Soil Survey of Iowa, Report No. 61—Howard County Soils

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SOIL SURVEY OF IOWA
HOWARD COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section
Soils

Soil Survey Report No. 61
October, 1930
Ames, Iowa
IOWA AGRICULTURAL EXPERIMENT STATION

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33 Mills County.

*For list of additional publications on soils see inside back cover.
SOIL SURVEY OF IOWA

Report No. 61—HOWARD COUNTY SOILS

By W. H. Stevenson and P. E. Brown, with the assistance of C. L. Orrben, L. W. Forman, H. R. Meldrum and R. E. Bennett

IOWA AGRICULTURAL EXPERIMENT STATION
C. F. Curtiss, Director
Ames, Iowa
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HOWARD COUNTY SOILS*

Howard County is located in northeastern Iowa in the third tier of counties west of the Mississippi River, and to the north it borders the state of Minnesota. It is almost entirely in the Iowan drift soil area, and the soils are mainly of glacial origin. The Mississippi loess soil area extends over the northeastern corner of the county, and in that section the soils were laid down by wind action.

The total area of the county is 468 square miles or 299,520 acres. Of this area, 293,434 acres or 97.9 percent are in farm land. The total number of farms is 1,682 and the average size is 174 acres. Owners operate 44.8 percent of the farm land and the remaining 55.2 percent is operated by renters. The following figures taken from the Iowa Yearbook of Agriculture for 1928 show the utilization of the farm land of the county:

- Acreage in general farm crops: 182,846
- Acreage in farm buildings, public highways and feed lots: 14,196
- Acreage in pasture: 89,437
- Acreage in waste land not utilized for any purpose: 1,831
- Acreage in farm woodlots used for timber only: 1,836
- Acreage in farm land lying idle: 3,272
- Acreage in crops not otherwise listed: 56

THE TYPE OF AGRICULTURE IN HOWARD COUNTY

The type of agriculture practiced in Howard County at the present time consists chiefly of a system of general farming, including the production of corn, oats, hay and occasional cash crops of wheat, barley or flax, along with the raising and feeding of dairy cattle, beef cattle and hogs. The chief source of income on most farms is from the sale of livestock. Hog raising and feeding is the most extensively developed livestock industry. Dairying is practiced to some extent, and on many farms considerable income is derived from this source. The raising of beef cattle is an important livestock industry in the county, and some sheep raising is practiced. Formerly, practically all of the grain and forage that was raised was fed on the farms. In recent years more grain has been sold. At the present time, however, the greater portion is used for feeding purposes. On individual farms some income is derived from the sale of special crops such as wheat, barley, rye, buckwheat, flax and potatoes. The sale of poultry and poultry products is coming to be considered an important source of income to the farmers in the county.

There is a considerable area of waste land in the county, some of which might

*See soil survey of Howard County, Iowa, by C. L. Orrben of the Iowa Agricultural Experiment Station in charge and A. L. Gray of the United States Department of Agriculture. Field operations of the Bureau of Soils, 1925.
be made productive thru the adoption of proper methods of soil management. General recommendations for the handling of waste lands cannot be given as there are various causes for unproductiveness. Later in this report, in the description of individual soil types, suggestions will be offered regarding the best methods of handling unproductive areas of various soil types. Where the conditions are more or less abnormal, advice regarding soil treatments may be secured upon request from the Soils Section of the Iowa Agricultural Experiment Station.

GENERAL FARM CROPS GROWN IN HOWARD COUNTY

The general farm crops grown in Howard County in the order of their importance are corn, oats, hay, barley, potatoes, flax, buckwheat, wheat and rye. The acreage, yields and value of these crops are given in table I.

Corn leads all other crops in value and is second in crop acreage. In 1928 it was grown on 20 percent of the total farm land and average yields amounted to 31.3 bushels per acre. On the better farms, where good systems of soil management are being practiced, yields are very much higher. The most popular varieties are Silver King, Minnesota 13, Kossuth Reliance, Early Murdock, Calico, Iowa Silvermine and crosses and strains of these varieties. Early maturing varieties are necessary in this county. Formerly, practically all of the corn crop was fed on the farms, but in recent years more of it has been utilized as a cash crop. Some of the corn is used for fodder and in a few cases hogging down is practiced. There are a number of silos in the county, and much of the crop is used for silage. At

TABLE I. ACREAGE YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN HOWARD COUNTY, IOWA*
the present time the major portion of the corn is produced for feeding purposes, but there is some sale of corn on the markets, chiefly from the tenant farms.

Oats are grown extensively, being the leading crop in acreage and second in value to corn. In 1928 oats were grown on 20.4 percent of the total farm land, and average yields amounted to 33 bushels per acre. In favorable seasons and on the better soils, yields are frequently higher. The most commonly grown varieties are Kherson, Iowa 103, Iowa 105 and Early Champion. Practically all of the oats grown are utilized as feed for work animals, dairy cows and hogs. A small amount is sold on the markets.

Hay is the third crop in acreage and value. Clover and timothy mixed is the hay crop most extensively grown. Average yields amounted to 0.86 ton per acre in 1928 when this crop was produced on 6.6 percent of the total farm land. Clover alone is grown to a very small extent and its average yield in 1928 was 1.27 tons per acre. During the same season timothy hay occupied 5.1 percent of the total farm land and averaged 0.83 ton per acre. Some timothy is grown for seed. Alfalfa is produced on a small acreage. Average yields in 1928 were estimated at 2.77 tons per acre. Some sweet clover is grown. Both alfalfa and sweet clover may be grown successfully with proper methods of handling and soil treatment. Both crops would prove of value from the standpoint of improving the soil conditions. Wild hay is grown on a considerable acreage, especially in the broad, poorly drained swales. In 1928, wild hay was grown on 3.9 percent of the total farm land, and average yields amounted to 0.84 ton per acre.

Barley is grown to some extent, in 1928 being found on 2 percent of the total farm land. Average yields of this crop amounted to 29.4 bushels per acre. Most of the crop is used for feeding purposes on the farms, but in some cases barley serves as a cash crop.

Potatoes are grown on practically all farms and are an important crop. In 1928 the average yield amounted to 162 bushels per acre. Practically all of the potatoes produced are utilized for home consumption.

Minor crops grown include wheat of both spring and winter varieties, rye, soybeans, popcorn, flax and buckwheat. Wheat is produced on a very limited acreage, the spring varieties being utilized more largely. In 1928 the average yield of this crop amounted to 17.9 bushels per acre. Rye is grown to a very limited extent. Some flax is grown on newly drained areas. Buckwheat frequently serves as a substitute crop. Soybeans are grown on small areas, chiefly on an experimental basis. Several of these minor crops serve as cash crops on individual farms.

THE LIVESTOCK INDUSTRY IN HOWARD COUNTY

The livestock industry in Howard County includes the raising and fattening of hogs, the raising and feeding of beef cattle, dairying, sheep raising and some horse raising. The following figures taken from the Iowa Monthly Crop Report of July, 1928, giving the Jan. 1, 1928, estimates made by the Bureau of Agricultural Economics of the United States Department of Agriculture in cooperation with the Iowa State Department of Agriculture, show the extent of the livestock industry:
Hog raising is one of the most important of the livestock industries. On the average 45 head of hogs are kept on each farm, but the actual number varies widely depending upon the particular conditions. The Duroc Jersey, Poland China and Chester White are the most popular breeds. On Jan. 1, 1928 there were 58,000 hogs on the farms in the county. The sale of hogs provides the chief source of income on most farms.

Dairying is a profitable industry and there are a number of farms operated on a definite dairy basis. Ordinarily the herds consist of from 25 to 30 cows. The Holstein breed is usually preferred. There are some Jersey, Guernsey and Brown Swiss cattle. Milking strains of beef cattle and grades also are used for dairy purposes. Milk and cream are disposed of at creameries. There is one cheese factory at Jamestown. The butter produced at the creameries is shipped to Chicago and eastern markets.

The raising and feeding of beef cattle is practiced quite extensively, and the sale of beef cattle provides a large part of the farm income. The Shorthorn, Angus and Hereford are the most popular breeds. Many feeders are purchased on the market, pastured thru the summer, fed heavily on corn and concentrates for a period varying between 60 and 100 days and marketed as fat cattle.

The sheep industry is of minor importance, but the sale of sheep provides considerable income on individual farms. On Jan. 1, 1928, there were 7,500 sheep on the farms in the county. The Shropshire, Hampshire and Southdown are the favorite breeds. Flocks of from 20 to 75 head of sheep are kept on many farms in the wooded sections of the county.

The raising of horses is practiced to a very limited extent, one or two colts being raised each year on many farms to provide work animals. A few horses are available for sale. The Belgian, Percheron and Clydesdale are the breeds most commonly found.

The value of the farm land in Howard County varies widely, depending upon its location with reference to towns and railway facilities, improvements, character of the soil, topography and fertility conditions. The better type of farm land will average in value somewhere around $200 per acre, while that in the rougher sections will average about $50 per acre.

THE FERTILITY IN HOWARD COUNTY SOILS

The soils in Howard County generally may be considered satisfactorily productive, but in many cases larger crop yields may be secured thru the adoption of proper methods of farm management. Some of the land in the county is poorly drained, and in such cases the installation of tile is the first treatment needed. The Clyde silt loam on the drift upland, and especially the mucky phase, is very poorly drained. There are areas in some of the other types where drainage would be beneficial. In general it may be said that wherever the soil is not properly drained and water stands on the land for long periods following each rainfall, the installation of tile would be very desirable.
All the surface soils in the county are acid in reaction, and the application of lime is very desirable for the best growth of general farm crops and particularly for legumes such as clover and alfalfa. It is important that all of the soils be tested for lime requirements, and that lime be applied in the amounts shown to be necessary in order to correct the acidity. The yields of most legumes are increased to a very large extent by the application of lime, and in many cases considerable increases are secured in yields of corn and small grain. Farmers in this county should see to it that their soils are tested regularly, at least once in a four-year rotation, preferably preceding the legume crop, and that lime is applied as needed. Only in this way will they be enabled to secure the best crop growth and maintain the fertility of their soils permanently.

Some of the soil types are not particularly high in organic matter and nitrogen, and in such cases applications of fertilizing materials supplying these constituents are desirable. The lack of organic matter and nitrogen is evidenced particularly in the sandy soils such as the Dickinson fine sandy loam, Dickinson loam, Lindley fine sandy loam and Carrington fine sandy loam on the drift uplands. The Fayette silt loam on the loessial upland and the O'Neill and LaCrosse types on the terraces are also poorly supplied with organic matter. In some of the other types, such as the Carrington, Floyd and Tama soils, the addition of a fertilizer supplying organic matter would be very desirable. On all the soils it is important that organic matter be supplied regularly if the content is to be maintained. Farm manure is an extremely valuable fertilizer for use on all of these soils and large increases in the yields of general farm crops are secured from its application. It is also important that all crop residues be turned under in order to aid in maintaining the supply of organic matter. The use of leguminous crops as green manures is of large value in supplying nitrogen as well as organic matter to the soil. The light colored, coarse textured types will be benefited particularly by green manures and farm manure, and the addition of these fertilizing materials is necessary in all cases for the maintenance of soil fertility.

Most of the soils are rather poorly supplied with phosphorus, and the use of phosphorus fertilizers will certainly be needed in the near future. Experiments which have been carried out on these soils and the experiences of some farmers show that superphosphate or rock phosphate may be used in many cases at the present time with large profit. Tests of both of these phosphorus carriers are recommended. Farmers may conduct simple tests under their own conditions and determine whether or not phosphorus will be of value on their soils and which phosphate carrier may be applied with the larger profit.

Complete commercial fertilizers cannot be recommended for general use on these soils at the present time. It seems possible that phosphorus fertilizers will generally bring about quite as large crop increases at a lower cost per acre. There is no objection to the use of any complete commercial fertilizer, however, if it proves profitable. Farmers who are interested are urged to test complete fertilizers on their land in comparison with superphosphate before making an extensive application of the complete brand. In this way they may determine the relative profit which may be secured from the two materials. Commercial nitrogenous fertilizers are probably unnecessary on these soils inasmuch as nitrogen may be
more cheaply and quite as satisfactorily supplied by turning under leguminous crops as green manures. Commercial potassium fertilizers may prove profitable for use in certain cases, but tests should always be carried out on small areas before they are applied extensively. Only by carrying out such tests is it possible to be sure of economic returns from an application.

Erosion occurs to a limited extent in the county, and some of the upland types have been rather badly washed. Usually, however, the washing is of the sheet erosion type, and hence is less evident altho quite as injurious as the gully type. In a later section of the report suggestions will be offered regarding the handling of soils to prevent the injurious erosive action of water.

THE GEOLOGY OF HOWARD COUNTY

The early geological history of Howard County is of little significance in connection with the study of the soil conditions at the present time. The earlier rock deposits were very largely buried by later deposits of drift and loess and have little influence on present day soil conditions. Only in the east central part of the county, near Cresco, are there any extensive evidences of the early rock formations. Limestone exposures occur along the streams, and in the hilly sections fragments of rock are scattered over the surface of the ridges and slopes. The Turkey River flowing thru this area has cut thru the limestone, forming a rough walled gorge. Thin layers of drift or loess cover these rock formations, and the Dodgeville loam has been mapped in the drift section and the Dodgeville silt loam in the loess section. The surface soil is very shallow in both these types, varying from 4 to 12 inches in thickness. It rests upon a reddish-brown, waxy, stiff, compact clay which is derived from the underlying limestone. The Dodgeville soils are the only types which are influenced by the rock formations.

All of the soils of the county with the exception of the Dodgeville types are derived from glacial and loessial materials. At least three times during the glacial age, great ice sheets swept over the county and upon their retreat left behind vast deposits of debris or glacial till. The earliest of these glacial deposits, the pre-Kansan, consisted of a greenish-blue or grayish-blue clay filled with gravel and boulders. This early deposit had no effect on the soil types present except in the case of some of the subsoils.

The second glacier, the Kansan, swept over the county and deposited drift material consisting largely of blue clay, containing much sand and gravel and occasionally boulders. When weathered the Kansan till is a reddish-brown grading into a yellowish, boulder clay. The subsoils of the Lindley types are derived from the Kansan till. It has also undoubtedly affected the subsoils of some of the other drift types.

The third glacier, the Iowan, covered all but the northeastern part of the county, depositing a layer of glacial till varying from 10 to 20 feet in thickness. The original drift material consisted of a yellowish clay, containing coarse gravel and many boulders. Almost 95 percent of the total area of the county is covered by the Iowan drift material. The soils of the Carrington, Clyde, Floyd and Dickinson series are derived from the Iowan drift. The dark colored, well drained types
are found in the Carrington and Dickinson series, the latter being developed over the more sandy drift deposits. The Clyde soils have formed in the poorly drained valleys and swales and the Floyd soils on the flat uplands.

Later in geological history, when climatic conditions were quite different than at present, a layer of very finely divided silty material known as loess was deposited over the Kansan till in the northeastern part of the county. This deposit is extremely variable in depth, and considerable erosion has occurred in some of the areas covered. The soils of the Tama and Fayette series have been formed from the loess. In the forested areas the lighter colored soil is known as the Fayette. The soils developed on the prairie areas are darker and are mapped in the Tama series. There is a loessial covering over lime rock in this section of the county, and the soil type developed under these conditions is known as the Dodgeville silt loam.

Second bottomlands or terraces have formed to a limited extent along the main streams of the county. Here soils of the O'Neill, Bremer and LaCrosse series have been mapped. The bottomlands are found in narrow strips along the various streams, and the soils formed are classified in the Wabash series. The terrace and bottomland soils are mainly of drift origin. Only in the northeastern part of the county where the loessial material occurs on the upland is there evidence of loessial origin in the terrace and bottomland soils.

PHYSIOGRAPHY AND DRAINAGE

The topography of Howard County is somewhat variable in the various sections. In general the surface is a gently undulating plain except in the northeastern part of the area which is distinctly hilly. This hilly section extends over about 20 square miles and corresponds roughly to the loessial section of the county. In the vicinity of Cresco along the streams, there has been very extensive erosion and considerable areas of the Dodgeville loam, a shallow soil resting on limestone, are mapped. In the remaining portions of the county, the topographic features are most pronounced adjacent to the rivers and larger streams. The broad drift plain originally present has been cut by the streams, considerable erosion has occurred in places and the topography has become somewhat rough. On the divides between the streams and especially on the broad, inter-stream areas in the central and western parts of the county east and west of Crane Creek, the topography is gently undulating.

