advanced and damaged more by hot winds.
(5) Dry, hot season.

*The Bluegrass Field was established in the fall of 1917 on the farm of H. C. Schroeder near Bluegrass, in Scott County. It is located in the SW corner of the NE¼ of the NW ¼ of Section 32, T. 78 N and R. 2 E.

grown in practically all seasons. Some of the gains were pronounced as on the clover in 1920 and 1924 and on the oats in 1923, 1926, 1929 and 1931. Increases were also obtained on the corn in 1922, 1925, 1928, 1930 and 1933.

Rock phosphate with crop residues and limestone showed a beneficial effect on the crops grown in practically all seasons. Considerable increases were noted on the clover in 1920 and 1924 and increases were obtained on the oats in 1927, 1929 and 1931 and on the corn in 1921, 1922, 1925, 1928, 1930, 1932 and 1933. Superphosphate with residues and limestone showed slightly larger effects than rock phosphate in some seasons, but usually the differences were of little significance. Some of the increases brought about by superphosphate were somewhat less than those occasioned by rock phosphate. Complete commercial fertilizer with crop residues and limestone showed slightly larger effects than superphosphate in some years, but in other seasons the results obtained were very similar to those brought about by superphosphate, and sometimes smaller effects were evident.

### The Letts Field

The data obtained in the experiment on the Muscatine silt loam on the Letts Field in Muscatine County are given in table 13. Manure increased the yields in all but one season. Large increases were noted on the corn in 1923, 1929 and 1932, on the barley in 1930 and on the red clover in 1931. In the other seasons, except 1928, there were noticeable increases from manure. Limestone with manure increased the crops in all seasons, the largest beneficial effects appearing on the oats in 1925, on the corn in 1929 and 1932 and on the red clover in 1931.

Rock phosphate with manure and limestone increased the crop yields in practically all seasons. Appreciable effects were evident on the oats in 1919, on the winter wheat in 1920, on the timothy and clover in 1921, on the oats in 1925, on the corn in 1928 and on the red clover in 1931. Superphosphate with manure and limestone showed slightly larger increases than rock phosphate on the timothy and clover in 1921, on the corn in 1923, 1924, 1928 and 1933 and on the oats in 1925. In the other seasons similar increases to those obtained with rock phosphate were evident, and sometimes a smaller effect was obtained by the use of superphosphate. Complete commercial fertilizer with manure and limestone showed larger effects than superphosphate in some seasons, particularly on the corn in 1928 and 1932 and on the clover in 1931. In the latter case, however, it had about the same effect as rock phosphate. In most instances the increases were very similar to those brought about by superphosphate and in some cases were actually less.

Crop residues showed little effect on the crop yields in most seasons. Limestone with residues increased the yields in all but two seasons, showing particularly large effects on the oats in 1919, on the corn in 1928 and 1929 and on the timothy and clover in 1921. Superphosphate with residues and limestone increased yields more than rock phosphate in one or two seasons, particularly on the oats in 1925, on the corn in 1929 and on the red clover in 1931. Usually, however, the two phosphates showed similar effects. In one or two cases,

TABLE 13. FIELD EXPERIMENT, MUSCATINE SILT LOAM, MUSCATINE COUNTY, LETTS FIELD,* SERIES I

| Plot no. | Treatment | 1918 corn bu. per A. | 1919 oats bu. per A. | 1920 w. wheat bu. per A. (1) | 1921 timothy and clover tons per A. | 1922 timothy and clover tons per A. (2) | 1923 corn bu. per A. | 1924 corn bu. per A. | 1925 oats bu. per A. | 1926 clover tons per A. (2) | 1927 clover tons per A. (2) | 1928 corn bu. per A. (3) | 1929 corn bu. per A. (4) | 1930 barley bu. per A. | 1931 red clover tons per A. | 1932 corn bu. per A. | 1933 corn bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 75.4 | 57.8 | 17.1 | 2.12 | ... | 68.2 | 65.7 | 50.9 | ... | ... | 58.1 | 53.8 | 20.9 | 0.49 | 87.2 | 83.6 |
| 2 | Manure | 77.8 | 58.6 | 20.6 | 2.13 | ... | 83.5 | 71.8 | 56.9 | ... | ... | 51.2 | 67.5 | 26.6 | 1.19 | 97.9 | 87.1 |
| 3 | Manure+limestone | 77.2 | 58.6 | 23.9 | 2.26 | ... | 81.7 | 83.0 | 66.7 | ... | ... | 53.1 | 83.2 | 27.4 | 1.76 | 108.4 | 94.8 |
| 4 | Manure+limestone+rock phosphate | 82.9 | 62.6 | 28.5 | 2.58 | ... | 85.2 | 81.0 | 75.4 | ... | ... | 61.3 | 80.6 | 28.3 | 1.98 | 98.5 | 98.4 |
| 5 | Manure+limestone+superphosphate | 83.7 | 62.6 | 27.5 | 2.73 | ... | 91.2 | 87.1 | 83.8 | ... | ... | 65.2 | 78.8 | 27.9 | 1.77 | 100.3 | 99.6 |
| 6 | Manure+limestone+complete commercial fertilizer | 84.8 | 67.4 | 31.2 | 2.76 | ... | 83.2 | 84.5 | 78.7 | ... | ... | 89.8 | 70.2 | 26.6 | 1.99 | 103.6 | 94.6 |
| 7 | Check | 78.4 | 51.0 | 19.9 | 2.10 | ... | 63.2 | 67.1 | 56.0 | ... | ... | 73.8 | 49.0 | 17.6 | 1.31 | 90.9 | 86.5 |
| 8 | Check | 68.0 | 57.2 | ... | 2.16 | ... | 73.2 | 69.8 | 57.4 | ... | ... | 58.1 | 40.0 | 19.1 | 0.50 | 86.4 | 79.2 |
| 9 | Crop residues | 69.0 | 56.4 | 20.6 | 2.13 | ... | 67.7 | 67.3 | 59.1 | ... | ... | 56.6 | 37.7 | 20.1 | 0.75 | 85.8 | 73.2 |
| 10 | Crop residues+limestone | 68.8 | 51.0 | 19.6 | 2.49 | ... | 78.0 | 72.0 | 60.4 | ... | ... | 53.3 | 67.5 | 26.3 | 1.32 | 90.5 | 91.2 |
| 11 | Crop residues+limestone+rock phosphate | 74.4 | 67.4 | 23.9 | 2.63 | ... | 79.0 | 76.5 | 62.9 | ... | ... | 75.3 | 73.9 | 27.2 | 1.42 | 89.9 | 88.5 |
| 12 | Crop residues+limestone+superphosphate | 75.4 | 55.0 | 24.3 | 2.54 | ... | 80.0 | 75.6 | 71.0 | ... | ... | 62.2 | 76.0 | 26.9 | 1.51 | 88.8 | 83.5 |
| 13 | Crop residues+limestone+complete commercial fertilizer | 78.4 | 69.4 | 22.5 | 2.58 | ... | 79.2 | 73.6 | 72.1 | ... | ... | 75.3 | 75.2 | 25.2 | 1.71 | 87.9 | 86.8 |
| 14 | Check | 68.5 | 47.0 | 16.5 | 2.12 | ... | 61.7 | 65.3 | 58.8 | ... | ... | 61.1 | 36.2 | 15.9 | 1.07 | 75.5 | 75.2 |

(1) Yield lost on plot 8.
(2) Field was pastured, no results.
(3) Hogs damaged plots 1, 2, 3, 8, 9, and 10.
(4) Corn drilled across plots, difficult to get uniform samples.

*The Lets Field was laid out in the fall of 1917 on the John Eliason farm 2 miles north of Letts in Muscatine County. The series is located in the SW corner of the NE ¼ of the NW ¼ of Section 31, T. 76 N, and R. 3 W.

rock phosphate had a larger effect than superphosphate. Complete commercial fertilizer with residues and limestone had much the same effect as superphosphate in most seasons. It had a larger beneficial effect on the corn in 1928 and on the clover in 1931. In some instances actually smaller yields were obtained than by the use of superphosphate.

### The Cedar Field

The data obtained on the Grundy silt loam on the Cedar Field in Mahaska County are shown in table 14. Manure increased the crop yields on this soil in practically all seasons. The beneficial effects were particularly evident on the oats in 1923 and 1931, on the wheat in 1924 and 1932 and on the corn in 1928. Limestone with manure increased the crops in most seasons. The greatest effects from limestone appeared on the corn in 1922, 1927 and 1930, and on the oats in 1923 and 1931.

Rock phosphate with manure and limestone brought about small gains in crops in several cases, but there were no large effects from this material. Superphosphate with manure and limestone had slightly greater effects than rock phosphate in one or two seasons, but the gains were not large. Muriate of potash with manure, limestone and superphosphate had small beneficial effects on the crops grown in several seasons, but no large increases were found. Complete commercial fertilizer with manure and limestone had no larger effect than phosphates in most years, and where there were differences they were small.

### The Libertyville Field

The data obtained in the experiment on the Grundy silt loam on the Libertyville Field in Jefferson County are given in table 15. Manure increased the crops grown on this field in every season. Very large effects were shown on the clover and timothy in 1927 and 1928, on the oats in 1926 and on the corn in 1923, 1925, 1929, 1930 and 1932. Limestone with manure increased the crop yields in most years. The soybeans in 1931 and the corn in 1925 and 1929 showed the largest effects from the treatment. In some seasons there were no beneficial effects.

Rock phosphate with manure and limestone showed small benefits in some seasons, the clover and timothy in 1927 and the oats in 1926 showing slight gains. In the other seasons there was little or no effect. Superphosphate with manure and limestone showed a slightly greater influence than rock phosphate in one or two cases, as on the corn in 1925 and the clover and timothy in 1928, but usually there was little difference in the effect of the two phosphates. Muriate of potash with manure, limestone and superphosphate sometimes gave increases in the crops, as on the clover and timothy in 1927 and 1928, on the soybeans in 1931 and on corn in 1925, 1929 and 1932. Complete commercial fertilizer with manure and limestone had a greater effect than superphosphate in every season, but generally there were no large differences. Only in one or two instances was there any increase over the treatment with superphosphate and muriate of potash.

TABLE 14. FIELD EXPERIMENT, GRUNDY SILT LOAM, MAHASKA COUNTY CEDAR FIELD,* SERIES I

| Plot no. | Treatment | 1922 corn bu. per A. | 1923 oats bu. per A. | 1924 w. wheat bu. per A. | 1925 w. wheat bu. per A. | 1926 clover tons per A. (1) | 1927 corn bu. per A. | 1928 corn bu. per A. | 1929 corn bu. per A. (2) | 1930 corn bu. per A. | 1931 oats bu. per A. | 1932 w. wheat bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 54.6 | 39.0 | 33.0 | 22.9 | ... | 73.2 | 65.7 | 70.3 | 44.8 | 47.7 | 24.8 |
| 2 | Manure | 50.8 | 46.0 | 41.5 | 24.4 | ... | 68.3 | 79.4 | 62.5 | 44.8 | 57.4 | 28.3 |
| 3 | Manure+limestone | 57.8 | 54.7 | 38.7 | 24.5 | ... | 72.6 | 81.3 | 60.7 | 49.6 | 60.9 | 27.9 |
| 4 | Manure+limestone+rock phosphate | 58.7 | 46.0 | 43.0 | 28.7 | ... | 72.6 | 76.6 | 64.0 | 49.2 | 60.9 | 26.6 |
| 5 | Check | 51.1 | 40.8 | 37.6 | 22.2 | ... | 66.9 | 55.3 | 50.2 | 46.0 | 48.8 | 24.8 |
| 6 | Manure+limestone+superphosphate | 54.9 | 46.0 | 40.8 | 28.2 | ... | 73.1 | 71.7 | 64.9 | 48.0 | 58.6 | 29.0 |
| 7 | Manure+limestone+superphosphate+ muriate of potash | 60.3 | 46.0 | 42.3 | 31.2 | ... | 78.4 | 69.0 | 67.7 | 52.2 | 55.5 | 26.0 |
| 8 | Manure+limestone+complete commercial fertilizer | 56.8 | 42.5 | 36.8 | 30.9 | ... | 60.7 | 67.4 | 63.2 | 44.7 | 59.0 | 23.4 |
| 9 | Check | 65.3 | 38.1 | 35.2 | 22.8 | ... | 62.5 | 67.8 | 49.4 | 44.2 | 43.2 | 17.2 |

(1) Field pastured; no results.
(2) High yield on plot 1 due to better drainage.
Field discontinued in 1933.
*The Cedar Field was laid out in the fall of 1921 on the farm of W. O. Barnard, south of Cedar in Mahaska County. The series is located in the NE ¼ of the SE ¼ of Section 24, R. 15 W., T. 74 N.

