Soil Survey of Iowa, Report No. 77—Washington County Soils

P. E. Brown  
*Iowa State College*

C. L. Orrben  
*Iowa State College*

H. R. Meldrum  
*Iowa State College*

A. J. Englehorn  
*Iowa State College*

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SOIL SURVEY OF IOWA
WASHINGTON COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Farm Crops and Soils Section
Soils Subsection

Soil Survey Report No. 77
March, 1935
Ames, Iowa
IOWA AGRICULTURAL EXPERIMENT STATION

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SOIL SURVEY OF IOWA

Report No. 77—WASHINGTON COUNTY SOILS

By P. E. Brown, C. L. Orrben, H. R. Meldrum and A. J. Englehorn

IOWA AGRICULTURAL
EXPERIMENT STATION

R. E. Buchanan, Director
Ames, IOWA
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WASHINGTON COUNTY SOILS

By P. E. Brown, C. L. Orrben, H. R. Meldrum and A. J. Englehorn

Washington County is located in southeastern Iowa in the second tier of counties west of the Mississippi River and in the third tier north of the Missouri state line. It lies partly in the Mississippi loess and partly in the Southern Iowa loess soil areas and hence the soils are all of loessial origin.

The total area of the county is 566 square miles or 362,240 acres. Of this area, 349,501 acres, or 96.4 percent are in farm land. The total number of farms is 2,237 and their average size is 156 acres. Owners operate 50.6 percent of the total farm land and renters the remaining 49.4 percent. The following figures from the Iowa Yearbook of Agriculture for 1932 show the utilization of the farm land of the county:

<table>
<thead>
<tr>
<th>Description</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acreage in general farm crops</td>
<td>204,203</td>
</tr>
<tr>
<td>Acreage in farm buildings, public highways and feedlots</td>
<td>14,831</td>
</tr>
<tr>
<td>Acreage in pasture</td>
<td>119,271</td>
</tr>
<tr>
<td>Acreage in wasteland not utilized for any purpose</td>
<td>4,301</td>
</tr>
<tr>
<td>Acreage in farm woodlots used for timber only</td>
<td>6,057</td>
</tr>
<tr>
<td>Acreage in crop land lying idle</td>
<td>838</td>
</tr>
<tr>
<td>Acreage in crops not otherwise listed</td>
<td>100</td>
</tr>
</tbody>
</table>

THE TYPE OF AGRICULTURE IN WASHINGTON COUNTY

The type of agriculture now followed in Washington County is mainly general farming. Corn, oats and hay are the general farm crops grown, corn being the most important, followed in order by oats and hay. Barley, rye and wheat acreages are small. Practically all of the crops produced are fed to livestock—hogs, cattle and sheep. Some grain is sold on the rented farms but the practice is not at all general. Hog raising is the chief livestock industry followed in order by cattle raising and feeding, sheep raising and feeding, and horse and mule raising. The majority of the farmers combine grain production with livestock raising, and many farms are operated on a strictly livestock basis. Income on the farms is derived mainly from the sale of livestock and livestock products, supplemented by the sale of surplus crops in individual cases. The poultry industry adds something to the income on many farms and is proving a valuable addition to the farming enterprise.

There is a considerable acreage of waste land in the county, and much of it might be reclaimed and made productive by the adoption of proper methods of soil treatment. General recommendations for the handling of such waste areas cannot be given as the causes of infertility are too variable. Later in this report,

1 See Soil Survey of Washington County, Iowa, by C. L. Orrben of the Iowa Agricultural Experiment Station and W. H. Buckhannan of the United States Department of Agriculture. Field operations of the Bureau of Soils, Series 1930, Project No. 243 of the Iowa Agricultural Experiment Station.
under the discussion of the individual soil types, suggestions will be offered for
the treatment of land out of production at present as well as for areas which
are not producing what they should. In special cases, for more or less abnormal
conditions, advice regarding treatments may be obtained from the Soils Sub-
section of the Iowa Agricultural Experiment Station.

THE FARM CROPS GROWN IN WASHINGTON COUNTY

The general farm crops grown in Washington County in the order of their
importance are corn, oats, hay, alfalfa, soybeans, wheat, potatoes, barley and
rye. The acreage yield and value of these crops in the county are shown in
table 1.

Corn is the chief crop grown, both in acreage and value. In 1932 it was
grown on 32.03 percent of the total farm land, and average yields of 51.5 bushels
per acre were reported, which is considerably above the average for the state
for that year, which was 42.7 bushels. On the better soils and under the best
systems of soil management, however, the yields are much higher than these
average figures, in anything like favorable seasons. In fact it is reported that
yields may go as high as 80 bushels per acre, and on cleared steep slopes which
are too often used for corn, the yields may be as low as 20 bushels per acre.
Large late-maturing heavy-yielding varieties of corn are preferred. The yellow
corns are favored. Reid Yellow Dent, King Dent, Wilson, Walden Dent, and
certain strains of hybrid corn are the most popular varieties. Bloody Butcher,
Boone County White and strains of the mentioned varieties are also grown.
About 88 percent of the corn is husked for grain, and the remainder is hogged-
down or cut for silage. Most of the crop is used for feed on the farms; a few
tenant farmers sell their crop at the local elevators.

Oats are second in importance to corn. In 1932 this crop was grown on 14
percent of the total farm land, with average yields of 37.9 bushels per acre.
Under the most favorable conditions the yields are much higher than this, and
all of the soils are well adapted to the growing of oats, except perhaps the heavy
black types on which the crop is apt to lodge. The main varieties are Iogold,
Iowar, Richland and Albion. Oats fit well into the rotation, following corn and
serving as a nurse crop for the clover or clover-timothy mixture. The crop is
used for feed for work animals or is ground and used in dairy cattle and hog
rations. Very little of the crop is sold for cash.

Hay ranks third in acreage and value. In 1932 clover hay was grown on 3.99
percent of the total farm land with average yields of 1.35 tons per acre, timothy
hay was grown on 1.79 percent of the farm land with average yields of 1.02 tons
per acre and clover and timothy mixed was grown on 3.23 percent of the total
farm land with average yields of 1.31 tons per acre. All other tame hay was
grown in 1932 on 1.13 percent of the farm land with average yields of 1.07 tons
per acre. The value of the hay crop is high, the clover showing the greatest
value with the clover and timothy mixture second. Some clover is grown for
seed, in 1932 the acreage used in this way amounting to 1.25 percent of the
farm land. Some timothy is also used for seed. On many farms the second crop
of clover is cut for seed. Most of the clover seed is produced near Kalona,
northwest of Brighton and north of Wellman.
**TABLE 1. ACREAGE, YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN WASHINGTON COUNTY, IOWA**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acreage</th>
<th>Percentage of total farm land of county</th>
<th>Bushels or tons per acre</th>
<th>Total bushels or tons</th>
<th>Average price**</th>
<th>Total value of crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>111,958</td>
<td>32.03</td>
<td>51.5</td>
<td>5,765,837</td>
<td>$0.12</td>
<td>$691,900</td>
</tr>
<tr>
<td>Oats</td>
<td>48,957</td>
<td>14.00</td>
<td>18.2</td>
<td>885,606</td>
<td>0.10</td>
<td>148,650</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>1,905</td>
<td>0.54</td>
<td>18.2</td>
<td>34,632</td>
<td>0.33</td>
<td>11,428</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>111</td>
<td>0.03</td>
<td>14.9</td>
<td>1,651</td>
<td>0.33</td>
<td>544</td>
</tr>
<tr>
<td>Barley</td>
<td>853</td>
<td>0.24</td>
<td>22.4</td>
<td>19,069</td>
<td>0.20</td>
<td>3,913</td>
</tr>
<tr>
<td>Rye</td>
<td>98</td>
<td>0.02</td>
<td>12.7</td>
<td>1,241</td>
<td>0.24</td>
<td>297</td>
</tr>
<tr>
<td>Clover hay (mixed)***</td>
<td>13,979</td>
<td>3.99</td>
<td>1.35</td>
<td>18,872</td>
<td>6.00</td>
<td>113,232</td>
</tr>
<tr>
<td>Timothy hay</td>
<td>6,263</td>
<td>1.79</td>
<td>1.02</td>
<td>6,388</td>
<td>4.50</td>
<td>28,746</td>
</tr>
<tr>
<td>Corn and timothy hay</td>
<td>11,304</td>
<td>3.23</td>
<td>1.31</td>
<td>14,808</td>
<td>6.00</td>
<td>88,848</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>1,114</td>
<td>0.31</td>
<td>3.17</td>
<td>3,531</td>
<td>8.00</td>
<td>28,248</td>
</tr>
<tr>
<td>All other tame hay</td>
<td>3,963</td>
<td>1.13</td>
<td>1.07</td>
<td>4,260</td>
<td>6.00</td>
<td>25,560</td>
</tr>
<tr>
<td>Soybeans sown with other crops</td>
<td>868</td>
<td>0.24</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Soybeans sown alone</td>
<td>3,790</td>
<td>1.08</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Soybeans harvested for beans</td>
<td>1,708</td>
<td>0.48</td>
<td>10.7</td>
<td>33,694</td>
<td>0.42</td>
<td>14,151</td>
</tr>
<tr>
<td>Potatoes</td>
<td>258</td>
<td>0.07</td>
<td>101.0</td>
<td>26,159</td>
<td>0.37</td>
<td>9,678</td>
</tr>
<tr>
<td>Timothy seed</td>
<td>1,567</td>
<td>0.44</td>
<td>5.2</td>
<td>8,153</td>
<td>0.25</td>
<td>7,745</td>
</tr>
<tr>
<td>Clover seed</td>
<td>4,879</td>
<td>1.25</td>
<td>0.91</td>
<td>3,976</td>
<td>6.00</td>
<td>23,556</td>
</tr>
<tr>
<td>Sweet clover****</td>
<td>54</td>
<td>0.01</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

*Iowa Yearbook of Agriculture, 1932.

**Average state farm values Dec. 1, 1932, except timothy and alfalfa hay, clover seed, which are estimated.

****Sweet clover not included.

All varieties for all purposes.

The acreage in alfalfa is increasing. In 1932 this crop was grown on 0.31 percent of the total area with average yields of 3.17 tons per acre. It is a valuable crop, and when the land is properly limed, good seed is used and the seed is inoculated, the crop proves very successful. Many small fields from 3 to 15 acres in size are now in alfalfa. The crop is used mainly for hay or hog pasture. Some sweet clover is grown and is used for cattle and hog pasture as well as for a green manure crop. It makes an excellent growth and pasture, but the land must be limed for it to be grown successfully. Both alfalfa and sweet clover might be grown much more extensively than they are at present, with distinct advantage in increasing feed production and increasing soil fertility.

Wheat is a cash crop, but the acreage in recent years has been small. In 1932 winter wheat was grown on 0.54 percent of the farm land with an average yield of 18.2 bushels per acre. Very little spring wheat was grown in that year. Kanred, Turkey, Iobred and strains of Marquis are the chief varieties grown.

Barley is increasing in favor with the introduction of heavy-yielding varieties such as Trebi. Other varieties grown are Velvet and Oderbrucker. Some rye is grown but it is not an important crop. Some soybeans are being grown and are proving a valuable crop. In 1932 this crop was grown for beans on 0.48 percent of the farm land. Some soybeans were sown with other crops, and some were sown alone.

Potatoes are grown on practically all farms to supply the home demand. In 1932 this crop was grown on a very small total acreage with average yields of
101 bushels per acre. A few special crops are grown. Tomatoes, sweet pumpkins, sweet corn and cabbage are grown and sold to the canning factory at Brighton. In the vicinity of Riverside the tomato crop is contracted for by factories at Muscatine and Iowa City. One farmer near Kalona grows peppermint, distills the oil and markets the product in Chicago.

THE LIVESTOCK INDUSTRY IN WASHINGTON COUNTY

The livestock industry includes the raising and feeding of hogs and beef cattle, dairying, sheep raising and the raising of horses and mules, named in the order of their importance.

Hog raising is the most important of the livestock industries. On the dairy farm, there is a quantity of skim milk available for feeding and on the beef cattle farms the hogs follow the steers in the feedlot. The Federal Farm Board survey estimates the shipment of hogs from the county annually at 2,400 car-loads. Many farms are operated on a hog-farm basis. Gilts are selected at intervals to replace the old brood sows. Purebred sires are used for one year and then either sold or traded for new animals. The number of brood sows kept depends upon the extent to which the farmer practices hog raising and upon the supply of corn. Very few farmers purchase feed for fattening hogs and if more pigs are raised than can be fed they are sold to a neighbor to finish. The Duroc Jersey, Poland China, Hampshire and Chester White are the favorite breeds of hogs. A few Tamworths are raised. The fattened hogs are shipped to Chicago or taken to Ottumwa for sale.

The largest cattle feeders are located in Jackson, Cedar, Oregon, Washington, Franklin and Seventy-six townships, which constitute the heaviest corn-producing section of the county. A few farmers in the hilly areas near Noble and Crawfordville pasture beef cattle throughout the grazing season. Only a small number of beef cattle are raised on the farms. Young feeders are purchased on the Kansas City or Omaha markets or bought direct from the Texas ranges. Hereford, Shorthorn and Aberdeen Angus are the favorite breeds named in the order of preference. The feeding period extends over a period ranging from 100 to 200 days, depending upon the feed available and the finish desired by the feeder. The finished steers are sold at the Chicago and Ottumwa stockyards.

Dairying is practiced to some extent, especially in the vicinity of Kalona, Brighton and Wellman, where limited crop land areas, because of rolling and hilly topography along the Skunk and English rivers, and an abundance of pasture have stimulated interest in dairying. The popular breeds are the Holstein-Friesian, Jersey and Guernsey. Most of the dairy cows are good grade animals. The milk is separated and the cream sold to local creameries. The total value of dairy products marketed in 1930 was reported at $195,079, and the value of all products marketed was estimated at $400,000 annually.

Sheep raising is a minor industry. A few head are kept on farms which have extensive pasturage and a few lambs are raised. The wool usually is sold through pools. Horses and mules are raised to keep up the farm supply, one or two colts being raised annually.

The poultry industry provides some income but it is usually regarded as a side line. As a matter of fact the sale of poultry and poultry products adds
considerably to the farm income in many cases. Two large turkey farms where from 1,000 to 3,000 birds are raised annually, are located in the county.

THE FERTILITY SITUATION IN WASHINGTON COUNTY

Crop yields obtained on much of the land in Washington County are fairly satisfactory, but much larger crops might be grown if proper methods of soil management were adopted. Larger yields per acre are always economically desirable, and with approved rotations and the best treatments of the soil, it is possible to obtain increases.

The drainage situation is not entirely adequate everywhere, and wherever there is not a sufficiently rapid removal of water following rains, the drainage of the land should be improved. This is the first treatment necessary to permit satisfactory crop yields. The Grundy silty clay loam, certain areas in the Grundy silt loam, the Muscatine silt loam, the Putnam silt loam, the Marion silt loam, and the Bremer and Wabash types on the uplands, terraces and bottomlands, respectively, are all in need of drainage and require tiling to make them productive.

All the soil types in the county are acid in reaction, and they must be limed if the yields of general farm crops are to be satisfactory and especially if legumes are to be grown. All the soils should be tested at least once in the rotation, preferably preceding the legume crop, and lime applied as needed, in order that the best yields of crops may be obtained and the land kept permanently productive.

Several of the soils in the county are low in organic matter as is apparent by their light color. These types obviously need additions of materials supplying organic matter to make them more productive. On the coarse textured types, too, it is especially necessary that applications of organic matter be made, in order to make them more absorptive and retentive of moisture and hence less apt to be droathy. But even on those soils which are apparently well supplied with organic matter and black in color, it is necessary to add organic matter regularly to maintain the supply. The Lindley, Clinton, Putnam, Marion, Jackson, Calhoun and O'Neill soils on the uplands and terraces particularly need organic matter. In some cases the occurrence of a sandy or gravelly subsoil may make the need for organic matter imperative. This is the case with the Shelby and O'Neill soils. Those types like the Lindley fine sandy loam, the Tama fine sandy loam, and the O'Neill fine sandy loam especially need organic matter because of their sandy nature. The other types in the county which are not so deficient at present will also respond to the use of organic matter. Such soils as the Grundy, Tama, Waukesha, Chariton and Bremer all need regular applications of organic matter-supplying materials to maintain their content.

Farm manure is the chief material which is used for supplying the soils with organic matter and it has large value, bringing about definite increases in crop yields. The use of all crop residues also helps to maintain the organic matter in soils, and these materials should be thoroughly utilized. The turning under of legumes as green manures will be of value on many of the soils, particularly wherever the supply of farm manure is limited and liberal amounts of this material cannot be applied. On the sandy types and those lighter in color and
poorer in organic matter it is often desirable to use legumes as green manures to supplement the farm manure.

The phosphorus supply is so low that it is evident that additions of a phosphate fertilizer will be needed in the very near future even if they are not of value now. It is apparent from experiments, however, that either rock phosphate or superphosphate might be used now with profit on many of the soils. Superphosphate may be of the more value on some soils, such as the light-colored, coarse-textured types, but rock phosphate will probably bring about just as large effects on the darker richer soils. These two phosphates should be tested to determine which will prove the more profitable under any particular set of conditions.

The use of complete commercial fertilizers will probably not prove as profitable as superphosphate, according to the experiments which have been carried out on some of the most important soil types. Superphosphate is less expensive and hence the complete commercial fertilizer must bring about much larger increases in crop yields to prove as economically desirable. Ordinarily the results from the two materials have been similar. On some soils, with special crops, the use of a complete fertilizer may prove of value, but tests should be made comparing the two materials, using small areas, and then applications may be made to larger areas with assurance of profit.

Commercial nitrogenous fertilizers are not recommended for general use in the county at the present time. In small amounts as top dressings, they may be used, especially for special crops or truck crops, but for general farm crops, the addition of nitrogen to the soil, when it is needed can usually be accomplished more economically and just as satisfactorily by turning under inoculated legumes as green manures. Ordinarily the soils of this county probably will not respond to the use of commercial potassium carriers, but sometimes the addition may be of value. To determine the need for such materials a test under the particular conditions on the farm should be made.

Erosion occurs to some extent, being evidenced in the Tama silt loam, the Clinton silt loam, the Shelby loam and the Lindley silt loam on the uplands, some areas of these types being marked with gullies which indicate an advanced stage in erosion, and others being subject to extensive sheet washing which is carrying away the surface soil with great rapidity where the systems of soil management are not properly worked out and the land is improperly handled as to cropping and management. Wherever erosion is occurring or where gullies have been formed, some method should be adopted for the prevention or control of the destructive action and for the filling of the gullies.
THE GEOLOGY OF WASHINGTON COUNTY

The geological history of Washington County is of significance agriculturally only insofar as it concerns the glacial and loessial deposits. The native bedrock is buried so deeply under these deposits that it has no effect whatever upon soil conditions.