The Fayette silt loam in the northeastern part of the county is rolling to hilly in topography, and the Tama silt loam is rolling. The Carrington soils in the drift portion of the area are generally slightly undulating to rolling in topography. The Dickinson soils are very similar to the Carrington topographically. The Lindley types are rather rough. The Floyd and Clyde soils are level to flat in topography, and the Dodgeville soils present no striking topographic features.

Various streams and intermittent drainageways extend into practically all parts of the upland, and the natural drainage system is well developed. Rather extensive areas of terrace and bottomland soils occur along Crane Creek, the North Branch Turkey and the Wapsipinicon rivers in the southwestern corner of the county.
In general the streams are bordered by narrow areas of the first and second bottomlands.

Drainage is brought about by the Upper Iowa River with its tributaries in the northern part of the county, the Wapsipinicon and the Little Wapsipinicon rivers in the southwestern part, Crane Creek with its tributaries in the central western section, the Little Turkey River in the southeastern corner and the Turkey, the North Branch Turkey and the South Branch Turkey rivers with their various tributaries in the central eastern section.

Drainage conditions are generally satisfactory in the county except for the areas of Clyde silt loam, and especially the mucky phase of this type, the areas of Floyd silt loam and some of the terrace and bottomland soils, especially the Bremer and Wabash types. Occasionally there are poorly drained areas in some of the upland types of the Carrington series, but ordinarily these soils are naturally well drained. The accompanying map indicates the extensive natural drainage system of the county, and it is evident that a lack of drainage could be expected only in limited areas.

The installation of tile would be of much value in the case of the Clyde silt loam, the mucky phase of this type and in the Floyd silt loam. Wherever small areas of poorly drained soils occur in any of the other types, tiling would be of value. Some of the terrace types as the Bremer soils are in need of drainage,
and in the case of the Wabash soils on the bottoms, tiling would be of value and protection from overflow is necessary.

THE SOILS OF HOWARD COUNTY

The soils of Howard County are grouped into four classes on the basis of their origin and location: drift, loess, terrace, and swamp and bottomland soils. Drift soils are formed from glacial material left behind on the surface of the land when the glaciers retreated. They are variable in composition and contain boulders, pebbles and considerable coarse sand. Loess soils are fine, dust-like deposits made by the wind at some time when climatic conditions were different than at present. Terrace soils are old bottomlands which have been raised above overflow by a deepening of the river channel or by a decrease in the volume of the streams which deposited them. Swamp and bottomland soils occur in low, poorly drained areas or along streams where they are subject to more or less frequent overflow. The extent and occurrence of these groups of soils are shown in table II.

The drift soils cover more than three-fourths of the area of the county, 83.7 percent. The loess soils are of minor extent, covering only 3.3 percent of the total area. Terrace soils are limited in occurrence, occupying 6.5 percent of the area. Bottomland soils are slightly more extensive, covering 7.5 percent of the area.

There are 18 soil types, and these with the mucky phase of the Clyde silt loam and the rough stony land make a total of 20 separate soil areas. There are 10 drift soils including the mucky phase of the Clyde silt loam, three loess types, four terrace soils and three bottomland types including the rough, stony land. The areas of the different soil types are shown in table III.

The Carrington silt loam is the largest drift soil and the most extensively developed individual type. It covers 25.9 percent of the total area. The Carrington loam is the second largest drift soil and the second most extensively developed type, covering 21.9 percent of the area. The Clyde silt loam with the mucky phase which is very limited in extent is the third largest type, covering 16.1 percent of the county. The Floyd silt loam is the fourth largest drift soil and the fifth type in the area, covering 6.5 percent of the county. The Dickinson fine sandy loam is slightly smaller in area, covering 5.9 percent. The Dodgeville loam covers 3.8 percent, the Lindley fine sandy loam 1.5 percent, the Carrington fine sandy loam 0.8 percent and the Dickinson loam 0.3 percent of the area.

The Fayette silt loam is the largest loess type, covering 1.7 percent of the area.

<table>
<thead>
<tr>
<th>Soil group</th>
<th>Acres</th>
<th>Percent of total area of county</th>
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</thead>
<tbody>
<tr>
<td>Drift soils</td>
<td>247,744</td>
<td>82.7</td>
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<tr>
<td>Loess soils</td>
<td>10,176</td>
<td>3.3</td>
</tr>
<tr>
<td>Terrace soils</td>
<td>19,264</td>
<td>6.5</td>
</tr>
<tr>
<td>Swamp and bottomland soils</td>
<td>22,336</td>
<td>7.5</td>
</tr>
<tr>
<td>Total</td>
<td>299,520</td>
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</table>

TABLE II. AREAS OF DIFFERENT GROUPS OF SOILS IN HOWARD COUNTY
TABLE III. AREAS OF DIFFERENT SOIL TYPES IN HOWARD COUNTY

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<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Acres</th>
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<tbody>
<tr>
<td>83</td>
<td>Carrington silt loam</td>
<td>77,696</td>
<td>25.9</td>
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<tr>
<td>1</td>
<td>Carrington loam</td>
<td>65,536</td>
<td>21.9</td>
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<tr>
<td>84</td>
<td>Clyde silt loam</td>
<td>48,000</td>
<td>16.1</td>
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<tr>
<td>230</td>
<td>Clyde silt loam (mucky phase)</td>
<td>384</td>
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<td>198</td>
<td>Floyd silt loam</td>
<td>19,456</td>
<td>6.5</td>
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<tr>
<td>175</td>
<td>Dickinson fine sandy loam</td>
<td>17,536</td>
<td>5.9</td>
</tr>
<tr>
<td>223</td>
<td>Dodgeville loam</td>
<td>11,264</td>
<td>3.8</td>
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<tr>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>4,672</td>
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<td>4</td>
<td>Carrington fine sandy loam</td>
<td>2,368</td>
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<tr>
<td>174</td>
<td>Dickinson loam</td>
<td>832</td>
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<th>Soil No.</th>
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<th>Acres</th>
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<tbody>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>4,032</td>
<td>1.3</td>
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<tr>
<td>163</td>
<td>Fayette silt loam</td>
<td>5,184</td>
<td>1.7</td>
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<tr>
<td>204</td>
<td>Dodgeville silt loam</td>
<td>960</td>
<td>0.3</td>
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<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Acres</th>
<th>Percent of total area of county</th>
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<tr>
<td>108</td>
<td>O'Neill loam</td>
<td>9,920</td>
<td>3.3</td>
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<tr>
<td>110</td>
<td>O'Neill fine sandy loam</td>
<td>8,064</td>
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<tr>
<td>88</td>
<td>Bremer silt loam</td>
<td>1,216</td>
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<tr>
<td>231</td>
<td>LaCrosse sandy loam</td>
<td>64</td>
<td>0.1</td>
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<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Acres</th>
<th>Percent of total area of county</th>
</tr>
</thead>
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<tr>
<td>49</td>
<td>Wabash loam</td>
<td>20,032</td>
<td>6.7</td>
</tr>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>1,728</td>
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</tr>
<tr>
<td>78</td>
<td>Rough stony land</td>
<td>576</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>299,520</td>
<td></td>
</tr>
</tbody>
</table>

The Tama silt loam is slightly smaller, covering 1.3 percent of the county. The Dodgeville silt loam is minor in extent, covering 0.3 percent of the area. The O’Neill loam is the largest terrace soil, covering 3.3 percent of the area. The O’Neill fine sandy loam is smaller, covering only 2.7 percent of the county. The Bremer silt loam and the LaCrosse sandy loam are minor in area, covering 0.4 and 0.1 percent of the county respectively. The Wabash loam is the largest bottomland soil and the fourth largest individual type, covering 6.7 percent of the area. The Wabash silt loam is much smaller in extent, covering only 0.6 percent of the county. There is a small area of rough, stony land, covering 0.2 percent of the total area.

Some relations are apparent between the topographic features of the uplands and the various soil types which are mapped. On the drift uplands, the Clyde and Floyd soils are found on the flat to depressed areas. The Carrington soils occur in the gently undulating to rolling sections, and the Lindley soils are found on the more strongly rolling to rough and broken parts of the county. The Dickinson soils occur in a similar topographic position to the Carrington types. On the loessial uplands the Fayette soils are developed in the rougher sections, while the Tama and Dodgeville soils are found on the more gently undulating to slightly rolling areas. The terrace and bottomland soils show very little evidence of topographic variation. They are quite generally level to flat in topography.
The Fertility in Howard County Soils

Samples were taken for analysis from each of the soil types in the county except the mucky phase of the Clyde silt loam and the rough, stony land. The more extensively developed types were sampled in triplicate, but only one sample was taken in the case of the minor types. All samplings were made with the greatest care so that the results would be representative of the various soil types and that there would be no effect from previous treatments of the soil or from any abnormal soil conditions. Samples were taken at three depths, 0 to 6 2/3 inches, 6 2/3 to 20 inches and 20 to 40 inches, representing the surface soil, the subsurface soil and the subsoil, respectively.

Analyses were made for total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirement. The official methods were employed for the phosphorus, nitrogen and carbon determinations and the Truog qualitative test was used for the limestone requirement determinations. 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 IV. They are calculated on the basis of 2 million pounds of surface soil per acre.

The phosphorus content of the soils varies considerably, ranging from 969 to 6,330 pounds per acre.

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>Carrington silt loam</td>
<td>1,531</td>
<td>5,947</td>
<td>57,057</td>
<td></td>
<td>6,330</td>
</tr>
<tr>
<td>1</td>
<td>Carrington loam</td>
<td>1,313</td>
<td>4,260</td>
<td>45,322</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>84</td>
<td>Clyde silt loam</td>
<td>1,441</td>
<td>9,640</td>
<td>80,555</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>198</td>
<td>Floyd silt loam</td>
<td>1,979</td>
<td>6,120</td>
<td>74,228</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>175</td>
<td>Dickinson fine sandy loam</td>
<td>969</td>
<td>2,000</td>
<td>20,097</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>223</td>
<td>Dodgeville loam</td>
<td>996</td>
<td>3,400</td>
<td>36,896</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>1,373</td>
<td>3,400</td>
<td>39,023</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>4</td>
<td>Carrington fine sandy loam</td>
<td>1,104</td>
<td>3,160</td>
<td>34,060</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>174</td>
<td>Dickinson loam</td>
<td>1,279</td>
<td>3,840</td>
<td>36,759</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>1,279</td>
<td>5,040</td>
<td>48,704</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>163</td>
<td>Fayette silt loam</td>
<td>1,360</td>
<td>2,720</td>
<td>26,942</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>204</td>
<td>Dodgeville silt loam</td>
<td>1,091</td>
<td>4,280</td>
<td>43,168</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>108</td>
<td>O'Neill loam</td>
<td>1,549</td>
<td>5,760</td>
<td>50,231</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>110</td>
<td>O'Neill fine sandy loam</td>
<td>1,144</td>
<td>2,800</td>
<td>33,296</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>88</td>
<td>Bremer silt loam</td>
<td>1,884</td>
<td>7,720</td>
<td>74,610</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>231</td>
<td>LaCrosse sandy loam</td>
<td>1,697</td>
<td>1,880</td>
<td>18,898</td>
<td></td>
<td>2,000</td>
</tr>
</tbody>
</table>

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.
pounds per acre in the Dickinson fine sandy loam up to 2,329 pounds in the Wabash silt loam. There is no definite evidence of a relationship between the phosphorus content of the soils and the various soil groups. The bottomland soils are somewhat better supplied on the average than the upland types, which might be expected inasmuch as there has been less plant growth on them and smaller removal of plant food constituents. Generally, there is a much wider variation in the phosphorus content among the soils of the various groups than between groups.

There is some indication of a relationship between the various soil series and the phosphorus supply. The Floyd silt loam is the highest in phosphorus content of the drift soils, and the Dodgeville and Dickinson soils are generally the lowest. On the terraces the Bremer and LaCrosse types are higher than the O’Neill, and on the loessial uplands the Dodgeville silt loam is lower than the Tama and Fayette types. Apparently those factors which are important in the differentiation of soil series have an influence on the phosphorus content of the soils. Thus, the color of the soil, the topography, the character of the subsoil and the origin and previous history of the soil all influence the supply of this element. Soils which are darker in color, more level to flat in topography and have heavier subsoils are richer in phosphorus, while the lighter colored types, those more rolling in topography and the coarser textured soils are poorer in this constituent.

The effect of the texture of the soil on the phosphorus content is indicated in several cases. On the drift upland the Carrington silt loam is richer than the loam, and the loam is better supplied than the fine sandy loam. The Dickinson loam contains more than the Dickinson fine sandy loam. The Dodgeville silt loam on the loessial upland is richer than the Dodgeville loam. The O’Neill loam on the terraces is better supplied than the fine sandy loam, and the Wabash silt loam on the bottoms is richer than the Wabash loam. It seems evident from these results that heavy textured soils may be expected to contain more phosphorus than the sandy types. Thus, silt loams are ordinarily better supplied than loams and loams are richer than sandy loams.

From the analyses of all the soils it is quite evident that the phosphorus supply is so low that this element may be a limiting factor in crop growth in the very near future. There is probably a lack of available phosphorus in many of the soil types at the present time. Certainly some phosphorus fertilizer will be needed very soon on these soils to maintain the supply of this constituent even if it is not necessary at the present time.

The soils of the county vary considerably in nitrogen content, ranging from 1,880 pounds in the LaCrosse sandy loam up to 9,640 pounds in the Clyde silt loam. There is no evidence of any relationship between the nitrogen content of the soils and the various soil groups, but the differences seem to reflect the variations in characteristics which serve to distinguish the various soil series. The differences in color, topography and subsoil characteristics indicate differences in nitrogen content. Thus, on the drift upland the Clyde silt loam is the richest in nitrogen. This soil is the darkest in color, level to depressed in topography and has a heavy textured subsoil. The Floyd silt loam is richer than the Carrington, Dickinson, Lindley and Dodgeville types. Like the Clyde silt loam, it is level in
HOWARD COUNTY SOILS

topography and has a rather impervious subsoil. The Carrington soils are somewhat better supplied than the Dickinson, which is due largely to the heavier subsoil conditions. They are very much the same in color. The Lindley soils and Dodgeville types are low in nitrogen because of their rough topography and the shallowness of their surface soils. On the loessial upland the Fayette silt loam is lower in this element than the Tama, due to its rougher topography and lighter color. On the terraces the Bremer soils are much better supplied than the O'Neill and LaCrosse. The Bremer soils are also darker in color and have heavier subsoils. The LaCrosse sandy loam is lower than the O'Neill types.

The influence of the texture of the soil on the nitrogen content is further indicated by the fact that the Carrington silt loam is higher in nitrogen than the loam, which in turn is better supplied than the fine sandy loam. The Dickinson loam is richer than the fine sandy loam and the Dodgeville silt loam is better supplied than the Dodgeville loam. On the terraces the O'Neill loam is richer than the O'Neill fine sandy loam, and on the bottomlands the Wabash silt loam is better supplied than the Wabash loam. In general it appears that fine textured types are richer in nitrogen than coarser textured soils. Silt loams are richer in nitrogen than loams, and these in turn are better supplied than sandy loams or sands.

The majority of the soils are fairly well supplied with nitrogen, but in some cases the amount present is not sufficient to provide for the needs of crops for a long period of years. Some fertilizing material supplying nitrogen will be needed on many of these soils in the near future, and in some cases additions are desirable at the present time.

The content of organic carbon in the soils varies much as the nitrogen. The amount present ranged from 18,898 pounds in the LaCrosse sandy loam up to 80,555 pounds in the Clyde silt loam. These are the same types which were the highest and lowest respectively in nitrogen. As was noted in the case of nitrogen, there was no evidence of a relationship between the organic carbon content and the various soil groups, but the characteristics which serve to differentiate the various soil series seem to be reflected in the content of organic matter. The dark colored types like the Clyde, Carrington and Tama are higher in organic matter than the light colored soils like the Lindley and Fayette. Those occurring in level or depressed areas like the Clyde and Floyd types are generally higher in organic matter than types like the Carrington and Dickinson which are more rolling in topography. Soils having heavy textured subsoils are higher in organic matter than those with sandy subsoils. Thus, the Carrington types are richer than the Dickinson and Lindley soils, and the Bremer soils on the terraces are better supplied than the O'Neill and LaCrosse.