## The Agency Field

The data obtained in the experiment on the Grundy silt loam on the Agency Field in Wapello County are shown in table 16. Manure proved of value on this soil in practically all seasons. The largest crop increases were shown on the oats in 1919, 1925 and 1930, on the hay in 1921, 1922 and 1927, and on the corn in 1928, 1929 and 1933. There was also a definite increase on the wheat in 1931. Limestone with manure brought about increases in practically all cases. The beneficial effects of limestone were especially evident on the hay crops, but increases were also shown on some of the corn and oat crops.

Rock phosphate with manure and limestone increased the crop yields in every season, some of the increases being large. The hay crops were particularly benefited by rock phosphate, and considerable gains were obtained on the oats in 1919 and 1930, on the corn in 1923 and 1929 and on the wheat in 1925 and 1931. Superphosphate with manure and limestone showed larger effects than rock phosphate in most seasons. There were no strikingly large differences except in the case of the hay crop in 1922. In 1921, 1923, 1929 and 1933 rock phosphate gave somewhat larger effects than superphosphate. Only on the hay crop in 1921, the clover and timothy in 1927, the clover in 1932, the corn in 1928 and 1929 and the wheat in 1931 was there any greater effect from complete fertilizer.

Crop residues showed little effect on the various crops grown. Limestone with residues increased the crops in practically every season. Only on the wheat in 1926 was there no increase from the use of limestone. In some cases and on certain of the crops the beneficial effects were very definite. This is particularly true of the hay crop in 1921 and 1922, of the clover in 1927 and 1932, of the corn in 1928 and 1929 and of the wheat in 1931.

Rock phosphate with residues and limestone increased the crop yields in practically all seasons. Some increases were quite distinct as on the hay crop in 1921, 1922 and 1927, on the wheat in 1926, on the corn in 1928 and 1929 and on the oats in 1930. Superphosphate with residues and limestone showed larger effects than did rock phosphate in several seasons. It had smaller effects than rock phosphate, however, on the clover in 1921, on the oats in 1925 and on the corn in 1928 and 1929 and practically the same effect on the corn in 1923 and on the wheat in 1920. Complete commercial fertilizer with residues and limestone gave similar increases to those brought by superphosphate. Only in one case was there a striking difference.

## The Mt. Union Field

The data obtained on the Grundy silty clay loam on the Mt. Union Field, Series I, in Henry County are given in table 17. Manure increased crop yields in all but one season. In some cases the effects of manure were particularly large as, for example, on the corn in 1920, 1923 and 1930 and on the soybeans in 1929. In all cases, however, the increases were definite. The use of limestone with manure gave small increases in the various crops grown, the gains being quite large in some cases as on the corn in 1924, 1927 and 1931.

Rock phosphate with manure and limestone increased the crops in a small way in most seasons. Superphosphate with manure and limestone distinctly increased the crops in most seasons. Some gains were quite definite, and, in general, the effects of superphosphate were much the same as those brought about by rock phosphate. Complete commercial fertilizer with manure and limestone gave about the same effect as superphosphate in most cases, showing up slightly better in one or two cases and being less effective in other seasons.

TABLE 15. FIELD EXPERIMENT, GRUNDY SILT LOAM, JEFFERSON COUNTY LIBERTYVILLE FIELD,* SERIES I

| Plot no. | Treatment | 1923 corn bu. per A. | 1924 corn bu. per A. (1) | 1925 corn bu. per A. | 1926 oats bu. per A. (2) | 1927 clover and timothy tons per A. | 1928 clover and timothy tons per A. | 1929 corn bu. per A. | 1930 corn bu. per A. | 1931 soybeans tons per A. | 1932 corn bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 79.2 | ... | 37.5 | 38.1 | 0.88 | 1.50 | 53.9 | 49.9 | 2.26 | 59.0 |
| 2 | Manure | 86.0 | ... | 43.5 | 52.5 | 1.55 | 2.58 | 66.2 | 59.1 | 2.35 | 71.7 |
| 3 | Manure+limestone | 90.7 | ... | 59.5 | 40.8 | 1.46 | 2.34 | 74.2 | 61.1 | 2.70 | 72.9 |
| 4 | Manure+limestone+rock phosphate | 83.0 | ... | 54.5 | 46.3 | 1.51 | 2.29 | 70.0 | 60.0 | 2.79 | 71.2 |
| 5 | Check | 77.5 | ... | 41.5 | 35.0 | 1.11 | 2.08 | 59.2 | 58.8 | 2.26 | 62.1 |
| 6 | Manure+limestone+superphosphate | 78.2 | ... | 60.3 | 39.8 | 1.42 | 2.49 | 69.7 | 59.5 | 2.61 | 69.1 |
| 7 | Manure+limestone+superphosphate+muriate of potash | 77.5 | ... | 65.0 | 43.6 | 1.79 | 2.76 | 73.9 | 58.9 | 2.96 | 75.5 |
| 8 | Manure+limestone+complete commercial fertilizer | 80.7 | ... | 64.5 | 45.2 | 1.71 | 2.53 | 71.2 | 64.5 | 2.79 | 73.0 |
| 9 | Check | 79.0 | ... | 40.1 | 33.4 | 0.74 | 1.74 | 53.5 | 58.7 | 1.83 | 61.7 |

(1) Corn replanted on account of cold wet weather and poor germination; corn did not mature: no results.

(2) Oats badly lodged, making sampling difficult. Dry weather and rust injured oats. Field discontinued in 1933.

*The Libertyville Field was laid out in the fall of 1923 on the farm of J. L. McCleary, west of Libertyville in Jefferson County. The series was located in the southwest corner of the SE ¼ of the SE ¼ of Section 12, R. 11 W., T. 71 N.

TABLE 16. FIELD EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY, AGENCY FIELD,* SERIES I

| Plot no. | Treatment | 1918 corn bu. per A. (1) | 1919 oats bu. per A. | 1920 w. wheat bu. per A. (2) | 1921 timothy and clover T. per A. (3) | 1922 timothy tons per A. (4) | 1923 corn bu. per A. | 1924 corn bu. per A. | 1925 oats bu. per A. | 1926 w. wheat bu. per A. (5) | 1927 clover tons per A. (6) | 1928 corn bu. per A. | 1929 corn bu. per A. | 1930 oats bu. per A. (7) | 1931 w. wheat bu. per A. | 1932 red clover tons per A. | 1933 corn bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 63.5 | 44.9 | 22.7 | 1.92 | 2.00 | 72.7 | 46.4 | 66.2 | 21.7 | 1.28 | 83.3 | 66.8 | 52.3 | 20.4 | 2.24 | 54.5 |
| 2 | Manure | 64.5 | 62.2 | 31.5 | 2.09 | 2.20 | 71.8 | 51.9 | 70.8 | 19.0 | 1.96 | 89.4 | 72.7 | 63.7 | 28.3 | 2.05 | 62.1 |
| 3 | Manure+limestone | 66.8 | 58.3 | 36.7 | 2.20 | 2.25 | 79.2 | 52.2 | 73.8 | 21.8 | 2.28 | 100.5 | 72.6 | 64.8 | 26.4 | 2.31 | 71.8 |
| 4 | Manure+limestone+rock phosphate | 68.8 | 63.6 | 38.7 | 2.52 | 2.30 | 86.8 | 54.0 | 80.6 | 35.3 | 2.14 | 105.4 | 83.4 | 80.8 | 39.3 | 2.35 | 75.8 |
| 5 | Manure+limestone+superphosphate | 70.0 | 66.6 | 40.0 | 2.39 | 2.80 | 85.4 | 60.2 | 77.9 | 38.9 | 2.05 | 97.8 | 78.2 | 83.3 | 38.2 | 2.38 | 72.9 |
| 6 | Manure+limestone+complete commercial fertilizer | 66.0 | 65.6 | 34.7 | 2.52 | 2.50 | 83.0 | 55.4 | 77.3 | 30.7 | 2.47 | 101.0 | 85.1 | 68.6 | 43.6 | 2.50 | 77.6 |
| 7 | Check | 59.3 | 54.5 | ... | 1.82 | 2.30 | 69.7 | 43.3 | 67.8 | 14.7 | 1.29 | 74.4 | 63.3 | 50.6 | 21.0 | 1.83 | 58.8 |
| 8 | Crop residues | 58.5 | 49.0 | 31.4 | 1.81 | 2.20 | 66.3 | 43.7 | 66.4 | 18.7 | 1.28 | 76.4 | 67.6 | 56.6 | 21.2 | 1.91 | 57.8 |
| 9 | Crop residues+limestone | 61.3 | 59.5 | 43.8 | 2.02 | 2.40 | 71.3 | 50.7 | 72.1 | 18.6 | 1.69 | 83.5 | 73.2 | 59.5 | 28.3 | 2.14 | 65.1 |
| 10 | Crop residues+limestone+rock phosphate | 61.8 | 61.2 | 36.4 | 2.33 | 2.65 | 73.1 | 54.9 | 75.9 | 26.0 | 2.14 | 96.6 | 77.5 | 70.8 | 30.9 | 2.32 | 67.5 |
| 11 | Crop residues+limestone+superphosphate | 63.5 | 61.2 | 36.3 | 2.19 | 2.75 | 80.7 | 55.5 | 74.6 | ... | 2.26 | 93.4 | 69.0 | 72.4 | 36.0 | 2.29 | 68.6 |
| 12 | Crop residues+limestone+complete commercial fertilizer | 62.5 | 63.6 | 35.6 | 2.17 | 2.65 | 70.4 | 54.4 | 78.4 | ... | 2.14 | 93.6 | 77.3 | 85.5 | 38.5 | 2.35 | 70.7 |
| 13 | Check | 52.5 | 52.0 | 22.8 | 1.56 | 2.40 | 63.9 | 42.7 | 58.5 | ... | 0.91 | 67.0 | 56.5 | 55.5 | 28.7 | 1.36 | 60.1 |

(1) Corn damaged slightly by hail in July and 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.
(7) Oats later in maturity on plot 6, damaged by hot winds.

*The Agency Field was laid out in the fall of 1917, on the Johnson Brothers farm, northeast of Agency, in Wapello County. The series is located in the northeastern corner of NW ¼ of the SE ¼ of Section 30, R. 12 W., T. 72 N.