During the glacial age, at least two great ice sheets swept across the county and each left a vast deposit of glacial debris or till. Little evidence remains of the first glaciation, the pre-Kansan, except for layers of sand which appear occasionally in the beds of boulder clay, and have been found in certain well borings. These sands indicate the lapse of some time between the pre-Kansan deposit and the later deposition of the Kansan drift.

The second glacier, the Kansan, covered the entire county, and when it melted a deep layer of glacial till was left, filling old valleys and spreading thinly over old hills. The depth of the deposit was, therefore, quite variable, ranging from a few feet up to 125 feet in thickness. The original Kansan drift was a bluish clay containing many small boulders and occasionally a large one. When weathered the upper layer of this till has been oxidized to a yellowish-brown to reddish-brown in color, depending upon the extent of oxidation which has occurred. The later covering of loess has been completely washed away by erosion in many areas, causing the underlying drift to be exposed. The accumulation of organic matter has darkened the color and it now appears as a dark grayish-brown in many areas. The soils of the Shelby and Lindley series are derived entirely or in large part from the Kansan drift deposit.

In a later period, geologically, when conditions were quite different than the present, there was laid down over the surface of the land a deposit of wind-blown material known as loess. This fine, dust-like or silty material was deposited uniformly over the previous topographic features, in a layer ranging from 18 to 25 feet in thickness. This layer has been very seriously eroded in many areas, and the deposit of silt is now from 1 to 18 feet in thickness, while in many areas, as noted above, it has been completely removed, exposing the drift below. The loess, when unweathered is a yellow to light gray silt loam to silty clay loam. Weathering and accumulation of organic matter have darkened it, and in many of the types the color is a dark grayish-brown. Some of the types are still light in color. The soils of the Grundy, Muscatine, Tama, Clinton, Putnam and Marion series are derived from this loess deposit, and the Lindley silt loam is partly of loessial origin.

There are considerable areas of terraces and swamp and bottomland soils in the county. These have been formed by stream action and are extremely variable in character and depth. The soils are partly of loessial origin and partly of drift origin as might be expected from the nature of their formation. The series mapped includes the Waukesha, Bremer, Jackson, Calhoun, Chariton and O’Neill soils on the terraces and the Wabash, Cass and Genesee on the bottomlands.

PHYSIOGRAPHY AND DRAINAGE

The topography of Washington County ranges from hilly or broken near the large streams, and rolling on the narrower divides, to level on the broad areas
between the streams. The most extensive level area extends diagonally south­eastward across the county, beginning in the western part of Seventy-Six Township and extending through Washington to Crawfordsville. Here the tributaries of the streams have not as yet cut through the uplands, and the level divides are naturally poorly drained. The greater part of the county, however, has been rather completely cut by stream action. Rolling areas are found at some distance from the streams usually, while near the streams, the land often becomes decidedly hilly or broken. Rock outcrops are frequently found at the bases of the slopes.

The valleys of the various streams are usually wide, and terraces are found on one or both sides of the streams. The terraces are wide along the Iowa River in Iowa Township, along the English River in English River and Lime Creek townships, and along the Skunk River in Brighton Township. Along the smaller streams there are only narrow areas of bottomland and usually no second bottom-
lands. The bottoms of the larger streams are wider, and extensive areas of first bottomland soils are found along the English and Skunk rivers.

Drainage is brought about by the Iowa River, the Skunk River and their tributaries. The chief tributaries of the Iowa include the English River, and Smith, Lime, Caine, Davis, Goose and Long creeks, which drain the northern and eastern parts of the county. The chief tributaries of the Skunk River are Dutch, Crooked and Williams creeks. Dutch Creek drains the extreme southwestern section of the county, Williams Creek the extreme southern part and Crooked Creek, including the West Fork of the creek, and Clemons Creek drains the south central part of the county.

Natural drainage is not adequately developed in certain sections as is indicated on the accompanying drainage map. Broad areas throughout the central part of the county need additional drainage. Extensive areas of the Grundy silt loam, and especially the Grundy silty clay loam on both sides of the West Fork of Crooked Creek, which flows southeastward through the center of the county, need artificial drainage. Other areas need tiling, especially on some of the broad terraces of the Bremer soils and on some of the bottomlands. Individual areas in other types may need drainage in special cases. This is true of Muscatine silt loam, Putnam silt loam, Marion silt loam, and the Chariton and Calhoun soils on the terraces.
THE SOILS OF WASHINGTON COUNTY

The soils of Washington County are grouped into four classes on the basis of origin and location. These groups are drift soils, loess soils, terrace soils, and swamp and bottomland soils. Drift soils are deposits made by glaciers and they consist of materials varying widely in composition and containing sand and some boulders. Loess soils are fine dust-like deposits made by the wind at some previous geological time. Terrace soils are old bottomlands which have been raised above overflow by a decrease in the stream's volume or by a deepening of the river channel. Swamp and bottomland soils occur in low-lying poorly drained areas or along streams and are subject to overflow.

The occurrence of these groups of soils is shown in table 2. Drift soils cover 12 percent of the total area. Loess soils are most extensively developed, covering 68.7 percent of the county. Terrace soils cover 6.7 percent and bottomland soils 12.6 percent of the total area.

<table>
<thead>
<tr>
<th>Soil group</th>
<th>Acres</th>
<th>Percentage of total area of county</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drift soils</td>
<td>43,328</td>
<td>12.0</td>
</tr>
<tr>
<td>Loess soils</td>
<td>249,472</td>
<td>68.7</td>
</tr>
<tr>
<td>Terrace soils</td>
<td>23,808</td>
<td>6.7</td>
</tr>
<tr>
<td>Swamp and bottomland soils</td>
<td>45,632</td>
<td>12.6</td>
</tr>
<tr>
<td>Total</td>
<td>362,240</td>
<td></td>
</tr>
</tbody>
</table>

There are 23 individual soil types in the county. Three are drift types, 8 loess soils, 8 terrace soils and 4 bottomland soils. They are distinguished on the basis of certain definite characteristics described in the appendix to this report. The type names denote certain group characteristics described later. The areas of the different soil types are given in table 3.

The Lindley silt loam is the largest of the drift soils, covering 9.3 percent of the county. It is the fifth largest type in the area. The Shelby loam is second in size in the drift group, covering 2.6 percent of the area. The Lindley fine sandy loam is minor in area, covering only 0.1 percent of the county. The Grundy silt loam is the largest of the loess soils and the largest individual type. It covers 22.9 percent of the total area. The Clinton silt loam is the second loess soil and the second type, covering 20 percent of the total area. The Tama silt loam is the third largest type and the third loess soil. It covers 15 percent of the county. The Grundy silty clay loam is the fourth largest loess soil, covering 8.8 percent of the area. The Putnam silt loam is fifth covering 1.6 percent of the county. The Marion silt loam covers only 0.2 percent, and the Muscatine silt loam and the Tama fine sandy loam cover 0.1 percent of the area, respectively.

The Bremer silt loam is the largest of the terrace soils, covering 2.8 percent of the total area. The Waukesha silt loam is the second terrace type, and it covers 1 percent of the county. The Jackson silt loam is third, covering 0.9 percent, the Calhoun silt loam, fourth, covering 0.7 percent, the Chariton silt loam, fifth, covering 0.6 percent, the Bremer silty clay loam, sixth, covering 0.5 percent, and the Waukesha loam and the O'Neill fine sandy loam each cover...
only 0.1 percent of the county. The Wabash silt loam is the largest of the bottomland soils and the fourth largest individual type in the county. It covers 9.5 percent of the total area. The Genesee silt loam is second among the bottomland soils, covering 1.6 percent of the county; the Cass fine sandy loam is third, covering 0.8 percent and the Wabash silty clay loam is fourth, covering 0.7 percent of the area.

A rather distinct relation exists between the topographic features and the soil types, at least on the uplands. The Grundy silt loam and silty clay loam, the Muscatine silt loam, and the Putnam and Marion silt loams occur on the more nearly level to gently undulating uplands, while the Tama soils and the Clinton, Lindley and Shelby types are found in the more strongly rolling to rough uplands. Where the Grundy silty clay loam is present the topography is almost depressed and drainage is poor. Areas are also present in the Grundy silt loam, the Putnam silt loam and the Marion silt loam where there is very little in the way of topographic features and the land is flat and poorly drained. In contrast, some of the areas in the Shelby and Lindley types are so rough that they cannot be cultivated. The Tama soils are strongly rolling in many places. On the terraces there is little difference in topography, and the Bremer soils, the Calhoun and Chariton types, are somewhat depressed, while the Waukesha, Jackson and O’Neill soils are a little higher than the majority of the second bottomlands. The bottomlands are all level.

### TABLE 3. AREAS OF DIFFERENT SOIL TYPES IN WASHINGTON COUNTY

<table>
<thead>
<tr>
<th>Soil legend</th>
<th>Soil no.</th>
<th>Soil type</th>
<th>Acres</th>
<th>Percentage of total area of county</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRIFT SOILS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ls</td>
<td>32</td>
<td>Lindley silt loam</td>
<td>33,728</td>
<td>9.3</td>
</tr>
<tr>
<td>S</td>
<td>79</td>
<td>Shelby loam</td>
<td>9,408</td>
<td>2.6</td>
</tr>
<tr>
<td>Lf</td>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>192</td>
<td>0.1</td>
</tr>
<tr>
<td>LOESS SOILS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>64</td>
<td>Grundy silt loam</td>
<td>83,072</td>
<td>22.9</td>
</tr>
<tr>
<td>Cl</td>
<td>80</td>
<td>Clinton silt loam</td>
<td>72,640</td>
<td>20.0</td>
</tr>
<tr>
<td>T</td>
<td>120</td>
<td>Tama silt loam</td>
<td>54,386</td>
<td>15.0</td>
</tr>
<tr>
<td>Gs</td>
<td>115</td>
<td>Grundy silty clay loam</td>
<td>31,872</td>
<td>8.8</td>
</tr>
<tr>
<td>P</td>
<td>66</td>
<td>Putnam silt loam</td>
<td>5,760</td>
<td>1.6</td>
</tr>
<tr>
<td>M</td>
<td>67</td>
<td>Marion silt loam</td>
<td>768</td>
<td>0.2</td>
</tr>
<tr>
<td>Tf</td>
<td>259</td>
<td>Tama fine sandy loam</td>
<td>576</td>
<td>0.1</td>
</tr>
<tr>
<td>Ms</td>
<td>50</td>
<td>Muscatine silt loam</td>
<td>448</td>
<td>0.1</td>
</tr>
<tr>
<td>TERRACE SOILS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bo</td>
<td>88</td>
<td>Bremer silt loam</td>
<td>10,048</td>
<td>2.8</td>
</tr>
<tr>
<td>Ws</td>
<td>75</td>
<td>Waukesha silt loam</td>
<td>3,648</td>
<td>1.0</td>
</tr>
<tr>
<td>J</td>
<td>81</td>
<td>Jackson silt loam</td>
<td>3,200</td>
<td>0.9</td>
</tr>
<tr>
<td>C</td>
<td>42</td>
<td>Calhoun silt loam</td>
<td>2,432</td>
<td>0.7</td>
</tr>
<tr>
<td>Ch</td>
<td>105</td>
<td>Chariton silt loam</td>
<td>2,112</td>
<td>0.6</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>Bremer silty clay loam</td>
<td>1,664</td>
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</tr>
<tr>
<td>Wm</td>
<td>60</td>
<td>Waukesha loam</td>
<td>576</td>
<td>0.1</td>
</tr>
<tr>
<td>Of</td>
<td>110</td>
<td>O’Neill fine sandy loam</td>
<td>128</td>
<td>0.1</td>
</tr>
<tr>
<td>SWAMP AND BOTTOMLAND SOILS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>28</td>
<td>Wabash silt loam</td>
<td>34,406</td>
<td>9.5</td>
</tr>
<tr>
<td>Gf</td>
<td>71</td>
<td>Genesee silt loam</td>
<td>5,760</td>
<td>1.6</td>
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<tr>
<td>Cf</td>
<td>130</td>
<td>Cass fine sandy loam</td>
<td>2,752</td>
<td>0.8</td>
</tr>
<tr>
<td>We</td>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>2,624</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>362,240</td>
<td></td>
</tr>
</tbody>
</table>
THE FERTILITY IN WASHINGTON COUNTY SOILS

Samples were taken for analysis from all soil types except the Muscatine silt loam which was not sampled owing to its small occurrence and unimportance agriculturally. The more extensively developed types were sampled in triplicate, while the minor types were represented with only one sample. All samplings were made with the greatest care that they should be thoroughly representative of the types and that any variations because of local conditions or special soil treatments should be eliminated. The samples were taken at three depths, 0 to 6% inches, 6% to 20 inches, and 20 to 40 inches, representing the surface soil, subsurface soil and the subsoil, respectively.

Total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirements were determined on all the samples. Official methods were followed for the phosphorus, nitrogen, organic carbon and inorganic carbon. The Truog qualitative test was used for the determinations of the limestone requirements. The results given in the tables are the averages of duplicate determinations on all samples of soil.

The Surface Soils

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

The supply of phosphorus is extremely variable, ranging from 525 pounds per acre in the Lindley fine sandy loam to 2,113 pounds per acre in the Wabash silt loam. No very definite relation is indicated between the phosphorus

<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>32</td>
<td>Lindley silt loam</td>
<td>767</td>
<td>1,720</td>
<td>19,198</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>79</td>
<td>Shelby loam</td>
<td>700</td>
<td>2,400</td>
<td>27,542</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>525</td>
<td>560</td>
<td>9,899</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>64</td>
<td>Grundy silt loam</td>
<td>1,421</td>
<td>4,820</td>
<td>53,694</td>
<td></td>
<td>6,500</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>889</td>
<td>1,920</td>
<td>21,925</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>1,333</td>
<td>4,040</td>
<td>45,649</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>115</td>
<td>Grundy silty clay loam</td>
<td>1,016</td>
<td>4,340</td>
<td>57,116</td>
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<td>7,000</td>
</tr>
<tr>
<td>66</td>
<td>Putnam silt loam</td>
<td>1,212</td>
<td>2,880</td>
<td>33,732</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>67</td>
<td>Marion silt loam</td>
<td>660</td>
<td>1,720</td>
<td>18,516</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>259</td>
<td>Tama fine sandy loam</td>
<td>713</td>
<td>1,800</td>
<td>19,089</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>88</td>
<td>Bremer silt loam</td>
<td>1,225</td>
<td>3,880</td>
<td>45,595</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>75</td>
<td>Waukesha silt loam</td>
<td>1,050</td>
<td>3,080</td>
<td>34,114</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>81</td>
<td>Jackson silt loam</td>
<td>1,010</td>
<td>3,480</td>
<td>38,096</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>42</td>
<td>Calhoun silt loam</td>
<td>1,252</td>
<td>3,360</td>
<td>35,178</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>105</td>
<td>Chariton silt loam</td>
<td>1,212</td>
<td>3,400</td>
<td>40,936</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>43</td>
<td>Bremer silty clay loam</td>
<td>1,764</td>
<td>5,840</td>
<td>71,992</td>
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<td>4,000</td>
</tr>
<tr>
<td>60</td>
<td>Waukesha loam</td>
<td>1,037</td>
<td>1,480</td>
<td>21,406</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>110</td>
<td>O'Neill fine sandy loam</td>
<td>754</td>
<td>1,040</td>
<td>12,080</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>1,616</td>
<td>5,560</td>
<td>62,584</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>71</td>
<td>Genesee silt loam</td>
<td>1,279</td>
<td>2,320</td>
<td>29,860</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>130</td>
<td>Cass fine sandy loam</td>
<td>1,353</td>
<td>2,800</td>
<td>29,615</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silt loam</td>
<td>2,113</td>
<td>5,000</td>
<td>66,587</td>
<td></td>
<td>4,000</td>
</tr>
</tbody>
</table>
content and the soil groups except that the bottomland soils, on the average, seem to be much better supplied with the element than the upland soils. This might be expected since there has been more crop growth on the uplands and hence a much greater removal of plant food constituents. The drift types, too, seem to be much lower than the loess soils which is characteristic of the soil series represented. The series in the drift group are naturally lower in plant food than most of the series in the loess group. The terrace soils are very similar on the average, to the loess types.

A relation between the soil series and the phosphorus content, is indicated, however. Thus on the loess uplands the Grundy soils are the richest, followed by the Tama, Putnam, Clinton and Marion in the order named. On the terraces the Bremer types are the richest, followed by the Chariton, Calhoun, Waukesha, Jackson and O'Neill. On the bottomlands, the Wabash types are the highest and the Cass and Genesee follow as named.

These differences certainly indicate the effects of those characteristics which serve to distinguish soil series. The color of the surface soil, the topographic position and the character of the subsoil are the most important characters involved. Soils like the Grundy and Tama which are the darkest in color are richer in phosphorus than the lighter colored Putnam types. These, in turn, are richer in phosphorus than the still lighter soils of the Clinton and Marion series. The Bremer soils are the blackest of the terrace soils and the highest in phosphorus. The Chariton, Calhoun and Waukesha are darker in color than the Jackson and O'Neill, and they are higher in phosphorus. The Wabash soils are darker in color than the Cass and Genesee. The Cass soils are darker than the Genesee and richer in phosphorus. Similarly the effects of topography may be traced. The Grundy soils are more nearly level in topography and hence richer in plant food than the Tama, while the Bremer types are flat to depressed in topography and higher in plant food. The subsoil characters are likewise important. The O'Neill soils on the terraces have sandy or gravelly subsoils and are the lowest in plant food. The same is true with the Cass soil on the bottoms; it has a sandy subsoil and hence is lower in phosphorus than the Wabash types. The drift soils are all low in plant food, due partly to the light color, the origin of the material, the rough to hilly topography and the frequently sandy subsoil. The loess types are richer owing to their darker color, heavier subsoil condition, origin and less rough topography.

The effects of soil texture are shown in the analyses. The Lindley fine sandy loam is lower than the Lindley silt loam in phosphorus. The Tama silt loam is higher than the fine sandy loam of that series, but the Grundy silty clay loam is lower than the Grundy silt loam which is contrary to the usual results. The Bremer silty clay loam on the terraces is higher than the silt loam and the Waukesha silt loam is higher than the loam. On the bottomlands the Wabash silty clay loam is higher than the Wabash silt loam. In general it appears that finer textured soils are richer in phosphorus than coarse textured soils. Thus, silty clay loams are higher than silt loams which are richer than loams, and these, in turn, are better supplied than sandy loams or sands.

The soils of Washington County are so low in phosphorus that it is apparent
that additions must be made soon, even if phosphate fertilizers do not prove of value now. There is evidence, however, that a phosphate fertilizer would be beneficial to many of the soils of the county now.

The nitrogen supply in the soils varies widely, ranging from 560 pounds per acre in the Lindley fine sandy loam up to 5,840 pounds per acre in the Bremer silty clay loam. These are the same soils which were the lowest and highest, respectively, in phosphorus. Again there is little evidence of any relationship between the nitrogen content and soil groups, although the terrace and bottomland soils average somewhat higher than the upland types, as might be expected. The loessial upland soils are better supplied than the drift types, and the swamp and bottomland soils are a little richer than the terrace soils. Some greater differences are found within groups, however, than between groups.