The influence of the texture of the soil is also important, and soils which are fine textured are generally higher in organic matter than those that are coarse textured. Thus the Carrington silt loam is richer than the loam which in turn is higher in organic carbon than the fine sandy loam of the same series. The Dickinson loam is richer than the fine sandy loam, and the O'Neill loam is better supplied than the O'Neill fine sandy loam. On the bottomlands the Wabash silt loam is richer than the Wabash loam.

In the lighter colored, sandy textured soils, the supply of organic matter is not
high, and the use of some fertilizing material supplying organic matter is very desirable at the present time. On all the soils, however, the regular addition of some material supplying organic matter is necessary if the fertility of the land is to be maintained.

All of the soil types in the county are acid in reaction in the surface soil, and, therefore, all are in need of lime. When legumes are to be grown it is especially important that lime be applied, but beneficial effects from the use of lime are shown on all farm crops. The analyses show no inorganic carbon in any of the soils, and the limestone requirements of the various types as given in the table indicate rather extensive lime needs. These results should be considered merely indicative, however, and lime should be applied to soils only after special tests have been made. Farmers may test their own soils for acidity and lime requirement or they may send a small sample to the Soils Section of the Iowa Agricultural Experiment Station where it will be tested free of charge. It is very important that all the soils in the county be tested and that lime be applied as necessary if the best crop yields are to be secured.

THE SUBSURFACE SOILS AND SUBSOILS

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

The results of the analyses of the surface soils seem to indicate quite accurately the needs of the soils of the county, and apparently it is not necessary to consider

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>Carrington silt loam</td>
<td>2,289</td>
<td>7,013</td>
<td>68,974</td>
<td></td>
<td>7,330</td>
</tr>
<tr>
<td>84</td>
<td>Clyde silt loam</td>
<td>1,750</td>
<td>3,920</td>
<td>40,195</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>198</td>
<td>Floyd silt loam</td>
<td>2,424</td>
<td>5,520</td>
<td>57,648</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>175</td>
<td>Dickinson fine sandy loam</td>
<td>1,778</td>
<td>2,960</td>
<td>24,632</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>223</td>
<td>Dodgeville loam</td>
<td>2,020</td>
<td>5,920</td>
<td>51,049</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>2,020</td>
<td>2,480</td>
<td>26,033</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>174</td>
<td>Dickinson loam</td>
<td>1,104</td>
<td>2,560</td>
<td>20,997</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>1,938</td>
<td>6,880</td>
<td>64,484</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>163</td>
<td>Fayette silt loam</td>
<td>2,800</td>
<td>3,230</td>
<td>17,725</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>204</td>
<td>Dodgeville silt loam</td>
<td>1,992</td>
<td>4,960</td>
<td>45,595</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>108</td>
<td>O'Neill loam</td>
<td>1,426</td>
<td>2,000</td>
<td>22,197</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>110</td>
<td>O'Neill fine sandy loam</td>
<td>1,508</td>
<td>2,960</td>
<td>31,360</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>88</td>
<td>Bremer silt loam</td>
<td>2,532</td>
<td>4,000</td>
<td>53,503</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>231</td>
<td>LaCrosse sandy loam</td>
<td>2,478</td>
<td>2,480</td>
<td>17,125</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>49</td>
<td>Wabash loam</td>
<td>4,066</td>
<td>8,400</td>
<td>95,717</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>2,882</td>
<td>8,640</td>
<td>98,826</td>
<td></td>
<td>8,000</td>
</tr>
</tbody>
</table>
### TABLE VI. PLANT FOOD IN HOWARD COUNTY, IOWA, SOILS

Pounds per acre of 6 million pounds of subsoil (20-40")

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>Drift soils: Carrington silt loam</td>
<td>2,087</td>
<td>5,900</td>
<td>38,341</td>
<td>8,000</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Drift soils: Carrington loam</td>
<td>2,139</td>
<td>5,090</td>
<td>30,106</td>
<td>2,081</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>Drift soils: Clyde silt loam</td>
<td>3,192</td>
<td>4,120</td>
<td>18,121</td>
<td>2,167</td>
<td></td>
</tr>
<tr>
<td>198</td>
<td>Drift soils: Floyd silt loam</td>
<td>3,393</td>
<td>3,100</td>
<td>24,589</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>175</td>
<td>Drift soils: Dickinson fine sandy loam</td>
<td>1,818</td>
<td>2,300</td>
<td>10,553</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>223</td>
<td>Drift soils: Dodgeville loam</td>
<td>3,030</td>
<td>4,440</td>
<td>24,297</td>
<td>8,000</td>
<td></td>
</tr>
<tr>
<td>136</td>
<td>Drift soils: Lindley fine sandy loam</td>
<td>2,362</td>
<td>3,520</td>
<td>6,978</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Drift soils: Carrington fine sandy loam</td>
<td>2,667</td>
<td>4,280</td>
<td>36,241</td>
<td>7,000</td>
<td></td>
</tr>
<tr>
<td>174</td>
<td>Drift soils: Dickinson loam</td>
<td>1,414</td>
<td>3,260</td>
<td>20,370</td>
<td>6,000</td>
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</tr>
<tr>
<td></td>
<td><strong>LOESS SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>Loess soils: Tama silt loam</td>
<td>2,262</td>
<td>5,580</td>
<td>40,659</td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td>163</td>
<td>Loess soils: Fayette silt loam</td>
<td>4,200</td>
<td>3,260</td>
<td>15,298</td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>Loess soils: Dodgeville silt loam</td>
<td>2,907</td>
<td>7,180</td>
<td>94,166</td>
<td>9,405</td>
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</tr>
<tr>
<td></td>
<td><strong>TERRACE SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>Terrace soils: O'Neill loam</td>
<td>1,818</td>
<td>1,980</td>
<td>9,816</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>Terrace soils: O'Neill fine sandy loam</td>
<td>1,818</td>
<td>3,320</td>
<td>17,506</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>Terrace soils: Bremer silt loam</td>
<td>3,594</td>
<td>5,420</td>
<td>54,749</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>231</td>
<td>Terrace soils: LaCrosse sandy loam</td>
<td>1,737</td>
<td>8,200</td>
<td>10,038</td>
<td>1,000</td>
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</tr>
<tr>
<td></td>
<td><strong>SWAMP AND BOTTOMLAND SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Swamp and Bottomland soils: Wabash loam</td>
<td>5,133</td>
<td>13,680</td>
<td>111,097</td>
<td>8,000</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Swamp and Bottomland soils: Wabash silt loam</td>
<td>2,625</td>
<td>5,900</td>
<td>43,113</td>
<td>6,000</td>
<td></td>
</tr>
</tbody>
</table>

in detail the analyses of the lower soil layers. No large content of any of the essential plant food constituents appears to be present in the subsurface or subsoil layers of any of the types; hence there is little chance that deficiencies in the surface soil will be supplied from below. In most instances the supply of plant food in the subsurface soil and the subsoil is actually lower than in the surface soil; therefore the needs of the soils as indicated by the analyses of the surface layer, are emphasized.

Considering the data given in tables V and VI, it is apparent that the supply of phosphorus in the soils of the county is low and phosphorus fertilizers will certainly be needed in the near future and will probably be of value in many cases at the present time. The supply of organic matter and nitrogen is not high in any of the types and in some instances is rather low; therefore the need for some fertilizing material supplying organic matter and nitrogen is evident. Regular applications of such fertilizing materials must be made if the supply is to be kept up. The soils are generally acid throughout the soil section, but the Dodgeville types, the Floyd silt loam and the Clyde silt loam show a lime content in the subsoil. The presence of lime in the subsoil, however, has little effect on the need of the surface soil, and in all cases where acidity is shown in the surface soil, the application of lime is necessary for the best growth of general farm crops and particularly of legumes.

**Greenhouse Experiments**

Two greenhouse experiments were carried out on soils from Howard County.
to secure information regarding the fertilizer needs of the soils and the value of certain fertilizing materials. These tests were made on the Carrington loam and the Carrington silt loam, two of the most important soil types in the county. In addition the results of the greenhouse experiment on the Clyde silt loam from Floyd County are included.

The treatments employed in these experiments include the application of manure, lime, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. These materials were used in amounts which were ordinarily employed in the field; hence the results indicate quite definitely the fertilizer effects which may be secured in the field. Manure was applied at the rate of 10 tons per acre, lime was added in sufficient amounts to neutralize the acidity of the soil, rock phosphate was added at the rate of 2,000 pounds per acre, superphosphate at the rate of 250 pounds per acre, a standard 2-12-2 complete commercial fertilizer at the rate of 300 pounds per acre and muriate of potash

Fig. 3. Wheat and clover on Carrington loam from Howard County, greenhouse experiment.

Fig. 4. Clover in greenhouse experiment on Carrington loam from Howard County.
at the rate of 50 pounds per acre. Wheat and clover were grown in the experiments, the clover being seeded about one month after the wheat was up.

THE RESULTS ON THE CARRINGTON LOAM

The results of the experiment on the Carrington loam from Howard County are given in table VII, the figures being the averages of the yields on duplicate pots. The superphosphate showed a slight beneficial effect on the wheat and brought about a large increase on the clover. Lime with the superphosphate increased the yield of wheat considerably and more than doubled the clover yield. The manure alone showed a very large effect on the wheat and on the clover, giving much larger yields than were secured with the application of the lime and superphosphate. Superphosphate applied with the manure increased the wheat yield and had a very large effect on the clover. Lime with the manure and superphosphate benefited both crops. The muriate of potash with the manure, lime and superphosphate increased the yield of wheat to a small extent and showed a pronounced benefit on the clover.

THE RESULTS ON THE CARRINGTON SILT LOAM

The results of the experiment on the Carrington silt loam from Howard County are given in table VIII.

Fig. 5. Wheat and clover on Carrington silt loam from Howard County, greenhouse experiment.
The superphosphate increased the yields of both the wheat and clover to a very pronounced extent, showing particularly large effects on the clover. Lime applied with the superphosphate showed a small effect on the wheat but brought about a pronounced increase in the clover. Manure alone gave a large increase in the yields of both crops. Superphosphate with the manure increased the yields in a very definite way, showing the largest effects on the clover. Lime with the superphosphate and manure proved of benefit to the clover and gave a small increase in the wheat. Muriate of potash with the manure, lime and superphosphate brought about a small increase in the yield of wheat but had a very pronounced effect on the clover.

**TABLE VIII. GREENHOUSE EXPERIMENT, CARRINGTON SILT LOAM, HOWARD COUNTY**

<table>
<thead>
<tr>
<th>Pot No.</th>
<th>Treatment</th>
<th>Weight of wheat grain in grams</th>
<th>Weight of clover in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>7.2</td>
<td>37.9</td>
</tr>
<tr>
<td>2</td>
<td>Superphosphate</td>
<td>11.1</td>
<td>66.9</td>
</tr>
<tr>
<td>3</td>
<td>Limestone + superphosphate</td>
<td>13.1</td>
<td>78.3</td>
</tr>
<tr>
<td>4</td>
<td>Manure</td>
<td>16.4</td>
<td>67.7</td>
</tr>
<tr>
<td>5</td>
<td>Manure + superphosphate</td>
<td>18.0</td>
<td>78.9</td>
</tr>
<tr>
<td>6</td>
<td>Manure + limestone + superphosphate</td>
<td>18.4</td>
<td>85.8</td>
</tr>
<tr>
<td>7</td>
<td>Manure + limestone + superphosphate + potassium</td>
<td>19.1</td>
<td>117.1</td>
</tr>
</tbody>
</table>

**RESULTS ON THE CLYDE SILT LOAM FROM FLOYD COUNTY**

The results of the experiment on the Clyde silt loam from Floyd County are given in table IX. The beneficial influence of manure on this type is evidenced by the increased yields of wheat and clover which were secured in this test. Apparently the use of manure is very desirable on this soil in spite of the fact that it is black in color and well supplied with organic matter. It is acid in reaction, and applications of lime are necessary for best crop growth. The clover crop in this test was benefited materially by the application of lime. No effect was shown on the wheat, but frequently grain crops do not respond to additions of lime. The application of rock phosphate with manure and lime brought about an increase in the yield of wheat but showed little effect on the yield of clover. The superphosphate with the manure and lime increased the yield of wheat slightly but gave a pronounced increase in the yield of clover. The complete commercial fertilizer

Fig. 6. Clover in greenhouse experiment on Carrington silt loam, Howard County.
showed the largest effect on the wheat crop but had a smaller influence on the clover than did the superphosphate.

Field Experiments

No field experiments have been carried out in Howard County but the results of tests which are under way in adjacent counties on the same soil types as those which occur extensively in Howard County will be given in this report to indicate the influence of certain fertilizer treatments. The data obtained on the Carrington silt loam on the Charles City Field in Floyd County, on the Carrington silt loam on the Osage Field in Mitchell County, on the Carrington loam on the Waverly Field No. 2, Series I and II, in Bremer County, on the Carrington loam on the Jesup Field in Black Hawk County, and on the Carrington loam on the Independence Field in Buchanan County are included. The results obtained on these fields may be considered definitely applicable to conditions in Howard County.

These field experiments are all planned to determine the relative value of various soil treatments. They are laid out on land which is representative of the individual soil types and are permanently located by installation of corner stakes. All precautions are taken in the application of fertilizers and in the harvesting of the crops to secure accurate results.

These experiments are carried out under both the livestock and grain systems of farming, manure being applied in the former and crop residues being utilized in the latter. Other fertilizing materials tested include limestone, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. Manure is applied at the rate of 8 tons per acre once in the rotation. Limestone is used in sufficient amounts to neutralize the acidity of the soil. Rock phosphate is added at the rate of 1,000 pounds per acre once in the rotation. Until 1925 this material was applied at the rate of 2,000 pounds per acre once in the rotation. Superphosphate is applied at the rate of 120 pounds of the 20 percent material per acre three times in the four-year rotation. Until 1923 this fertilizer was applied at the rate of 200 pounds of the 16 percent material per acre annually. The old standard 2-8-2 complete commercial fertilizer was applied until 1923 at the rate of 300 pounds per acre annually. Until 1929 the 2-12-2 standard brand was applied at the rate of 202 pounds per acre annually. In 1929 the 2-12-6 complete fertilizer was employed in a sufficient amount to supply the same phosphorus as

### TABLE IX. GREENHOUSE EXPERIMENT, CLYDE SILT LOAM, FLOYD COUNTY

<table>
<thead>
<tr>
<th>Pot No.</th>
<th>Treatment</th>
<th>Weight of wheat grain in grams</th>
<th>Weight of clover in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>4.8</td>
<td>10.1</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>6.3</td>
<td>14.3</td>
</tr>
<tr>
<td>3</td>
<td>Manure + limestone</td>
<td>6.2</td>
<td>16.7</td>
</tr>
<tr>
<td>4</td>
<td>Manure + limestone + rock phosphate</td>
<td>6.7</td>
<td>16.8</td>
</tr>
<tr>
<td>5</td>
<td>Manure + limestone + superphosphate</td>
<td>6.8</td>
<td>20.9</td>
</tr>
<tr>
<td>6</td>
<td>Manure + limestone + complete commercial fertilizer</td>
<td>7.6</td>
<td>17.7</td>
</tr>
</tbody>
</table>
is contained in the 120 pounds of 20 percent superphosphate. The muriate of potash is applied at the rate of 50 pounds per acre three years out of four in the four-year rotation.

THE CHARLES CITY FIELD

The results secured on the Carrington silt loam on the Charles City Field in Floyd County are given in table X. The application of manure increased the crop yields in every season showing the largest effect on the corn in 1926 and on the timothy and clover in 1928. Lime with the manure increased the yields in 1925 and 1928 to a considerable extent but showed little effect on the corn and oats in 1926 and 1927. Rock phosphate with the manure and lime showed no effect on the corn in 1925 but increased the yield of that crop considerably in 1926. It also brought about definite increases in the oats in 1927 and in timothy and clover in 1928. Superphosphate with the manure and lime brought about a large increase in the corn in 1925 but had slightly less effect than the rock phosphate on the corn in 1926. It showed somewhat better effects than the rock phosphate on the oats in 1927. The results from the two phosphates were about the same on the timothy and clover in 1928. The muriate of potash with the manure, lime and superphosphate showed no significant beneficial effects on any of the crops. The complete commercial fertilizer with the manure and lime had less effect than the superphosphate in most cases. On the corn in 1926 it exerted a slightly greater effect.