TABLE 17. FIELD EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY, MT. UNION FIELD,* SERIES I

| Plot no. | Treatment | 1918 corn bu. per A. | 1919 w. wheat bu. per A. (1) | 1920 corn bu. per A. (2) | 1921 oats bu. per A. | 1922 w. wheat bu. per A. | 1923 corn bu. per A. | 1924 corn bu. per A. (3) | 1925 oats bu. per A. (4) | 1926 clover tons per A. (5) | 1927 corn bu. per A. | 1928 corn bu. per A. | 1929 soybeans tons per A. | 1930 corn bu. per A. | 1931 corn bu. per A. (6) | 1932 oats bu. per A. | 1933 corn bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 57.2 | 8.3 | 45.0 | 25.4 | 21.3 | 45.3 | 23.4 | 35.1 | ... | 49.5 | 51.0 | 2.18 | 46.7 | 41.3 | 34.7 | 61.1 |
| 2 | Manure | 61.3 | 11.8 | 52.0 | 27.7 | 22.0 | 65.0 | 27.5 | 36.8 | ... | 52.7 | 53.9 | 2.44 | 56.2 | 34.6 | 37.9 | 64.3 |
| 3 | Manure+limestone | 62.0 | 12.0 | 52.5 | 27.0 | 22.1 | 65.6 | 35.7 | 37.6 | ... | 62.0 | 55.6 | 2.35 | 54.3 | 42.3 | 43.2 | 61.5 |
| 4 | Manure+limestone+rock phosphate | 63.1 | 11.3 | 47.0 | 31.7 | 23.4 | 68.3 | 34.7 | 41.1 | ... | 53.3 | 57.2 | 2.70 | 56.3 | 33.5 | 45.7 | 67.4 |
| 5 | Manure+limestone+superphosphate | 65.5 | 13.1 | 49.0 | 35.1 | 28.5 | 66.9 | 37.3 | 45.5 | ... | 53.5 | 54.3 | 2.53 | 53.4 | 39.3 | 48.3 | 67.0 |
| 6 | Manure+limestone+complete commercial fertilizer | 59.4 | 12.2 | 50.0 | 42.1 | 27.7 | 67.4 | 30.7 | 40.8 | ... | 48.7 | 53.1 | 2.44 | 56.5 | 40.6 | 49.9 | 68.8 |
| 7 | Check | 57.4 | 10.2 | 44.0 | 37.0 | 21.0 | 34.9 | 22.1 | 30.2 | ... | 52.4 | 50.5 | 2.26 | 45.5 | 41.9 | 39.7 | 56.6 |
| 8 | Crop residues | 54.1 | 9.8 | 48.5 | 32.6 | 24.4 | 38.4 | 22.7 | 27.5 | ... | 58.3 | 51.6 | 2.09 | 49.2 | 42.6 | 37.9 | 58.4 |
| 9 | Crop residues+limestone | 56.9 | 8.9 | 47.5 | 33.9 | 21.7 | 39.7 | 21.3 | 29.8 | ... | 54.3 | 47.4 | 1.74 | 48.3 | 44.1 | 37.9 | 59.7 |
| 10 | Crop residues+limestone+rock phosphate | 58.9 | 10.9 | 47.5 | 30.3 | 25.2 | 40.2 | 20.0 | 34.6 | ... | 49.0 | 50.2 | 2.53 | 54.2 | 40.6 | 44.8 | 64.8 |
| 11 | Crop residues+limestone+superphosphate | 61.8 | 10.7 | 44.5 | 38.5 | 29.5 | 39.4 | 25.5 | 37.3 | ... | 46.4 | 47.8 | 2.18 | 52.3 | 37.0 | 41.9 | 64.7 |
| 12 | Crop residues+limestone+complete commercial fertilizer | 61.0 | 10.5 | 46.5 | 36.0 | 27.8 | 44.2 | 29.9 | 35.9 | ... | 58.1 | 48.7 | 2.44 | 57.6 | 36.3 | 43.7 | 64.1 |
| 13 | Check | 59.0 | 11.3 | 49.0 | 34.5 | 22.4 | 36.2 | 22.7 | 29.8 | ... | 55.6 | 51.8 | 1.83 | 50.3 | 39.9 | 36.3 | 52.6 |

(1) Poor quality wheat due to hot, dry weather and scab.
(2) Poor stand of corn due to wet spring, causing poor germination.
(3) Early frost damaged corn considerably.
(4) Thin stand of oats due to dry spring.
(5) Field pastured, no results.
(6) Hot, dry season.

*The Mt. Union Field, Series I, was established in the fall of 1917 on the farm of Oscar Eckey near Mt. Union in Henry County. It is located on the east side of the NW ¼ of the NW ¼ of Section 14, T. 72 N, R. 5 W in Canaan Township. This soil was basic to start with and no limestone was applied until 1922.

Crop residues had little effect on the yields of the various crops grown. Limestone with residues increased crop yields in several cases. In no instance was the gain large. Rock phosphate with residues and limestone showed small effects on the crops grown. Only in a few cases were the gains very definite, as on the soybeans in 1929. Superphosphate with residues and limestone had a much larger effect than did rock phosphate in many seasons. In the later years of the test, however, rock phosphate had the better effects, possibly because these years were generally somewhat deficient in rainfall. Complete commercial fertilizer with residues and limestone showed slightly larger effects than superphosphate in some seasons, but in general the differences between the effects of the two fertilizers were not large.

## The Millerton Field

The data obtained in the experiment on the Shelby loam on the Millerton Field in Wayne County are shown in table 18. Manure increased the crop yields on this soil in most seasons, the largest effects being shown on the corn in 1925. There was no effect on the clover in 1924, nor on the alfalfa in 1929. Limestone with manure brought about increases in some cases on the grain crops, particularly on the corn in 1926. It had little effect, however, on the clover in 1924 or on the alfalfa in 1929.

Rock phosphate with manure and limestone increased the crop yields in all seasons, showing large effects on the clover in 1924, on the alfalfa in 1929, on the corn in 1925 and on the oats in 1927 and 1931. Superphosphate with manure and limestone showed larger effects than rock phosphate on the wheat in 1923, on the clover in 1924, on the oats in 1927 and on the alfalfa in 1928

TABLE 18. FIELD EXPERIMENT, SHELBY LOAM, WAYNE COUNTY MILLERTON FIELD,* SERIES I

| Plot no. | Treatment | 1922 corn bu. per A. (1) | 1923 w. wheat bu. per A. | 1924 clover tons per A. | 1925 corn bu. per A. | 1926 corn bu. per A. | 1927 oats bu. per A. | 1928 alfalfa tons per A. (2) | 1929 alfalfa tons per A. (3) | 1930 corn bu. per A. (4) | 1931 oats bu. per A. | 1932 oats bu. per A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Check | 60.8 | 10.3 | 0.76 | 58.3 | 34.0 | 30.7 | ... | 0.48 | 12.2 | 39.4 | 27.8 |
| 2 | Manure | 63.0 | 14.5 | 0.69 | 65.3 | 36.0 | 30.7 | ... | 0.46 | 18.8 | 42.8 | 31.8 |
| 3 | Manure+limestone | 63.4 | 10.3 | 0.86 | 64.3 | 44.4 | 24.9 | ... | 1.35 | 18.0 | 43.2 | 30.7 |
| 4 | Manure+limestone+rock phosphate | 64.2 | 15.1 | 1.09 | 72.3 | 49.2 | 31.9 | 1.16 | 1.72 | 18.0 | 71.7 | 32.9 |
| 5 | Check | 58.1 | 9.6 | 0.92 | 60.6 | 35.2 | 29.9 | ... | 0.35 | 16.5 | 38.7 | 21.1 |
| 6 | Manure+limestone+superphosphate | 60.5 | 16.4 | 1.32 | 64.2 | 41.6 | 36.7 | 1.33 | 2.40 | 16.5 | 55.5 | 32.3 |
| 7 | Manure+limestone+superphosphate+ muriate of potash | 64.7 | 17.0 | 1.54 | 60.6 | 43.6 | 38.3 | 1.40 | 2.34 | 9.1 | 59.0 | 38.7 |
| 8 | Manure+limestone+complete commercial fertilizer | 65.6 | 17.6 | 1.29 | 59.3 | 46.0 | 41.6 | 1.28 | 2.47 | 8.6 | 59.0 | 40.3 |
| 9 | Check | 59.8 | 10.9 | 1.03 | 54.7 | 36.8 | 31.2 | ... | 0.41 | ... | 43.4 | 25.0 |

(1) No limestone applied for the 1922 corn.
(2) Few scattered plants on plots 1, 2, 3, 5, and 9. First cutting clipped back. Results on 1 cutting in August.
(3) Total of 3 cuttings. Plots 1, 2, 5, and 9 mostly timothy. Plot 3 partly timothy.
(4) Very dry season. Corn fired badly. Plot 9 — no corn.
(5) Field discontinued in 1933 due to economy program.

*The Millerton Field was established in the fall of 1921 on the farm of J. C. Davis, east of Millerton in Wayne County. It is located in the NW ¼ of the NE ¼ of Section 26, R. 21 W., T. 70 N. in Union Township.

and 1929. On the corn crops, however, rock phosphate seemed to have a somewhat larger effect, and especially on the oats in 1931 was the effect of rock phosphate particularly evident.

Muriate of potash with manure, limestone and superphosphate slightly increased the crop yields in most seasons. It had no large effects except on the clover in 1924. In two cases there was no effect from potash. Complete commercial fertilizer with manure and limestone showed slightly larger effects from the superphosphate in several seasons. It showed less effects on the clover in 1924, on the corn in 1925 and on the alfalfa in 1928.

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

Some general indications of the fertilizer needs of the soils of Poweshiek County have been obtained in the laboratory, greenhouse, and field experiments which have been discussed earlier in this report. It is possible, therefore, to make some rather general recommendations for the handling of the various soils in the county. These recommendations are based upon the experiences of farmers as well as upon the results of experiments, and any of the suggestions offered may be put into effect under individual farm conditions. Later in the report there will be given some suggestions for the treatment of individual soil types.

### LIMING

All the soils in Poweshiek County are acid in reaction and they are, therefore, in need of applications of limestone if they are to be most satisfactorily productive. The analyses given earlier in this report have indicated the need for lime on the various soil types in the county. The results of the tests on the subsurface soils and subsoils show that the acidity is not confined to the surface soil but extends down through the lower soil layers. Evidently the use of limestone on all the soils of the county is very desirable at the present time and especially for the growth of the legumes, such as sweet clover and alfalfa.

Soils vary considerably in acidity and lime needs, even when the type is the same, and general recommendations for the amount of limestone to apply cannot be made. The figures given in table 4 merely indicate roughly the lime requirements of the soils. It is most important that every soil or the soil in each field be tested individually for lime needs before any application is made. Only in this way will it be possible to apply the proper amount of limestone. Farmers may test their own soils for acidity or lime requirements but it will usually prove more satisfactory if they will send a small sample to the Soils Subsection of the Iowa Agricultural Experiment Station, where it will be tested free of charge, and recommendations made regarding treatment.

It is quite generally recognized that the most satisfactory yields of most farm crops are obtained on land which is not acid in reaction, and the use of lime to correct acidity is a common farm practice. It is especially necessary to lime acid soils if such legumes as sweet clover or alfalfa are to be grown as these crops will not grow on acid soils. In the case of such crops, therefore, the application of limestone may mean the difference between no crop at all, and a satisfactory crop. But with all farm crops the use of limestone exerts a beneficial effect, and for permanent fertility the regular addition of limestone is necessary to keep the land from becoming acid.

The beneficial effects of limestone on various general farm crops have been indicated in the experiments discussed earlier in this report showing the results of the tests on the Tama silt loam, the Grundy silt loam, the Clinton silt loam, the Muscatine silt loam and the Shelby loam. In all these cases the use of limestone has proved profitable, increasing the yields of legume crops and of the other general farm crops grown. Other soil types would undoubtedly respond

in quite as large a way to the use of limestone and might even give greater returns. The experiences of many farmers bear out the conclusion that the use of lime on acid soils is a basic treatment which is necessary for the proper soil management practices. By the use of lime it is possible to grow the best legumes in the rotation, and without lime these legumes will not grow on acid soils. With the proper growing of legumes, the soil may be kept up and built up in organic content and nitrogen, and the first step in permanent fertility is, therefore, taken.

It is not sufficient to lime the land once and expect that application to serve for all time. Soils lose lime rapidly when they are under intensive cultivation and it is necessary to test the land regularly and apply lime as it is needed if the reaction is to be kept what it should be. The best time to test the soil is just preceding the growing of the legume crop of the rotation, then the lime needed may be applied at a time when it will do the most good, and that is on the legume crop. But the grain crops which follow the legume will also be benefited directly by the lime and indirectly by the increased legume residues left in the soil.