Evidence is presented of a relationship between the soil series and the nitrogen supply. The characteristics which determine the series, such as color, topography, subsoil and origin seem to have a rather definite effect on the nitrogen supply. The Grundy soils on the loess uplands, are darkest in color and highest in nitrogen. The Tama soils are darker than the other types except the Grundy and they are richer in nitrogen. The Marion silt loam is the lightest in color and it is the lowest in nitrogen. On the drift uplands the Shelby is darker than the Lindley soils and is higher in nitrogen. On the terraces the Wabash soils are higher in nitrogen and darker in color than the Cass and Genesee. Soils like the Clinton are lower in nitrogen than the soils like the Grundy also, because they have lighter subsoils and are more rolling to rough in topography. The Tama soils are lower in nitrogen than the Grundy owing to their more rolling topography. The Bremer soils on the terraces are richer in nitrogen partly because of their heavy subsoils and more nearly level to depressed topographic position. The Wabash soils are richer than the Cass owing to their heavy subsoils. The O’Neill soils on the terraces and the Cass types on the bottoms are low in plant food partly because of their sandy or gravelly subsoils. The origin of the soils is also important as the loess soils are richer than the drift types on the average.

There is also some evidence of a relationship between nitrogen and the soil texture. Thus the Lindley silt loam is richer than the Lindley fine sandy loam, the Tama silt loam is much higher in nitrogen than the fine sandy loam, the Bremer silty clay loam is richer than the silt loam, the Waukesha silt loam is higher than the loam, but the Grundy silty clay loam is lower than the silt loam, and the Wabash silty clay loam is not as high as the silt loam, which is contrary to the usual results. The difference in the two latter cases, however, is small. In general it appears that fine textured soils are higher than coarse textured types. Thus silty clay loams are richer than silt loams, silt loams are higher than loams and loams are better supplied than fine sandy loams or sands.

While the nitrogen supply is not extremely low in some of the soils of the county, in a number of cases the content is too low for good crops. In such cases the application of nitrogenous materials is very necessary now. On all the soils, however, regular use of nitrogenous fertilizing materials is needed if the supply is to be maintained. Thorough utilization of all farm manure and
crop residues and the turning under of legumes as green manures will permit of
the maintenance of the nitrogen content and will also provide a means of
building up the supply wherever it is low at present.

The total organic carbon content of the soils varies in much the same way as
in the case of nitrogen. The range is from 9,899 pounds per acre in the Lindley
fine sandy loam up to 71,992 pounds per acre in the Bremer silty clay loam.
These are the same types which showed the lowest and highest content of
nitrogen, respectively. The same relationships between the organic carbon and
the soil groups are noted as in the case of nitrogen. The terrace and bottom­
land groups are a little higher in organic matter than the upland soils, and the
drift soils are lower than the loessial types. But there are greater differences
within groups than between groups.

The relationships between the organic matter and the soil series are quite
definite. The Shelby loam is much higher than the Lindley soils. The Grundy
soils are the highest on the loessial uplands, followed in order by the Tama,
Putnam, Clinton and Marion. These differences are a direct result of the
differences in color of the soils in the different series, the differences in topo­
graphy and subsoil character as well as differences in origin of the soils. The
drift soils are lower than the loessial types, the lighter colored types are lower
than the darker colored soils, those soils more nearly level in topography are
better supplied with organic matter than the rolling to rough types, and those
soils which have heavy subsoils are also richer in organic matter. The same
sort of relationships appear among the terrace soils. The Bremer types which
are the blackest in color and the more nearly level to flat in topography and
have the heaviest subsoils are the richest in organic matter. The lighter colored
soils, like the Jackson and Calhoun and those with sandy subsoils like the O’Neill
are lowest in organic matter content. In the same way types on the bottoms,
like the Wabash, which are darker in color and heavier in the subsoil are richer
than the lighter colored Genesee and the sandy subsoil Cass.

The relationship to texture is shown in some cases. Thus the Lindley silt
loam is richer in organic matter than the fine sandy loam; the Grundy silty
clay loam is higher than the silt loam; the Tama silt loam is richer than the fine
sandy loam; and the Waukesha silt loam is higher than the loam. The Wabash
silty clay loam is lower than the silt loam which is contrary to the usual results.
In general it is evident that soils of fine texture are richer in organic matter
than the coarse textured types. Thus silty clay loams are usually higher than
silt loams, silt loams are richer than loams and loams are higher than sandy
loams or sands.

The soils of Washington County are not unusually high in organic matter,
and it is evident that in many instances there is a need of adding some fertilizing
material supplying organic matter at the present time. On the lighter colored
soils and those more rolling in topography and wherever the subsoil is sandy
or gravelly, the use of organic matter is especially necessary. On all the soils,
however, the regular use of organic matter is required to keep up the supply.
The use of farm manure, crop residues and legumes as green manures is essential
on the soils of this county.
The relationship between the carbon content and the content of nitrogen in soils often shows definitely the rate at which the organic matter is decomposing and hence the rate at which the plant food constituents are being changed into an available form. In many of the soils in Washington County, this relationship is such that it is apparent that available plant food is not being produced properly for the best crop yields. Thus in the Lindley silt loam, the Shelby loam, the Clinton silt loam, the Tama silt loam, the Marion silt loam, the Tama fine sandy loam and a number of the terrace and bottomland soils, there is certainly too slow a production of plant food in an available form. On these soils the use of farm manure would prove of especially large value as this fertilizing material has a very definite effect upon the production of available plant food, stimulating the decomposition processes and bringing about a great change in the availability processes. Experiences in the field have shown the large value of farm manure on these soils.

The soils are all acid in reaction and show no content of inorganic carbon. The tests indicate that the lime requirements of all the soils are high. The results given in the table, however, should not be accepted as showing the exact lime needs of all the soils of these types in the field. Soils vary so widely in acidity or lime requirements that tests should always be made of the soil in a particular field before lime is applied. In this way it is possible to apply the proper amount of limestone and obtain the best results. It is apparent from these results, however, that all the soils must be tested for lime needs and that limestone should be applied as needed, if the best crop yields, especially of legumes, are to be obtained.

The Subsurface Soils and Subsoils

The results of the analyses of the subsurface soils and subsoils are shown in tables 5 and 6. There is no especially large content of plant food constituents in the lower soil layers and no striking deficiencies, and hence it is unnecessary to consider these analyses in detail. The conclusions drawn from a consideration of the results of the analyses of the surface soils are quite indicative of the fertilizer needs of the soils, and would not be changed in any particular by the results for the lower soil layers.

GREENHOUSE EXPERIMENTS

Greenhouse experiments were carried out on two soils from Washington County, in order to determine their needs and to test the value of certain fertilizing materials. These experiments were carried out on the Putnam silt loam and the Clinton silt loam, two of the important types.

The treatments employed in these tests included manure, limestone, superphosphate and muriate of potash. Manure was added at the rate of 10 tons per acre, limestone in sufficient amounts to neutralize the soil acidity, superphosphate was added at the rate of 250 pounds per acre and muriate of potash at the rate of 50 pounds per acre. Wheat and clover were grown in the tests, the clover being seeded when the wheat was up. The results obtained may be considered to indicate fairly well what may be expected in the field from the same treatments.
### TABLE 5. PLANT FOOD IN WASHINGTON COUNTY, IOWA, SOILS

Pounds per acre of 4 million pounds of subsurface soil (6"-20")

<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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>914</td>
<td>1,520</td>
<td>14,725</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>79</td>
<td>Shelby loam</td>
<td>942</td>
<td>2,320</td>
<td>27,315</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>1,076</td>
<td>640</td>
<td>8,944</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>64</td>
<td>Grundy silt loam</td>
<td>2,518</td>
<td>7,200</td>
<td>88,463</td>
<td></td>
<td>7,000</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>1,830</td>
<td>2,080</td>
<td>16,961</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>2,182</td>
<td>5,760</td>
<td>66,538</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>115</td>
<td>Grundy silty clay loam</td>
<td>1,426</td>
<td>5,280</td>
<td>81,782</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>66</td>
<td>Putnam silt loam</td>
<td>1,616</td>
<td>2,480</td>
<td>31,742</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>67</td>
<td>Marion silt loam</td>
<td>1,480</td>
<td>1,440</td>
<td>15,980</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>259</td>
<td>Tama fine sandy loam</td>
<td>1,534</td>
<td>2,720</td>
<td>35,669</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>2,362</td>
<td>7,600</td>
<td>95,236</td>
<td></td>
<td>7,000</td>
</tr>
<tr>
<td>75</td>
<td>Waukesha silt loam</td>
<td>1,696</td>
<td>5,760</td>
<td>62,584</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>81</td>
<td>Jackson silt loam</td>
<td>1,212</td>
<td>2,800</td>
<td>30,569</td>
<td></td>
<td>5,000</td>
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<td>42</td>
<td>Calhoun silt loam</td>
<td>1,884</td>
<td>4,180</td>
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<td>5,000</td>
</tr>
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<td>105</td>
<td>Chariton silt loam</td>
<td>1,588</td>
<td>4,944</td>
<td>46,631</td>
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<td>6,000</td>
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<td>Bremer silty clay loam</td>
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<td>89,881</td>
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<td>120</td>
<td>Waukesha loam</td>
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<td>1,760</td>
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<td></td>
<td>4,000</td>
</tr>
<tr>
<td>110</td>
<td>O’Neill fine sandy loam</td>
<td>1,212</td>
<td>2,080</td>
<td>20,070</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,181</td>
<td>5,520</td>
<td>87,700</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>71</td>
<td>Genesee silt loam</td>
<td>2,962</td>
<td>6,000</td>
<td>72,701</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>130</td>
<td>Cass fine sandy loam</td>
<td>2,208</td>
<td>2,160</td>
<td>23,779</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>4,416</td>
<td>5,480</td>
<td>96,644</td>
<td></td>
<td>4,000</td>
</tr>
</tbody>
</table>

### TABLE 6. PLANT FOOD IN WASHINGTON 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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Lindley silt loam</td>
<td>1,373</td>
<td>1,440</td>
<td>19,143</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>79</td>
<td>Shelby loam</td>
<td>1,373</td>
<td>2,400</td>
<td>28,469</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>136</td>
<td>Lindley fine sandy loam</td>
<td>1,575</td>
<td>720</td>
<td>7,199</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>64</td>
<td>Grundy silt loam</td>
<td>2,665</td>
<td>5,280</td>
<td>62,420</td>
<td></td>
<td>6,500</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>3,231</td>
<td>2,280</td>
<td>16,961</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>2,667</td>
<td>3,720</td>
<td>49,086</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td>115</td>
<td>Grundy silty clay loam</td>
<td>1,636</td>
<td>4,280</td>
<td>64,793</td>
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<td>2,000</td>
</tr>
<tr>
<td>66</td>
<td>Putnam silt loam</td>
<td>2,302</td>
<td>2,760</td>
<td>25,878</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>67</td>
<td>Marion silt loam</td>
<td>2,745</td>
<td>2,280</td>
<td>20,943</td>
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<td>8,000</td>
</tr>
<tr>
<td>259</td>
<td>Tama fine sandy loam</td>
<td>2,139</td>
<td>2,760</td>
<td>33,214</td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,181</td>
<td>5,520</td>
<td>87,700</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>71</td>
<td>Genesee silt loam</td>
<td>2,962</td>
<td>6,000</td>
<td>72,701</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>130</td>
<td>Cass fine sandy loam</td>
<td>2,208</td>
<td>2,160</td>
<td>23,779</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>4,416</td>
<td>5,480</td>
<td>96,644</td>
<td></td>
<td>4,000</td>
</tr>
</tbody>
</table>

### SWAMP AND BOTTOMLAND SOILS

<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>26</td>
<td>Wabash silt loam</td>
<td>3,432</td>
<td>7,800</td>
<td>131,305</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>71</td>
<td>Genesee silt loam</td>
<td>4,767</td>
<td>9,360</td>
<td>105,207</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>130</td>
<td>Cass fine sandy loam</td>
<td>3,111</td>
<td>2,760</td>
<td>26,670</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>6,258</td>
<td>10,680</td>
<td>121,589</td>
<td></td>
<td>4,000</td>
</tr>
</tbody>
</table>
Results on the Putnam Silt Loam

The results obtained in the experiment on the Putnam silt loam are given in table 7.

Manure increased the wheat yield to a considerable extent and brought about a large increase in the clover also. Limestone with manure gave a further increase in the wheat and had a very large effect upon the clover. Superphosphate alone had slightly more effect upon wheat than manure and limestone but had less effect upon clover. Manure with superphosphate gave a greater effect than superphosphate alone on wheat and also on clover. Limestone with superphosphate had a greater effect upon both crops than manure and limestone. Manure, limestone and superphosphate did not show any increase over the effect of manure and superphosphate or limestone and superphosphate in the case of the wheat, but a slightly larger effect was exerted upon clover. Muriate of potash with manure, limestone and superphosphate increased both crops, showing a considerable effect upon the clover.

Results on the Clinton Silt Loam

The data obtained in the experiment on the Clinton silt loam are shown in table 8.

The application of manure to this soil brought about a large increase in both

<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>3.95</td>
<td>66.65</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>5.15</td>
<td>77.25</td>
</tr>
<tr>
<td>3</td>
<td>Manure+limestone</td>
<td>6.05</td>
<td>80.95</td>
</tr>
<tr>
<td>4</td>
<td>Superphosphate</td>
<td>6.40</td>
<td>77.75</td>
</tr>
<tr>
<td>5</td>
<td>Manure+superphosphate</td>
<td>6.80</td>
<td>81.25</td>
</tr>
<tr>
<td>6</td>
<td>Limestone+superphosphate</td>
<td>7.70</td>
<td>83.10</td>
</tr>
<tr>
<td>7</td>
<td>Manure+limestone+superphosphate</td>
<td>6.35</td>
<td>84.65</td>
</tr>
<tr>
<td>8</td>
<td>Manure+limestone+superphosphate+muriate of potash</td>
<td>6.80</td>
<td>98.00</td>
</tr>
</tbody>
</table>

Fig. 3. Greenhouse experiment. Clover on Putnam Silt Loam.
TABLE 8. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM, WASHINGTON 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>3.15</td>
<td>50.10</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>3.40</td>
<td>78.45</td>
</tr>
<tr>
<td>3</td>
<td>Manure+limestone</td>
<td>3.45</td>
<td>87.35</td>
</tr>
<tr>
<td>4</td>
<td>Superphosphate</td>
<td>3.55</td>
<td>72.00</td>
</tr>
<tr>
<td>5</td>
<td>Manure+superphosphate</td>
<td>3.85</td>
<td>77.25</td>
</tr>
<tr>
<td>6</td>
<td>Limestone+superphosphate</td>
<td>4.95</td>
<td>75.35</td>
</tr>
<tr>
<td>7</td>
<td>Manure+limestone+superphosphate</td>
<td>3.90</td>
<td>90.50</td>
</tr>
<tr>
<td>8</td>
<td>Manure+limestone+superphosphate+muriate of potash</td>
<td>3.55</td>
<td>95.95</td>
</tr>
</tbody>
</table>

wheat and clover crops, showing a particularly large effect on clover. Limestone with manure had little effect upon wheat but brought about a large increase in clover. Superphosphate alone had a greater effect upon wheat than that caused by manure and limestone, but the effect was much less on clover. Manure and superphosphate gave an increase in wheat over superphosphate alone and also caused a gain in clover. Limestone with superphosphate had a much greater effect upon wheat than manure and superphosphate but showed a smaller effect upon the clover. Manure, limestone and superphosphate did not increase the wheat yield over that brought about by manure and superphosphate or limestone and superphosphate, but there was a large increase in clover from the three materials applied together. Muriate of potash with manure, limestone and superphosphate had a slight effect upon wheat but brought about a definite increase in clover.

FIELD EXPERIMENTS

No field experiments are located in Washington County, but tests are in progress in a number of adjacent counties on the same soil types as occur extensively in this county. The results of these experiments will be presented and discussed here as they indicate what may be expected from the same fertilizer treatments on the same soil types in this county. Results of tests included are those on the Grundy silt loam on the Mt. Pleasant Field, Series 100 and Series

Fig. 4. Greenhouse experiment. Clover on Clinton Silt Loam.
200 in Henry County, and on the Agency Field in Wapello County, on the Clinton silt loam on the Princeton Field in Scott County and on the Keosauqua Field in Van Buren County; on the Tama silt loam on the Newton Field in Jasper County and on the West Branch Field in Cedar County; on the Grundy silty clay loam on the Mount Union Field Series I in Henry County; and on the Shelby loam on the Millerton Field in Wayne County.

These field experiments are all carried out on land which is thoroughly representative of the soil type involved. The fields include 9 or 13 plots, 155 feet 7 inches by 27 feet and are one-tenth of an acre in size. They are permanently located by the installation of corner stakes, and great care is taken in applying fertilizers and harvesting the crops to insure satisfactorily accurate results.

The experiments are carried out under both the livestock and grain systems of farming. In the former manure is applied as a basic treatment while in the latter crop residues are employed. The other fertilizers tested include limestone, superphosphate, rock phosphate, a complete commercial fertilizer and muriate of potash. Manure is applied at the rate of 8 tons per acre once in the 4-year rotation. The crop residue treatment consists of plowing under the cornstalks, cut with a disc or stalk cutter in the spring after having been winter pastured. Sometimes the second crop of clover is plowed under, but usually it is used for seed, hay or pasture and only the residues are plowed down. Limestone is applied in amounts sufficient to neutralize the acidity of the soil. Rock phosphate is added at the rate of 500 pounds per acre once in the 4-year rotation. Until 1923 this material was applied at the rate of 1 ton per acre once in 4 years, and from 1923 to 1932 at the rate of 1,000 pounds per acre once in 4 years. Superphosphate is added at the rate of 120 pounds of the 20 percent material per acre, 3 times in the 4-year rotation, not being applied to the legume. Until 1923, 16 percent superphosphate was added at the rate of 200 pounds per acre annually. The 20 percent material was first employed in 1929. Until 1923 the old standard 2-8-2 complete commercial fertilizer was used, being applied at the rate of 300 pounds per acre annually. From 1923 to 1929 a standard 2-12-2 brand was employed, the application being made at the rate of 200 pounds per acre annually. This applied the same amount of phosphorus as that added in superphosphate. Since 1929, a 2-12-6 fertilizer has been used on the Grundy and Tama soils, a 2-16-2 on the Grundy silty clay loam, and a 4-16-4 on the Clinton, Marion and Shelby soils. Muriate of potash is applied at the rate of 25 pounds per acre 3 years out of 4 in the 4-year rotation.