TABLE X. FIELD EXPERIMENT, CARRINGTON SILT LOAM, FLOYD COUNTY, CHARLES CITY FIELD, SERIES I

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>1925 Corn bu. per acre</th>
<th>1926 Corn bu. per acre</th>
<th>1927 Oats bu. per acre</th>
<th>1928 Timothy and clover tons per acre</th>
<th>1929 Corn bu. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>62.6</td>
<td>44.4</td>
<td>45.6</td>
<td>0.81</td>
<td>80.2</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>75.7</td>
<td>56.8</td>
<td>54.3</td>
<td>1.05</td>
<td>77.8</td>
</tr>
<tr>
<td>3</td>
<td>Manure + limestone</td>
<td>86.2</td>
<td>55.2</td>
<td>56.6</td>
<td>1.16</td>
<td>86.2</td>
</tr>
<tr>
<td>4</td>
<td>Manure + limestone + rock phosphate</td>
<td>86.2</td>
<td>62.4</td>
<td>59.4</td>
<td>1.28</td>
<td>86.2</td>
</tr>
<tr>
<td>5</td>
<td>Check</td>
<td>62.6</td>
<td>45.2</td>
<td>50.8</td>
<td>1.05</td>
<td>62.6</td>
</tr>
<tr>
<td>6</td>
<td>Manure + limestone + superphosphate</td>
<td>92.6</td>
<td>60.4</td>
<td>60.9</td>
<td>1.28</td>
<td>92.6</td>
</tr>
<tr>
<td>7</td>
<td>Manure + limestone + superphosphate + potassium</td>
<td>91.1</td>
<td>56.0</td>
<td>55.2</td>
<td>1.30</td>
<td>91.1</td>
</tr>
<tr>
<td>8</td>
<td>Manure + limestone + complete commercial fertilizer</td>
<td>80.2</td>
<td>61.2</td>
<td>54.9</td>
<td>1.21</td>
<td>80.2</td>
</tr>
<tr>
<td>9</td>
<td>Check</td>
<td>63.3</td>
<td>41.2</td>
<td>45.7</td>
<td>0.76</td>
<td>63.3</td>
</tr>
</tbody>
</table>

(1) Corn replanted, due to cutworm damage. Second planting did not mature, no results.

THE OSAGE FIELD

The results secured on the Carrington silt loam on the Osage Field, Series I, in Mitchell County, are given in table XI. The application of manure increased the crop yields on this soil in practically all cases. In some seasons very large increases were noted as on the oats in 1920, the clover in 1921, the clover and timothy in 1925 and the corn in 1926. Lime with manure increased the crop yields to a considerable extent in all but three cases. No influence was shown on the corn
### Table XI. Field Experiment, Carrington Silt Loam, Mitchell County, Osage Field, Series I

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>1918 Corn bu. per A. (1)</th>
<th>1919 Corn bu. per A.</th>
<th>1920 Oats bu. per A. (2)</th>
<th>1921 Clover tons per A. (3)</th>
<th>1922 Corn bu. per A. (4)</th>
<th>1923 Corn bu. per A. (5)</th>
<th>1924 Oats bu. per A.</th>
<th>1925 Clover and Timothy tons per A. (7)</th>
<th>1926 Corn bu. per A.</th>
<th>1927 Corn bu. per A. (8)</th>
<th>1928 Oats bu. per A.</th>
<th>1929 Corn bu. per A. (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>46.5 55.8 34.6 1.09 58.8 42.3</td>
<td>72.4 0.97 37.3 25.9 60.1 1.47</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>52.8 60.0 60.3 1.55 58.0 50.8</td>
<td>71.0 1.25 51.4 26.6 69.2 2.14</td>
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</tr>
<tr>
<td>3</td>
<td>Manure + lime</td>
<td>52.8 70.0 56.3 1.98 56.8 64.1</td>
<td>82.8 1.64 56.0 41.4 82.8 1.94</td>
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</tr>
<tr>
<td>4</td>
<td>Manure + lime + rock phosphate</td>
<td>54.8 72.0 61.2 2.14 74.3 70.7</td>
<td>86.5 1.68 57.0 43.5 81.7 1.59</td>
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</tr>
<tr>
<td>5</td>
<td>Manure + lime + superphosphate</td>
<td>46.4 77.0 61.2 1.82 76.0 70.7</td>
<td>98.0 1.90 55.7 40.9 71.5 1.90</td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>Manure + lime + complete commercial fertilizer</td>
<td>44.5 79.0 67.3 3.13 72.3 70.2</td>
<td>102.9 1.92 60.8 38.8 72.1 1.66</td>
<td></td>
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</tr>
<tr>
<td>7</td>
<td>Check</td>
<td>38.8 67.0 59.8 1.48 50.0 53.7</td>
<td>74.3 1.24 46.0 25.5 63.5 1.78</td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Crop residues</td>
<td>37.7 65.0 55.5 1.55 51.0 45.2</td>
<td>71.0 1.34 45.0 25.9 64.7 1.69</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Crop residues + lime</td>
<td>39.7 74.0 60.0 3.13 55.8 36.5</td>
<td>81.6 1.61 52.0 38.8 61.1 1.83</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>10</td>
<td>Crop residues + lime + rock phosphate</td>
<td>47.4 75.0 61.8 1.55 57.7 76.4</td>
<td>90.0 1.74 52.5 26.6 69.2 0.70</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Crop residues + lime + superphosphate</td>
<td>44.2 73.0 59.8 1.44 62.3 64.9</td>
<td>78.4 1.67 51.0 25.9 70.0 1.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Crop residues + lime + complete commercial fertilizer</td>
<td>48.8 78.0 67.3 1.79 65.5 56.9</td>
<td>87.1 1.55 50.9 37.3 66.9 1.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Check</td>
<td>39.7 67.0 53.1 1.59 52.0 35.3</td>
<td>75.6 0.80 44.0 30.4 56.7 1.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Four tons lime applied.
(2) Plot 1, low yield, oats down badly; 4 tons lime applied in September.
(3) Clover pastured heavily in spring.
(4) Corn down badly on checks and crop residue plots.
(5) Dry weather on plot 11 due to pocket gophers.
(6) Poor stand on plot 11 due to pocket gophers.
(7) Clover mostly killed out in spring due to ice sheet; good stand of timothy.
(8) Plot 10 damaged by gophers.
(9) Plots damaged by fall and early spring pasturing.

In 1918 or in 1922, or on the oats in 1920, but in all other cases considerable gains were noted. The clover in 1921, the clover and timothy in 1925 and the clover in 1929 were benefited to a particularly large extent. Large increases were also secured on the corn in 1923 and in 1927 and on the oats in 1928.

Rock phosphate with the manure and lime increased crop yields in practically all seasons. The largest effects were evidenced on the corn in 1922 and 1923. In most cases the increases from the rock phosphate were not very large. The superphosphate with the manure and lime showed somewhat larger effects than the rock phosphate on the corn in 1918, 1919, 1922, on the oats in 1924 and on the clover in 1925 and 1929. In several cases, however, the rock phosphate gave somewhat better results as evidenced on the clover in 1921, on the corn in 1928 in 1926 and 1927 and on the oats in 1928. The complete commercial fertilizer with the manure and lime showed somewhat larger effects than the superphosphate in a number of cases. In some seasons, however, the superphosphate gave superior results. In general the differences between the two materials were not large.

The crop residues showed little influence on the crops grown in most seasons.
Lime with the residues brought about increases in crop yields in the majority of cases, and in most seasons the increases were quite pronounced. The clover in 1925 and in 1929 was benefited to a particularly large extent. Large increases were also noted on the corn in 1923, 1926 and 1927 and on the oats in 1924. The rock phosphate with the manure and lime increased the yields of the various crops grown in most seasons. The largest beneficial effect of the rock phosphate was evidenced on the clover and timothy in 1925 and on the clover in 1929. There was also a considerable increase on the oats in 1920 and in 1924. The beneficial effects on the corn were generally quite small. The superphosphate with the crop residues and lime showed somewhat greater effects than the rock phosphate in some seasons, particularly on the clover and timothy in 1925, on the corn in 1927 and on the oats in 1928. In many cases, however, the rock phosphate gave somewhat greater effects, but in general the differences were not very striking. The complete commercial fertilizer with the crop residues and lime showed a greater effect on crop yields than the superphosphate in most seasons. In some cases the differences were considerable, as for example, on the clover in 1921, but in general the complete commercial fertilizer did not give results which were sufficiently large to warrant the use of the more expensive material.

THE WAVERLY FIELD

The results secured on the Carrington loam on the Waverly Field No. 2, Series I, are given in table XII. The beneficial effect of manure is indicated on all but one crop, the clover in 1922. In most cases manure brought about large crop increases, particularly on the corn in 1918 and on the oats in 1921 and 1928. Lime with the manure increased the yields in most seasons, showing the largest effects on the oats in 1921, on the corn in 1927, on the oats in 1925 and on the sweet clover in 1929. The yield on plot 3 in 1919 was evidently abnormal.

The rock phosphate with the manure and lime increased the crop yields to a very pronounced extent in some seasons, but in one or two cases showed no beneficial effects. The clover in 1919 was greatly increased as was the oats in 1925 and 1928 and the corn in 1927. The superphosphate showed a greater effect than the rock phosphate in most seasons but the differences were not large. In two cases the superphosphate showed less effect than the rock phosphate and in one instance the results were almost exactly alike. The complete commercial fertilizer had a greater influence than the superphosphate in one or two cases, but in general the results were similar. Large increases were noted, however, in 1925 and 1929 from the complete commercial fertilizer.

The crop residues had little effect on the various crops grown. Lime with the residues increased the crop yields in all cases and in some instances very large gains were noted, particularly on the clover in 1919 and 1922, on the corn in 1927 and on the sweet clover in 1929. Large effects were also shown on the oats in 1921, 1925 and 1928. The rock phosphate with the crop residues and lime increased the crop yields considerably in practically all cases, the largest influences being noted on the clover, the sweet clover and the oats in 1925 and in 1928. The superphosphate with the crop residues and lime had a larger effect than the
## TABLE XII. FIELD EXPERIMENT, CARRINGTON LOAM, BREMER COUNTY, WAVERLY FIELD NO. 2, SERIES I

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>1918 Oats bu. per A. (1)</th>
<th>1919 Clover tons per A.</th>
<th>1920 Corn bu. per A. (2)</th>
<th>1921 Clover tons per A. (3)</th>
<th>1922 Corn bu. per A. (4)</th>
<th>1923 Corn bu. per A. (5)</th>
<th>1924 Corn bu. per A. (6)</th>
<th>1925 Corn bu. per A. (7)</th>
<th>1926 Clover tons per A. (8)</th>
<th>1927 Corn bu. per A.</th>
<th>1928 Oats bu. per A.</th>
<th>1929 Clover tons per A. (9)</th>
<th>1930 Corn bu. per A.</th>
<th>1931 Corn bu. per A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>42.8</td>
<td>1.50</td>
<td>47.8</td>
<td>25.7</td>
<td>2.22</td>
<td>11.0</td>
<td>11.0</td>
<td>1.0</td>
<td>11.0</td>
<td>35.2</td>
<td>60.1</td>
<td>1.75</td>
<td>56.5</td>
<td>34.3</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>61.0</td>
<td>7.56</td>
<td>56.3</td>
<td>34.3</td>
<td>2.20</td>
<td>24.7</td>
<td>63.9</td>
<td>24.7</td>
<td>63.9</td>
<td>53.2</td>
<td>52.2</td>
<td>2.0</td>
<td>8.0</td>
<td>20.8</td>
</tr>
<tr>
<td>3</td>
<td>Manure + lime</td>
<td>64.0</td>
<td>1.05</td>
<td>57.5</td>
<td>50.6</td>
<td>2.32</td>
<td>30.4</td>
<td>77.7</td>
<td>30.4</td>
<td>77.7</td>
<td>65.8</td>
<td>45.4</td>
<td>1.5</td>
<td>11.0</td>
<td>57.9</td>
</tr>
<tr>
<td>4</td>
<td>Manure + lime + rock phosphate</td>
<td>65.2</td>
<td>1.60</td>
<td>58.0</td>
<td>40.3</td>
<td>2.10</td>
<td>34.3</td>
<td>87.8</td>
<td>34.3</td>
<td>87.8</td>
<td>63.4</td>
<td>61.3</td>
<td>1.1</td>
<td>11.0</td>
<td>31.1</td>
</tr>
<tr>
<td>5</td>
<td>Manure + lime + complete commercial fertilizer</td>
<td>72.1</td>
<td>2.35</td>
<td>44.0</td>
<td>35.7</td>
<td>2.78</td>
<td>42.1</td>
<td>103.3</td>
<td>42.1</td>
<td>103.3</td>
<td>62.9</td>
<td>57.9</td>
<td>0.9</td>
<td>20.8</td>
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(1) Six tons lime, fall 1917.
(2) Soybeans planted in corn, both crops poor. Wet spring injured plots in center series. Plots 5 and 6 and crop residue plots weedy.
(3) Plot 3 too high, many morning glory vines on plot.
(4) Stand uneven on 2 and 4.
(5) No crop yields secured owing to drought.
(6) Crop damaged by frost; phosphate plots showed more maturity.
(7) Harley seeded by mistake on plot 1. Unable to account for high yield on plot 5.
(8) Field pastured; no results taken.
(9) Plots damaged by sheep.

Rock phosphate in practically every season. In some cases the gains were pronounced, as on the clover in 1919 and 1922. In other cases the differences were not large. The complete commercial fertilizer with the crop residues and lime had about the same effect as the superphosphate, showing a slightly greater influence in some cases and a smaller effect in others.

The results secured in Series II on the Waverly field are given in table XIII. Here again manure brought about large increases in crop yields in practically every season. The clover in 1920 and 1921, the corn in 1922 and 1923 and the alfalfa in 1927, 1928, and 1929 showed the largest influences from the use of manure. The application of lime with the manure brought about distinct gains in the crop yields in every season. In some cases the gains were very large as on the clover in 1920 and 1921, on the sweet clover in 1925, on the corn in 1923, on the oats in 1924 and on the alfalfa in 1926, 1927, 1928 and 1929.

The rock phosphate with the manure and lime had a beneficial effect on the crop yields in most seasons. The differences, however, were small and in some cases no gains were noted. The superphosphate with the manure and lime increased the yields considerably in most seasons, the largest effect being noted on
TABLE XIII. FIELD EXPERIMENT. CARRINGTON LOAM, BREMER COUNTY, WAVERLY FIELD NO. 2, SERIES II

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(1) Six tons lime applied in fall 1917. Heavy rains washed 11, 12 and 13 badly.
(2) Plots 1 and 2 poorer in fertility than other plots.
(3) Dry season.
(4) Plot 13 high, probably due to manure application made thru error.
(5) Low yield on plot 12 due to part of crop lost in threshing.
(6) Grasshoppers destroyed the crop on plot 1 and damaged west side of all plots.
(7) Two cuttings. First cutting mostly timothy on plots 1 and 13. Timothy seeded in 1926 to thicken stand.
(8) Two cuttings. First cutting mostly timothy on plots 1 and 13. Timothy seeded in 1926 to thicken stand.
(9) Two cuttings. First cutting mostly timothy on plots 1 and 13. Timothy seeded in 1926 to thicken stand.
(10) Crop residue series damaged by gophers.

The crop residues had little effect on the crop yields, small increases being noted in one or two cases only. Lime with the residues increased the crop yields in a very pronounced way, in some cases bringing about very large increases, for example, on the sweet clover in 1925 and on the alfalfa in 1926, 1927, 1928 and 1929. The rock phosphate with the crop residues and lime increased the yields in most cases, the influence being considerable on the clover crop and on the oats in 1924. The superphosphate with the residues and lime showed a larger effect than the rock phosphate in one or two cases, but the differences were small and the returns were generally about the same. The complete commercial fertilizer showed a larger effect than the superphosphate in some cases, particularly on the clover and timothy in 1921 and on the alfalfa in 1927 and 1928, but in other instances the effects were smaller.
The results secured on the Carrington loam on the Jesup Field, Series II, in Black Hawk County, are given in table XIV. The beneficial effect of manure on this soil is evidenced by the increased crop yields secured in practically all seasons. Large gains resulted from the application of manure on the clover in 1919, on the clover and timothy in 1920 and on the corn in 1921, 1922, 1926, 1927 and 1929. Lime with the manure proved of value, in many cases considerable increases in the yields of crops being secured. The oats in 1918, the clover and timothy in 1920, the oats in 1923, the clover in 1924, the corn in 1927 and 1929 and the oats in 1928 showed pronounced effects from the addition of lime.