## MANURING

There is a wide range in the organic matter or humus content of the soils of Poweshiek County. Some of the types are very dark in color and apparently fairly well supplied with organic matter. Others, however, are light in color and deficient in humus. The soils of the Lindley, Shelby, Clinton, Jackson and Genesee series are particularly lacking in organic matter as is indicated in the lighter color of the surface soils of most of these soils. But the Carrington, Tama, Waukesha and Judson series are not any too well supplied although they are darker in color. In many areas of these soils the organic matter is not nearly adequate for the best conditions in the soils for the growth of crops. And even in the case of the Grundy and Muscatine types it is necessary to supply organic matter regularly or the content will soon become deficient. In fact it may be said that on all the soils of the county it is very important that some fertilizing materials supplying organic matter be applied regularly if the supply is to be kept up. On the lighter colored poorer soils, the addition of such materials is especially necessary at the present time, and the use of larger amounts of the fertilizing materials is desirable.

The cheapest and best means of building up and keeping up the supply of organic matter in soils is by the proper preservation and application of all the manure produced on the farm. Under the livestock system of farming, the use of the manure will aid materially in maintaining the fertility of the land, and the yields of general farm crops are often increased considerably by the application of farm manure. The experiments which have been described earlier in this report have shown the large effects of manure on the yields of farm crops, on various soil types. The beneficial effects were indicated on the Tama silt loam, on the Clinton silt loam, on the Grundy silt loam, on the Muscatine silt loam, on the Shelby loam and on the Grundy silty clay loam. Increases in crops, often very large, were obtained by the use of manure in the tests on these soils. And they are not the poorest soils in the county, but rather the best types, the richest in organic matter and fertility.

The poorer soils would respond in a much larger way to the use of manure, and in fact on some of the lighter-colored soils, the use of manure or the addition of some other material supplying organic matter is essential for the growing of crops with any degree of success. The regular application of farm manure to the soils of the county is recommended in order to aid in obtaining the best crop yields and in maintaining permanent fertility.

The proper utilization of all the crop residues will also aid in keeping up the content of organic matter in soils. On livestock farms the residues may be used for feed or bedding, as is usually the case, and returned to the land with the manure. On the grain farm they are stored and often allowed to decompose partially before they are applied. They may in some cases be applied directly to the land. Under any type of farming it is very important that all the residues be utilized as they are of large fertility value. The cornstalks should not be burned or otherwise destroyed, as they add fertility to the land and their value is destroyed by burning.

On most livestock farms there is an inadequate production of manure to permit of applications to all the land on the farm, even in small amounts. On the grain farm there is little or no manure produced, and on the general farm too little manure is produced to be of any large value on all the land. In all cases, therefore, it is necessary to supplement the farm manure or substitute something for it, if the organic matter content of the soil is to be kept up. The use of legumes as green manures is the best means of building up and keeping up the organic matter in the soils, along with the use of residues and all the farm manure produced. When they are inoculated as they should be for the best results, legumes are able to draw upon the free nitrogen of the atmosphere for their content of that constituent, and hence when they are turned under in the soil they may add considerable amounts of nitrogen to the land, along with the organic matter which they supply in a very valuable form. Green manuring would certainly prove of large value on many of the soils in Poweshiek County at the present time and especially on those types which are most lacking in organic matter, and nitrogen and are the lightest in color and the poorest in productivity. The effects on the latter types would of course be especially large, but the yields of crops on all the types would be increased by the proper use of legumes as green manures. Green manuring is not a practice which can be followed blindly or carelessly, however, as undesirable effects may occur if the green material does not decompose in the soil or is slow in decomposing. Farmers in Poweshiek County may build up and keep up the organic matter in their soils by proper use of farm manure, residues and green manures.

## THE USE OF COMMERCIAL FERTILIZERS

Most of the soils in Poweshiek County are low in phosphorus, and it is evident that this essential plant food constituent is not present in sufficient amounts to meet the needs of crops for many years. It appears that in some instances

an insufficient amount is present for crops in the immediate future. Certainly phosphate fertilizers will be needed in this county in the very near future if they are not necessary now, and the indications are that they might be used in many cases with profit at the present time.

The two phosphate fertilizers most commonly used are rock phosphate and superphosphate. Rock phosphate is usually applied at the rate of 1,000 pounds per acre once in 4 years. Superphosphate is added normally at the rate of 120 pounds of the 20 percent material 3 years out of 4 in the 4-year rotation. Superphosphate contains phosphorus in an immediately available form, while it is more slowly available in rock phosphate. Frequently rock phosphate does not show the largest effects until the second year after application, while superphosphate shows immediate results. Superphosphate is more expensive than rock phosphate, but the smaller application means that the actual cost of the fertilizer is less. Rock phosphate must, therefore, bring about larger beneficial effects on crops if it is to prove as economically desirable.

The influence of the two phosphates on crops grown on several of the major soil types in the county has indicated that these materials often may be employed with profit. The Tama silt loam, the Clinton silt loam, the Grundy silt loam, the Muscatine silt loam, the Shelby loam and the Grundy silty clay loam all show beneficial effects from the use of one or the other of the phosphates.

The other soil types would certainly give just as large or larger effects. It is impossible, however, to choose between rock phosphate and superphosphate, as the results vary considerably under varying soil conditions. Sometimes rock phosphate seems to be the better and in other instances superphosphate proves superior. The safest procedure is to test the two phosphates on small areas under individual farm conditions and thus determine which is the better to use under those conditions. Simple tests may be carried out on any farm and farmers are urged to determine the needs of their own soils for phosphorus and which phosphate should be used, by carrying out tests on their own land.

The nitrogen content of the soils of the county is quite as variable as the phosphorus. Some of the types are fairly well supplied, while others are in need of additions of nitrogen. The light colored soils are low in nitrogen, and additions are especially necessary on these types. In all cases, however, nitrogen must not be overlooked when systems of permanent fertility are planned. Nitrogen is lost from soils very rapidly when they are cultivated. Crops remove large amounts, and there is a constant loss in the drainage water. It is essential, therefore, that nitrogen be supplied regularly if the content of the soils is to be kept up.

The turning under of the crop residues returns to the land some of the nitrogen removed by the crops grown, and the plowing under of farm manure adds considerable amounts of nitrogen which would otherwise be lost from the soil. But the method which really adds nitrogen to the soil is the practice of green manuring, using legumes. These crops when well inoculated take much of their nitrogen from the atmosphere, and hence they may add large

amounts to the soil. The practice of green manuring with legumes will be most desirable on many of the soils of Poweshiek County at the present time to increase the supply of nitrogen and at the same time, of course, it adds to the necessary supply of organic matter. On the lighter colored, poorer soils the practice would be of particularly large value. But the practice will also be of value on the richer soils as a means of maintaining the nitrogen content. By the proper use of legumes as green manures it will not be necessary to purchase and apply expensive commercial nitrogenous fertilizers. These materials cannot be recommended for general use in the county at present. They may be employed with profit in some cases or for special crops, but they are too expensive for use with general farm crops. If they are to be used, tests should always be carried out on small areas before any extensive application is made.

The potassium content of the soils of the county is undoubtedly adequate and if there is a sufficiently rapid production of the element in an available form there should be no need for the application of a commercial potassium fertilizer. They may be of value in some cases for special crops but their general use for farm crops cannot be recommended. In any case they should not be employed until tests have been carried out on small areas and the value of the treatment definitely shown.

Certain complete commercial fertilizers may be of value on some of the soils of the county at the present time, but their general use cannot be recommended. Certainly no complete brand should be applied to a large area until it has been tested on a small area and its value proved for the particular conditions. Comparisons have been made of some of the more common complete brands with superphosphate and rock phosphate in the tests which have been discussed, and in general it appears that the phosphates may give quite as desirable results and at a lower cost. The complete fertilizers are more expensive than the phosphates and they must therefore, give much larger crop increases to prove as profitable for use. It seems that tests on the farm comparing any complete brand with superphosphate would be desirable before the complete fertilizer is used at all extensively. There is no objection to the use of a complete commercial fertilizer and no injury to the soil from the treatment. It is merely a question of the profit to be obtained from the use of the fertilizer, and naturally that material should be employed which will bring about the most economic crop production.

## DRAINAGE

The natural drainage system of the county is fairly adequate as has been shown in the drainage map given earlier in this report. The major streams with their tributaries and the intermittent drainage lines provide for the rather thorough drainage of much of the upland and terrace areas. There are, however, some soils which are poorly drained and there are some areas in normally well-drained soils, which are not entirely satisfactory from the drainage standpoint. The Grundy silt loam and particularly the Grundy

silty clay loam and the Muscatine silt loam on the uplands are not well drained naturally in many cases. The Grundy silty clay loam is always in need of artificial drainage unless that has been provided and many areas in the Grundy silt loam and the Muscatine silt loam are poorly drained. There are poor drainage conditions in the Bremer soils on the terraces and the Wabash soils on the bottomlands are poorly drained, too. These latter soils must of course, also be protected from overflow if they are to be successfully cultivated even after being thoroughly drained. All these soils must be provided with better drainage if they are to be made most satisfactorily productive.

The first treatment needed by soils that are too wet is the proper drainage by the installation of drainage ditches or the laying of tile. No other treatment will be of any value until the drainage situation has been corrected. While the expense of tiling may be considerable, the increased crop yields obtained will more than offset the outlay. For the best results and the most economic production of crops the drainage factor must be taken care of, in this county as everywhere.

## THE ROTATION OF CROPS

The continuous growing of any one crop very quickly reduces the fertility of the land. While this is generally recognized the large value of certain crops often leads farmers to practice the destructive one-crop system. They lose sight of the fact that it is not only a destructive practice but that it is economically unsound. The value of all the crops grown over a period of years is much greater when a good rotation of crops is followed than when one crop is grown continuously, even if that crop is the so-called "money" crop. The reason for this is that the yields do not decline so rapidly under the rotation system. The profit from the crops of a rotation is greater over a period of years, and at the same time there is not such a reduction in the fertility of the soil. The proper rotation of crops is essential to a system of permanent agriculture.

There have been no particular rotation experiments in Poweshiek County but some rotations may be suggested which will be of value in the county. In fact almost any rotation will be worth while provided it contains a legume crop and the money crop of the area. The following are desirable rotations which may be used in the county or which may serve as a basis upon which a suitable rotation may be devised.

### 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 5-year rotation by cutting out either the second or sixth year and to a 4-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 5 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 5 years. This field should then be used for the 4-year rotation outlined above and the alfalfa shifted to one of the fields which previously was in the 4-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 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 2-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 land. There are two types of erosion, sheet washing and gullying. Sheet erosion is the washing away of the surface soil. Gullying is more striking in appearance, since gulches or ravines may be formed.

Erosion occurs to a considerable extent in Poweshiek County, its effect being evidenced very definitely on the Shelby loam, the Lindley types, the Clinton silt loam and the Tama silt loam. All these soils are affected more or less seriously by the washing action of water, and sheet erosion has occurred to a most disastrous extent in many cases. The appearance of gullies is still more striking evidence of the erosion which has occurred, and entirely too many of them are found throughout the county. It is apparent that there are many

cases in the county where some means of prevention or control of the destructive action of erosion should be adopted.

Various methods are followed to control and prevent 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. Gullies may be prevented from forming by thorough drainage or by the use of sod strips. Large gullies may be similarly filled or prevented from occurring. Erosion in bottomlands may be prevented by straightening the streams, by tiling and by planting trees up the drainage channels. Hillside erosion may be controlled by the use of organic matter, by growing cover crops, by contour discing, by terracing, by deep plowing, or by the use of sod strips or a system of strip cropping.[2]

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2 Clyde, A. W. Terracing to Reduce Erosion. Iowa State College, Ext. Bul. 172. 1931.

## INDIVIDUAL SOIL TYPES IN POWESHIEK COUNTY[3]

There are 17 soil types in Poweshiek County, and these with the light colored phase of the Grundy silt loam and the colluvial phase of the Wabash silt loam make a total of 19 separate soil areas. They are divided into four groups on the basis of origin and location: drift soils, loess soils, terrace soils and swamp and bottomland soils.