The Mt. Pleasant Field

The data obtained in the field experiment on the Grundy silt loam on the Mt. Pleasant Field, Series 100 in Henry County are given in table 9. Manure has proved valuable on this soil as is indicated by the increased crop yields in most seasons. The beneficial effects of manure appeared particularly on the corn in 1920 and 1928, on the oats in 1926 and on the clover in 1927. Small increases were obtained on these crops in other seasons. The application of limestone along with manure brought about crop increases which were very large in some years. The corn in 1917, 1920, 1928, 1929 and 1932 showed very large increases from the use of limestone. The oats in 1922 and the clover in
### TABLE 9. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY, MT. PLEASANT FIELD, SERIES 100

| Plot no. | Treatment | 1916 corn bu. per A. | 1917 corn bu. per A. | 1918 oats bu. per A. | Total | 1919 corn bu. per A. | 1920 corn bu. per A. | 1921 corn bu. per A. | 1922 oats bu. per A. | 1923 soybeans tons per A. | 1924 corn bu. per A. | 1925 corn bu. per A. | 1926 oats bu. per A. | 1927 clover tons per A. | 1928 corn bu. per A. | 1929 corn bu. per A. | 1930 oats bu. per A. | 1931 soybeans tons per A. | 1932 corn bu. per A. | 1933 corn bu. per A. | 1934 oats bu. per A. | 1935 soybeans tons per A. |
|----------|-----------|----------------------|----------------------|----------------------|-------|----------------------|----------------------|----------------------|----------------------|----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| 1        | Check     | 27.4                 | 36.0                 | 72.3                 | 2.22  | 1.65                 | 3.87                 | 34.5                 | 54.3                 | 35.9                      | 19.5                 | 25.0                 | 18.6                 | 37.8                 | 2.26                 | 64.4                 | 21.1                 | 63.4                 | 18.6                 | 37.8                 | 2.26                 |
| 2        | Manure    | 22.2                 | 37.5                 | 75.1                 | 2.29  | 1.50                 | 3.79                 | 57.0                 | 56.7                 | 39.8                      | 35.9                 | 39.4                 | 40.1                 | 45.0                 | 1.81                 | 30.3                 | 2.00                 | 39.3                 | 2.98                 | 47.4                 | 31.4                 |
| 3        | Manure + limestone | 15.3                | 55.0                | 74.8                 | 2.34  | 1.65                 | 3.99                 | 76.6                 | 59.5                 | 62.1                      | 38.7                 | 40.6                 | 35.9                 | 66.3                 | 42.5                 | 37.9                 | 2.00                 | 79.9                 | 33.8                 |
| 4        | Manure + limestone + rock phosphate | 40.4                | 66.0                | 76.5                 | 2.78  | 2.15                 | 4.93                 | 81.8                 | 67.5                 | 63.3                      | 66.0                 | 50.6                 | 47.3                 | 1.46                 | 78.3                 | 55.4                 | 43.7                 | 2.96                 | 74.7                 | 58.4                 |
| 5        | Manure + limestone + superphosphate | 55.9                | 73.6                | 85.1                 | 3.72  | 2.75                 | 6.47                 | 77.7                 | 72.8                 | 70.1                      | 60.7                 | 64.4                 | 66.4                 | 1.56                 | 77.3                 | 54.3                 | 59.4                 | 2.96                 | 78.7                 | 70.1                 |
| 6        | Manure + limestone + complete commercial fertilizer | 54.1                | 76.8                | 80.8                 | 3.68  | 3.25                 | 6.93                 | 67.5                 | 64.9                 | 70.6                      | 62.0                 | 63.7                 | 70.9                 | 1.31                 | 84.3                 | 61.8                 | 60.1                 | 3.14                 | 73.4                 | 60.1                 |
| 7        | Crop residues | 47.9                | 69.1                | 76.5                 | 2.20  | 2.20                 | 4.40                 | 65.0                 | 69.7                 | 66.1                      | 54.0                 | 54.1                 | 40.2                 | 0.51                 | 52.7                 | 27.8                 | 35.9                 | 2.26                 | 58.2                 | 22.1                 |
| 8        | Crop residues + limestone | 41.7                | 50.8                | 81.3                 | 2.30  | 2.00                 | 4.30                 | 67.5                 | 65.7                 | 54.8                      | 52.0                 | 55.0                 | 40.6                 | 0.89                 | 58.3                 | 26.8                 | 39.7                 | 2.53                 | 65.2                 | 34.1                 |
| 9        | Crop residues + limestone + rock phosphate | 30.3                | 47.1                | 93.2                 | 2.22  | 2.22                 | 4.44                 | 80.6                 | 66.1                 | 49.0                      | 55.3                 | 56.2                 | 39.9                 | 0.67                 | 50.7                 | 23.9                 | 46.2                 | 2.79                 | 65.1                 | 43.9                 |
| 10       | Crop residues + limestone + superphosphate | 30.4                | 52.7                | 96.4                 | 2.85  | 90.0                 | 65.0                 | 57.9                 | 57.7                 | 38.5                      | 57.8                 | 56.5                 | 38.5                 | 60.7                 | 56.4                 | 56.8                 | 2.61                 | 65.8                 | 44.8                 |
| 11       | Crop residues + limestone + complete commercial fertilizer | 30.6                | 54.7                | 99.9                 | 3.21  | 75.5                 | 66.9                 | 54.8                 | 59.3                 | 37.2                      | 57.2                 | 48.4                 | 1.43                 | 63.3                 | 39.3                 | 59.4                 | 2.44                 | 66.3                 | 44.8                 |
| 12       | Crop residues + limestone + complete commercial fertilizer + superphosphate | 27.0                | 52.8                | 93.6                 | 3.15  | 51.2                 | 67.1                 | 61.9                 | 59.7                 | 58.1                      | 47.3                 | 1.28                 | 72.7                 | 60.3                 | 51.0                 | 2.44                 | 70.8                 | 51.5                 | 2.44                 | 68.6                 | 32.9                 |

(1) Season wet, corn weedy but good quality.
(2) Short season, early frost.
(3) Cattle trampled plot 1.
(4) Corn not uniform.
(5) Three tons limestone applied, oats thin and down. Smartweed bad in plots 11 and 12.
(6) No record on account of weeds.
(7) Low yield due to very dry season and considerable rust.
(8) Very poor stand on check plots.
(9) Poor yield on plots 1 and 2 due to low, wet area.
(10) Poor yield on plots 1 and 2 due to low, wet area.
(11) Clover killed out; soybeans substituted.
(12) Wet spring followed by hot dry weather in June and July damaged oats.

*The Mt. Pleasant Field, Series 100, was established in 1914 on the State Hospital Farm, at Mt. Pleasant in Henry County. It is located in the SE ¼ of the SW ¼ of Section 14, T. 71 N., R. 6 W., Center Township.
1927 were also largely increased. Small increases were obtained in practically all seasons from the application of limestone.

Rock phosphate with manure and limestone gave increases in crops which were definite in all cases, and in some instances very large gains were noted. This was true for the clover in 1919 and 1927, the corn in 1925, 1928 and 1929, and the oats in 1926. Superphosphate with manure and limestone likewise showed a large influence on crop yields in all seasons and in all but three instances gave a larger effect on crop growth than that brought about by rock phosphate. A greater effect was shown on the clover in 1919 and 1927, on corn in 1925, on the oats in 1926 and on this crop in 1930. In the other seasons the differences were not so large but they were quite definite. Complete commercial fertilizer with manure and limestone showed very similar effects to those brought about by the superphosphate. In some instances the increases were somewhat larger while in other seasons the effects were less definite than those from superphosphate. On the average it seems that just as large effects may be brought about by superphosphate.

Crop residues showed no large effects on yields. In a few instances small gains were noted. Limestone with crop residues brought about distinct increases in yields. This was true of the oats in 1919 and 1930, the corn in 1920 and 1928 and the clover in 1927. In other seasons beneficial effects were shown but not so definitely. Rock phosphate and superphosphate with residues and limestone brought about crop increases in practically all cases. In general superphosphate seemed to be somewhat more effective than rock phosphate. The differences were not large in some seasons but with the clover in 1919 and 1927 and the oats in 1926 superphosphate proved very much superior to rock phosphate. In one or two instances rock phosphate had more effect than superphosphate. Complete commercial fertilizer in general showed about the same effect as superphosphate.

The results obtained in the experiment on the Grundy silt loam on the Mt. Pleasant Field in Henry County, Series 200 are given in table 10. Beneficial effects of manure are evident in increased crop yields obtained in all but two seasons. Large increases were noted on the oats in 1921, on the clover in 1926 and 1930 and on the corn in 1927. Limestone with manure increased the crops in nearly all seasons. Considerable increases were obtained, for example, with the corn in 1920, 1924, 1929, 1928, 1931, 1932 and 1933, and the clover in 1926 and 1930.

Rock phosphate with manure and limestone brought about increases in some seasons showing up particularly well on the oats in 1921, 1925 and 1929, on the clover in 1922, 1926 and 1930, and on the corn in 1927, 1928 and 1933. Superphosphate with manure and limestone showed a greater effect than rock phosphate in some seasons, especially on the corn in 1920, on the oats in 1921 and 1929, and on the clover in 1926 and 1930. In other seasons the effects were less or similar to those brought about by rock phosphate. Complete commercial fertilizer with manure and limestone had larger effects than superphosphate in one or two cases, notably on the corn in 1920 and on the clover in 1922. In most of the other seasons the effects were less evident than those brought about by superphosphate.
TABLE 10. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY
MT. PLEASANT FIELD,* SERIES 200**

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>1919 corn bu. per A.</th>
<th>1920 corn bu. per A.</th>
<th>1921 oats bu. per A.</th>
<th>1922 clover tons per A.</th>
<th>1923 corn bu. per A.</th>
<th>1924 corn bu. per A.</th>
<th>1925 oats bu. per A.</th>
<th>1926 clover tons per A.</th>
<th>1927 corn bu. per A.</th>
<th>1928 corn bu. per A.</th>
<th>1929 oats bu. per A.</th>
<th>1930 clover tons per A.</th>
<th>1931 corn bu. per A.</th>
<th>1932 corn bu. per A.</th>
<th>1933 corn bu. per A.</th>
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<td>1</td>
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<td>65.7</td>
<td>48.1</td>
<td>36.9</td>
<td>1.6</td>
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<td>49.3</td>
<td>50.9</td>
<td>0.10</td>
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<td>47.3</td>
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<td>51.4</td>
<td>65.3</td>
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<td>48.9</td>
<td>1.6</td>
<td>77.3</td>
<td>66.0</td>
<td>55.0</td>
<td>0.69</td>
<td>44.4</td>
<td>42.3</td>
<td>22.1</td>
<td>1.23</td>
<td>55.5</td>
<td>74.9</td>
<td>58.4</td>
</tr>
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<td>69.8</td>
<td>33.5</td>
<td>2.1</td>
<td>85.0</td>
<td>72.7</td>
<td>60.9</td>
<td>1.09</td>
<td>60.0</td>
<td>54.7</td>
<td>24.0</td>
<td>1.43</td>
<td>65.2</td>
<td>89.5</td>
<td>50.1</td>
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<tr>
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<td>42.6</td>
<td>2.4</td>
<td>84.5</td>
<td>70.4</td>
<td>65.9</td>
<td>1.31</td>
<td>76.9</td>
<td>77.0</td>
<td>46.8</td>
<td>1.97</td>
<td>67.2</td>
<td>86.9</td>
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<td>2.4</td>
<td>77.6</td>
<td>73.3</td>
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<td>76.6</td>
<td>77.3</td>
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<td>67.2</td>
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<td>46.5</td>
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<td>80.0</td>
<td>65.7</td>
<td>60.4</td>
<td>1.15</td>
<td>65.0</td>
<td>73.6</td>
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<td>2.15</td>
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<td>89.7</td>
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<td>2.1</td>
<td>58.3</td>
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<td>0.52</td>
<td>47.5</td>
<td>45.0</td>
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<td>47.7</td>
<td>71.4</td>
<td>52.7</td>
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<td>9</td>
<td>Crop residues + limestone</td>
<td>71.0</td>
<td>76.3</td>
<td>40.0</td>
<td>2.6</td>
<td>73.3</td>
<td>34.7</td>
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<td>0.76</td>
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<td>51.3</td>
<td>76.1</td>
<td>59.8</td>
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<tr>
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<td>Crop residues + limestone + rock phosphate</td>
<td>75.1</td>
<td>75.1</td>
<td>43.8</td>
<td>2.8</td>
<td>69.0</td>
<td>38.0</td>
<td>52.5</td>
<td>0.86</td>
<td>59.7</td>
<td>68.0</td>
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<td>57.1</td>
<td>73.1</td>
<td>61.1</td>
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<td>68.0</td>
<td>40.7</td>
<td>63.2</td>
<td>0.96</td>
<td>53.8</td>
<td>64.0</td>
<td>34.7</td>
<td>1.98</td>
<td>57.4</td>
<td>71.9</td>
<td>61.3</td>
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<tr>
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<td>Crop residues + limestone + complete commercial fertilizer</td>
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<td>90.1</td>
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<td>2.6</td>
<td>74.3</td>
<td>41.3</td>
<td>60.4</td>
<td>0.99</td>
<td>47.2</td>
<td>70.0</td>
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<td>1.68</td>
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<td>21.0</td>
<td>0.48</td>
<td>53.3</td>
<td>71.1</td>
<td>44.3</td>
</tr>
</tbody>
</table>

(1) Three tons limestone applied, oats lodged in spots.
(2) Two crops on all but crop residue plots. Yields represent only first cutting.
(3) Plots 7 to 13 were partly burned off in April. Check plots badly infested with weeds.
(4) Low yield in plot 2 due to wet spot in field.
(5) Wet season cut oat yield.
(6) Hot, dry season.
(7) Crop residues had little effect on the crops grown in the different seasons. Limestone with residues brought about beneficial effects on most crops. The clover in 1922, 1926, and 1930 was definitely increased. The corn was increased in 1923, 1927, 1928, 1931, 1932 and 1933. In the other seasons the effects were small and not so definite.

Rock phosphate with residues and limestone proved valuable in practically all cases. Some crop increases were not large and in one or two instances no increases were obtained. Superphosphate with crop residues and limestone showed larger effects than rock phosphate in practically all seasons. The influence was much greater on the corn in 1920, on the oats in 1925, and on the clover in 1926. In the other seasons the effects were about the same or slightly less than those caused by rock phosphate. Complete commercial fertilizer with residues and limestone showed a larger effect than superphosphate.
in one or two cases, but in general the differences were small and there was no evidence of superiority of complete fertilizer over superphosphate.

**The Agency Field**

The data obtained in the experiment on the Grundy silt loam on the Agency Field in Wapello County are given in table 11. Manure proved valuable on this soil in practically all seasons. The largest crop increases were shown on the oats in 1919, 1925 and 1930, on the hay in 1921, 1922 and 1927, on the corn in 1928, 1929 and 1933 and on the wheat in 1931. Limestone with manure brought about increases in practically all cases. Beneficial effects of limestone were especially evident on the hay crops but increases were also shown in some cases on the corn and oats.

Rock phosphate with manure and limestone increased crop yields in every season, in some cases large effects being noted. The hay crops were particularly benefited by rock phosphate and considerable gains were obtained on the oats in 1919 and 1930, on the corn in 1923 and 1929 and on the wheat in 1926 and 1931. Superphosphate with manure and limestone showed larger effects than rock phosphate in most seasons. There were no strikingly large differences except in the case of the hay crop in 1922. In 1921, 1923, 1928, 1929 and 1933 rock phosphate gave somewhat larger effects on the corn and in 1925 on the oats. Complete commercial fertilizer with manure and limestone generally showed somewhat smaller effects than superphosphate. Only on the hay crop in 1921, the clover and timothy in 1927, the clover in 1932, the corn in 1928 and 1929 and the wheat in 1931 was there any greater effect from complete fertilizer.

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

Rock phosphate with the residues and limestone brought about increases in crop yields in practically all seasons. In some instances the increases were quite distinct as on the hay crop in 1921, 1922 and 1927, on the wheat in 1926, on the corn in 1928 and 1929 and on the oats in 1930. Superphosphate with residues and limestone showed larger effects than did rock phosphate in several seasons. It had smaller effects than rock phosphate, however, on the clover in 1921, on the oats in 1925 and on the corn in 1928 and 1929 and practically the same effect on the corn in 1923 and on the wheat in 1920. Complete commercial fertilizer with the residues and limestone gave similar increases to those brought about by superphosphate. Only in one case was there a striking difference. On the corn in 1923 complete commercial fertilizer showed no effect.

**The Princeton Field**

The data obtained in the field experiment on the Clinton silt loam on the Princeton Field in Scott County are presented in table 12. Manure increased
### TABLE 11. FIELD EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY, AGENCY FIELD,* SERIES I

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>1918 Corn bu. per A. (1)</th>
<th>1919 Oats bu. per A.</th>
<th>1920 Wheat bu. per A. (2)</th>
<th>1921 Timothy and clover T. per A. (3)</th>
<th>1922 Wheat bu. per A.</th>
<th>1924 Corn bu. per A.</th>
<th>1925 Oats bu. per A.</th>
<th>1926 Wheat bu. per A.</th>
<th>1927 Clover tons per A. (6)</th>
<th>1928 Corn bu. per A.</th>
<th>1929 Corn bu. per A.</th>
<th>1930 Oats bu. per A. (7)</th>
<th>1931 Wheat bu. per A.</th>
<th>1932 Red clover tons per A.</th>
<th>1933 Corn bu. per A.</th>
</tr>
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<tbody>
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<td>1</td>
<td>Check</td>
<td>63.5</td>
<td>44.9</td>
<td>22.7</td>
<td>1.92</td>
<td>2.00</td>
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<td>66.8</td>
<td>52.3</td>
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<td>70.8</td>
<td>19.0</td>
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<td>2.25</td>
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<td>26.4</td>
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<td>2.30</td>
<td>86.5</td>
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<td>93.6</td>
<td>77.3</td>
<td>85.5</td>
<td>58.5</td>
<td>2.35</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Check</td>
<td>52.5</td>
<td>52.0</td>
<td>22.8</td>
<td>2.19</td>
<td>2.40</td>
<td>63.9</td>
<td>42.7</td>
<td>58.5</td>
<td>1.91</td>
<td>0.91</td>
<td>67.0</td>
<td>56.5</td>
<td>55.5</td>
<td>28.7</td>
<td>1.36</td>
</tr>
</tbody>
</table>

(1) Corn damaged slightly by hail in July and dry weather in August.
(2) Sample No. 7 lost in transit; wheat badly down. Light dressing of manure to all plots by mistake in winter of 1920. Lime applied in November.
(3) Pastured after first crop.
(4) Pastured after first crop.
(5) Wet weather prevented seeding of plots 11, 12 and 13.
(6) Mostly timothy.
(7) Oats in maturity on plot 6, damaged by hot winds.