The rock phosphate with the manure and lime increased the crop yields in several seasons, altho in general no large effects were secured. Only with the corn in 1926 and 1929, and the oats in 1928 were there any large increases from the rock phosphate. In most cases the gains were small and in one or two seasons no increases at all were secured. The superphosphate with the manure and lime had a larger effect than the rock phosphate in one or two instances, for example, on the clover in 1919 and 1924 and on the oats in 1928. In most seasons small differences between the effects of the two phosphates were noted. The complete commercial fertilizer with the manure and lime increased the crop yields slightly

**TABLE XIV. FIELD EXPERIMENT, CARRINGTON LOAM, BLACK HAWK COUNTY, JESUP FIELD, SERIES II**

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<td>67.6</td>
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(1) Three and one-half tons lime applied.
(2) Plots 9 and 10 in swale and poorly drained.
(3) Oats thin, dry season.
(4) Plot 7 poor, due to poor drainage, plot 13 high, due to old yard location.
(5) Plots were pastured.
(6) Crop residue plots were left in pasture and not plowed.
(7) Plots 8, 9, 10, 11, 12 and 13 were still in pasture.
(8) Plots 8, 9, 10, 11, 12 and 13 in pasture.
(9) Crop residue plots discontinued. Yield on a 15 percent moisture basis.
more than did the superphosphate in most seasons. In general, however, the dif­ferences were slight, and in one or two cases the complete commercial fertilizer showed less effect than the superphosphate. The greatest difference in favor of the complete commercial fertilizer appeared on the clover in 1919 and the clover and timothy in 1920.

The crop residues had little effect on the crops grown in most seasons. In one or two cases increases were secured, as on the clover in 1924. Lime with the residues increased the crop yields only in one or two seasons. The rock phosphate with the crop residues and lime brought about pronounced increases in the yields of crops in several cases, but in two instances no effects were noted. The superphosphate with the residues and lime had a greater effect than the rock phosphate in most seasons. The differences in favor of the superphosphate in some cases were quite pronounced, as on the clover and timothy in 1920 and on the clover in 1924. The complete commercial fertilizer with the crop residues and lime had a larger effect than the superphosphate on most of the crops grown. In some cases the gains were quite considerable, as on the oats in 1918, the clover in 1919 and the corn in 1922.

THE INDEPENDENCE FIELD

The results secured on the Carrington loam on the Independence Field, Series II, in Buchanan County, are given in table XV. The application of manure increased the crop yields in all but one season showing very large effects in practically all cases. The largest increases were obtained on the corn in 1921, 1924, 1925 and

<table>
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<th>Plot No.</th>
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<th>1922 Oats bu. per A.</th>
<th>1923 Timothy and Clover tons per A.</th>
<th>1924 Corn bu. per A. (1)</th>
<th>1925 Corn bu. per A. (1)</th>
<th>1926 Oats bu. per A.</th>
<th>1927 Timothy and Clover tons per A.</th>
<th>1928 Corn bu. per A. (1)</th>
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(1) This plot is affected by a grove of trees that lie near it.
(2) Yield on a basis of 15 percent moisture.
1929, on the oats in 1926, on the timothy and clover in 1923 and on the clover in 1927. Lime with the manure showed beneficial effects on the crops grown in all but one season. The largest benefit from the application appeared on the timothy and clover in 1923. The rock phosphate with the manure and lime showed beneficial effects on the crops in most seasons. The largest increase was secured on the timothy and clover in 1923. It had no influence on the corn in 1924 and 1929 or on the oats in 1926. In the other seasons small beneficial effects were evidenced. The superphosphate with the manure and lime showed larger effects than the rock phosphate in several seasons. It had a much greater effect on the corn in 1924 and on the oats in 1926 and showed slightly larger benefits in other seasons. It had less effect than the rock phosphate, however, on the timothy and clover in 1923. The effects on the corn in 1928 and 1929 were very similar for the two phosphates. The complete commercial fertilizer with the manure and lime showed less effect than the superphosphate in most seasons. It had somewhat larger effects on the corn in 1928 and 1929 but in all other cases was less effective than the superphosphate.

The crop residues in most cases had little effect on the various crops grown. The clover in 1927 showed some beneficial effect and the corn in 1929 was also benefited to some extent. Lime with the crop residues increased the crop yields in all but one season, the largest beneficial effect appearing on the timothy and clover in 1923. There was also a large increase in the oats in 1926. The corn in 1928 was the only crop which was not benefited by the lime. The rock phosphate with the crop residues and lime increased the crop yields in most seasons. It had no effect on the oats in 1922 or on the clover in 1927 but showed beneficial effects in all other cases. The largest influence from the application appeared on the timothy and clover in 1923. The superphosphate with the crop residues and lime showed a much greater effect than the rock phosphate on the oats in 1922 and somewhat larger effects in several other seasons. It had less influence, however, than the rock phosphate on the corn in 1928 and 1929 and had much less effect on the timothy and clover in 1923. The complete commercial fertilizer with the crop residues and lime showed slightly larger effects than the superphosphate in a number of cases. The timothy and clover in 1923 and the clover in 1927 were benefited materially by the complete commercial fertilizer. Larger effects also appeared in the case of the corn in 1924, 1925 and 1929, and on the oats in 1926. In the other seasons the superphosphate had the greater influence.

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

The results of the laboratory, greenhouse and field experiments which have been discussed earlier in this report indicate the fertilizer treatments which will prove most desirable for use on the soils of this county. It is possible at the present time, therefore, to offer a few general recommendations regarding the handling of some of the more extensively developed soils. The suggestions which will be made in the following pages are based upon the results of the experimental
work carried out on the main soil types of the county and also upon the experiences of many farmers. Only those treatments are suggested which have been shown to be of value in practice and which may be put into operation on any farm.

Liming

All the soil types in the county are acid in reaction in the surface soil as was shown in the analyses discussed earlier in this report. In general the acidity extends down thru the lower soil layers. In the Dodgeville types, the Floyd silt loam and the Clyde silt loam, some lime is present in the lower subsoil. This fact, however, does not change the need for lime in the surface soil of these types. It may be said, then, that all the soils in the county are in need of lime for the best growth of general farm crops and particularly of legumes.

There is considerable variation in the lime requirements of the various soil types, but only the figures given in table IV should be considered indicative. To determine accurately the need for lime on any area, soil from that area should be tested. There is a wide difference in the acidity of soils in different fields and considerable difference in soils of the same type in different areas. Only by testing a particular soil is it possible to determine the proper amount of lime to apply. Farmers may test their own soils for acidity or lime requirement, but it will usually be more satisfactory for them to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station where it will be tested free of charge.

It is rarely possible to secure the best yields of general farm crops on acid soils. The legumes, such as sweet clover, alfalfa and red clover, are especially sensitive to acidity and may fail on extremely acid soils. Corn and small grain crops are less sensitive to acid conditions in the soil than are the legumes, but even in the case of these crops, maximum crop yields are usually not obtainable on acid soils. It is desirable, therefore, that acid soils be tested and that lime be applied as needed if the most satisfactory yields of general farm crops and especially of legumes are to be secured.

The beneficial effects of liming were indicated in the greenhouse and field experiments discussed earlier. The Carrington silt loam, the Carrington loam and the Clyde silt loam are all acid in reaction and are in need of lime. Large increases in crop yields were secured on these types from the use of lime. The other soil types in the county would respond in quite as large a way or perhaps even to a greater extent to the application of lime. Numerous tests in the field and the practical experiences of farmers have shown the value of lime on the acid soils of this county.

It is not only important that lime be applied at the present time on these soils, but this material should be added to the soil regularly as tests show it to be needed. One application of lime will not suffice. Whenever a soil shows acidity, lime should be applied. It is recommended that all soils be tested at least once in a four-year rotation, preceding the legume crop. The addition of lime may then be made when it is most needed and where it will have the greatest effect. The legume crop will be benefited to the largest extent, but the succeeding grain crops will also reflect the influence of the lime.
Manuring

Most of the soil types in Howard County are fairly well supplied with organic matter as is indicated by their dark color. Some of the soils, however, are lighter in color and hence lower in organic matter. Some of the sandy types, especially the sandy loams and fine sandy loams, are rather poorly supplied. The Carrington fine sandy loam, Dickinson fine sandy loam and Lindley fine sandy loam are particularly in need of organic matter and this is the case also with the O'Neill fine sandy loam and the LaCrosse sandy loam on the terraces. Even on the darker colored soils, the application of fertilizing materials supplying organic matter is distinctly profitable. On these soils organic matter must be applied regularly if the supply is to be kept up. On the light colored soils the addition of fertilizing materials supplying organic matter is necessary at the present time.

The best and cheapest source of organic matter on the farm is farm manure. The proper preservation and application of all the manure produced on the farm will aid materially in building up and maintaining the fertility of the soil. Large increases in the yields of general farm crops may be secured by the use of manure. Experiments which have been discussed earlier have shown the large effects of this fertilizing material on the Carrington silt loam, the Carrington loam and the Clyde silt loam. Crop yields on many of the other types in the county, and especially on those which are light in color and sandy in texture, undoubtedly would be greatly increased by the addition of manure. The liberal application of farm manure is recommended for all the soils of this county if the best crop yields are to be secured.

The thorough utilization of all crop residues is also of value as a means of maintaining the organic matter supply in the soil. On livestock farms the residues are used for feed or bedding and may then be returned to the land with the manure. Under the grain system of farming they may be allowed to decompose partially or may be applied directly to the land. Under both types of farming, these materials should not be burned or otherwise destroyed but should be returned to the soil.

In many cases the supply of manure on the livestock farm is inadequate to meet the needs of all the land. Some other material must be utilized in such cases as a source of organic matter. On grain farms where little or no manure is produced, it is essential that some means of supplying organic matter be resorted to. In both cases the turning under of leguminous crops as green manures is a very desirable practice. Inoculated legumes not only supply organic matter to the soil, but they also add nitrogen which they have taken from the atmosphere. Thus they have large value in increasing crop yields. Green manuring may be practiced with profit at the present time on many of the soils in Howard County. On the lighter colored, sandy textured types, the beneficial influence will be particularly evident, but increased crop yields may be secured on practically all of the soils. Care is necessary in connection with green manuring, and the practice should not be followed blindly nor carelessly. Under proper conditions it is very much worth while. Farmers in this county should take precautions necessary to maintain the supply of organic matter in their soils by the proper use of farm manure, green manures and crop residues.
The Use of Commercial Fertilizers

There is no large content of phosphorus in any of the soils of Howard County as has been indicated by the results of the analyses previously discussed. It is evident that the supply of phosphorus is insufficient to provide for the best crop growth on these soils over a long period of years. It is certain that the use of a phosphate fertilizer will be needed on these soils in the near future, and it seems quite probable that the application of some phosphorus carrier might be of large value at the present time.

The field and greenhouse experiments on the major soil types in this county have shown large crop increases from the use of rock phosphate or superphosphate. Beneficial effects from these materials have been shown on the Carrington silt loam, the Carrington loam and the Clyde silt loam. The other types in the county undoubtedly would respond in a very similar way to the application of a phosphate fertilizer. In some cases superphosphate seems to be somewhat preferable, but in other instances rock phosphate gave quite as large an effect.

Rock phosphate is less expensive than superphosphate, but it is applied in larger amounts, usually at the rate of about 1,000 pounds per acre once in a four-year rotation. Superphosphate is usually applied at the rate of 150 pounds per acre annually for three out of four years in the four-year rotation. Rock phosphate contains phosphorus in a form from which it must be changed in the soil to be made available. This change may take place slowly. Frequently rock phosphate does not show large effects until the second year after application, while superphosphate, which carries the element phosphorus in an immediately available form, gives quicker results.

Definite recommendations cannot be made at the present time regarding the use of these two phosphates on the soils of this county. It seems quite certain that some phosphate fertilizer should be employed, but whether superphosphate or rock phosphate would prove more profitable can be determined only by tests carried out under individual farm conditions. It is recommended and urged, therefore, that farmers test both materials on their farms and determine which is the more desirable.

The supply of nitrogen in the soils of Howard County is not abnormally low, but in some of the types the supply is not high and the need for this element is evident. This is the case with the lighter colored, sandy soils. On all the types in the county, however, some fertilizing materials supplying nitrogen must be applied regularly if the present content of the soil is to be maintained. Nitrogen is removed from the land constantly in the drainage waters and by plant growth, and unless some return is made the supply will soon become deficient.

Under the livestock system of farming, the use of farm manure will aid materially in maintaining the supply of nitrogen in the soil. The proper preservation and application of manure to this land will reduce the need for additions of other nitrogen-containing fertilizers. Crop residues also supply nitrogen, and the use of these materials will aid in maintaining the supply.

The use of leguminous crops as green manures is undoubtedly the best and cheapest means of building up and keeping up the nitrogen content of the soil. If
the legumes are well inoculated, as they should be, a large part of the nitrogen which they contain is taken from the atmosphere; therefore, when the crop is turned under the nitrogen content of the soil may be considerably increased. Many of the soils in this county would be benefited materially by green manuring, especially where the supply of nitrogen and organic matter is not high.

The use of commercial nitrogenous fertilizers cannot be recommended on the soils of this county at the present time. Small amounts may prove of value as top dressings for certain crops. These materials should always be tested, however, on small areas before they are applied extensively. Ordinarily the utilization of crop residues and farm manures and the turning under of leguminous crops as green manures will supply sufficient nitrogen to provide for the best crop growth.

The supply of potassium in the soils of this county is generally adequate to meet the needs of farm crops for many years to come. If there is a sufficiently rapid production of available potassium, there should be no need for the use of commercial potassium fertilizers. These materials cannot be recommended, therefore, for general use on the soils of the county at the present time. Small amounts may be of value in some cases as top dressings and for certain crops, but tests should always be conducted on small areas before extensive applications are made.

The effects of a complete commercial fertilizer on some of the more important soil types in the county have been indicated in the experiments which have been discussed. Frequently considerable increases in crop yields have been secured. In general, however, the phosphates have been found to give quite as large effects, and as they are much less expensive they would seem to be much more desirable for general use. If it is desired to apply a complete commercial fertilizer to the land, tests should be carried out comparing the effects of the material with superphosphate. If tests conducted on small areas indicate larger crop increases than those brought about by the superphosphate, then the complete fertilizer may be used on an extensive scale with assurance of profit. Farmers who are interested are urged to test complete commercial fertilizers under their particular conditions to determine whether or not they may be used profitably.

**Drainage**

As has been indicated earlier, the natural drainage system of the county is generally quite adequate, and most of the soils are well drained. In a few areas, however, artificial drainage is necessary. On the level to depressed areas of the Clyde silt loam, the mucky phase of this type and on the Floyd silt loam, the installation of tile is very desirable. The Bremer soils on the terraces are in need of drainage, and on the bottomlands the Wabash types are poorly drained. These latter soils must also be protected from overflow if they are to be satisfactorily cropped. Wherever drainage conditions are not entirely satisfactory in the county, tiling would prove of value. It is the first treatment needed on some of the soils, and satisfactory crop yields cannot be expected until some provision is made for the removal of excess moisture. No other treatments will be of value and no fertilizing material will prove profitable if the soils are too wet. Altho the expense involved is often considerable, farmers will find that the increased crop yields secured will more than pay for the installation.
The Rotation of Crops

The continuous growing of any one crop very quickly reduces the fertility of the soil. Crop yields decrease rapidly and the growing of the crop soon becomes unprofitable. Extensive experiments and much farm experience have definitely demonstrated the fact that the rotation of crops is a very desirable practice. Even if crops of less money value are included it is more profitable to follow a rotation.

The maintenance of the fertility of the land is also more readily accomplished under a good crop rotation.