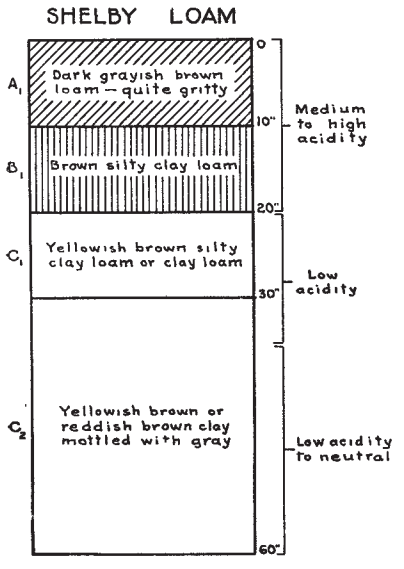
### DRIFT SOILS

There are four drift soils in the county classified in the Shelby, Carrington and Lindley series. Together they cover 13.3 percent of the total area.

### Shelby Loam (S) (79)

The Shelby loam is the largest of the drift soils, and the third largest soil type in the county, covering 8.1 percent of the total area. It occurs in many narrow strips along the various streams of the county, except in the northern part where the Carrington loam occurs in similar locations. It is found on the slopes along the streams and smaller drainage ways, being developed where erosion has removed the original covering of loess and exposed the underlying drift of the Kansan glaciation.

The surface soil of the type is a dark grayish-brown loam, to a depth of about 10 inches, in many places being quite gritty. Below this and continuing to a depth of about 20 inches there is the transitional layer of brown silty clay loam streaked with some dark organic material from above. The subsoil to a depth of about 30 inches is a yellowish-brown silty clay loam to clay loam, containing considerable sand and gravel and a few boulders. Below this point there is a yellowish-brown or reddish-brown clay mottled with gray and containing pockets of sand and gravel. The thickness and color of the surface soil is extremely variable on the different slopes. On the steeper areas, the soil is thin, and spots occur where the dark-colored surface soil has been entirely removed and the yellowish-brown or reddish-brown subsoil is exposed. On the lower slopes the dark colored material is much thicker, ranging from 15 to 30 inches in thickness. On many of the gentler hill slopes along the upper parts of the streams, the soil mapped as Shelby loam resembles the Carrington loam, and in many places the boundary lines between the two types have been placed arbitrarily.




[3] The descriptions of individual soil types given in this section of the report very closely follow those in the report of the Bureau of Soils.

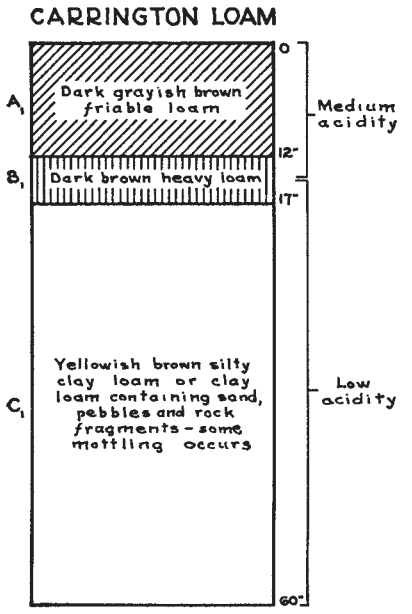
Only about 65 percent of the Shelby loam is farmed, the remainder being in pasture. Corn is grown most extensively on the cultivated areas, and oats and hay are the other main crops. The productiveness of the soil varies with the degree of slope and hence the extent of erosion, which has occurred. On the more level areas and on the lower slopes the yields are much the same as on the better soils on the uplands, but this is true for only a comparatively small proportion of the total area of the type. Where the surface soil is thin and the subsoil is close to the surface or exposed the yields are very low. On the bare spots which are reddish-brown in color, the soil is sticky and plastic and contains much grit and some boulders. In dry periods some of the spots dry out and become very hard and others contain seepy areas where the soil is called "push" soil because when it is plowed, it pushes ahead of the plow and does not turn a furrow, or it sticks to the plow. In general the yields on such areas are very low, and until the areas are properly tiled which involves laying tile around the edges of the spots, organic matter is applied in liberal amounts and the soil is plowed deeply either with a deep tillage machine or the use of a subsoiler attachment to the plow, satisfactory crops cannot be obtained.

The Shelby loam is chiefly in need of erosion control and a building up in organic matter and plant food if it is to be made satisfactorily productive. The steeper slopes should of course be kept in permanent pasture or timber and only the gentler slopes and more level areas put into cultivation. The liberal application of farm manure is very desirable on this soil to increase the supply of organic matter and the turning under of legumes as green manures will also help materially. The soil is acid in reaction and the application of limestone is needed for the best growth of legumes and also for the most satisfactory yields of other general farm crops. The proper supplying of organic matter will also aid in protecting the soil from such serious washing, making the soil more absorptive. Contour plowing and discing, terracing and strip cropping will also serve to protect the land from erosion when it is cultivated. Proper rotation of crops with less corn and cultivated crops and more hay and pasture crops will prevent erosion to a very large degree. The land in this type, when cultivated will also undoubtedly respond to the application of a phosphate fertilizer, and tests of superphosphate are recommended. The experiments which have been discussed earlier in this report have shown the large value of the application of farm manure, limestone and a phosphate in increasing the productivity of the soil.

### Carrington Loam (C) (1)

The Carrington loam is the second largest drift soil, covering 3.7 percent of the total area. It occurs in narrow strips on the gentle slopes to tributary drainageways in all parts of the county but mainly in the northern part. There are no large areas of the type but many small, narrow, irregular-shaped areas.

The surface soil of the Carrington loam to a depth of about 12 inches is a dark grayish-brown friable loam which contains considerable amounts of silt and in places is almost a silt loam in texture. From 12 to 17 inches there is a




dark brown heavy loam streaked with dark organic matter brought down from above. The lower subsoil is a yellowish-brown silty clay loam or clay loam containing some sand, pebbles and rock fragments. There is some mottling in the lower subsoil. In the extreme northern part of the county, on slopes which are gently sloping, the surface soil is almost a silt loam in texture. Here the original silty or loessial layer has been less completely removed by erosion. On many slopes small areas of the underlying yellowish-brown or reddish-brown silty clay drift are exposed. These areas range in size from 10 to more than 100 feet long and from 3 to 15 feet in width. On a few hill slopes erosion has removed the entire surface soil, and yellowish-brown or reddish-brown gritty clay areas with some sand, gravel and boulders cover the entire slope. Some seepage spots occur on the slopes.

Except for a comparatively small acreage on the steeper slopes, all the land in Carrington loam is in cultivation. Corn is the most important crop, with small grains and hay crops being grown quite extensively. The yields are about the same on this soil as on the Tama silt loam, being slightly lower in some areas, usually the more strongly rolling parts.

The type is well drained and is chiefly in need of protection from erosion and of additions of organic matter if it is to be made more satisfactorily productive. Liberal applications of farm manure would prove of large value, and the turning under of legumes as green manures would be of help too. The soil is acid and must be limed for the growth of legumes, especially sweet clover and alfalfa. The use of a phosphate fertilizer would be worth while, and tests of rock phosphate and superphosphate are urged. The field experiments on this soil have shown the large effect of manure, limestone and a phosphate in increasing the productivity of the soil.

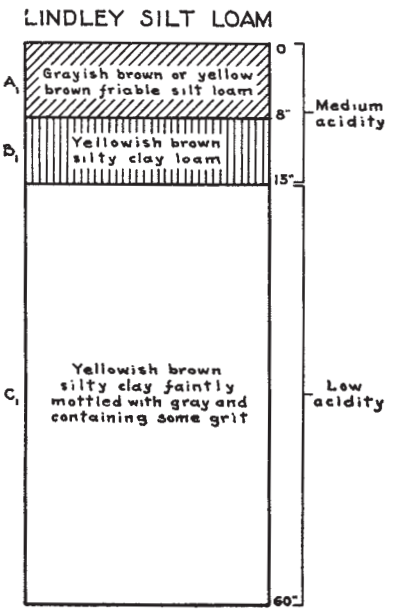
### Lindley Silt Loam (Ls) (32)

The Lindley silt loam is the third largest drift soil in the county, but it is small in area, covering only 1 percent of the total area. It occurs in narrow strips on the steeper stream slopes in the southwestern part of the county, mainly along the North Skunk River and its larger tributaries and in the northern part along Bear and Walnut creeks.

The surface soil of the type is a grayish-brown or yellowish-brown friable silt loam, extending to a depth of about 8 inches. The soil from 8 to 15 inches is a yellowish-brown silty clay loam. The subsoil below 15 inches is a yellowish-brown silty clay containing considerable grit, the quantity increasing with

depth. Small boulders are found in some areas on the surface soil and quite generally in the subsoil.

About one-half of the type is cultivated, the remainder being in woodland and is utilized to some extent for pasture. The soil was originally timbered, and there is a scattered tree growth on some of the uncultivated areas now. The yields of corn and other general farm crops on the cultivated areas are low. The soil is chiefly in need of organic matter if it is to be made more productive. Liberal applications of farm manure are needed, and the turning under of legumes as green manures will also help. The type is acid and must be limed for legumes. The use of a phosphate fertilizer would be of value, and tests of superphosphate are recommended. The steeper and rougher areas of the soil should undoubtedly be left in pasture and trees, and only the more gently rolling areas should be cultivated.




### Lindley Loam (L) (65)

The Lindley loam is a minor type in the county, covering only 0.5 percent of the total area. It occurs in the same general location as the Lindley silt loam, on the steeper slopes to the streams in the southwestern part of the county, along the North Skunk River and in the northeastern part along Bear and Walnut creeks. It is found, however, on the steepest slopes, and the areas are all small and narrow.

The surface soil to a depth of about 12 inches is a grayish-brown or yellowish-brown heavy loam. The upper subsoil to about 17 inches is a lighter yellowish-brown clay. The lower subsoil is lighter in color, being a bright yellow clay, mottled with gray and some brown. Many black iron stains occur below 30 inches. Sand, gravel, grit and some boulders are found throughout the soil profile and the amounts of these materials usually increase with depth.

Only a small part of the Lindley loam is cultivated, the most of the land being in permanent pasture or timber. Originally the land was all timbered with hardwoods, mostly oaks, elm and hickory. Most of the type should certainly be left in pasture and timber. If cultivated the soil must be protected from erosion and built up in organic matter. The liberal application of farm manure and the turning under of legumes as green manures would increase the supply of organic matter and make the soil more productive. It is acid in reaction and must be limed for legume growth. The use of a phosphate fertilizer would help, and tests of superphosphate are desirable.

## LOESS SOILS

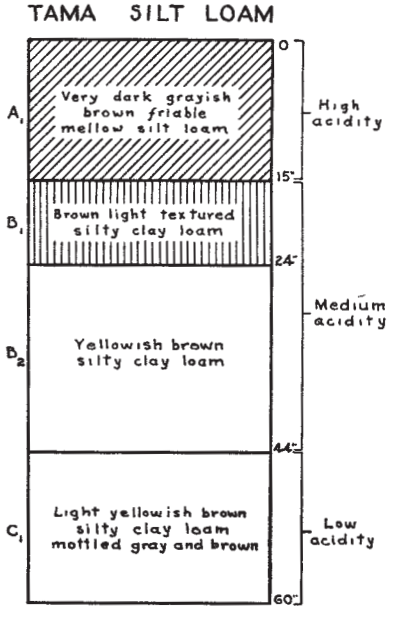
There are six loess soils in the county classified in the Tama, Clinton, Grundy and Muscatine series. Together they cover 69.6 percent of the total area.

## Tama Silt Loam (Ts) (120)

The Tama silt loam is by far the largest soil type in the county and the largest loess soil. It covers 52.6 percent of the total area. It occurs on the uplands in all parts of the county, and there are many extensive individual areas of the type.