*The Agency Field was laid out in the fall of 1917, on the Johnson Brothers farm, northeast of Agency, in Wapello County. The series is located in the northeastern corner of NW ¼ of the SE ¼ of Section 30, R. 12 W., T. 72 N.*
| Plot no. | Treatment | 1918 w. wheat bu. per A. | 1919 com bu. per A. | 1920 corn bu. per A. | 1921 oats bu. per A. | 1922 clover tons per A. | 1923 corn bu. per A. | 1924 oats bu. per A. | 1925 w. wheat bu. per A. | 1926 clover tons per A. | 1927 corn bu. per A. | 1928 corn bu. per A. | 1929 oats bu. per A. | 1930 w. wheat bu. per A. | 1931 red clover tons per A. | 1932 corn bu. per A. | 1933 corn bu. per A. |
|---------|-----------|------------------------|-------------------|---------------- ---|-------------------|-----------------------|-------------------|-------------------|------------------------|-----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 1       | Check     | 40.7                   | 69.3              | 61.8                | 27.7               | 41.4                   | 54.0               | 65.8              | 13.6                   | 0.96                  | 67.8              | 64.6              | 46.5              | 15.3              | 0.96              | 97.9              | 78.1              |
| 2       | Manure    | 37.4                   | 67.0              | 63.3                | 28.4               | 1.90                  | 63.2               | 64.8              | 23.6                   | 1.57                  | 79.7              | 72.7              | 74.9              | 23.2              | 1.02              | 109.8             | 89.4              |
| 3       | Manure-limestone | 43.0               | 68.2              | 70.6                | 32.1               | 2.15                  | 70.2               | 65.3              | 27.5                   | 2.06                  | 97.3              | 74.2              | 70.6              | 26.9              | 1.87              | 113.0             | 96.9              |
| 4       | Manure-limestone-rock phosphate | 47.4               | 67.5              | 73.5                | 31.9               | 2.25                  | 75.2               | 63.1              | 31.2                   | 2.08                  | 96.4              | 71.3              | 71.2              | 27.9              | 1.98              | 111.3             | 96.7              |
| 5       | Manure-limestone-superphosphate | 45.2               | 64.0              | 70.8                | 35.1               | 2.99                  | 75.2               | 75.1              | 31.8                   | 2.31                  | 96.9              | 79.2              | 80.7              | 30.0              | 1.98              | 117.4             | 96.7              |
| 6       | Manure-limestone-complete commercial fertilizer | 37.3               | 68.4              | 73.0                | 36.4               | 2.34                  | 68.1               | 71.9              | 32.4                   | 2.15                  | 89.8              | 75.9              | 36.1              | 2.52              | 111.3             | 98.9              |
| 7       | Check     | 31.7                   | 57.0              | 57.5                | 24.4               | 1.60                  | 53.0               | 62.2              | 16.9                   | 0.73                  | 59.7              | 50.3              | 9.7               | 17.3              | 0.87              | 95.9              | 66.2              |
| 8       | Crop residues | 32.9               | 59.6              | 29.6                | 1.47               | 55.2               | 64.4              | 15.5               | 7.2                   | 57.4               | 52.2              | 44.3              | 17.5              | 0.82              | 94.9              | 73.7              |
| 9       | Crop residues-limestone | 31.7               | 62.4              | 67.2                | 39.7               | 2.14                  | 61.8               | 65.6              | 23.8                   | 1.35                  | 74.6              | 66.6              | 60.1              | 1.29              | 103.2             | 87.2              |
| 10      | Crop residues-limestone-rock phosphate | 35.0               | 64.1              | 68.7                | 29.8               | 2.28                  | 65.0               | 63.4              | 26.7                   | 2.06                  | 81.3              | 69.8              | 58.6              | 23.3              | 1.60              | 97.2              | 82.7              |
| 11      | Crop residues-limestone-superphosphate | 31.7               | 66.6              | 61.5                | 31.1               | 2.18                  | 68.0               | 75.1              | 27.1                   | 2.03                  | 89.0              | 74.4              | 41.9              | 30.6              | 2.08              | 100.6             | 80.4              |
| 12      | Crop residues-limestone-complete commercial fertilizer | 36.2               | 65.2              | 69.5                | 30.8               | . . .                  | 70.1               | 73.5              | 28.3                   | 2.25                  | 85.8              | 74.6              | 68.1              | 31.2              | 2.25              | 104.7             | 85.8              |
| 13      | Check     | 28.2                   | 59.5              | 59.0                | 25.5               | . . .                  | 58.6               | 54.4              | 17.5                   | 0.98                  | 64.0              | 54.4              | 52.1              | 19.0              | 1.06              | 95.5              | 77.8              |

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

*The Princeton Field was established in the fall of 1917 on the Kroeger Bros. farm, near Princeton in Scott County. It is located in the northwest corner of the SW 1/4 of the NE 1/4 of Section 10, T. 79 N, R. 5 E, in Princeton Township.
yields on this soil in nearly every season. In some cases considerable increases were obtained, as for example on the wheat in 1925, on the corn in 1923, 1927, 1928, 1932 and 1933 and on the clover in 1922 and 1926. Limestone with manure increased still further the yields of crops. Beneficial effects were particularly evident on the clover in 1922, 1926 and 1931 and on the corn in 1927 and 1933. Increases in the yields of wheat and oats were also obtained in most cases and in corn yields in other seasons.

Rock phosphate with manure and limestone increased the crop yields in most seasons. The gains, however, were not generally large. Superphosphate with manure and limestone gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of superphosphate were not any greater than those brought about by rock phosphate. The oats in 1924, the clover in 1926 and the corn in 1932 showed the largest effects from superphosphate. Complete commercial fertilizer with manure and limestone gave somewhat greater effects than superphosphate in most seasons, but in other cases the beneficial influence was less and in no case was there any considerable gain from the use of complete fertilizer over that brought about by superphosphate.

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

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

The Keosauqua Field

The results obtained on the Clinton silt loam on the Keosauqua Field in Van Buren County are shown in table 13. Manure increased crop yields in every season, showing the largest effect on the clover in 1925, the clover and timothy in 1929, the oats in 1931, and corn in 1926 and 1932. In several cases yields were low because of unfavorable seasonal conditions. Limestone with manure brought about increases in crops in most instances, the greatest influence appearing on the clover in 1925 and the clover and timothy in 1929, on the oats in 1924 and 1928 and on the corn in 1927 and 1932.

Rock phosphate with manure and limestone had a beneficial effect in every season. Sometimes the gains were not very large, but with the clover in 1925, the corn in 1923 and 1926, and the oats in 1924 the increases were quite definite.
### TABLE 13. FIELD EXPERIMENT, CLINTON SILT LOAM, VAN BUREN COUNTY

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>1923 corn bu. per A.</th>
<th>1924 oats bu. per A.</th>
<th>1925 clover tons per A.</th>
<th>1926 corn bu. per A. (1)</th>
<th>1927 corn bu. per A. (2)</th>
<th>1928 oats per A.</th>
<th>1929 clover &amp; timothy tons per A.</th>
<th>1930 corn bu. per A.</th>
<th>1931 oats bu. per A.</th>
<th>1932 corn bu. per A.</th>
<th>1933 oats bu. per A. (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>49.0</td>
<td>27.8</td>
<td>0.87</td>
<td>33.3</td>
<td>15.7</td>
<td>9.1</td>
<td>0.46</td>
<td>13.0</td>
<td>25.4</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>50.4</td>
<td>36.6</td>
<td>1.52</td>
<td>58.7</td>
<td>25.3</td>
<td>18.2</td>
<td>0.98</td>
<td>22.0</td>
<td>50.5</td>
<td>46.1</td>
<td>15.9</td>
</tr>
<tr>
<td>3</td>
<td>Manure+limestone</td>
<td>50.4</td>
<td>53.3</td>
<td>1.87</td>
<td>62.7</td>
<td>37.4</td>
<td>21.6</td>
<td>1.84</td>
<td>22.5</td>
<td>56.1</td>
<td>69.5</td>
<td>21.1</td>
</tr>
<tr>
<td>4</td>
<td>Manure+limestone+rock phosphate</td>
<td>58.1</td>
<td>61.3</td>
<td>2.08</td>
<td>83.9</td>
<td>37.4</td>
<td>25.1</td>
<td>1.87</td>
<td>58.6</td>
<td>70.9</td>
<td>24.3</td>
<td>19.2</td>
</tr>
<tr>
<td>5</td>
<td>Check</td>
<td>57.1</td>
<td>22.1</td>
<td>1.52</td>
<td>54.7</td>
<td>31.4</td>
<td>21.6</td>
<td>0.94</td>
<td>24.5</td>
<td>46.3</td>
<td>46.8</td>
<td>19.2</td>
</tr>
<tr>
<td>6</td>
<td>Manure+limestone+superphosphate</td>
<td>60.0</td>
<td>61.7</td>
<td>2.69</td>
<td>76.9</td>
<td>37.2</td>
<td>25.1</td>
<td>2.28</td>
<td>56.1</td>
<td>68.8</td>
<td>23.2</td>
<td>19.2</td>
</tr>
<tr>
<td>7</td>
<td>Manure+limestone+superphosphate+ muriate of potash</td>
<td>59.0</td>
<td>71.0</td>
<td>2.87</td>
<td>78.7</td>
<td>40.9</td>
<td>37.4</td>
<td>2.81</td>
<td>62.4</td>
<td>72.2</td>
<td>30.3</td>
<td>23.2</td>
</tr>
<tr>
<td>8</td>
<td>Manure+limestone+complete commercial fertilizer</td>
<td>59.0</td>
<td>36.3</td>
<td>2.65</td>
<td>78.7</td>
<td>38.9</td>
<td>35.2</td>
<td>1.92</td>
<td>23.4</td>
<td>67.4</td>
<td>67.3</td>
<td>28.3</td>
</tr>
<tr>
<td>9</td>
<td>Check</td>
<td>41.9</td>
<td>25.8</td>
<td>1.00</td>
<td>48.0</td>
<td>15.7</td>
<td>13.5</td>
<td>0.69</td>
<td>23.3</td>
<td>54.7</td>
<td>38.9</td>
<td>19.2</td>
</tr>
</tbody>
</table>

(1) Yield on plot 8 not correct; unable to account for error.
(2) Low yield on plot 1 due to poor condition of seed bed.
(3) Late backward season; poor quality corn.
(4) Hot, dry season.
(5) Wet spring followed by hot, dry weather in June and July seriously damaged oats.

*The Keosauqua Field was established in the fall of 1922 on the farm of J. W. McIntosh, southeast of Keosauqua in Van Buren County. It is located in the SW 1/4 of the NW 1/4 of Section 6, T. 68 N, R. 9 W, in Henry Township.

Superphosphate with manure and limestone had a greater effect than rock phosphate on the clover in 1925 and the clover and timothy in 1929. In other seasons, however, the effects were only slightly larger than those brought about by rock phosphate or were actually smaller. Complete commercial fertilizer with manure and limestone had slightly greater effects than superphosphate in one or two instances, but in general the differences between the effects of the two are not significant. Muriate of potash with manure, limestone and superphosphate had a beneficial effect on the crops grown in most seasons. The largest effects appeared on the clover in 1925 and on the clover and timothy in 1929. In the other seasons the gains were not strikingly large.

### The Newton Field

The data obtained in the field experiment on the Tama silt loam on the Newton Field in Jasper County are shown in table 14. Manure increased yields in all but one season, the largest effect appearing on the clover in 1927 and on the corn in 1928, 1929 and 1931. Limestone with manure caused crop increases in most instances, large effects being shown on the clover in 1927 and on the corn in several seasons.

Rock phosphate with manure and limestone gave increased yields, usually. The greatest effect was shown on the clover in 1927 and on the oats in 1926 and 1930. Increases appeared also on some of the corn crops. Superphosphate with manure and limestone had a greater effect in most seasons, particularly on the oats in 1926 and 1933 and on the corn in several cases. In some years rock phosphate had just as large or even larger effects than superphosphate. Muriate of potash with manure, limestone and superphosphate usually showed little effect. Only in one or two instances were increases from this material of any
TABLE 14. FIELD EXPERIMENT, TAMA SILT LOAM, JASPER COUNTY NEWTON FIELD,* SERIES I

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>1923 red clover (tons per A.)</th>
<th>1924 corn (bu. per A.)</th>
<th>1925 corn (bu. per A.)</th>
<th>1926 oats (bu. per A.)</th>
<th>1927 red clover (tons per A.)</th>
<th>1928 corn (bu. per A.)</th>
<th>1929 corn (bu. per A.)</th>
<th>1930 oats (bu. per A.)</th>
<th>1931 corn (bu. per A.)</th>
<th>1932 corn (bu. per A.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>1.28</td>
<td>58.5</td>
<td>52.5</td>
<td>57.9</td>
<td>1.13</td>
<td>69.4</td>
<td>57.3</td>
<td>46.5</td>
<td>59.4</td>
<td>69.3</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>1.36</td>
<td>59.5</td>
<td>51.7</td>
<td>56.5</td>
<td>1.17</td>
<td>64.0</td>
<td>60.5</td>
<td>67.3</td>
<td>73.7</td>
<td>39.5</td>
</tr>
<tr>
<td>3</td>
<td>Manure-limestone</td>
<td>1.35</td>
<td>61.7</td>
<td>55.5</td>
<td>56.3</td>
<td>1.42</td>
<td>66.9</td>
<td>64.5</td>
<td>46.8</td>
<td>57.1</td>
<td>72.3</td>
</tr>
<tr>
<td>4</td>
<td>Manure-limestone-rock phosphate</td>
<td>1.45</td>
<td>66.8</td>
<td>57.9</td>
<td>52.0</td>
<td>1.79</td>
<td>72.9</td>
<td>62.4</td>
<td>67.5</td>
<td>76.4</td>
<td>42.8</td>
</tr>
<tr>
<td>5</td>
<td>Check</td>
<td>1.42</td>
<td>57.8</td>
<td>55.3</td>
<td>49.4</td>
<td>1.27</td>
<td>69.3</td>
<td>56.5</td>
<td>46.8</td>
<td>57.1</td>
<td>72.3</td>
</tr>
<tr>
<td>6</td>
<td>Manure-limestone-superphosphate</td>
<td>1.32</td>
<td>66.3</td>
<td>53.9</td>
<td>67.3</td>
<td>1.79</td>
<td>78.2</td>
<td>67.7</td>
<td>69.2</td>
<td>68.7</td>
<td>72.4</td>
</tr>
<tr>
<td>7</td>
<td>Manure-limestone-superphosphate-muriate of potash</td>
<td>1.35</td>
<td>65.9</td>
<td>58.7</td>
<td>63.3</td>
<td>1.81</td>
<td>78.2</td>
<td>68.3</td>
<td>63.9</td>
<td>78.3</td>
<td>50.3</td>
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<tr>
<td>8</td>
<td>Manure-limestone-complete commercial fertilizer</td>
<td>1.34</td>
<td>66.1</td>
<td>53.6</td>
<td>76.9</td>
<td>1.72</td>
<td>81.2</td>
<td>67.2</td>
<td>77.7</td>
<td>73.7</td>
<td>46.5</td>
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<tr>
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<td>Check</td>
<td>1.20</td>
<td>56.0</td>
<td>49.6</td>
<td>51.9</td>
<td>1.20</td>
<td>73.4</td>
<td>59.7</td>
<td>45.7</td>
<td>58.2</td>
<td>65.1</td>
</tr>
</tbody>
</table>

(1) Plots 8 and 9 damaged considerably by hail.
(2) Hot dry weather in June and July reduced yields.

♦The Newton Field was established in the fall of 1922 on the H. S. Martin farm, northeast of Newton in Jasper County. It is located in the SE ¼ of the NE ¼ of Section 30, T. 80 N and R. 18 W in Kellogg Township.

significance. Complete commercial fertilizer with manure and limestone had a slightly greater effect than superphosphate in one or two seasons but in general the difference between the effects of the two materials was not of any importance.

The West Branch Field

The data obtained in the field experiment on the Tama silt loam on the West Branch Field in Cedar County are shown in table 15. Manure increased yields in all but one season. The greatest effects were shown on the clover in 1922 and 1930, on the oats in 1925 and 1929, and on the corn in 1927 and 1928.

TABLE 15. FIELD EXPERIMENT, TAMA SILT LOAM, CEDAR COUNTY WEST BRANCH FIELD,* SERIES I

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>1922 clover tons per A.</th>
<th>1923 corn bu. per A.</th>
<th>1924 corn bu. per A.</th>
<th>1925 corn bu. per A.</th>
<th>1926 clover tons per A.</th>
<th>1927 corn bu. per A.</th>
<th>1928 corn bu. per A.</th>
<th>1929 corn bu. per A.</th>
<th>1930 clover tons per A.</th>
<th>1931 corn bu. per A.</th>
<th>1932 corn bu. per A.</th>
<th>1933 corn bu. per A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>2.20</td>
<td>61.3</td>
<td>29.5</td>
<td>62.1</td>
<td>49.7</td>
<td>69.9</td>
<td>66.0</td>
<td>1.97</td>
<td>102.1</td>
<td>86.7</td>
<td>103.1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>2.40</td>
<td>65.3</td>
<td>32.0</td>
<td>72.2</td>
<td>59.9</td>
<td>75.7</td>
<td>72.6</td>
<td>2.80</td>
<td>100.0</td>
<td>89.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Manure-limestone-rock phosphate</td>
<td>2.60</td>
<td>66.0</td>
<td>34.7</td>
<td>97.0</td>
<td>60.2</td>
<td>76.7</td>
<td>76.0</td>
<td>2.99</td>
<td>96.0</td>
<td>90.3</td>
<td>96.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Manure-limestone-superphosphate</td>
<td>2.50</td>
<td>64.8</td>
<td>32.3</td>
<td>89.0</td>
<td>61.1</td>
<td>71.7</td>
<td>76.0</td>
<td>2.57</td>
<td>97.1</td>
<td>95.5</td>
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<td>Check</td>
<td>2.10</td>
<td>64.5</td>
<td>32.1</td>
<td>63.2</td>
<td>47.0</td>
<td>58.6</td>
<td>62.4</td>
<td>1.88</td>
<td>92.0</td>
<td>77.9</td>
<td>92.0</td>
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<td>6</td>
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<td>2.90</td>
<td>81.3</td>
<td>37.5</td>
<td>100.7</td>
<td>63.9</td>
<td>76.1</td>
<td>75.0</td>
<td>2.95</td>
<td>101.0</td>
<td>94.4</td>
<td>101.0</td>
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<tr>
<td>7</td>
<td>Manure-limestone-complete commercial fertilizer</td>
<td>3.00</td>
<td>71.4</td>
<td>36.3</td>
<td>98.0</td>
<td>66.8</td>
<td>74.3</td>
<td>57.3</td>
<td>2.26</td>
<td>97.9</td>
<td>91.0</td>
<td>97.9</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Manure-limestone-complete commercial fertilizer</td>
<td>2.70</td>
<td>70.6</td>
<td>37.3</td>
<td>93.4</td>
<td>68.2</td>
<td>82.1</td>
<td>80.6</td>
<td>2.58</td>
<td>98.1</td>
<td>93.1</td>
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<tr>
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<td>Check</td>
<td>2.10</td>
<td>65.3</td>
<td>38.6</td>
<td>67.2</td>
<td>56.5</td>
<td>66.9</td>
<td>68.8</td>
<td>1.62</td>
<td>89.3</td>
<td>84.8</td>
<td>89.3</td>
<td></td>
</tr>
</tbody>
</table>

(1) Field was pastured: no results taken.
(2) Sheep lay on plots 1 and 2 when pasturing field.