No special rotation experiments have been carried out in Howard County but some general recommendations may be offered regarding rotations. Some very desirable rotations are listed from among which one may be chosen to serve as a basis on which a rotation may be worked out for any individual farm in the county. Almost any rotation will prove of value provided it contains a legume and money crops.

1. SIX-YEAR ROTATION

First year—Corn
Second year—Corn
Third year—Wheat or oats (with clover, or clover and grass)
Fourth year—Clover, or clover and grass
Fifth year—Wheat (with clover, or grass and clover)
Sixth year—Clover, or clover and grass

This rotation may be reduced to a five-year rotation by cutting out either the second or sixth year and to a four-year rotation by omitting the fifth and sixth years.

2. FOUR OR FIVE-YEAR ROTATION

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

3. FOUR-YEAR ROTATION WITH ALFALFA

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

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)
HOWARD COUNTY SOILS

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 clover)
Third year—Clover

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

The Prevention of Erosion

Erosion is the carrying away of soil thru the free movement of water over the surface of the land. If all the rain falling on the ground were absorbed, erosion could not occur; hence it is evident that the amount and distribution of rainfall, the character of the soil, the topography or “lay of the land” and the cropping of the soil are the factors which determine the occurrence of this injurious action.

There are two types of erosion, sheet washing and gullyng. The former may occur over a rather large area, and the surface soil may be removed to such a large extent that the subsoil may be exposed and crop growth prevented. Gullying is more striking in appearance but is less harmful and is usually more easily controlled. If a rapidly widening gully is allowed to go unchecked, however, an entire field may soon be made useless for farming purposes.

Erosion occurs to some extent in some of the soils of Howard County. On the drift uplands the Carrington soils are injured to some extent and the Lindley types are sometimes badly washed. On the loessial uplands the Fayette silt loam is sometimes badly eroded, and in some areas of the Tama silt loam considerable washing has occurred. Wherever erosion occurs some means to prevent or control it should be adopted.

The means which may be employed to control or prevent erosion in Iowa may be considered under five headings as applicable to “dead furrows,” to small gullies, to large gullies, to bottoms and to hillside erosion.

EROSION DUE TO DEAD FURROWS

Dead furrows or back furrows when running with a slope or at a considerable angle with it frequently result in the formation of gullies.

"Plowing In"—It is quite customary to “plow in” the small gullies that result from dead furrows, and in level areas this process may be effective. In the more rolling areas, however, it is best to supplement the “plowing in” with a series of “staked in” dams or earth dams.

"Staking In"—This method is better than “plowing in” since it requires less work and there is less danger of washing out. The process consists of driving in several series of stakes across the gully and up the entire hillside at intervals of from 15 to 50 yards according to the steepness of slope. The stakes in each series should be placed 3 or 4 inches apart. Usually it is advisable to weave some brush about the stakes, allowing the tops of the brush to point upstream. Additional
brush may also be placed above the stakes with the tops pointing upstream which permits the water to filter thru but holds the fine soil.

_Earth Dams_—Earth dams consist of mounds of soil placed at intervals along the slope. There are some objections to the use of earth dams, but in many cases they may be effective in preventing erosion in dead furrows.

**SMALL GULLIES**

Gullies result from the enlargement of surface drainageways and may occur in cultivated land, on steep hillsides in grass or other vegetation, in bottomlands or at any place where water runs over the surface of the soil. Small gullies may be filled in several ways, but it is not practicable to fill them with soil for this method takes much work and is not lasting.

_Checking Overfalls_—The formation of small gullies or ditches is practically always the result of overfalls. An easy method of checking an overfall is to put in an obstruction of straw and brush staked down with posts. One or more posts are set firmly in the ground in the bottom of the gully. Brush is intertwined between the posts, straw is well tramped down behind them and the straw and brush are held in place by cross pieces nailed to the posts.

_“Staking In”_—The simplest and most satisfactory method of controlling small or moderate sized gullies is the staking in operation recommended for the control of dead furrow gullies.

_The Straw Dam_—A simple method of preventing erosion in small gullies is to fill them with straw. The filling may be done at threshing time with some saving of time and labor. The straw is usually piled near the lower part of the gully, but if it is rather long or branching, the straw should be placed near the middle or below the junction of the branches or more than one dam should be used.

_The Earth Dam_—The use of an earth dam or mound of earth across a gully may be a satisfactory method of controlling erosion under some conditions. In general, unless a suitable outlet under the dam for surplus water is provided, the earth dam cannot be recommended. When such an outlet is provided, the dam is called a “Christopher” or “Dickey” dam.

_The “Christopher” or “Dickey” Dam_—This modification of the earth dam consists merely in laying a line of tile down the gully beneath the dam. An elbow or a “T”, called the surface inlet, usually extends 2 or 3 feet above the bottom of the gully. A large tile should be used in order to provide for flood waters, and the dam should be provided with a cement or board spillway or run-off to prevent any cutting back by the water flowing from the tile. The earth dam should be made somewhat higher and wider than the gully and higher in the center than at the sides to reduce the danger of washing. It is advisable to grow a crop upon the dam. Sorghum, or even oats or rye will be found satisfactory, and a later seeding of grass is a good practice.

_The Adams Dam_—This dam is practically the same as the “Christopher” or “Dickey” dam. In fact the principle of construction is identical. In some sections the name “Adams Dam” has been applied and hence it is mentioned separately.
The Stone or Rubble Dam—Where stones abound they are frequently used in constructing dams for the control of erosion.

The Rubbish Dam—The use of rubbish in controlling erosion is a method sometimes followed, and a great variety of materials may be employed. The results are, in the main, rather unsatisfactory, and the method is a very unsightly one.

The Woven Wire Dam—The use of woven-wire, especially in connection with brush or rubbish, has sometimes proved satisfactory for the prevention of erosion in small gullies.

Sod Strips—The use of narrow strips of sod along natural surface drainage-ways may often prevent these channels from washing into gullies as the sod serves to hold the soil in place. Bluegrass is the best crop to use for the sod, but timothy, redtop, clover or alfalfa may serve as well. For quick results thickly planted sorghum may be employed.

The Concrete Dam—One of the most effective means of controlling erosion is by the use of the concrete dam, provided the Dickey system is used in connection with it. Concrete dams are, however, rather expensive. Owing to their high cost and the difficulty involved in securing a correct design and construction, such dams cannot be considered as adapted to general use on the farm.

Drainage—The ready removal of excess water may be accomplished by a system of tile drainage properly installed. The removal of water to a depth of the tile increases the water absorbing power of the soil and thus decreases the tendency toward erosion.

LARGE GULLIES

Erosion in large gullies or ravines may in general be controlled by the same methods as for small gullies. The Dickey dam is the only method that can be recommended for controlling and filling large gullies, and it seems to be giving very satisfactory results at the present time.

BOTTOMLANDS

Erosion frequently occurs in bottomlands. Where such low-lying areas are crossed by small streams the land may be very badly cut up and rendered almost entirely valueless for farming purposes.

Straightening and Tiling—The straightening of the larger streams in bottomland areas may be accomplished by any community, and while the cost is considerable, large areas of land may thus be reclaimed.

Trees—Erosion is sometimes controlled by rows of such trees as willows extending up the drainage channels. While the method has some good features it is not generally desirable.

HILLSIDE EROSION

Hillside erosion may be controlled by certain methods of soil treatment which also aid materially in securing satisfactory crop growth.

Use of Organic Matter—Organic matter or humus is the most effective means of increasing the absorbing power of the soil; hence it proves very effective in preventing erosion. Farm manures may be used for this purpose, or green manures may be employed if farm manure is not available in sufficient amounts.
Growing Crops—The growing of crops, such as alfalfa, that remain on the land continuously for a period of two or more years is often advisable on steep hill-sides. Alsike clover, sweet clover, timothy and redtop are also desirable for use in such locations.

Contour Disking—Disking around a hill instead of up and down the slope or at an angle to it is frequently very effective in preventing erosion. This practice is called "contour disk ing" and has proven satisfactory.

Sod Strips—The use of narrow strips of sod is very desirable for preventing gully formation. The sod protects the field from the flow of water during rains and prevents the washing away of the surface soil.

Deep Plowing—Deep plowing increases the absorptive power of the soil and hence decreases erosion. It is especially advantageous when done in the fall.

INDIVIDUAL SOIL TYPES IN HOWARD COUNTY*

There are 18 soil types in Howard County and these with the mucky phase of the Clyde silt loam and the rough stony land make a total of 20 soil areas. They are divided into four groups according to their origin and location. These groups are drift soils, loess soils, terrace soils and swamp and bottomland soils.

Drift Soils

There are nine drift soils in the county which together with the mucky phase of the Clyde silt loam make ten drift soil areas. They are classified in the Carrington, Clyde, Floyd, Dickinson, Dodgeville and Lindley series. Together they cover 82.7 percent of the county.

CARRINGTON SILT LOAM (83)

The Carrington silt loam is the most extensively developed soil type in the county and the largest drift soil. It covers 25.9 percent of the area. It is found in large areas on the uplands in the central, western and southern townships. It is the chief type on the broad divides between the streams in the drift section of the county. It is associated with the Floyd silt loam and the Clyde silt loam which occur in narrow strips thruout the Carrington silt loam areas. It is separated from the streams by areas of Carrington loam and the terrace and bottomland soils.

The surface soil of the Carrington silt loam is a very dark grayish-brown silt loam, extending to a depth of 10 inches. The soil mass is largely made up of fine, soft granules which become larger and more distinct in the lower part of the layer. To a depth of 18 inches the color is a very dark grayish-brown to brown, and the texture is heavier changing to a silty clay loam. Below 18 inches the texture is a silty clay loam and the color is a brown or yellowish-brown changing into a more friable yellowish-brown silty clay loam. At a depth of 4 feet the drift material is splotched and variegated with gray, yellow and brown. Boulders are common on the surface of the soil and thru the soil section.

There are some variations in the soil as it occurs thruout the county. In the more undulating to rolling areas, the surface soil is higher in content of very fine

*The descriptions of individual soil types given in this section of the report very closely follow those in the Bureau of Soils report.
sand. The color and thickness of the surface soil also vary considerably. On the ridges the soil is not so dark in color, and the surface soil is usually not more than eight inches in thickness. In a few isolated areas, mainly in Afton and Howard townships, the surface soil is almost a loam, and the boundary between the loam and silt loam areas is of necessity placed quite arbitrarily. Included also in the areas of the Carrington silt loam are small areas of poorly drained soils which would be mapped as the Floyd silt loam or the Clyde silt loam if they were large enough. In such areas the surface soil is a dark brown to almost black silt loam, extending to a depth of 12 to 18 inches at which point it grades into a gray and drab compact clay. The subsoil at 35 inches is a yellowish-brown clay loam.

In topography the Carrington silt loam is level or undulating and the natural drainage is good. Even in the level areas the water runs away readily thru the soil and subsoil, and only rarely or at short intervals is the soil too wet. Where associated with the Floyd and Clyde soils, and especially in areas where the soil in narrow strips is really Floyd silt loam or Clyde silt loam, drainage is needed and the installation of tile would be of value.

General farm crops give quite satisfactory yields in most cases on this soil type. Corn yields range from 20 to 50 bushels per acre with an average yield between 35 and 40 bushels. Under favorable conditions, the yields are much higher. Oats give yields as high as 80 to 90 bushels per acre. The average yield is between 50 and 60 bushels. Wheat yields from 20 to 25 bushels per acre and hay from 1½ to 2 tons. The minor crops grown include barley, rye, flax, buckwheat and potatoes. Truck and garden crops are raised only for home use. Corn is the leading crop followed by oats and hay. The other general farm crops mentioned are of minor importance. There is no natural timber growth in the county, but a scattered growth of oaks, elms, willows and maples occurs along fence rows and highways. Practically all of the farmsteads have windbreaks or shelterbelts as a protection against winter winds.

Increased crop yields may be secured on the Carrington silt loam in many cases by the adoption of better methods of soil management. The use of a good crop rotation including a legume is essential, and the value of turning under a portion of the legume crop is very large. The soil will respond to a liberal addition of farm manure and this material should be applied. The use of lime is necessary for the best growth of general farm crops and especially of legumes, as the soil is acid in reaction. The use of a phosphate fertilizer would undoubtedly bring about large crop increases. The experiments, which have been reported earlier in this report, have shown the large value of manure, lime and a phosphate fertilizer when added to this soil. The use of a complete commercial fertilizer may not be as desirable as the use of superphosphate as

<table>
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<tr>
<th>CARRINGTON SILT LOAM</th>
<th>High Acidity</th>
<th>Medium Acidity</th>
<th>Low Acidity</th>
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<tbody>
<tr>
<td>A</td>
<td>Very dark grayish brown silt loam</td>
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<tr>
<td>B</td>
<td>Brown silty clay loam</td>
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<tr>
<td>B₂</td>
<td>Yellowish brown silty clay loam - Some gritty material - Heaviest layer of profile</td>
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<tr>
<td>C₁</td>
<td>Yellowish brown gritty light silty clay loam</td>
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<tr>
<td>C₂</td>
<td>Gray, yellow &amp; brown gritty silty clay loam - Parent material</td>
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the latter is cheaper and may bring about quite as large crop increases. Tests of complete fertilizers in comparison with superphosphate on small areas on individual farms are very desirable to determine the value of each under particular conditions. It is very desirable also that farmers test the relative value of rock phosphate and superphosphate on their own farms in order to learn which may be used with the greatest profit. The results thus far secured in an experimental way have shown that one or the other phosphate may be used profitably, but the results vary under different conditions; hence definite recommendations cannot be made.

CARRINGTON LOAM (1)

The Carrington loam is the second largest soil type, covering 21.9 percent of the total area. It is most extensively developed in the central and east central parts of the county. It is the main soil type in a belt 8 or 10 miles wide found on both sides of the Chicago, Milwaukee and St. Paul Railway northwestward from Cresco. Here the areas occur on the ridges and slopes bordering the Clyde and Floyd soils along the stream channels. In other parts of the county, the areas occupy slopes bordering the streams and knolls which rise above the level or undulating plain of the Carrington silt loam upland. The areas along the streams are usually from ¼ to ¾ of a mile wide and the knolls usually comprise less than 40 acres.

The surface soil of the Carrington loam is a very dark, grayish-brown, loose or finely granular loam, extending to a depth of about 10 inches. The lower part of the surface layer is slightly darker in color, heavier in texture and more granular in structure than the upper part. Below the surface soil is a slightly heavier layer, becoming somewhat lighter in color in the lower parts. This grades into a brown or yellowish-brown silty clay loam which is very similar to the subsoil of the Carrington silt loam. The parent material is slightly altered glacial drift. Gravel and boulders are found scattered over the surface and thru the soil.

There are some variations in the Carrington loam in the different areas. In some places the surface soil is more or less sandy. This is especially true where the type occurs on knolls or kames. These areas if of sufficient size would have been mapped as a sandy loam. They are usually less than 3 or 4 acres in extent. The boundary lines between the loams and silt loams cannot be sharply drawn and are usually placed quite arbitrarily. In both types there are varying quantities of very fine sand which makes the textural determination difficult. This is especially true in Howard Center, Saratoga and Howard townships.

In topography the Carrington loam is rolling or sharply rolling and drainage is good. Approximately 90 percent of the total area of the soil is under cultivation. General farm crops produce quite satisfactorily. Along the lower slopes of the main streams there is a scattering growth of timber, consisting mainly of oak,
hickory, elm and maple. Trees are also planted around the farmsteads and woodlots.

Crop yields on the Carrington loam are very similar to those secured on the silt loam. Corn yields from 35 to 50 bushels per acre, oats from 40 to 50 bushels, wheat from 15 to 20 bushels and hay from 1 to 2 tons per acre. Under favorable seasonal conditions quite large yields of all the general farm crops may be secured.