The surface soil of the Tama silt loam to a depth of about 15 inches is a very dark grayish-brown silt loam, mellow and friable and appearing black when wet. From 15 to about 24 inches there is a gradual change from the darker colored surface soil to the lighter colored subsoil, the soil in this layer being a brown light silty clay loam. The lower part of this layer is colored and marked with streaks of dark organic matter from above. Below 24 inches the subsoil is a yellowish-brown uniform silty clay loam. At 44 inches there is a slight change in the color and texture, the material becoming more silty, and faint mottlings of gray and brown appear. Iron stains also appear at this depth.

In topography the Tama silt loam is gently rolling to rolling. The type occurs on the gently rolling upland slopes from the divides toward the lower stream valleys, and natural drainage is well established. Sheet erosion is occurring on the more rolling areas and the slopes adjacent to the streams are sufficiently eroded so that in many places the underlying drift is exposed. The surface soils in these areas are usually mapped as the Shelby or Carrington soils, but there are some small areas which contain considerable grit that are included with the Tama soils because of their small extent.



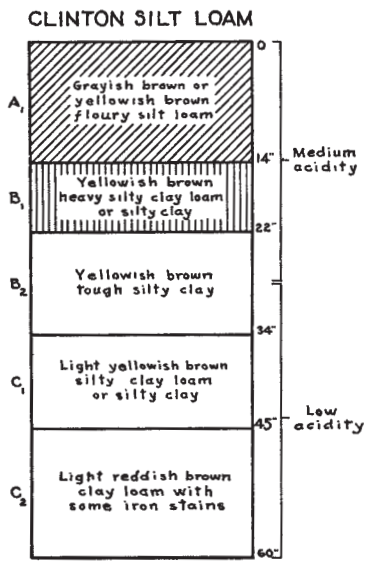

Practically all the land in the Tama silt loam is under cultivation, and general farm crops are grown. The yields of crops are somewhat higher than the average for the county. Corn averages about 45 bushels per acre, with high yields of 80 bushels per acre reported. The average yield of oats is 38 bushels per acre with yields of 50 and 55 bushels per acre common in favorable seasons and under good systems of soil management. Timothy and clover make up the most of the hay acreage, and good yields of this crop are obtained. Alfalfa is grown, and when the soil is limed, good seed is used and the seed is inoculated, the yields of this crop are high. Sweet corn is grown on a small acreage largely for the canning factory at Grinnell. Some soybeans are grown largely with the corn for hogging-down. Other minor crops include barley, rye, wheat, pop corn and small fruits and truck crops. Some tree fruits are also raised.

Most of these special crops are grown mainly for home consumption, with some sale on the local markets in favorable seasons.

The Tama silt loam may be made more productive by the adoption of better methods of soil management. The soil will respond in a very large way to applications of farm manure. The turning under of a legume as a green manure would also prove of value, in building up the supply of organic matter in the soil and reducing the danger of erosion. The soil is acid in reaction, and liming is necessary for the best growth of all crops and especially legumes. The use of a phosphate fertilizer would undoubtedly prove worth while. Tests of rock phosphate and superphosphate are recommended. The experiments on Tama silt loam which have been reported have shown the large value of the use of farm manure, limestone and a phosphate fertilizer in making the soil more productive. These treatments are all needed for permanent fertility.

## Clinton Silt Loam (Cs) (80)

The Clinton silt loam is the second largest loess soil in the county and the fourth type in the area, covering 7.4 percent of the total area. It occurs in numerous areas varying widely in size, on the rolling uplands adjacent to or near the larger streams. It is found largely in the southwest corner of the county along the North Skunk River, Sugar, Moon and Buck creeks. There are also fairly large areas on the slopes and uplands adjoining Deep River, North English River, Walnut Creek and Bear Creek.




The surface soil of the Clinton silt loam is a moderately dark, grayish-brown or yellowish-brown smooth floury silt loam, extending to a depth of about 14 inches. At this depth the soil changes abruptly to a yellowish-brown heavy silty clay loam or silty clay. Below 22 inches the subsoil is a yellowish-brown tough silty clay, extending to a depth of 34 inches. At this point the material changes to a light yellowish-brown silty clay loam or silty clay, somewhat lighter in texture than the layer above. Below 45 inches there is a light reddish-brown clay loam with some iron stains.

There are some variations in the typical soil in different areas. Thus in the southwest corner of the county there are areas of a medium textured loessial sand, covering hill crests or slopes. These deposits range from a few inches to more than 30 inches in depth. The surface soil from 2 to 8 inches thick, is dark brown while the lower part of the surface soil and the subsoil

consists of a uniform yellowish-brown sand. These spots are too small to separate on the map, but they are indicated by symbols. A few of these sandy spots occur in areas of the darker Tama silt loam near the boundaries of the Clinton silt loam.

There are other variations in the type. On the east side of Sugar Creek Township there are a few small areas of a gray rather than buff soil having a very friable subsoil, and a light silt loam surface soil. The depth to which the characteristic heavy yellowish-brown or reddish-brown silty clay layer occurs is variable. In some places it is found immediately below the surface soil and in other places 3 feet or more below the surface. Where the layer is deep, the upper subsoil layer is usually a friable heavy yellowish-brown silty clay loam or silty clay. Areas in which this type of subsoil occur are usually found where the Clinton silt loam grades into the Fayette silt loam, the latter soils having friable and more pervious subsoils.

The Clinton silt loam is gently rolling to sharply rolling in topography, and drainage is everywhere adequate to excessive. In the more rolling areas erosion is active, and many slopes have been very quickly gullied when they have been broken and brought under cultivation. There is active erosion in many areas at the present time, and the fact that erosion has occurred to a disastrous extent in the past is evidenced by the thin surface soil in many places and the frequent exposures of the subsoil.

The Clinton silt loam was originally timbered, mostly with oak, elm, hickory and ash. Sumac and hazel brush form a dense undergrowth on many slopes and ridges. More than half the type is now in cultivation, the remainder being used for pasture and timber. General farm crops are grown, and on the areas where better rotations are followed and the soil management practices are adequate, the yields are about the same as on the Tama silt loam. In general, however, the yields are lower on this type. Wheat yields range from 15 to 25 bushels per acre and oats from 20 to 40 bushels. Hay yields are good, clover and timothy being the chief hay crop.

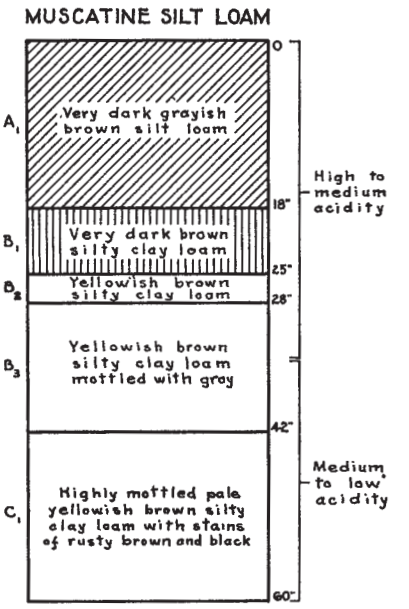
This type is chiefly in need of additions of organic matter if it is to be cultivated. The steeper slopes should not be brought under cultivation but should be kept in permanent pasture or in timber. The need to protect the soil from erosion is always evident. The liberal use of farm manure and the turning under of legumes as green manures will not only make the soil more productive and fertile but will also make it more absorptive and less liable to erode. The type is acid and in need of lime for general farm crops and especially legumes. There is need also for the use of a phosphate fertilizer, and tests of superphosphate are recommended. The experiments which have been carried out on this soil have shown the large effects of the use of manure, limestone and a phosphate. They are necessary for satisfactory crop yields on the soil and for permanent fertility.

### Muscatine Silt Loam (Ms) (30)

The Muscatine silt loam is the third largest loess soil and the fifth largest type in the county, covering 6.9 percent of the total area. It occurs in many

areas in the county, occupying the level to flat interstream divides in all sections except the southeastern part of the county.

The surface soil of the Muscatine silt loam is a very dark grayish-brown to almost black heavy silt loam, extending to a depth of about 18 inches. In places it is almost a silty clay loam, and usually at a depth of about 10 inches the texture becomes a silty clay loam. From 18 to 25 inches there is a very dark brown silty clay loam, streaked and spotted with dark organic matter. From 25 to about 28 inches there is a yellowish-brown silty clay loam mottled with gray and brown, and from 28 to 42 inches the subsoil is similar except that there is more mottling, and below 42 inches the substratum is a highly mottled pale yellowish-brown silty clay loam stained with rusty brown and black.




There are many variations in the subsoil in the different areas, all gradations occurring from the friable silty clay loam subsoil of the Tama silt loam to the heavier subsoil of the Grundy. In some areas there is a gradual change from the one type to the other and the boundaries are placed rather arbitrarily. On the flat areas the texture of the surface soil is practically a silty clay loam and the soil might have been mapped as Muscatine silty clay loam, except that the areas were not sufficiently large to show on the map. These areas range in size from 5 to about 20 acres, and they are more in need of drainage than the typical soil. Both surface soil and subsoil are heavier than the typical silt loam.

The Muscatine silt loam is all under cultivation, and general farm crops are grown. Corn yields average about 50 bushels per acre with variations both sides of this average depending upon the adequacy of the drainage of the soil and the seasonal conditions. Oats yield well, but in wet seasons they are apt to lodge. The yields range from 38 to 65 bushels per acre. Hay crops do well, ranging from 1 to 2 tons per acre. Alfalfa is grown in some cases and yields from 3 to 5 tons per acre.

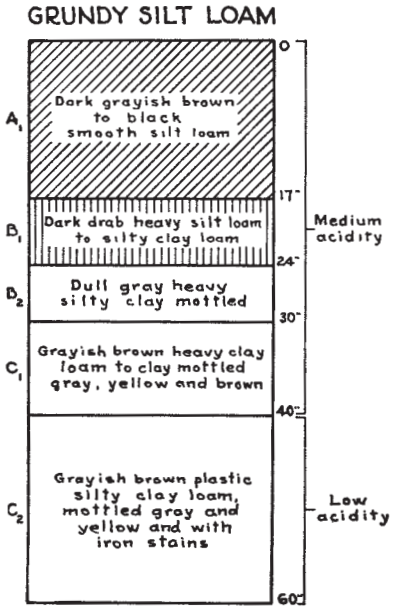
The chief need of the Muscatine silt loam is for adequate drainage and until this is provided yields will not be as high as they should be on the soil. Tiling is usually necessary on the type because of its level to flat topographic position and its heavy impervious subsoil. When well drained the yields on the type are high. It will be benefited by normal applications of farm manure, especially when newly drained. It is acid and must be limed for legume growth. It will also respond to the application of a phosphate fertilizer, and tests of rock phosphate and superphosphate are recommended. The experiments which have been carried out on the soil have shown the value of manure,

limestone and a phosphate on the type; they increase the yields of crops and make the land more productive.

## Grundy Silt Loam (G) (64)

The Grundy silt loam is the fourth largest loess soil, covering 2.3 percent of the total area of the county. It occurs only in the southeastern part of the county, occupying the flat interstream divides, a position similar to that of the Muscatine silt loam in the other parts of the county.

The surface soil of the Grundy silt loam is a dark grayish-brown to black smooth silt loam, extending to a depth of about 17 inches. From 17 to 24 inches there is a dark drab heavy silt loam to silty clay loam. From 24 to 30 inches the subsoil is a dull gray heavy silty clay mottled to some extent, and from 30 to 40 inches the substratum is a grayish-brown heavy clay loam to clay mottled with gray, yellow and brown and marked with iron stains.




Within areas mapped as Grundy silt loam there are a few small depressed areas where the surface soil is somewhat heavier, approaching a silty clay loam in texture. These spots need more attention to drainage if they are to be made satisfactorily productive. There is often an arbitrary boundary between the Grundy silt loam and the Muscatine silt loam as they grade into each other. The soil drains a little slower than the Muscatine silt loam in most cases, but the differences are slight and both soils need more adequate drainage.