♦The West Branch Field was started in the spring of 1922 on the farm of Paul Pownall, southeast of West Branch, in Cedar County. It is located in the SW ¼ of the NE ¼ of Section 16, T. 79 N. and R. 4 W. in Springdale Township.
Limestone with manure gave increased crop yields in all but two seasons. The clover in 1922 and 1930 showed large increases as would be expected. Gains were also obtained, however, in the oats and corn crops in most instances.

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

The Mt. Union Field

The data obtained on the Grundy silty clay loam on the Mt. Union Field, Series I in Henry County are given in table 16. Manure brought about increased yields in all but one season. In some cases the effects of manure were particularly large as, for example, on the corn in 1920, 1923 and 1930 and on the soybeans in 1929. In every instance, however, the increases were definite. Limestone with manure gave small increases in the various crops grown, the gains being very large in some cases, as on the corn in 1924, 1927 and 1931.

Rock phosphate with manure and limestone increased the crops in a small way in most seasons. In one or two years no beneficial effects were noted. Superphosphate with manure and limestone brought about distinct increases in most seasons. Sometimes the gains were quite definite, and in general effects of superphosphate were much the same as those brought about by rock phosphate. Complete commercial fertilizer with manure and limestone usually gave about the same effect as superphosphate, showing up slightly better in one or two instances and being less effective in other seasons.

Crop residues had little effect on the yields. Limestone with the residues brought about increases in the yields of crops in several instances, but in no instance was the gain large. Rock phosphate with residues and limestone showed small effects. Only in a few cases were the gains very definite, as on the soybeans in 1929. Superphosphate with residues and limestone had a much larger effect than did rock phosphate in many seasons. In the latter years of the test, however, rock phosphate had the better effects, possibly because these years were generally somewhat deficient in rainfall. Complete commercial fertilizer with the residues and limestone showed slightly larger effects than superphosphate in some seasons, but in general the differences between the two fertilizers were not large.
### TABLE 16. FIELD EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY, MT. UNION FIELD,* SERIES I

| Treatment                                      | 1918 corn bu. per A. | 1919 wheat bu. per A. (1) | 1920 corn bu. per A. (2) | 1921 oats bu. per A. | 1922 corn bu. per A. (3) | 1924 corn bu. per A. | 1925 oats bu. per A. (4) | 1926 clover tons per A. (5) | 1927 corn bu. per A. | 1928 corn bu. per A. | 1929 soybeans tons per A. | 1930 corn bu. per A. | 1931 corn bu. per A. (6) | 1932 oats bu. per A. | 1933 corn bu. per A. | 1934 corn bu. per A. |
|------------------------------------------------|----------------------|---------------------------|--------------------------|----------------------|--------------------------|------------------------|---------------------------|---------------------------|-----------------------|-----------------------|--------------------------|-----------------------|------------------------|-----------------------|-----------------------|
| Check                                          | 57.2                 | 8.3                       | 45.0                     | 25.4                 | 21.3                     | 45.3                   | 23.4                     | 35.1                     | 49.5                  | 51.0                  | 2.18                     | 46.7                  | 41.3                   | 34.7                  | 61.1                  |
| Manure                                         | 61.8                 | 11.8                      | 52.0                     | 27.7                 | 22.0                     | 65.0                   | 27.5                     | 36.8                     | 52.7                  | 53.9                  | 2.44                     | 56.2                  | 56.9                   | 40.6                  | 64.3                  |
| Manure-limestone                               | 62.0                 | 12.0                      | 53.5                     | 28.7                 | 25.1                     | 65.6                   | 35.7                     | 39.7                     | 62.0                  | 55.6                  | 2.35                     | 54.3                  | 42.3                   | 42.3                  | 61.5                  |
| Manure-limestone-rock phosphate                 | 63.1                 | 11.3                      | 47.0                     | 31.7                 | 28.4                     | 68.3                   | 34.7                     | 41.1                     | 53.3                  | 57.2                  | 2.70                     | 56.3                  | 33.5                   | 45.7                  | 67.4                  |
| Manure-limestone-superphosphate                | 65.5                 | 13.1                      | 49.0                     | 35.1                 | 28.5                     | 66.9                   | 37.3                     | 45.5                     | 53.5                  | 54.3                  | 2.53                     | 53.4                  | 39.3                   | 48.3                  | 67.0                  |
| Manure-limestone-complete commercial fertilizer | 59.4                 | 12.2                      | 50.0                     | 42.1                 | 27.7                     | 67.4                   | 30.7                     | 40.8                     | 45.7                  | 53.1                  | 2.44                     | 56.5                  | 40.0                   | 49.9                  | 68.8                  |
| Check                                          | 57.4                 | 10.2                      | 44.0                     | 37.9                 | 21.0                     | 34.9                   | 22.1                     | 30.2                     | 52.4                  | 50.5                  | 2.26                     | 45.5                  | 41.9                   | 39.7                  | 56.6                  |
| Crop residues                                  | 54.1                 | 9.8                       | 48.5                     | 32.6                 | 24.4                     | 38.4                   | 22.7                     | 37.5                     | 58.3                  | 51.6                  | 2.09                     | 49.2                  | 42.6                   | 37.9                  | 58.4                  |
| Crop residues-limestone                        | 56.9                 | 8.9                       | 47.5                     | 33.9                 | 21.7                     | 39.7                   | 21.3                     | 39.8                     | 54.3                  | 47.4                  | 1.74                     | 48.3                  | 44.1                   | 37.9                  | 59.7                  |
| Crop residues-limestone-rock phosphate          | 58.9                 | 10.9                      | 47.5                     | 30.3                 | 25.2                     | 40.2                   | 20.0                     | 34.6                     | 49.0                  | 50.2                  | 2.53                     | 54.2                  | 40.6                   | 44.8                  | 64.8                  |
| Crop residues-limestone-superphosphate          | 61.8                 | 10.7                      | 44.5                     | 38.5                 | 29.5                     | 39.4                   | 25.5                     | 37.3                     | 46.4                  | 47.8                  | 2.18                     | 52.3                  | 47.0                   | 41.9                  | 64.7                  |
| Crop residues-limestone-complete commercial fertilizer | 61.0              | 10.5                      | 46.5                     | 36.0                 | 27.8                     | 44.2                   | 29.9                     | 35.9                     | 58.1                  | 48.7                  | 2.44                     | 57.6                  | 56.3                   | 43.7                  | 64.1                  |
| Check                                          | 59.0                 | 11.3                      | 49.0                     | 34.6                 | 22.4                     | 36.2                   | 22.7                     | 29.8                     | 55.5                  | 51.8                  | 1.83                     | 50.5                  | 39.9                   | 36.3                  | 52.6                  |

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

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

The data obtained in the field experiment on the Shelby loam on the Millerton Field in Wayne County are given in table 17. Manure increased yields in most seasons, the largest effects being shown on the corn in 1925. There was no effect on the clover in 1924 nor on the alfalfa in 1929. Limestone with manure brought about increases in some instances on the grain crops, particularly on the corn in 1926. It had little effect, however, on the clover in 1924 or on the alfalfa in 1929.

Rock phosphate with manure and limestone increased crop yields in all seasons, showing large effects on the clover in 1924, on the alfalfa in 1929, on the corn in 1925 and on the oats in 1927 and 1931. Superphosphate with manure and limestone showed larger effects than rock phosphate on the wheat in 1923, on the clover in 1924, on the oats in 1927 and on the alfalfa in 1928 and 1929. On the corn crop, however, rock phosphate seemed to have a somewhat larger effect, and especially on the oats in 1931 was the effect of rock phosphate particularly evident.

Muriate of potash with manure, limestone and superphosphate increased the crop yields to a small extent in most seasons. It had no large effects except on clover in 1924. In two cases there was no effect from the potash. Complete commercial fertilizer with manure and limestone showed slightly larger effects than superphosphate in several seasons. It showed less effect on the clover in 1924, on the corn in 1925 and on the alfalfa in 1929.

TABLE 17. FIELD EXPERIMENT, SHELBY LOAM, WAYNE COUNTY
MILLERTON FIELD,* SERIES I

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>1922 corn per A.</th>
<th>1923 wheat per A.</th>
<th>1924 clover tons per A.</th>
<th>1925 corn bu. per A.</th>
<th>1926 corn bu. per A.</th>
<th>1927 oats bu. per A.</th>
<th>1928 alfalfa tons per A.</th>
<th>1929 alfalfa tons per A.</th>
<th>1930 corn bu. per A.</th>
<th>1931 oats bu. per A.</th>
<th>1932 oats bu. per A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>60.8</td>
<td>10.3</td>
<td>0.76</td>
<td>58.3</td>
<td>34.0</td>
<td>30.7</td>
<td>0.48</td>
<td>12.2</td>
<td>39.4</td>
<td>27.8</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>63.0</td>
<td>14.5</td>
<td>0.69</td>
<td>65.3</td>
<td>36.0</td>
<td>30.7</td>
<td>0.46</td>
<td>18.8</td>
<td>42.8</td>
<td>31.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Manure+limestone</td>
<td>63.4</td>
<td>10.3</td>
<td>0.86</td>
<td>64.3</td>
<td>44.4</td>
<td>24.9</td>
<td>1.35</td>
<td>18.0</td>
<td>43.2</td>
<td>30.7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Manure+limestone+rock phosphate</td>
<td>64.2</td>
<td>15.1</td>
<td>1.09</td>
<td>72.3</td>
<td>49.2</td>
<td>31.9</td>
<td>1.16</td>
<td>18.0</td>
<td>71.7</td>
<td>32.9</td>
<td></td>
</tr>
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<td>0.92</td>
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<td>35.2</td>
<td>29.9</td>
<td>0.35</td>
<td>16.5</td>
<td>38.7</td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Manure+limestone+superphosphate</td>
<td>60.5</td>
<td>16.4</td>
<td>1.32</td>
<td>64.2</td>
<td>41.6</td>
<td>36.7</td>
<td>1.33</td>
<td>2.40</td>
<td>16.5</td>
<td>55.5</td>
<td>32.3</td>
</tr>
<tr>
<td>7</td>
<td>Manure+limestone+superphosphate+muriate of potash</td>
<td>64.7</td>
<td>17.0</td>
<td>1.54</td>
<td>60.6</td>
<td>43.6</td>
<td>38.3</td>
<td>1.40</td>
<td>2.34</td>
<td>9.1</td>
<td>59.0</td>
<td>38.7</td>
</tr>
<tr>
<td>8</td>
<td>Manure+limestone+complete commercial fertilizer</td>
<td>65.6</td>
<td>17.6</td>
<td>1.29</td>
<td>59.3</td>
<td>46.0</td>
<td>41.6</td>
<td>1.58</td>
<td>2.47</td>
<td>8.6</td>
<td>59.0</td>
<td>40.3</td>
</tr>
<tr>
<td>9</td>
<td>Check</td>
<td>59.8</td>
<td>10.9</td>
<td>0.83</td>
<td>54.7</td>
<td>36.8</td>
<td>31.2</td>
<td>0.41</td>
<td>43.4</td>
<td>25.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Field discontinued in 1933 due to economy program.

*The Millerton Field was established in the fall of 1921 on the farm of J. C. Davis, east of Millerton in Wayne County. It is located in the NW 1/4 of the NE 1/4 of Section 26, R. 21 W., T. 70 N., in Union Township.
THE NEEDS OF WASHINGTON COUNTY SOILS AS INDICATED
BY THE LABORATORY, GREENHOUSE AND FIELD TESTS

Indications of the soil needs of this county have been obtained by the laboratory, greenhouse and field experiments which have been discussed. From these tests it is possible to make some rather general recommendations regarding the handling of the soils. It is recognized that treatments must be varied on different farms and for varying field conditions, but usually the suggested methods will be applicable under anything like normal field conditions in the county. All the suggestions offered are based upon the practical experiences of farmers as well as upon the results of experiments. Only treatments are recommended that can be put into operation on any farm with little difficulty.

LIMING

All the soils in Washington County are acid in reaction and hence need limestone for the best growth of all farm crops—especially legumes, like sweet clover and alfalfa. The acidity is strong in the surface soils and extends down into the subsoils. The limestone requirements of the various soil types are indicated in the table given earlier in this report, but these figures should not be considered to do more than indicate quite roughly the soil needs in any field. Soils vary so widely in lime needs—even soils of the same type and in different fields—that it is quite essential to have the particular soil tested and its lime requirements determined before application is made. In this way it is possible to make the proper addition of limestone and to avoid an overly large addition or too small an application, both of which are undesirable. Farmers may test their own soils for acidity or lime needs, but it usually will prove more satisfactory if they will send a small sample to the Soils Subsection of the Iowa Agricultural Experiment Station. There it will be tested free of charge and recommendations made regarding treatment.

It is rather generally understood that the best yields of general farm crops cannot be obtained on acid soils and that such legumes as sweet clover and alfalfa will not grow at all under conditions of high acidity. Many other legumes will make only a poor growth on acid soils. It is quite impossible to make and keep soils properly productive without taking care of the acidity problem. Any attempt to devise a system of permanent soil management without lime for acid soils is foredoomed to failure. It may serve temporarily to grow such crops on the acid soils as will make a fair growth there, but the land will very quickly become unproductive, yields will decline rapidly and liming will become more and more necessary to permit good growth of all crops.

Earlier in this report experiments have been reported showing the large value from the application of limestone to acid soils. Beneficial effects were shown on the Tama silt loam, the Grundy silt loam, the Clinton silt loam, the Grundy silty clay loam, the Putnam silt loam and the Shelby loam.

The soils of the county must all be tested regularly in the rotation and limestone applied as needed if the best results are to be obtained with such cropping systems as are adapted to the land. One application of limestone will not suffice for all time, although the beneficial effect may continue over a long period of years. It is much safer, however, to have the soil tested in each rotation, just
preceding the growing of a legume, to insure the proper soil reaction, and also
to provide for the application of the right amount of lime. It is an easy matter
to have the soils tested, as this is done free of charge by the Soils Subsection
of the Iowa Agricultural Experiment Station, and the cost of applying lime-
stone is not prohibitive under normal conditions. The value of the treatment
more than offsets the cost of the application.

MANURING

The soils of Washington County vary widely in content of organic matter
depending upon origin and location and method of handling. Some of the soils
are light in color and evidently low in organic matter, while others are darker
in color and fairly well supplied. The Lindley, Clinton, Marion, Jackson,
Calhoun, O'Neil and Genesee soils are the poorest in content of organic matter,
and the Shelby, Grundy, Tama, Putnam, Bremer, Waukesha, Muscatine, Charit-
ton, Cass and Wabash are better supplied. But many of the types in these
latter series are not high in organic matter. This is the case with the Putnam,
Shelby and Chariton, especially, but it is also true of the other soils in individual
areas. On all the soils of the county, therefore, it is necessary that additions of
fertilizing materials supplying organic matter be made at regular intervals if
the supply is to be maintained. On the lighter colored types applications are
needed now to build up a proper supply.

The best means of increasing and maintaining organic matter in soils is by
proper preservation and application of all the manure produced on the farm.
Under the livestock system of farming, the manure, if all returned to the land
will aid materially in maintaining productivity. It is well known that farm
manure is one of the most effective fertilizers which can be employed, bringing
about large crop increases. But its value from the standpoint of permanent
soil fertility is not generally recognized. The experiments which have been
discussed earlier in this report have shown large beneficial effects from the use
of farm manure on the Putnam silt loam, Clinton silt loam, Grundy silt loam,
the Shelby loam, the Tama silt loam, and the Grundy silty clay loam. The
other soils would undoubtedly respond in just as large a way or even larger to
the use of farm manure. It is recommended that farm manure be applied to all
the soils in the county in as large amounts as the supply produced will permit
and at regular intervals in the rotation. In this way the land will be made
more productive now, and its fertility will be more nearly kept up. Manure
will aid greatly in maintaining organic matter, and hence the fertility of the soil.

Crop residues aid considerably in keeping up the supply of organic matter in
the soil. On the livestock farm the residues may be used for feed or bedding
and returned to the land with the manure. Under the grain system of farming
the residues are stored and allowed to decompose partly before being applied,
or they are applied directly to the soil. Under both systems of farming the
residues should all be returned to the land as they have considerable fertility
value. Cornstalks should not be burned or otherwise destroyed but should be
plowed down. At least the second crop of clover should be plowed under and
if the soil is particularly low in organic matter the entire crop should be
turned under.
The production of farm manure is always inadequate on the livestock farm to permit of the application of any considerable amount to all the land with any regularity. On the grain farm there is of course practically no production of manure, and some other source of organic matter must be sought. On both types of farms the use of inoculated legumes as green manures must be resorted to, as a means of building up and keeping up the organic matter. If thoroughly inoculated, as they should be, legumes may add considerable amounts of nitrogen as well as organic matter to the soil. This nitrogen is taken from the atmosphere and hence when added to the soil in this way, there is a real addition to the soil and the operation is actually a nitrogen fertilization by the use of a natural material. Green manuring would undoubtedly prove valuable on many of the soils in Washington county now, and the use of inoculated legumes as green manures is particularly desirable on the lighter-colored, poorer soils. But the practice will be worth while also on many of the other soils, and especially wherever the application of farm manure to the land is limited. The practice of green manuring should be considered as a supplement to or a substitute for the use of farm manure. Green manuring should not be followed blindly nor carelessly, however, as undesirable results may occur if the green materials are not decomposed sufficiently rapidly in the soil. On all Washington County soils it is important that the use of legumes as green manures be included in the regular farming operations.

THE USE OF COMMERCIAL FERTILIZERS

The phosphorus content of the soils, as mentioned earlier, is rather low and it is evident that this essential plant food constituent will soon be deficient in most instances for the best crop production. There is certainly such a limited supply of phosphorus that phosphate fertilizers are bound to be required in the very near future even if they are not absolutely necessary now. The experiments on these soils and the experiences of many farmers indicate that a phosphate fertilizer may be used profitably in many instances now.

There are two phosphorus fertilizers on the market which may be used to supply the soil’s phosphorus needs. These are rock phosphate and superphosphate. The phosphorus in the latter material is in a readily available form, while in rock phosphate it is necessary that the element be changed in the soil into an available form before it can be used by plants. Under favorable soil conditions, however, the transformation of the phosphorus into a utilizable form proceeds so rapidly that the effect on crops is just as great as that of superphosphate. Sometimes rock phosphate does not show its greatest effect until the second year, because of delay in the availability processes. Rock phosphate usually is applied at the rate of 500 to 1,000 pounds per acre once in a four-year rotation, the one-half ton application being the one usually employed. Superphosphate, on the other hand, is generally used at the rate of 120 pounds of the 20 percent material per acre annually, or three times in a 4-year rotation. Thus, while superphosphate is more expensive than rock phosphate, the smaller application makes the actual cost of the treatment less. Rock phosphate must, therefore, bring about larger crop increases if it is to prove as economically desirable, but the effects may persist over a longer period of years and com-
parisons must be made over several years. The comparative value of the two fertilizers cannot be determined by a 1-year test nor even by a test for 2 or 3 years.