The Carrington loam is a naturally fertile soil, and, as has been indicated, crop yields in general are quite satisfactory. Experiments which have been carried out on this type show, however, that large crop increases may be secured through proper methods of soil treatment. Liberal applications of farm manure and the turning under of legume crops as green manures would both be of value. The soil is acid in reaction and applications of lime are very much worth while, especially when legumes are grown. Increases are secured, however, in the yields of general farm crops by the use of lime. The application of a phosphate fertilizer has been found to be profitable on this soil, and either rock phosphate or superphosphate may be used to advantage. Definite recommendations regarding the use of these two materials cannot be made at the present time as results seem to vary under different conditions. It is suggested that farmers test the value of both phosphates under their individual farm conditions. The use of a complete commercial fertilizer does not seem to be as profitable as the application of superphosphate, but comparative tests on individual areas should be carried out before definite conclusions are reached. It is quite possible that a complete fertilizer might give very profitable returns under certain soil conditions. It must bring about very much larger crop increases, however, than those occasioned by the superphosphate if it is to prove as profitable. This is due to the fact that complete fertilizers are more expensive. The use of muriate of potash may be desirable in some instances on this soil, but its general use cannot be recommended at the present time.

CLYDE SILT LOAM (84)

The Clyde silt loam is the third largest soil type in the county. Together with the mucky phase which is very limited in extent, it covers 16.1 percent of the total area. It occurs in poorly drained depressions, marshy spots and old lake beds on the uplands. It is most extensively developed in the central and western townships along the intermittent drainage lines and the various streams which extend through the drift uplands in those portions of the county. It occurs only in narrow, finger-like areas in association with the Carrington silt loam and the Carrington loam on the rolling uplands, or with the Floyd silt loam on the more level to depressed upland areas. There are no large individual tracts of the type.

The surface soil of the Clyde silt loam is a very dark brown or black, mellow silt loam, extending to a depth of 1 or 2 inches. Below
this point to a depth of 10 to 12 inches, the soil is a dark grayish-brown or black, fine or coarse, granular heavy silt loam. The subsurface soil is a dark brown, heavy clay loam, sticky and tough when wet and hard when dry. At a depth of 26 to 32 inches the color grades from dark brown to dark gray, and the soil is a mixture of silt, clay, sand and fine gravel. At the lower depths the amount of sand increases until the material is a sandy loam, and brown or rust-brown iron stains are present. Boulders and niggerheads are found in the soil, either on the surface or thru the soil section.

It is difficult to separate the Clyde silt loam from the adjacent areas of the Floyd and Carrington soils, and the boundary lines are usually drawn quite arbitrarily. Where the Clyde adjoins these soils the subsoil is more yellow, indicating better drainage and better aeration and oxidation. Typically the Clyde silt loam contains no calcareous material either in the surface soil or thru the soil section. In some areas, however, there is some accumulation of calcareous material in the subsoil, and often when the soil has been drained artificially a coating of white appears on the surface. In such areas there is too large an accumulation of so-called alkali salts, and crops may be injured. These spots may be reclaimed thru proper drainage and treatment.

In topography the Clyde silt loam is depressed or slightly sloping towards the stream channels, and drainage is poor. While the type occupies a considerable acreage, it is relatively unimportant from the crop production standpoint. A few small areas have been reclaimed and brought under cultivation, but most of the soil is in its original wet, marshy condition and supports only a growth of wild slough grass, weeds, and in some localities a scant growth of willows. The better drained areas are farmed or seeded to blue grass. The type is used principally as pasture land and is best adapted to this purpose. The small areas which are drained and brought under cultivation are handled in much the same way as the Floyd and Carrington soils, and the yields in favorable seasons are quite satisfactory. In wet seasons the yields are low.

Drainage is the treatment most needed by the Clyde silt loam if it is to be satisfactorily cropped. Care is necessary in cultivating this soil, to prevent puddling and clodding. Newly drained areas will be benefited by small applications of farm manure. The type is acid in reaction and applications of lime are necessary. It will also respond to applications of a phosphate fertilizer, and either rock phosphate or superphosphate may be used. Where the so-called alkali spots occur, a liberal application of fresh horse manure is very beneficial after the area has been adequately drained, and the turning under of a green crop such as sweet clover as a green manure will prove of value. Applications of muriate of potash at the rate of 200 pounds per acre have been found effective on these spots.

The mucky phase of the Clyde silt loam is very limited in area, covering a total of only 384 acres. It occurs in depressions and in areas where water has stood on the surface practically the entire season and where water loving plants grow luxuriantly. The largest areas are mapped in Sections 15, 16 and 25, of Saratoga Township. Other small areas of the type occur throughout the county, generally at the heads of the drainage ways.
The surface soil of the mucky phase of the Clyde silt loam is a mucky material extending to a depth of 2 to 4 inches. There it grades into the typical surface soil of the Clyde silt loam. The subsurface soil and the subsoil are the same as in the typical Clyde silt loam.

The soil is of very little importance agriculturally owing to its small extent. In dry seasons it is utilized as pasture land, but in wet years it is marshy and of little value.

**FLOYD SILT LOAM (198)**

The Floyd silt loam is the fourth largest drift soil and the fifth type in area in the county. It covers 6.5 percent of the total acreage. It occurs in numerous tracts throughout the drift section of the county, the largest developments being found in the vicinity of Bonair, in Albion and Forest City townships, near Saratoga in Saratoga Township, in the southern part of Oakdale Township and west of Elma in Afton Township. It occupies two distinct positions in the county. Most commonly it borders the streams and lies between the Clyde silt loam on the broad swales and the well-drained upland soils of the Carrington and Dickinson series. These areas range in width from a few rods to three-fourths of a mile. It also occurs on the flat upland divides. Many areas are completely surrounded by a better drained soil which is lighter in texture.

The surface soil of the Floyd silt loam is a dark grayish-brown or almost black, single-grained or finely granular silt loam, extending to a depth of 14 to 18 inches. Here it grades into a gray and drab compact clay loam. The subsoil at about 34 inches consists of a yellowish-brown or yellow clay loam, containing some fine sand. Iron stains are abundant throughout the subsoil.

There are variations from the typical soil in the various areas of the type. Where it occurs between the Clyde silt loam and the sandy soils of the upland, the surface soil has been modified somewhat by wash from the higher land, and small areas of the Floyd loam have been formed. These areas are too small, however, to show on the map and they are included with the silt loam. The boundary lines between the Floyd silt loam and the Clyde silt loam are not sharply defined and are generally placed quite arbitrarily. In topography the Floyd silt loam is level to depressed and drainage is usually poor.

Most of the Floyd silt loam is under cultivation and general farm crops are grown. Corn yields from 35 to 50 bushels per acre, oats from 40 to 50 bushels, and hay from 1 to 2 tons per acre. The uncultivated areas are utilized as pasture and hay land. Occasionally there is a scattered growth of willows along the fence rows. The poor drainage of the type has led to the growth of many water-loving plants, and an accumulation of plant residues has brought about a high content of organic matter which gives the soil its dark brown to black color.
The chief need of the Floyd silt loam is adequate drainage. It is important that it be properly cultivated to prevent the soil from becoming puddled and cloddy. Small applications of farm manure are of value on this type to stimulate the production of available plant food. This treatment is especially desirable on newly drained areas. The soil is acid and in need of lime. It will respond to applications of a phosphate fertilizer, and tests of rock phosphate and superphosphate are recommended.

DICKINSON FINE SANDY LOAM (175)

The Dickinson fine sandy loam is the fifth largest drift soil and the sixth largest type in the county. It covers 5.9 percent of the total area. It occurs in numerous areas throughout the county, being most extensively developed south of Cresco in Vernon Springs and New Oregon townships. There are also large developments of the type in Albion, Forest City, Chester, Howard Center and Paris townships. Most of the areas are less than a square mile in extent.

The surface soil of the Dickinson fine sandy loam is a dark grayish-brown, loose, fine sandy loam, extending to a depth of 8 or 10 inches. Below this point the subsurface soil is a brown, loose, open, loamy fine sand or sand. Below 26 to 30 inches the subsoil consists of a yellowish-brown, incoherent sand which extends for several feet in depth.

There are variations from the typical soil in different parts of the county. Where the type borders the Carrington fine sandy loam, the subsurface soil contains some silt and clay and is heavier in texture. Gravel knolls of the type occur throughout the east central part of the county. The largest of these is found in Section 34 of Vernon Springs Township. In these areas the surface material consists of a brown, loose sand containing some fine gravel. Below 6 or 8 inches there is a yellowish-brown mixture of sand and fine and coarse gravel. Below 6 feet there are pockets of sand, fine gravel or coarse gravel. These gravelly areas are found on knolls or kames well above the surrounding plains. The drainage of the soil in these areas is excessive; in fact the type is apt to be excessively drained throughout its occurrence.

About 75 percent of the soil is under cultivation, corn, small grains and hay being grown principally. The uncultivated areas support a growth of oak, elm, ironwood, ash and maple and are utilized for pasture purposes. The yields of general farm crops are usually somewhat lower than on the adjacent areas of heavier soils. Corn yields from 25 to 35 bushels per acre, oats from 20 to 35 bushels and hay from 3½ to 1½ tons per acre. Truck crops, mainly watermelons and cantaloupes, are grown in the vicinity of Cresco. The entire crop is utilized locally. Garden crops also are grown and marketed locally.

The chief need of the Dickinson fine sandy loam is additions of organic matter to improve
the physical condition of the soil and lessen the danger of crop injury in dry seasons. Liberal applications of farm manure are of large value on this soil. The turning under of leguminous crops as green manures would also prove profitable. The type is acid in reaction and applications of lime are necessary, especially for the best growth of legumes. The use of superphosphate would undoubtedly increase crop yields when applied in addition to manure and lime. Where truck crops are grown the use of a good complete commercial fertilizer would undoubtedly prove of value.

DODGEVILLE LOAM (223)

The Dodgeville loam is the sixth largest drift soil in the county, covering 3.8 percent of the total area. It occurs mainly in the eastern part of the county in Vernon Springs and New Oregon townships, and in the northern part of Forest City Township. The most extensive developments of the type are found north and south of Cresco and north of Lime Springs. There are small areas also along the Wapsipinicon River in the southwestern part of the county.

The surface soil of the Dodgeville loam is a dark grayish-brown or black, friable loam extending to a depth of 8 inches. Below this point is a light brown, granular silt loam or silty clay loam underlaid at a depth of about 20 inches by a reddish-brown, stiff, waxy compact clay derived from the underlying limestone bedrock. Below 28 inches or less is a yellowish-brown rock flour or decomposed rock material. The bedrock is found below a depth of 30 inches.

There are some variations in the soil in different areas. The texture of the surface layer may vary from a loam to a sandy loam. It is impossible to map these variations. There is a wide difference in the depth of the surface soil and the material covering the bedrock. In some areas the surface soil is very shallow. Rock fragments occur commonly on the surface, especially on the steep slopes, and outcrops of the bedrock limestone are found at the base of the slopes along the streams in the vicinity of Cresco.

In topography the Dodgeville loam ranges from undulating to hilly or broken. Drainage is good or excessive. The soil is frequently damaged by erosion in seasons of heavy rainfall. Where the soil is deep and cultivation is practicable, general farm crops are grown. Yields, however, are usually lower than on the other soils in the county. Low yields are common in dry seasons. In seasons of abundant rainfall, fairly satisfactory crop yields may be secured.

The chief need of this type is the incorporation of organic matter, and liberal applications of farm manure would be of value. The turning under of a legume crop as a green manure would be worth while. The surface soil is acid, and applications of lime will be necessary for the best growth of legume crops. The use of a phosphate fertilizer would undoubtedly be
of value, and tests of rock phosphate and superphosphate are recommended.

LINDLEY FINE SANDY LOAM (136)

The Lindley fine sandy loam is a minor type, covering 1.5 percent of the total area of the county. It occurs in the wooded sections along the older streams. The larger areas are mapped along the Wapsipinicon River and Crane Creek in the southwestern part of the county. The most extensive areas occur 2 miles north and 1 mile south of Riceville, 2 miles southwest of Elma, north of Saratoga, north and south of Lourdes, and northeast of Bonair. Smaller areas of the type are found in other parts of the county.

The surface soil of the Lindley fine sandy loam is a grayish-brown, friable, fine sandy loam, extending to a depth of from 4 to 8 inches. Below this surface layer, the soil is a yellowish-brown, fine sandy loam which grades into a loam or sandy clay loam. At a depth of 30 inches the subsoil consists of a clay or silty clay, yellowish-brown in color, faintly mottled with gray and showing some iron stains. This is the parent glacial till and much glacial gravel and small boulders are present. Boulders are also found in many places throughout the soil section.

Variations appear in the soil as mapped in different areas. The texture of the surface soil varies from a loam and silt loam to a fine sandy loam. The areas of silt loam and loam are too small to show on the map, however, and have been included with the type. There is considerable variation in the depth of the surface soil. On the steeper slopes where much erosion has occurred, the soil is often very shallow and will average about 4 inches in thickness. On the smoother areas the soil often reaches a thickness of 8 inches. In topography the type is rolling or hilly and drainage is adequate. The steeper slopes are subject to erosion, and in many areas the surface layer has been completely washed away and the yellowish-brown subsoil is exposed.

The Lindley fine sandy loam was originally forested with oak, elm, maple, ash, walnut and hickory and an undergrowth of hazel brush and scrub oak. About one-half of the soil is still timbered. The remaining areas have been cleared and are utilized for cultivated crops. Corn yields from 30 to 45 bushels per acre, oats from 40 to 50 bushels and hay from 1 to 2 tons per acre on this type.

This soil is in need of organic matter and will be benefited materially by the liberal application of farm manure or the turning under of some green manure crop such as red clover or sweet clover. The type is acid in reaction and in need of lime. The use of a phosphate fertilizer would undoubtedly prove of value. It is particularly important that precautions be taken to protect the more rolling to steep areas from the injurious effects of erosion. Sheet washing may occur on such areas to a very undesirable extent and ditches and gullies are common. From among the suggestions made earlier, methods
for handling the soil to prevent erosion may be selected.

**CARRINGTON FINE SANDY LOAM (4)**

The Carrington fine sandy loam is a minor type covering 0.8 percent of the total area of the county. It occurs in small tracts in the drift section, the largest being found in Sections 6 and 7 of New Oregon Township and Section 12 of Paris Township. Most of the small areas are found on the plain east and north of the Turkey River and its tributaries.

The surface soil of the Carrington fine sandy loam is a dark grayish-brown, loose, fine sandy loam, extending to a depth of from 7 to 9 inches. The subsurface soil is a yellowish-brown, heavy, silt loam or silty clay loam having a coarse, granular structure and continuing to a depth of about 16 inches. The subsoil below this point is a gray and yellow, sandy and gravelly clay. Small pockets of sand are frequently found.

The type is associated with the Carrington loam and Dickinson fine sandy loam, usually occurring between these two soils. The boundary lines are sometimes placed rather arbitrarily, but there is a gradation from the Carrington fine sandy loam into the Carrington loam on the one hand and into the Dickinson fine sandy loam on the other. The surface of the soil is somewhat hummocky. Drainage is good to excessive.

Practically all of the type is under cultivation and general farm crops are grown. Yields, however, are lower than on the heavier soils. Corn yields from 25 to 35 bushels per acre, oats from 30 to 40 bushels and hay from 1 to 1½ tons per acre.

The type is particularly in need of organic matter to make it more retentive of moisture and reduce the danger of drouth injury to crops. Liberal applications of farm manure are of large value, and the turning under of leguminous crops as green manures would also improve crop yields. The type is acid and in need of lime. The use of a phosphate fertilizer would also be of value, and tests of superphosphate are recommended.

**DICKINSON LOAM (174)**

The Dickinson loam is a minor type, covering 0.3 percent of the total area. It occurs in a number of small areas in the drift section, the largest being mapped in Section 34 of Howard Center Township. Smaller areas are found in Paris, Vernon Springs and Howard Center townships. It is found closely associated with the Carrington loam and the Dickinson fine sandy loam.

The surface soil of the Dickinson loam is a dark grayish-brown, friable loam extending to a depth of about 9 inches. The subsurface soil is a grayish-brown or olive-brown clay loam containing considerable fine sand. Below 18 or 20 inches the subsoil consists of a yellowish-brown sandy loam. The substratum is a brown, gray and yellow, loose, open sand. In topography the type is undulating
to gently rolling and drainage is good to excessive. The type is not so drouthy as the fine sandy loam of the same series.

The application of organic matter is particularly necessary on this soil, and liberal additions of farm manure are of value. The turning under of a legume as a green manure would also improve the fertility of the type, supplying needed organic matter and nitrogen. The type is acid in reaction and in need of lime. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate are recommended.

Loess Soils

There are three loess types in the county, classified in the Tama, Fayette and Dodgeville series. They cover 3.3 percent of the total area.