All the land in this type is under cultivation, and general farm crops are grown. The yields are much the same as on the Muscatine silt loam, and when well drained the type is just as highly productive. The drainage factor must be taken care of, however, if good crops are to be obtained. The soil will be benefited by applications of farm manure just as noted in the case of the Muscatine silt loam. There is a need for lime to correct the acidity of the soil, especially for the growth of legumes. The use of a phosphate fertilizer would help, and tests of rock phosphate and superphosphate are recommended. These treatments have all been found to prove of value in the field experiments which have been carried out with the type, and in the experiences of many farmers.

## Grundy Silty Clay Loam (Gs) (115)

The Grundy silty clay loam is a minor type in the county, covering 0.3 percent of the total area. It occurs in a number of small areas within areas of the Grundy silt loam in the southeastern part of the county. These areas

occupy flat or slightly depressed portions of the upland divides, where drainage was originally quite inadequate and still is generally unsatisfactory.

The surface soil of the Grundy silty clay loam is a black heavy silty clay loam, sticky and tenacious when wet but breaking up into fine particles when dry. Below 8 inches the texture changes to a silty clay, but the dark-brown to black color extends to a depth of about 12 to 18 inches. At a depth of about 30 inches there is a grayish-yellow, gray or mottled gray and yellow silty clay loam or silty clay with many iron stains. This material gradually changes into the grayish-yellow silty clay loam of the parent loessial material, with the occurrence of many rusty-brown and black iron stains. A few small depressed areas within the type about 1½ miles east of Montezuma have a gray color below the surface soil. These spots are from 50 to 200 feet in diameter, and they do not drain as well as the surrounding area. A thin gray silt layer from ⅛ to ¾ inch thick occurs below the surface soil, being the thickest near the center of the depression.

All of the type is now under cultivation, and general farm crops are grown. When moisture conditions are satisfactory, the yields are just as good as on the Grundy silt loam. Corn averages about 45 bushels per acre, ranging from 40 to 80 bushels, on the well-drained land. Oats in favorable seasons yield from 40 to 60 bushels per acre but they are apt to lodge in wet seasons. Clover and timothy is the chief hay crop, yielding from 1½ to 3 tons per acre.

The chief need of this soil is for adequate drainage which requires more tile laid closer together than in the case of the Grundy silt loam. It must be plowed and cultivated under proper moisture conditions or it will bake and clod. In extremely dry weather large cracks sometimes form. Deep plowing and careful mulching will keep the soil in better physical condition. Cultivation is a little more difficult owing to the heavier character of the soil, but with proper drainage and plowing at the right time, the soil may be kept in good condition for crop growth. The application of small amounts of farm manure will prove of value on the type. The addition of limestone is necesary as the soil is acid in reaction. The use of a phosphate fertilizer would also help, and tests of rock phosphate and superphosphate are recommended. In the tests which have been carried out in the field it has been shown that these treatments would prove distinctly profitable.

### Grundy Silt Loam (light colored phase) (G) (260)

The light colored phase of the Grundy silt loam is a very minor soil in the county, covering only 0.1 percent of the total area. It occurs in a few areas in the northeastern part of the county, where it occupies flat divides adjacent to areas of light-colored rolling Clinton silt loam.

The surface soil to a depth of 10 inches is a grayish-brown floury silt loam, the lower part of which is in many places lighter colored. Below this point and extending to a depth of 18 inches there is a tough plastic olive-gray silty clay. The lower subsoil is a brown very tough plastic silty clay which below 25 inches becomes more yellow and contains gray mottlings and iron stains. The soil differs from the typical Grundy silt loam in the lighter color of the surface soil and the slightly grayer subsoil.

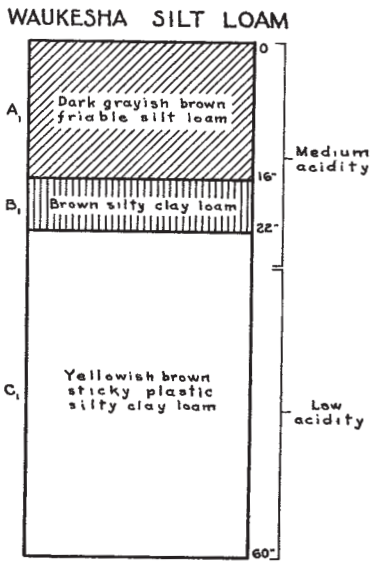
The greater part of the land is now under cultivation, and general farm crops are grown. The yields are somewhat lower than on the typical Grundy silt loam, as might be expected. The land is usually adequately drained now, and there is no need for further tiling. The soil needs mainly to be built up in organic matter and should receive liberal amounts of farm manure. It would also be benefited by the turning under of legumes as green manures. These treatments are extremely desirable if crop yields are to prove satisfactory. The type is acid in reaction and the application of limestone is necessary for the growth of all crops and especially legumes. The use of a phosphate fertilizer would be of value and tests of superphosphate are recommended.

## TERRACE SOILS

There are 5 terrace soils in the county, classified in the Waukesha, Judson, Bremer and Jackson series. Together they cover 1.5 percent of the total area.

### Waukesha Silt Loam (Wt) (75)

The Waukesha silt loam is the largest of the terrace soils, but it is small in total area, covering only 0.9 percent of the total area of the county. It occurs on the high terraces or second bottomlands along the larger streams of the county. The largest developments are along the North Skunk River, lying about 20 to 30 feet above the bottoms. Other fair-sized areas occur along Bear, Little Bear and Walnut creeks.




The surface soil of the type is a dark grayish-brown friable silt loam, extending to a depth of about 16 inches. From 16 to 22 inches there is a transitional layer consisting of a brown silty clay loam, marked with streaks of organic matter from above, these dark colorations decreasing with depth. The subsoil below 22 inches is a yellowish-brown sticky and plastic silty clay loam, containing practically no grit to a depth of 6 to 8 feet. There are some variations in the soil in different areas. In a few low depressed areas the surface soil is almost a silty clay loam in texture, and in other areas some sand has been washed down from the slopes and spread over the land.

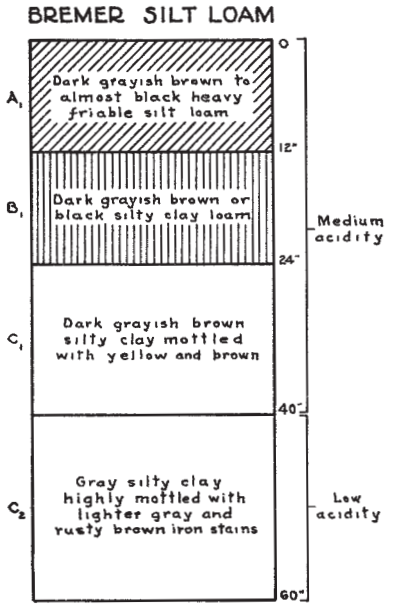
The Waukesha silt loam is flat in topography, the terraces on which it occurs being from 5 to 30 feet above the first bottomlands and well above overflow. The type is well drained and it is all under cultivation. General farm crops are grown, and the yields are much the same as on the Tama silt loam. The soil will respond in a very large way to the application of farm manure and the turning under of legumes as green manures will also help. The soil is acid and in need of liming. The use of a phosphate fertilizer would help, and tests of superphosphate are recommeded.

## Judson Silt Loam (Js) (131)

The Judson silt loam is a minor type in the county, covering only 0.2 percent of the total area. It occurs widely scattered along the second bottoms of the various streams of the county. Most of it is found in small disconnected strips as the bases of hill slopes adjacent to the bottomlands, and it lies above overflow. Areas of the type are found along Buck and Sugar creeks, which are tributaries of the North Skunk River, Bear Creek, the North Fork English River and a few smaller or tributary creeks.

The surface soil of the Judson silt loam is a dark grayish-brown friable silt loam, extending to a depth of about six inches, and containing some colluvial wash which consists of very fine sand from the adjacent drift slopes. From 6 to 28 inches there is a dark brown silt loam containing layers, ranging from one-half to 2 inches in thickness, of lighter silt material. The lower subsoil layer, below 28 inches is an almost black silty clay loam. The boundaries between this soil and the first bottom types are necessarily somewhat arbitrary, as there is a gradual change from one type to the others.

The type is all under cultivation, and the yields of farm crops are usually high. Corn yields from 45 to 70 bushels per acre, and small grain and hay yields are correspondingly good. The soil is well drained and chiefly in need of manure, lime to correct the acidity and a phosphate fertilizer to make it most satisfactorily productive. Yields of crops may be increased by proper treatments with these fertilizing materials.




## Bremer Silt Loam (Bl) (88)

The Bremer silt loam is a minor type in the area, covering only 0.2 percent of the county. It occurs on terraces, principally along the North Skunk River. A few small areas lie along the North Fork English River, Bear Creek and Walnut Creek. The terraces where the type occurs lie from 4 to 30 feet above the present flood plains of the streams and the soil occupies a flat, depressed position, usually at the back of the terraces where it joins the upland slopes. In some places there is a gradual slope toward the bottoms.

The surface soil of the Bremer silt loam is a very dark grayish-brown or almost black silt loam, which is heavy but friable. It extends to a depth of about 12 inches. From 12 to 24 inches there is a dark grayish-brown or black silty clay loam. From 24 to 40 inches the subsoil is a dark grayish-brown silty clay mottled with yellow and brown. Below 40

inches the lower subsoil is a gray silty clay highly mottled with lighter gray and rusty-brown iron stains. In a few areas the subsoil is lighter than typical and resembles the subsoil of the Waukesha silt loam in color and texture.

Practically all the land in the type is under cultivation, and the yields of general farm crops are much the same as on the Grundy silt loam. The type is not thoroughly drained and in some areas there is need for more adequate drainage before the yields of crops can be made entirely satisfactory. The soil will be benefited by small amounts of farm manure, especially on newly drained areas. Large applications, however, should not be made. The soil is acid and in need of lime for the best crop growth. The use of a phosphate fertilizer would help, and tests of rock phosphate and superphosphate are recommended.

### Bremer Silty Clay Loam (Bs) (43)

The Bremer silty clay loam is of very minor occurrence in the county, covering only 0.1 percent of the total area. It occurs only in a few small areas on the low terraces along the North Skunk River, the North Fork English River and Bear Creek.

The surface soil of the type to a depth of about 6 inches is a black sticky and plastic silty clay loam. From this point to a depth of 19 inches there is a uniform black tough plastic silty clay. From 19 to about 25 inches there is a transitional layer consisting of a dull gray heavy tough silty clay, discolored by dark organic matter streaks from above. The lower subsoil from 25 inches on down is an olive-gray heavy silty clay somewhat mottled with yellow, brown and a few rusty-brown and orange-brown iron stains.

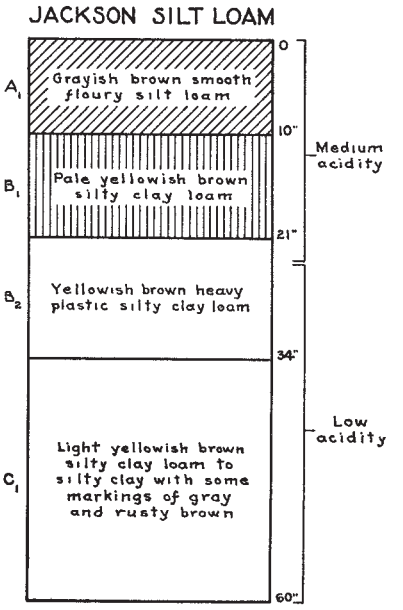
Most of the land in the type is under cultivation in spite of the fact that only a small percentage has been adequately drained. The land is particularly in need of drainage, if it is to be satisfactorily cropped and when well drained it is highly productive, giving yields similar to those obtained on the Grundy silty clay loam. When drained, the soil will be benefited by small applications of farm manure but large additions should not be made. The soil is acid and in need of liming, and the use of a phosphate fertilizer would prove of value. Tests of rock phosphate and superphosphate are desirable.