Beneficial effects of phosphate fertilizers on some of the soils in this county have been indicated in the results of the experiments discussed earlier in this report. The Tama silt loam, the Grundy silt loam, the Clinton silt loam, the Putnam silt loam, the Grundy silty clay loam and the Shelby loam have all responded to the use of rock phosphate or superphosphate. It is likely that similar results would be obtained with the other soil types, although in some cases the benefits would undoubtedly prove greater because some of the other soils are much lower in natural fertility than those tested. Sometimes one phosphate gave the better results while in other instances the other proved just as good or better. It is impossible, therefore, at the present time, to choose between rock phosphate and superphosphate for all individual farm conditions, even for the same soil type. The evidence indicates that one or the other phosphate may be used profitably, but the safest way for a farmer to determine which he should employ is to make a simple test on a small area before he makes an application to a large area. In this way he may determine the actual value of the phosphate fertilizer under his particular conditions.

The nitrogen supply in the soils is not high and in some cases it is actually low. On the lighter-colored, poorer soils, a lack of nitrogen is evident, and here the need of nitrogenous fertilizers is particularly shown. But on all the soils there is a need for the regular addition of fertilizing materials supplying nitrogen if the supply is to be maintained, as nitrogen is lost rapidly by the leaching process and by removal in crops.

Turning under of all crop residues and the proper use of the farm manure produced aid materially in maintaining the nitrogen supply, returning to the land a part of the element nitrogen removed in the crops grown. But the most desirable method of supplying nitrogen is by using inoculated legumes as green manures. These crops when thoroughly inoculated may take much of their nitrogen content from the atmosphere, and hence when they are turned under they add large amounts of the element to the soil and serve as real nitrogen fertilizers. They are undoubtedly the best and cheapest means of supplying nitrogen. At the same time they add organic matter. The use of commercial nitrogenous fertilizers cannot be recommended on the soils of this county at the present time, as the nitrogen content may be increased and kept up by the proper use of inoculated legumes as green manures. In special cases and for certain crops, such as truck crops, the use of some commercial nitrogen carrier may be valuable, but such fertilizers should not be applied to large areas until tests have been made on small areas and the value of the application determined.

Most of the soils are probably adequately supplied with potassium and it would not seem likely that the application of a commercial potassium fertilizer would be valuable. When soils are kept in good condition from the standpoint of drainage, cultivation, supply of organic matter, reaction and other plant food content, there is usually sufficient potassium produced in an available form to keep crops supplied. The addition of commercial potassium fertilizers cannot be recommended for the soils of this county at the present time. They may
prove of value in special cases, but they should not be employed extensively until they have been tested on small areas and their value definitely shown for the particular conditions.

Certain complete commercial fertilizers may be employed in some areas with profit, at least for special crops, and perhaps for some of the general farm crops. The experiments reported earlier showed some value from the application of these fertilizers, but in general the use of one or the other of the phosphates gave quite as large effects as the complete fertilizers and as the latter are more costly, the use of the phosphate seems preferable. Any complete commercial fertilizer must have a much larger effect upon crops than that shown by a phosphate in order to prove as economical. There is no possible objection to the use of complete commercial fertilizers and no injury to the soil from their application. It is merely a question of profit. If tests on small areas show them to be of value, then they may be added extensively with the assurance of profit. Such materials should not be employed until they have been tested and their value proven.

### DRAINAGE

The natural drainage system of the county is quite adequate except in the central part of the area, where there are extensive level to flat areas of rather poorly drained uplands. Thus areas of Grundy silt loam and Grundy silty clay loam are poorly drained. The location of these areas is shown on the drainage map given earlier in this report. Here the need of artificial drainage is evident. There are also other upland areas which need drainage. There are areas of the Putnam silt loam, the Marion silt loam, the Muscatine silt loam on the upland, of the Bremer silt loam and silty clay loam, the Calhoun silt loam and the Chariton silt loam on the terraces and of the Wabash soils on the bottomlands which are not adequately drained. In all these instances as well as with the Grundy soils, drainage is the first treatment needed if the land is to be made satisfactorily productive. In the case of the Wabash soils on the bottomlands, the land must also be protected from overflow if it is to be cultivated successfully.

It is well known that crop yields will not be satisfactory on any land which is too wet, and the first thing needed on such land is proper drainage. Tiling may prove of considerable cost, but the results in the way of improved crops will ordinarily more than pay the expense. In any case land which is not properly drained cannot be used successfully for crop growth until adequate drainage is provided.

### THE ROTATION OF CROPS

The continuous growing of any one crop will quickly reduce the fertility of the soil and crop yields will decline. This is generally known, but the profit from a certain crop may lead a farmer into this destructive system of cropping and cause him to lose sight of the fact that his land is being more rapidly depleted of fertility than if a good rotation were practiced. Even if crops of less money value are included in the rotation the total value of all the crops grown over a period of years will be greater under the rotation because of the larger crops grown.
There have not been any special rotation experiments conducted in Washington County but some rotations may be suggested which will undoubtedly be valuable. From among those suggested some one may be chosen to fit almost any condition, and any of them may serve as a basis upon which a suitable rotation may be worked out for any particular set of farm conditions. The following are some suggested rotations:

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 omitting the second or sixth year and to a four-year rotation by cutting out the fifth and sixth years.

2. Four or Five-Year Rotation

- **First year**—Corn
- **Second year**—Corn
- **Third year**—Wheat or oats (with clover or with clover and timothy)
- **Fourth year**—Clover (If timothy was seeded with the clover the preceding year, the rotation may be extended to 5 years. The last crop will consist principally of timothy.)

3. Four-Year Rotation with Alfalfa

- **First year**—Corn
- **Second year**—Oats
- **Third year**—Clover
- **Fourth year**—Wheat
- **Fifth year**—Alfalfa (The crop may remain on the land 5 years. This field should then be used for the 4-year rotation outlined above and the alfalfa shifted to one of the fields which previously was in the 4-year 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)

5. Three-Year Rotations

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

- **First year**—Corn
- **Second year**—Oats or wheat (with sweet clover)
- **Third year**—Sweet clover (The clover may be mixed clovers and used largely as pasture and green manure. This may be changed to a 2-year rotation by plowing down the sweet clover the following spring for corn.)

- **First year**—Wheat (with clover)
- **Second year**—Corn
- **Third year**—Cowpeas or soybeans
THE PREVENTION OF EROSION

Erosion is the carrying away of surface soil by the free movement of water over the land. There are two types of erosion, sheet washing and gullying. Sheet erosion is the washing away of the surface soil. Gullying is more striking in appearance, since gulleys or ravines may be formed.

Erosion occurs to a considerable extent in Washington County. Its effect is particularly evident in the Lindley and Shelby soils on the drift uplands and on the Tama and Clinton soils on the loess uplands. The injurious effects are frequently shown on these soils in a definite way. Gullying occurs, and in some cases the surface soil has been removed to a considerable extent by sheet washing. On many areas in the county some means of prevention or controlling the destructive action of erosion should be adopted.

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

Small gullies may be filled by the "staking in" operation, by the use of straw dams, earth dams, Christopher or Dickey dams, Adams dams, stone dams, rubbish dams, woven wire dams or concrete dams. Gullies may be prevented from forming by thorough drainage or by the use of sod strips. Large gullies may be similarly filled or prevented from occurring. Erosion in bottomlands may be prevented by straightening the streams, by tiling, and by planting trees up the drainage channels. Hillside erosion may be controlled by the use of organic matter, by growing cover crops, by contour disking, by terracing, by deep plowing, or by the use of sod strips or a system of strip cropping.2

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INDIVIDUAL SOIL TYPES IN WASHINGTON COUNTY

There are 23 soil types in Washington County. They are divided into four large 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 three drift soils in the county classified in the Lindley and Shelby series. Together they cover 12.0 percent of the total area.

Lindley Silt Loam (Ls) (32)

The Lindley silt loam is the largest of the drift soils in the area, covering 9.3 percent of the total area. It is developed in all parts of the county on steep wooded slopes adjacent to the streams. It is found mainly in narrow strips along the drainageways on both sides of the streams. The type is most extensively developed along the Skunk River and its tributaries in the southwestern townships, along Crooked Creek in the southeastern part of the county and along the English River and some of its tributaries in the northeastern townships.

The surface soil of the Lindley silt loam is a light gray silt loam containing some fine sand but not enough to make the soil a loam. This surface layer extends to a depth of about 6 inches, although there is considerable variation in the surface soil depth, and it may extend to a depth of only 1 inch or to a depth of 7 inches. From 6 to 10 inches there is a gray to brown loam layer—the transition layer from the surface to the subsoil. The upper subsoil to a depth of 30 inches is a reddish-brown stiff, plastic, tough, gritty clay loam to clay. This is underlaid by a yellowish-brown gritty clay or clay loam streaked with black and rusty-brown, to a depth of 45 inches and the substratum below 45 inches is a grayish-brown to gray clay with some stains of brown and black. Boulders are found in the subsoil and often scattered over the surface. Included with the type there are small areas of a soil derived from sandstone. These are found mostly north of Brighton on the bluffs at the edge of the Skunk River bottoms. In these areas the surface soil is a loam, and a thin layer of sandy clay subsoil rests on the sandstone bedrock. These included areas are small and unimportant agriculturally.

The Lindley silt loam in its natural state is heavily forested with hardwoods,
consisting mainly of hickory and oaks in addition to ash, elm, wild crab apple
and red haw and an undergrowth of hazel brush, buck brush and berry bushes.
Bluegrass thrives in the thinly forested areas. Most of the land is utilized for
pasture. Only a small proportion has been cleared and brought under cultiva-
tion. Although the slopes are gentle there is danger of serious erosion. The
land is better left in pasture, or at the most used for short rotations, with care
taken to prevent washing when it is cultivated. The soil is particularly in need
of organic matter if it is to be successfully cultivated. The liberal application
of farm manure and the turning under of legumes as green manures will im-
prove soil conditions materially, making it less subject to erosion, more retentive
of moisture and more fertile. The soil is acid in reaction and for the best growth
of legumes must be limed. Liming will also help for other crops. The use of
a phosphate fertilizer also undoubtedly would prove valuable, and tests of
superphosphate are advisable.

Shelby Loam (S) (79)

The Shelby loam is the second largest drift soil in the county, covering 2.6
percent of the total area. It occurs in many small areas on the steeper slopes
adjoining the drainage courses. There are no large areas of the type, but it is
most extensively developed in Lime Creek, English River, Washington and
Oregon townships, frequently being found along the small streams or tribu-
taries, separating the upland Tama soils from the bottomlands, which are
generally small and narrow.

The surface soil of the Shelby loam is a grayish-brown granular friable loam
extending to a depth varying from 4 to 7
inches. The upper subsoil to a depth of about
14 inches is a reddish-brown coarse gritty
silty clay loam. Below 14 inches the subsoil
is a yellow, brown and gray waxy, sticky,
gritty clay, in many places streaked with red-
dish-brown. Below 20 inches there is a yellow-
ish-brown gritty clay loam sticky and plastic
which below 50 inches becomes a gray stiff
plastic clay with some white streaks. The soil
has been formed from the old Kansan till
which underlies the entire area, the surface
covering of loess having been more or less
completely removed by erosion and the Shelby
loam developed from the drift material. In
some places there is still a small amount of
the loess covering, but not sufficient to change
the texture or character of the Shelby loam
in any important way.

Most of the land in this soil is too steep
to be cultivated and it should be left largely
in pasture. When it is cultivated very serious erosion results, and losses
of the surface soil are rapid. Only the more gentle slopes should ever be
brought under cultivation, and when this is done short rotations should be fol­
lowed. All precautions should be observed to keep the land from eroding. When
the type is cultivated it would respond in a distinctly profitable way to the
application of farm manure and the turning under of legumes as green manures.
These materials will increase the supply of organic matter and make the land
more fertile as well as preventing the rapid washing away of the soil by sheet
erosion. The type is acid in reaction and must be limed for legumes. The use
of a phosphate may prove of value and superphosphate should be tested. The
experiments reported earlier have shown the value of applications of manure,
limestone and a phosphate fertilizer in increasing the productivity of this soil.

Lindley Fine Sandy Loam (Lf) (136)

The Lindley fine sandy loam is a minor type, covering only 0.1 percent of the
total area. It is mapped only along the English River south of Kalona and
southeast of Riverside.

The surface soil of the type is a grayish-yellow or gray porous fine sandy loam
about 5 inches in depth. The texture of the soil is about the same to a depth
of 36 inches but the color becomes more yellow with depth. Below 35 inches
there are alternate layers of yellowish-gray clay and gray and yellow sand,
giving the stratified appearance of the type in road cuts.

The soil is forested and used only for forest growth or for pasture. It is of
no importance agriculturally owing to its small extent, its large use for forestry
purposes and the poor pasture which it supports. If it were to be cultivated
large amounts of organic matter supplied as farm manure or green manures
would be needed to build up the content of the soil and make it more productive.
Lime would also be needed as the soil is acid in reaction, and the use of a phos­
phate fertilizer would undoubtedly prove worth while.

LOESS SOILS

There are 8 loess soils in the county classified in the Grundy, Tama, Clinton,
Putnam, Marion and Muscatine series. Together they cover 68.7 percent of
the total area.

Grundy Silt Loam (G) (64)

The Grundy silt loam is the largest of the loess soils and the largest individual
soil type in the county, covering 22.9 percent of the total area. It occurs in
extensive areas on the slightly undulating uplands in the eight central town­
ships, being associated with the level to flat Grundy silty clay loam on the
upland divides and adjoining the Shelby, Clinton and Tama soils on the more
strongly rolling areas along the streams. The largest areas of the type are
found in Seventy-Six, Cedar, Jackson and Oregon townships. Considerable
areas are also present in the other townships, but the type does not occur so
largely in the extreme southern or extreme northern townships.

The surface soil of the Grundy silt loam to a depth of 12 inches is a very
dark grayish-brown friable silt loam. From 12 to 21 inches there is a light
silty clay loam, a dark yellowish-brown in color, and very granular. Between
21 and 27 inches there is a dark drab mottled yellow, brown and rusty brown silty clay to silty clay loam. The upper 2 or 3 inches of this horizon appears brown or grayish-brown in color, and below this, brown seems to be the basic color but there is often a black coating to the particles giving the soil a darker color. Below 27 inches and extending to a depth of about 35 inches the soil is an olive-gray tough plastic silty clay mottled with brown, yellow and some black iron stains. Below 35 inches the soil is a gray heavy plastic silty clay loam with brown and rusty-brown iron stains and some black streaks. Variations in drainage conditions alter the subsoil colors. Changes in depth of the dark colored surface soil occur with differences in topography. Where the soil grades into the Tama silt loam the subsoil shows more of a yellow color. There is also always a gradual change from the Grundy silt loam into the Grundy silty clay loam, and this means a gradual change in the texture of the surface soil from a silt loam to a silty clay loam.

The Grundy silt loam is all under cultivation and general crops are grown, chiefly corn, small grains and hay crops. Corn yields are extremely variable, ranging from 28 to 75 bushels per acre depending upon the way the soils have been managed. In many instances the land has been too heavily cropped to corn, and the yields have decreased to a low point. Where good soil management practices have been followed the corn yields are high. Yields of small grains are also variable and hay crops yield well, especially when the land is properly drained and limed. In some areas there is need for more adequate drainage of the land in this type, and wherever the soil is too wet some attention should be paid to this drainage factor. Care in handling the soil is also necessary to prevent it clodding and baking when it is cultivated. The addition of organic matter is very desirable as this will make the soil more moisture retentive, and particularly put it into a better condition physically which will allow for better cultivation and better aeration in the soil. The liberal application of farm manure will be of value on the soil and the turning under of legumes as green manures will also help. The soil is acid in reaction, and liming is necessary especially for the best growth of such legumes as alfalfa and sweet clover. The use of a phosphate fertilizer will help materially, and tests of rock phosphate and superphosphate are recommended. The experiments which have been discussed earlier have indicated the large value of applications of farm manure, limestone and rock phosphate or superphosphate to this soil.
The Clinton silt loam is the second largest loess soil and the second soil type in area in the county. It covers 20 percent of the total area, and occurs in the hilly sections of the county near the large streams. The type is most extensively developed in Iowa and Highland townships in the northwestern part of the county, in Lime Creek and English River townships in the northern part of the area and in Dutch Creek, Clay and Brighton townships in the southwestern corner of the county. These occurrences are found along the English River and the Skunk River, the largest streams of the county. Some of the type appears also along the West Fork Crooked Creek and in the south central part of the county.

The surface soil of the Clinton silt loam is a light gray to brownish-gray smooth silt loam extending to a depth of about 7 inches. The lower one inch of this surface layer though still smooth, fine-grained and floury changes slightly in color from gray to yellowish-gray. From 7 to 12 inches there is a yellowish-gray somewhat cloddy or very coarse granular smooth fine silt loam, firm but not compact. From 12 to about 22 inches there is a yellowish-brown heavy plastic compact silty clay loam, quite granular. Below 22 inches and extending to about 36 inches there is a dark yellowish-brown coarse, granular, compact, tough, plastic silty clay. Black and rusty-brown iron stains are common. The silty clay material becomes grayer in color at the lower part of this layer and finally grades into the gray and yellow parent loess, a compact silt loam, stained with black, brown and rusty-brown. Yellow is the predominant color, the gray appearing in streaks.

All the Clinton silt loam was originally covered by a dense forest growth consisting mainly of oaks and hickory. White oak was the predominant tree and the soil is often referred to as "white-oak" soil. About 50 percent of the land has been cleared and brought under cultivation. The remainder supports a forest growth and provides some pasture. Corn yields will average between 25 and 30 bushels per acre in normal seasons, oats will yield from 45 to 50 bushels and hay from 1½ to 2 tons of mixed hay per acre. Much lower yields than this are often obtained when the land has become badly run down and eroded, as is so often the case.

Land in the type which is steep and subject to erosion, undoubtedly should be kept in pasture and should not be used at all for the growing of corn and other cultivated crops. Land which is used for corn should be carefully handled to protect it from washing. Only the more gentle slopes should be cropped to corn and the method of contour farming, or strip cropping will aid materially.
in preventing erosion in such cases. With proper crop rotation and the liberal addition of organic matter, land in the type which is not too steep may be made more productive and at the same time protected from erosion by the use of organic matter. In addition to farm manure, the use of legumes as green manures would help materially to make the soil more retentive of moisture and less subject to sheet washing. The type is acid in reaction and must be limed for the most successful growth of general farm crops, and especially for the growth of legumes such as sweet clover and alfalfa. The use of a phosphate fertilizer would undoubtedly help and tests of superphosphate are urged. The experiments considered in this report have shown the large effects of manure, lime and phosphate on this soil. Large increases in yields may be secured and the land may be made and kept more productive.