TAMA SILT LOAM (120)

The Tama silt loam is the second largest loess type covering 1.3 percent of the total area of the county. It occurs only in the extreme northeastern part of the county in association with the Fayette silt loam. The largest and most typical tract is found on the divide between the Upper Iowa River and one of its larger tributaries in Albion Township. This tract varies in width from 1 mile to less than \( \frac{1}{4} \) mile.

The surface soil of the Tama silt loam is a friable, mellow silt loam very dark grayish-brown in color, extending to a depth of about 10 inches. The subsurface soil to a depth of 18 to 24 inches is a heavy silt loam or light silty clay loam, dark grayish-brown in color, splotched and streaked with lighter colored material. The subsoil to a depth of about 50 inches is a yellowish-brown, heavy silt loam or silty clay loam. The parent loess is a grayish yellow, friable silt loam containing iron stains and concretions and faint gray mottlings. In topography the type is gently rolling.

The Tama silt loam was originally prairie land and all of it is under cultivation. Corn yields from 45 to 50 bushels per acre, oats from 40 to 45 bushels and hay from 1 to 2 tons on this type. Other minor crops are grown and give satisfactory yields.

The Tama silt loam will respond to applications of farm manure and the turning under of leguminous crops as green manures. Large in-
creases in crop yields follow the use of farm manure. The type is acid in reaction and in need of lime. Phosphate fertilizers give profitable returns on this soil, and tests of rock phosphate and superphosphate are recommended.

**FAYETTE SILT LOAM (163)**

The Fayette silt loam is the largest loess soil in the county, covering 1.7 percent of the total area. It occurs in association with the Tama silt loam in the northeastern corner of the county. The largest area is mapped along the Upper Iowa River in Albion Township. Extensive areas occur throughout the loessial section of the county, not only in Albion Township but extending over into the northeastern corner of Forest City Township.

The surface soil of the Fayette silt loam is a rather dark grayish-brown silt loam becoming grayish-brown at a depth of 1 or 2 inches and extending to a depth of 10 inches. The subsurface soil is a light brown or yellowish-brown, light silty clay loam. Below 18 inches the subsoil is a more friable, brown or yellowish-brown, silt loam. Below 30 inches the parent material is a grayish-yellow silt loam. Rust brown stains occur below a depth of 4 feet. On the steeper slopes the surface soil has been washed away to some extent, and the surface layer is shallower than in the more level areas. The topography of the type is rolling to steeply rolling and drainage is good to excessive.

The type was originally forested with oak, elm, hickory, basswood and maple. About 70 percent of it is cleared and now utilized for general farming. Crop yields are somewhat lower than on the adjacent Tama silt loam, but they are above the average for the county. Corn, oats and other small grains and hay are the chief crops grown.

The chief need of this soil is the addition of organic matter. Liberal applications of farm manure would prove of value, and the turning under of leguminous crops as green manures would improve the crop yields. The type is acid in reaction and in need of lime. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate are recommended.

**DODGEVILLE SILT LOAM (204)**

The Dodgeville silt loam is a minor type, covering 0.3 percent of the total area. It occurs in the loessial section of the county in close association with the Tama and Fayette silt loams. The largest tracts are in Sections 19 and 20 of Albion Township and in Sections 11 and 12 of Forest City Township. A number of other small areas of the type are found in these two townships.

The surface soil of the Dodgeville silt loam is a dark grayish-brown, smooth, friable silt loam extending to a depth of about 9 inches. At this point it grades into a reddish-brown, residual clay, tough and plastic when wet and hard when dry. At a depth varying from 26 to 29 inches, this stiff, plastic clay changes
SOIL SURVEY OF IOWA

DODGEVILLE SILT LOAM

A Dark grayish brown friable silt loam
B Reddish brown tough plastic residual clay
C1 Yellowish brown rock flour
C2 Bed Rock (Limestone)

abruptly into a thin layer of yellowish-brown, disintegrated rock or rock flour. This in turn rests on the limestone bedrock.

There are variations in the soil in different areas. The surface material ranges in thickness from 4 to 6 inches on the eroded slopes to 14 inches on the flat divides. On the tops of the hills the deeper silt layer occurs, while on the slopes there is only a thin covering over the reddish-brown clay and rock. In some cases the reddish-brown clay is exposed, rock fragments appear on the surface and occasionally the rock crops out at the bases of hills. The topography of the type is strongly rolling to hilly and natural drainage is good to excessive.

About 50 percent of the type is under cultivation, the remainder being utilized as pasture or hay land. The yields of cultivated crops are often satisfactory, but there is so much variation in the soil, especially in the depth of the surface layer, that the yields are variable. In many cases they are quite low. The type is best adapted for use as pasture or hay land. The steeper slopes should certainly be utilized for pasture purposes as they are not adapted to cultivated crops. When cultivated the type needs to receive liberal additions of farm manure and leguminous crops as green manures in order to build up the content of organic matter and permit the retention of moisture. The type is inclined to be drouthy. The surface soil is acid in reaction, and applications of lime are necessary to secure good stands of legume crops. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate are recommended.

Terrace Soils

There are four terrace types in the county, classified in the O'Neill, Bremer and LaCrosse series. Together they cover 6.5 percent of the total area.

O'NEILL LOAM (108)

The O'Neill loam is the largest of the terrace soils, covering 3.3 percent of the total area of the county. It occurs on terraces lying 15 to 40 feet above the present flood plain of the streams. The most extensive areas are along the Upper Iowa River between Oakdale and Chester, along the Wapsipinicon River near Riceville, along Crane Creek south of Saratoga and Maple Leaf and along the north branch of the Turkey River.

The surface soil of the O'Neill loam is a dark grayish-brown, friable or mellow loam containing some coarse sand. It extends to a depth of 8 or 10 inches. At this point the soil grades into a light brown sandy clay loam containing a small amount of coarse sand and fine gravel. The subsoil below 22 inches is a yellowish-brown, loose, coarse sand and gravel.

There are many variations in the soils of the different areas as is commonly the case with soils of alluvial origin. Considerable variations in texture occur,
and small tracts of silt loam or sandy loam are included with the loam as they are too small to show on the map. The depth of the surface soil is extremely variable. In Section 19 of Afton Township an area is included which is not typical of the O'Neill soils. Here the lower part of the subsoil is a yellowish-brown silty clay loam and the gravel layer does not occur above a depth of 40 to 45 inches. The area is too small to separate. In some cases these areas which vary from the typical soil would have been mapped as Waukesha loam had they been of sufficient size. The surface of the soil is level. Drainage is good to excessive and crops often suffer in dry seasons.

About 80 or 85 percent of the O'Neill loam is under cultivation to corn, oats and hay. The remainder of the soil has a scant growth of trees and is utilized as pasture land. Corn yields from 25 to 40 bushels per acre, oats from 30 to 45 bushels and hay from 1 to 1½ tons per acre. Crop yields are quite satisfactory in seasons of abundant rainfall, but in dry years the yields are low.

The soil is chiefly in need of organic matter to permit the better retention of moisture and to reduce the danger of drought injury to crops. Liberal applications of farm manure would prove of value. The turning under of leguminous crops as green manures would also help to build up the soils in organic matter. The type is acid and in need of lime, especially for the growth of legumes. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate are recommended.

### O'Neill Fine Sandy Loam (110)

The O'Neill fine sandy loam is the second largest terrace soil, covering 2.7 percent of the area of the county. It occurs in association with the O'Neill loam on the high terraces, usually occupying a position between the areas of the loam and the first bottoms. The tracts of fine sandy loam are well above overflow, being 30 to 50 feet above the flood plains of the streams. The largest single area is in Sections 7, 8 and 17 of Paris Township, along the west bank of Crane Creek. Other small areas of the type are found scattered along various streams.

The surface soil of the O'Neill fine sandy loam is a dark grayish-brown, porous fine sandy loam containing some coarse sand and fine gravel. It extends to a depth of 7 or 8 inches, below which point it grades into a light
The type is particularly in need of protection from overflow if it is to be cultivated. When so protected and well drained, cultivated crops may be grown successfully. The soil is acid and lime would be of value, especially for the growth of legumes. The use of a phosphate fertilizer would be of value, and tests of superphosphate are recommended.

**WABASH SILT LOAM (26)**

The Wabash silt loam is a minor type, covering 0.6 percent of the total area of the county. It occurs in a number of small areas scattered on the bottomlands in various parts of the county. The largest single area is mapped in Sections 17 and 18 of Afton Township. Numerous other small areas of the type occur.

The surface soil of the Wabash loam is a dark brown or dark grayish-brown, smooth, friable silt loam, extending to a depth of 10 inches. From this point to a depth of 26 inches, the subsurface soil is a light brown, coarsely granular, heavy silt loam or silty clay loam. The subsoil is a gray and brown, mottled rusty brown or black clay. In topography the soil is level and drainage is poor. The type is subject to frequent overflow, and the fields remain wet for long periods in the spring and early summer. Considerable wash is carried down over the soil from the adjacent uplands.

Less than one-fourth of the soil is under cultivation, the remaining areas supporting a growth of bluegrass in the better drained land and slough grass on the wet areas. The areas are small and utilized usually for pasture purposes. When cultivated, after having been drained, good yields of crops may be secured. Corn yields from 40 to 60 bushels per acre. Small grains, however, are apt to lodge.

The chief need of this soil to be made more productive is protection from overflow and adequate drainage. It is acid and in need of lime, especially for the best growth of legumes. The use of a phosphate fertilizer would be of value and tests of superphosphate are recommended.
ROUGH STONY LAND (78)

There is a small area of rough stony land in the county which has been included with the bottomland soils. It covers 0.2 percent of the total area. The areas mapped include limestone bluffs and rocky slopes of no agricultural value. In most instances the bluffs rise almost perpendicularly from the stream beds. The largest areas occur along the Upper Iowa River near and east of Granger. The rocky slopes support a growth of oak, elm, hickory, basswood, birch, maple, walnut, ironwood and cherry. Some red cedar trees grow on the rocky ledges and steep rock covered bluffs east of Granger.
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

Map of Iowa showing the counties surveyed.
counties and on the different soils are worked out, old methods of treatment are emphasized as necessary or their discontinuance advised, and new methods of proven value are suggested.

**PLANT FOOD IN SOILS**

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

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

**THE "SOIL DERIVED" ELEMENTS**

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

**AVAILABLE AND UNAVAILABLE PLANT FOOD**

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

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

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

**REMOVAL OF PLANT FOOD BY CROPS**

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

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

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

It is evident from the table that the continuous growth of any common farm crop without returning these three important elements will lead finally to a shortage of plant food in the soil. The nitrogen supply is drawn on the most heavily by all the crops, but in the case of alfalfa and clover only a small part should be taken from the soil. If these legumes are inoculated as they should be, they will take most of their nitrogen from the atmosphere. The figures are therefore entirely too high for the nitrogen taken from the soil by these two crops, but the loss of nitrogen from the soil by removal in non-leguminous crops is considerable. The
### HOWARD COUNTY SOILS

#### TABLE I. PLANT FOOD IN CROPS AND VALUE

Calculating Nitrogen (N) at 16c (Sodium Nitrate (NaNO₃)), Phosphorus (P) at 12c (Superphosphate), and Potassium (K) at 6c (Potassium Chloride (KCl))

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>Plant Food, Lbs.</th>
<th>Value of Plant Food</th>
<th>Total Value of Plant Food</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nitrogen</td>
<td>Phosphorus</td>
<td>Potassium</td>
</tr>
<tr>
<td>Corn, grain</td>
<td>75 bu.</td>
<td>75</td>
<td>12.75</td>
<td>14</td>
</tr>
<tr>
<td>Corn, stover</td>
<td>2.25 T.</td>
<td>36</td>
<td>4.5</td>
<td>39</td>
</tr>
<tr>
<td>Corn, crop</td>
<td>36.7</td>
<td>111</td>
<td>17.25</td>
<td>53</td>
</tr>
<tr>
<td>Wheat, grain</td>
<td>30 bu.</td>
<td>42.6</td>
<td>7.2</td>
<td>7.8</td>
</tr>
<tr>
<td>Wheat, straw</td>
<td>1.5 T.</td>
<td>15</td>
<td>2.4</td>
<td>27</td>
</tr>
<tr>
<td>Wheat, crop</td>
<td>75.5</td>
<td>57.6</td>
<td>9.6</td>
<td>34.8</td>
</tr>
<tr>
<td>Oats, straw</td>
<td>50 bu.</td>
<td>33</td>
<td>5.5</td>
<td>8</td>
</tr>
<tr>
<td>Oats, crop</td>
<td>1.25 T.</td>
<td>15.5</td>
<td>2.5</td>
<td>26</td>
</tr>
<tr>
<td>Barley, grain</td>
<td>30 bu.</td>
<td>48.5</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td>Barley, straw</td>
<td>0.75 T.</td>
<td>9.5</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Rye, grain</td>
<td>30 bu.</td>
<td>29.4</td>
<td>7.8</td>
<td>21</td>
</tr>
<tr>
<td>Rye, straw</td>
<td>1.5 T.</td>
<td>12</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>Rye, crop</td>
<td>41.4</td>
<td>9</td>
<td>28.8</td>
<td>6.62</td>
</tr>
<tr>
<td>Potatoes</td>
<td>300 bu.</td>
<td>63</td>
<td>12.7</td>
<td>90</td>
</tr>
<tr>
<td>Alfalfa, hay</td>
<td>6 T.</td>
<td>300</td>
<td>27</td>
<td>144</td>
</tr>
<tr>
<td>Timothy, hay</td>
<td>3 T.</td>
<td>72</td>
<td>9</td>
<td>67.5</td>
</tr>
<tr>
<td>Clover, hay</td>
<td>3 T.</td>
<td>120</td>
<td>15</td>
<td>90</td>
</tr>
</tbody>
</table>

Phosphorus and potassium in the soil are also rapidly reduced by the growth of ordinary crops. While the nitrogen supply may be kept up by the use of leguminous green manure crops, phosphorus and potassium must be supplied by the use of expensive commercial fertilizers.

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

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

### REMOVAL FROM IOWA SOILS

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

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

### PERMANENT FERTILITY IN IOWA SOILS

The preliminary study of Iowa soils, already reported, revealed the fact that there is not an inexhaustible supply of nitrogen, phosphorus and potassium in the soils of the state. Potassium was found in much larger amounts than the other two elements, and it was concluded, therefore, that attention should be centered at the present time on nitrogen and phosphorus.

In spite of the fact that Iowa soils are still comparatively fertile and crops are still large, there is abundant evidence at hand to prove that the best possible yields of certain crops are not being...
obtained in many cases because of the lack of necessary plant foods or because of the lack of proper conditions in the soil for the growth of plants and the production, by bacteria, of available plant food.

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

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

CULTIVATION AND DRAINAGE

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

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

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

THE ROTATION OF CROPS

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

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

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

MANURING

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

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

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

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

THE USE OF PHOSPHORUS

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

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

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

LIMING

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

All Iowa soils should therefore be tested for acidity before the crop is seeded, particularly when legumes, such as alfalfa or red clover, are to be grown.

SOIL AREAS IN IOWA

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

With the exception of the northeastern part of the state, the whole surface of Iowa was in ages past overrun by great continental ice sheets. These great masses of ice moved slowly over the land, crushing and grinding the rocks beneath and carrying along with them the material which they accumulated in their progress. Five ice sheets invaded Iowa at different geological eras, coming from different directions and carrying, therefore, different rock material with them. The deposit, or sheet of earth debris left after the ice of such glaciers melts, is called "glacial till" or "drift" and is easily distinguished by the fact that it is usually a rather stiff clay containing pebbles of all sorts as well as large boulders of "nigger heads." Two of these drift
areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift was laid down at a much earlier period and is somewhat poorer in plant food than the Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

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

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

THE SOIL SURVEY BY COUNTIES

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

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

GENERAL SOIL CHARACTERISTICS

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

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

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

The common soil constituents may be given as follows:†

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

SOILS GROUPED BY TYPES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

* 25mm. equals 1 in. † Bureau of Soils Handbook.
Coarse Sand—More than 25 percent very coarse, coarse and medium sand, less than 50 percent of other grades, less than 20 percent silt and clay.

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

Gravels—More than 50 percent very coarse sand.

Stony Loams—A large number of stones over 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 the mapping may proceed rapidly.

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

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

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

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