### Jackson Silt Loam (J) (81)

The Jackson silt loam is a minor type, covering only 0.1 percent of the total area of the county. It occurs in a few small areas on the terraces along Walnut Creek and along Buck Creek at the Mahaska County line.

The surface soil of the Jackson silt loam is a grayish-brown smooth floury silt loam, extending to a depth of about 10 inches. From 10 to 21 inches there is a pale yellowish-brown silty clay loam containing much silt. The material becomes heavier with depth. Below 21 inches there is a yellowish-brown heavy plastic silty clay loam to a depth of 34 inches, and below this point the subsoil is a light yellowish-brown silty clay loam to silty clay with some markings of

gray and rusty-brown. Included with this soil because of its small area, there is a light-colored soil which differs from the typical Jackson silt loam. This soil is lighter textured and has a better subsoil drainage than the Jackson. The subsoil is a light yellowish-brown heavy silt loam or light silty clay loam. Small spots of sandy loam occur in places in the type too, and there are variations due to the colluvial wash from the adjacent uplands. The subsoil variations include the areas mentioned above and also other areas where the subsoil is somewhat lighter than typical.




The Jackson silt loam occupies terraces, usually from 6 to 10 feet above the first bottoms, and the land is nearly everywhere adequately drained. The soil is used for general farm crops, and the yields are much the same as on the Clinton silt loam on the uplands. The type is in need of organic matter especially, and liberal additions of farm manure would prove of large value. The turning under of legumes as green manures would also help. The soil is acid and in need of liming. The use of a phosphate fertilizer would prove worth while, and tests of superphosphate are urged.

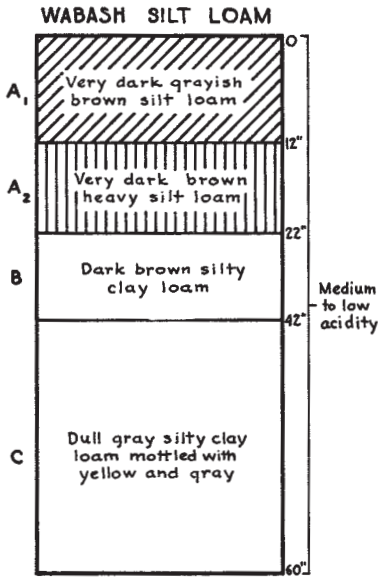
## SWAMP AND BOTTOMLAND SOILS

There are 4 swamp and bottomland soils in the county, classified in the Wabash and Genesee series, and together they cover 15.6 percent of the total area.

### Wabash Silt Loam (Wm) (26)

The Wabash silt loam is the largest of the bottomland soils and the second largest type in the county, covering 8.8 percent of the total area.It occurs along all the main streams and their tributaries, in many areas, varying widely in size, but usually in narrow strips along the streams. The soil is subject to overflow.

The surface soil of the Wabash silt loam to a depth of about 8 inches is a dark grayish-brown friable silt loam. From 8 to 17 inches there is a dark brown silt loam slightly heavier and darker than the surface soil. Below this and extending to a depth ranging from 24 to 28 inches there is a dark grayish-brown silty clay loam which changes abruptly to a moderately dark grayish-brown silty clay loam. From 28 inches on down there is a dark grayish-brown silty clay marked with black, brown and reddish-brown stains. Where the soil occurs in the draws at the heads of drainageways, silty materials have been carried down from the slopes, and here the soil is mapped as the colluvial phase. Many areas of heavier soil, really a silty clay loam, have been included with the type because of their small extent. Where these areas are




sufficiently large they have been separated as the silty clay loam. In the southwestern part of the county along the North Skunk River and its tributaries and along Walnut Creek in the northeastern part of the area, there are deposits of a lighter silty material, washed down from the Clinton silt loam slopes and spread over the dark-colored soil to a depth of a few inches. These spots have been included with the type because of their small extent.

On the wider bottoms, the areas of Wabash silt loam have a scattered growth of trees, mostly close to the stream channel. The native trees are chiefly post oak, ash, cottonwood, willow, red haw and thornapple. The greater part of the land is used for pasture as periodic floods endanger the crops. It produces a luxuriant growth of bluegrass and native pasture grasses. On the wider stream bottoms, there is a considerable acreage in corn, and yields in favorable seasons are high. Until the land is protected from overflow and well drained, it is better left in pasture and not cultivated. When cultivated it would respond to applications of farm manure, lime to correct its acidity and the use of a phosphate fertilizer.

### Wabash Silt Loam (colluvial phase) (Wm) (26a)

The colluvial phase of the Wabash silt loam is much smaller than the typical soil in area, covering 6.1 percent of the county. It occurs in many areas in all parts of the county, at the heads of the smaller drainageways and in the gentle draws. Definite channels have not yet been formed in many of these draws over much of the area, and in other parts the channels are quite shallow.

The surface soil of this type is a very dark grayish-brown friable silt loam extending to a depth of about 14 inches. From 14 to 30 inches there is a dark grayish-brown silty clay loam only slightly heavier than the surface soil. Between 30 and 42 inches the subsoil is a dark grayish-brown silty clay loam. The surface soil varies considerably in different areas, in many places consisting of layers of silty clay loam and silt loam, the silty clay loam patches being almost black in color.

Most of the land in the type is under cultivation, and yields of the general farm crops are much the same as those obtained on the Tama silt loam with which the type is associated. The drainage of the soil is usually adequate, but in some of the depressions where the soil is somewhat heavier in texture, tiling is necessary. Also in a few nearly flat basinlike bodies of the type at the heads of some of the tributary streams, drainage is needed. The soil will be benefited by an application of farm manure and the turning under of legumes as green manures. The type is acid in reaction and must be limed for the best growth of crops. The use of a phosphate fertilizer is necessary, and tests of superphosphate and rock phosphate are recommended.

## Wabash Silty Clay Loam (Wa) (48)

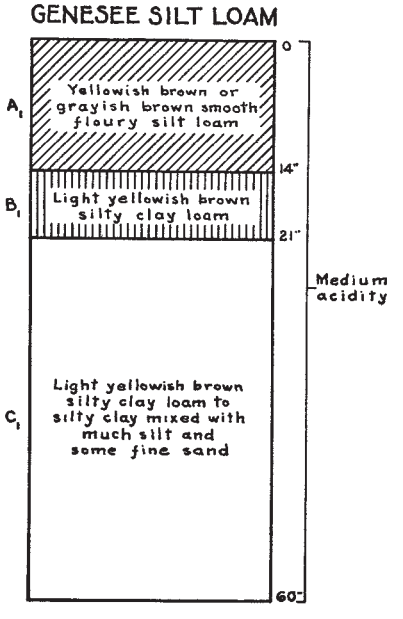
The Wabash silty clay loam is a minor type in the county, covering 0.6 percent of the total area. It occurs on the bottomlands along the various streams of the county, generally being found adjacent to the uplands, and separated from the stream channels by other bottomland types. The largest areas appear along the North Fork English River, the North Skunk River and Bear Creek. Small areas are found along other streams.

The surface soil to a depth of about 10 inches is a very dark grayish-brown of black heavy, sticky silty clay loam. From 10 to 19 inches there is a dark grayish-brown or black silty clay. Between 19 and 26 inches the soil is a dark grayish-brown or dark-gray silty clay, containing a few faint yellowish-brown mottlings. The lower subsoil layer is a yellowish-brown or grayish-brown silty clay, highly mottled with yellow and some gray. Iron stains are evident at a depth of 35 to 40 inches. Both the mottlings and stains increase with depth.

About one-half of the type is under cultivation and the remainder is in pasture. The soil occurs in flat basinlike positions, and hence it is naturally poorly drained. Small patches of muck occur in a few formerly ponded areas. These are evidence of the former poorly drained condition of the soil. When well drained the soil will produce excellent crops, provided, of course, there is no overflow. Corn yields from 40 to 60 bushels per acre in favorable seasons. Small grains do not do as well as they are apt to lodge. Hay crops grow well. Some wild hay is cut on the poorly drained areas. The soil will respond to light applications of farm manure. Liming is necessary to correct the acidity of the soil, and the use of a phosphate fertilizer would undoubtedly prove of value.

## Genesee Silt Loam (Gl) (71)

The Genesee silt loam is a minor type in the county, covering only 0.1 percent of the total area. It occurs on the bottomlands along some of the streams, most of it being found in Sugar Creek Township and a small area occurring along Walnut Creek in Jefferson Township.




The surface soil of the Genesee silt loam is yellowish-brown or grayish-brown smooth floury silt loam, extending to a depth of about 14 inches. From 14 to 21 inches there is a light yellowish-brown silty clay loam containing considerable silt and fine sand. Below 21 inches there is a light yellowish-brown clay loam mixed with much silt and some very fine sand. A few orange-brown iron stains and splotches occur, becoming more numerous below 36 inches. In places the soil consists of layers of darker colored silt and clay. Another variation is characterized by a layer of light-colored silt, from 4 to 20 inches thick, over black silty clay. Such

areas would have been mapped as Ray silt loam had they been of sufficient size, but they are included with the Genesee silt loam.

The type is used only for pasture and it is subject to periodic overflow. If it were to be cultivated it would be benefited by liberal applications of farm manure and the turning under of legumes as green manures. The soil is acid and must be limed, especially for legume growth. The use of a phosphate fertilizer would help, and tests of superphosphate would be desirable.

# 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 proved value are suggested.

### SOILS GROUPED BY TYPES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The common soil constituents may be given as follows:†

| | |
|---|---|
| Organic Matter | All partially destroyed or decomposed vegetable and animal matter. |
| 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—05.—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.

*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 1 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.

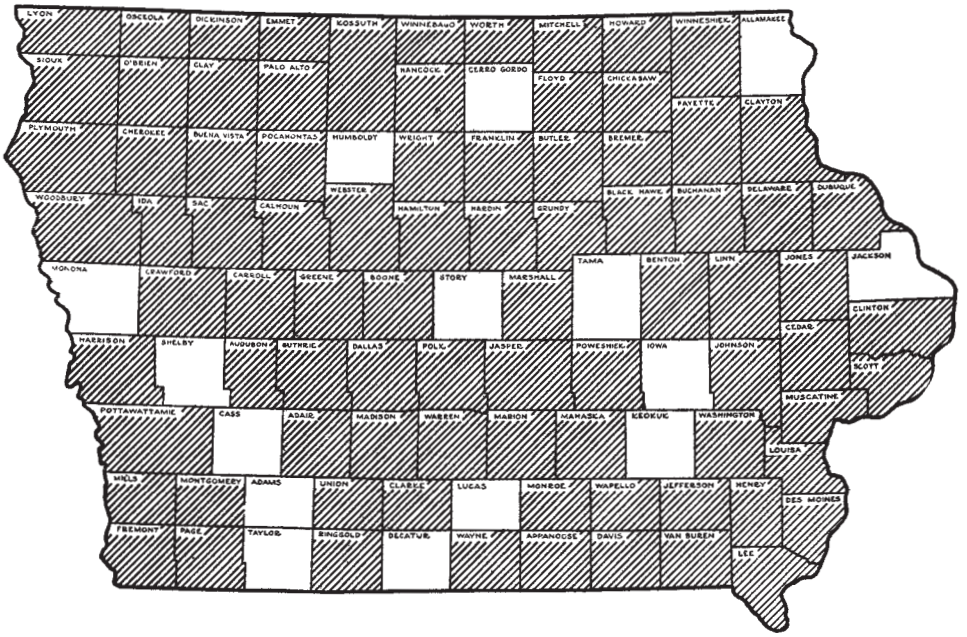
The section is the unit area by which each county is surveyed and mapped. The distances in the roads are determined by an odometer attached to the vehicle, and in the field by pacing, which is done with accuracy. The directions of the streams, roads, railroads, etc., are determined by the use of the 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 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 occcur.

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 inspections 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 section maps or 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.




Map of Iowa showing the counties surveyed.

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