**Tama Silt Loam (T) (120)**

The Tama silt loam is the third largest loess soil and the third type in the county. It covers 15 percent of the total area, and occurs on the rolling areas adjacent to the streams and their tributaries. The type is developed most extensively along the English River and its tributaries in the northern townships, particularly Lime Creek and English River townships. It also occurs in smaller narrower areas along some of the other streams, notably Whiskey Creek, North Fork Long Creek and South Fork Long Creek and the branches of Crooked Creek.

The surface soil of the Tama silt loam is a brown to dark brown, distinctly granular, mellow silt loam containing a small amount of very fine sand. This surface layer extends to about 8 inches. From 8 to 12 inches there is a layer of lighter brown silt loam becoming almost a yellowish-brown in the lower part. Below 12 inches and extending to about 45 inches there is a compact, firm, yellowish-brown silt loam to light silty clay loam, streaked with brown, rusty-brown or black, giving the layer a mottled appearance. From 45 inches on down there is the gray, brown and yellow compact silty clay loam to silty clay of the parent material.

Practically all of the Tama silt loam is cultivated, and general farm crops are grown. Corn yields from 20 to 50 bushels per acre, oats from 30 to 65 bushels per acre and hay from 1 to 2½ tons per acre. Yields are better on the soils which have been properly managed and protected from erosion. On some of the areas where poor systems of cropping have been followed and the land has been "corned" there has been a large loss of soil by sheet erosion, and crop yields are very poor.
The type needs organic matter if it is to be made more productive and protected from erosion. Liberal applications of farm manure help very much to build up the soil, and the turning under of legumes as green manures would also aid. The soil is acid in reaction and must be limed for the best growth of legumes and other general farm crops. The addition of a phosphate fertilizer would undoubtedly prove worth while, and tests of rock phosphate and superphosphate are recommended. The data reported earlier have shown the value of treating this soil with manure, lime and a phosphate. By proper treatment of the soil as suggested and following the best methods of protecting the land from erosion, the crops grown on the type will be more profitable, and the land will be maintained permanently productive. The chief need of the soil is for organic matter and to secure this in the form of leguminous green manures, the soil must be limed.

Grundy Silty Clay Loam (Gs) (115)

The Grundy silty clay loam is the fourth largest loess soil and the sixth type in the county in area. It covers 8.8 percent of the total. It occurs only on the broad flat divide which separates the English and the Skunk rivers. There are numerous quite extensive areas throughout the central townships, especially Cedar, Dutch Creek, Franklin and Seventy-Six townships.

The surface soil of the Grundy silty clay loam to a depth of about 12 inches is a dark grayish-brown or black distinctly granular silty clay loam. It is very sticky and black when wet. At the lower parts of this layer the soil is slightly heavier in texture and the color is more of a brown. From 12 to 22 inches there is a dark gray or drab compact clay loam with some yellow, brown and rusty-brown iron stains. From 22 to 39 inches there is a gray plastic and sticky clay loam, stained with brown, rusty-brown, gray and some black. Below this point there is the gray heavy, plastic silty clay loam to clay loam of the parent material.

Natural drainage of this soil is poor, and the land must be tiled out before it can be successfully cultivated. It is level to flat in topography and this with the heavy subsoil makes the soil very impervious to water and likely to be too wet. When properly drained the soil is highly productive, yielding more than the Grundy silt loam with which it is very closely associated. It is reported to produce from 10 to 20 bushels more of corn per acre than the Grundy silt loam when it is properly handled after being thoroughly drained. In draining this soil the lines of tile must be laid close together and if not properly laid they may quickly clog.

After drainage, the soil will respond to light applications of farm manure to stimulate available plant food production. Large amounts should not be employed, and the manure should not be applied just preceding the growing of a small grain crop as it is likely to cause lodging. The type is acid in reaction, and applications of lime are needed to permit of the best legume growth. The application of a phosphate fertilizer would also be of value, and tests of superphosphate and rock phosphate are recommended. The tests reported earlier have shown the effects of manuring, liming and applying phosphates to this soil.
Putnam Silt Loam (P) (66)

The Putnam silt loam is a minor type, covering only 1.6 percent of the total area. It is the fifth largest loess soil. It is developed most extensively in the southwestern part of the county in the more rugged sections along Skunk River, Dutch Creek and Crooked Creek and smaller areas lie between Davis and Goose creeks and north of the English River. There are also other areas present. The type is found associated with the Tama, Clinton and Grundy silt loams, and occurs on level ridge tops, adjoining the rougher Clinton and Tama soils and merging into the equally level areas of Grundy silt loam.

The surface soil of the Putnam silt loam to a depth of 6 inches is a dark gray fine floury silt loam, firm but not compact. There is a small percentage of very fine sand present. There are brown iron stains throughout the layer but especially in the lower part. Below 6 inches and to a depth of 11 inches there is the characteristic gray layer, which is a very fine, floury or ashy gray silt loam. From 11 to 14 inches there is a dull brown silty clay loam, the outer part of the particles being coated with light gray fine silt washed down from the layer above. Below 14 inches and to a depth of 33 inches there is a brown to yellowish-brown, dark gray or dark drab tough, plastic silt clay to clay. From 33 to 42 inches there is a drab, gray and yellowish-brown light silt clay loam. When dry it is gray mottled with yellow and yellowish-brown and spotted with black. Below 42 inches the soil is a gray silty clay mottled with yellow and yellowish-brown. In some areas the surface soil is lighter than typical, but these areas were too small to separate as the Marion silt loam. There are also variations in the depth of the gray layer.

Practically all of the type has been cultivated, but as only a small part of it has been drained, the yields are lower than on the better drained uplands. Corn yields 35 to 40 bushels per acre on the better managed areas, and the yields are often 25 bushels per acre on the poorer areas. Small grains do better than corn, yielding at the rate of 45 bushels per acre for oats and correspondingly high for barley. Hay yields are good when the seasons are favorable, but red clover often winterkills and dies out in the poorly drained spots.

The type is particularly in need of more adequate drainage if it is to be made more satisfactorily productive. The level topography and heavy impervious subsoil make artificial drainage quite necessary. The soil also needs additions of organic matter and liberal applications of farm manure are very desirable. The turning under of legumes as green manures would also help. The soil is acid and applications of limestone are needed especially for the growth of legumes. The use of a phosphate fertilizer would undoubtedly prove of value.
and tests of superphosphate are urged. The experiments reported on earlier have shown the value of manuring, liming, and the use of a phosphate fertilizer.

**Marion Silt Loam (M) (67)**

The Marion silt loam is a minor type, covering only 0.2 percent of the total area. It is referred to by many farmers as “chalk land” or “white land” because of its light color. It occurs in a number of small areas on narrow flat ridges within Clinton silt loam areas. The largest area of the type is found in Highland Township. There are scattered areas throughout the northern townships and in Marion and Clay townships in the southern part of the county.

The surface 6 inches of the Marion silt loam is a light gray to almost white silt loam, containing numerous iron concretions. From 6 to 12 inches there is an ashy gray fine silt loam, compact but not heavy. It contains black iron pellets and a rusty-brown and black streakiness. This layer is very similar to the gray layer in the Putnam silt loam. From 12 to 21 inches there is a gray and brown heavy, compact, clay loam to light silty clay loam. From 21 to 29 inches there is a drab, tough, plastic, waxy clay stained with black, and below 42 inches there is a drab heavy impervious clay somewhat stained with iron.

Practically all the Marion silt loam is under cultivation, and the yields of general farm crops are consistently low, lower than on the poorest areas of the Putnam silt loam. The type needs drainage, like the Grundy and Putnam soils, if it is to be made more productive. It is in need of organic matter, and liberal applications of farm manure are of large value. The turning under of legumes as green manures would also help. The soil is acid and must be limed for the best growth of crops and especially legumes. The use of a phosphate fertilizer would help, and tests of superphosphate are recommended. The chief needs of the soil are for drainage, organic matter and liming.

**Tama Fine Sandy Loam (Tf) (259)**

The Tama fine sandy loam is a minor type, covering only 0.1 percent of the total area. It occurs south of the English River in the vicinity of Wellman, in several areas varying considerably in size but all rather small. The soil was formed by the deposition of fine sand carried by wind action from the flood plain of the river to the ridges and slopes, covering the original silt material.

The surface soil of the Tama fine sandy loam is a dark brown friable fine sandy loam to a depth of about 11 inches, and beneath this there is the light brown fine silt loam transitional layer to a depth of 15 or 16 inches and then
there is the upper subsoil of a yellowish-brown heavy silt loam to light silty clay loam, compact and firm with some brown, black and rusty-brown mottlings. The lower subsoil below 45 inches is a gray, brown and yellow compact silty clay loam to silty clay.

The type is all under cultivation, and general farm crops are grown. The yields, however, are somewhat lower than on the Tama silt loam, because of the sandy nature of the soil and low organic matter content. The soil needs chiefly to receive large applications of farm manure and legumes turned under as green manures, to build up the supply of organic matter and make it more fertile. The soil is acid and must be limed for legumes. The use of a phosphate fertilizer would help, and tests of superphosphate are recommended.

**Muscatine Silt Loam (Ms) (30)**

The Muscatine silt loam is a minor type in the county, covering only 0.1 percent of the total area. It occurs in only one area in the southwestern corner of Dutch Creek Township, south of Valley and extending over into Clay Township.

The surface soil of the Muscatine silt loam to a depth of 12 inches is a dark brown granular, mellow silt loam, containing a small percentage of very fine sand. From 12 to 16 inches there is a brown to dark-brown light silty clay loam. From 16 to 24 inches there is a dark brownish-gray to drab heavy silt loam to silty clay loam, faintly mottled and stained with brown and rusty-brown iron stains. Below 24 inches there is the gray compact loam to silty clay loam subsoil, showing mottlings of yellow and brown, and some streaks of brown.

This soil is all cultivated, and general farm crops are grown. Yields are much the same as on the Grundy soils. In average years corn yields about 50 bushels per acre, oats 55 bushels and hay 1½ to 2 tons per acre. The type is in need of drainage in most areas as it is naturally poorly drained. It is acid in reaction and must be limed. The addition of organic matter is essential to build up the fertility and make the soil more productive. The use of farm manure helps by stimulating the available plant food production. The turning under of legumes as green manures would also help. A phosphate fertilizer would be worth while and tests of rock phosphate and superphosphate are urged.

**TERRACE SOILS**

There are 8 terrace soils in the county, classified in the Bremer, Waukesha, Jackson, Calhoun, Chariton and O'Neill series. Together they cover 6.7 percent of the total area.
Bremer Silt Loam (Bo) (88)

The Bremer silt loam is the largest of the terrace soils, covering 2.8 percent of the total area of the county. It occurs in large areas on the terraces along the various streams of the county. The largest areas are found along the English River and Skunk River, but there are numerous areas along many other streams and the smaller tributaries of the larger creeks. The terraces on which the type occurs are low, lying only a few feet above overflow.

The surface soil of the Bremer silt loam to a depth of 12 inches is a dark brown to almost black heavy silt loam. The depth of this surface layer varies somewhat in the different areas, ranging from 10 to 16 inches. Some areas contain more or less fine sand, while others have more fine clay in the surface soil. Between 12 and 24 inches there is a blue-black, plastic, sticky, waxy when dry, fine, faintly granular clay. Below 24 inches and extending to a depth of 40 inches the subsoil is a dark grayish-brown or gray heavy sticky silty clay loam. From 40 inches on down there is a dark gray to slate-gray sticky clay stained with brown, rusty-brown and black.

The type is all cultivated and corn is grown mostly. In some areas this crop is grown continuously. This is a bad practice and cannot be continued successfully; a good crop rotation should be adopted. Corn continues to do well on the soil in spite of the continuous cropping practice, but the yields will soon decline if a change is not made. Small grain crops do well when the soil is well drained, but they are apt to lodge. Hay crops are very satisfactory on this soil. The type needs to be more adequately drained in many areas if it is to be most successfully cropped as it is naturally rather poorly drained. Small applications of farm manure would help on newly drained areas to stimulate the production of available plant food. The use of lime is necessary as the soil is acid. The application of a phosphate fertilizer would help and tests of rock phosphate and superphosphate are recommended.

Waukesha Silt Loam (Ws) (75)

The Waukesha silt loam is the second largest terrace soil in the county, covering 1 percent of the total area. It occurs in many areas on the high terraces along the English River and the Skunk River and the larger tributaries to these streams. There are no large areas of the type, few exceeding one-half mile in width, and it occurs mainly as long narrow bands between the slopes and the first bottoms. The type is developed mostly in Iowa, English River and Lime Creek townships in the northern part of the county and in Brighton Township in the southern part.
The surface soil of the Waukesha silt loam is a dark brown friable silt loam extending to a depth of about 10 inches. From 10 to 22 inches there is a yellowish-brown heavy silt loam to light silty clay loam, marked with dark organic matter from above. Below 22 inches and to about 30 inches there is a yellowish-brown light silty clay loam to silty clay. Below 30 inches there is the yellowish-brown and gray subsoil which is silty clay loam to silty clay with some brown and black stains.

The Waukesha silt loam is all under cultivation and the yields of general farm crops are much the same as on the Tama silt loam and Grundy silt loam. The soil needs organic matter, and liberal applications of farm manure are recommended. The turning under of legumes as green manures would also help. The soil is acid, and additions of limestone are needed. The application of a phosphate fertilizer would also help, and tests of rock phosphate and superphosphate are desirable.

**Jackson Silt Loam (J) (81)**

The Jackson silt loam is a minor type in the county, covering only 0.9 percent of the total area. It occurs in numerous areas on the terraces along the larger streams. The type is developed mainly in Iowa and English River townships, the largest areas appearing in the vicinity of Riverside. There are also a number of areas in Crawford and Marion townships along Crooked Creek.

The surface soil of the Jackson silt loam is a gray silt loam to a depth of about 7 inches. It is almost white when dry. From 7 to 16 inches there is a yellowish-brown and gray heavy, compact, silt loam. The upper part of this layer shows more gray coloring than the lower part. The layer from 16 to 42 inches is a yellowish-brown heavy silt loam with streaks of gray, and some brown and rusty-brown stains. Below 42 inches there is a yellowish-brown silty clay loam to silty clay.

This soil is mostly under cultivation, and yields of general farm crops are much the same as on the Clinton silt loam on the upland, a type which the Jackson silt loam closely resembles. The chief need of the soil, as is indicated by its light color, is for the incorporation of organic matter. Liberal applica-
tions of farm manure would be valuable and the turning under of legumes as green manures would also be definitely worth while. The soil is acid, and must be limed for the growth of legumes and for the best yields of other general farm crops. Use of a phosphate fertilizer would undoubtedly prove of value and tests of superphosphate are recommended.

Calhoun Silt Loam (C) (42)

The Calhoun silt loam is a minor type, covering only 0.7 percent of the total area. It occurs on terraces along the English and Skunk rivers and some of the larger creeks. The largest areas of the type are found in English River Township, north and northeast of Richmond and west of Kalona, and in the southeast corner of the county.

The surface soil of the Calhoun silt loam is a light gray to brownish-gray smooth, friable floury silt loam extending to a depth of about 7 inches. When wet the soil is a light brown, but it dries out to a gray with a brownish cast. Between 7 and 11 inches there is the typical gray layer which characterizes the type. It consists of a light gray to white ashy silt loam heavily stained with rusty-brown iron stains. From 11 to 15 inches there is a coarse granular silty clay loam heavier than the layer immediately above but lighter than that below. Below 15 inches there is a yellow and gray silty clay to clay loam, which is quite plastic and very sticky when wet and apparently quite impervious. The upper part of the layer is gray in color with the yellow increasing with depth until at about 38 inches the mass appears yellowish-brown. Below that point the subsoil is a yellowish-brown to grayish-yellow silty clay loam to clay. There is some mottling in this layer and often up into the layer above. Variations in the type occur in different areas, especially in the depth of the gray layer. In some places this may be only one to two inches in thickness, and in other areas there may be several inches of it.

This soil is rather poorly drained naturally, and drainage is the first treatment needed to make the soil more productive. It has such a heavy impervious subsoil, and this with the impervious gray layer makes the movement of water very slow through the soil and hinders the absorption of the rain falling upon the soil. The addition of organic matter is also very important on this soil, and liberal applications of farm manure and the turning under of legumes as green manures would make the soil more retentive of moisture and also more productive. The type is acid in reaction and must be limed for the growth of legumes and for the best growth of other crops. The use of a phosphate fertilizer would certainly prove worth while and tests of superphosphate are very
desirable. Without treatments this soil is low in production and in fact is as low in productivity as any of the poorest soils in the area.

**Chariton Silt Loam (Ch) (105)**

The Chariton silt loam is a minor type, covering only 0.6 percent of the total area. It occurs on terraces principally along the English and Skunk rivers. The largest areas of the soil are found in Iowa Township southeast and southwest of Riverside. There are many small areas especially in English River and Clay townships.

The surface soil of the Chariton silt loam is a dark grayish-brown granular, mellow silt loam, extending to a depth of about 10 inches. From 10 to 14 inches there is a gray and brown structureless silt loam which at the lower part of the layer becomes a light brown floury silt loam. Between 14 and 17 inches there is an ashy gray silt loam layer which is characteristic of the soil. Between 17 and 30 inches there is a drab or gray and brown heavy compact or impervious plastic clay, which is strongly stained with iron, in rusty-brown and black concretions. Below 30 inches the subsoil is a gray or grayish-brown heavy impervious silt clay or clay, very sticky when wet and baking hard when dry. The depth of the surface layer is variable, ranging from 6 to 14 inches in different areas, and the ashy gray layer may consist of only one or two inches of floury silt loam in one area and be 6 or 8 inches in thickness in other places.

The Chariton silt loam is naturally poorly drained, and crop yields are low. When well drained the soil will produce from 35 to 40 bushels of corn per acre, and from 40 to 50 bushels of oats per acre. Hay crops are usually good. The type needs drainage first of all if it is to be made more productive. Then it will respond to liberal applications of farm manure and the use of legumes as green manures. It is acid and must be limed for the growth of legumes and for the best results with other general farm crops. The use of a phosphate fertilizer would certainly help, and tests of superphosphate are recommended.

**Bremer Silty Clay Loam (B) (43)**

The Bremer silty clay loam is a minor type, covering 0.5 percent of the total area. It occurs on the low, poorly drained terraces along the English and Skunk rivers. The largest areas are found in English River Township south of Kalona, and in Lime Creek Township, northwest of Wellman. There are numerous small areas of the type.

The surface soil of the Bremer silty clay loam is a very dark grayish-brown to black heavy, waxy, plastic silt clay loam to silty clay, extending to a depth
of about 14 inches. Sometimes the surface layer is 18 inches in depth, while in other cases it is somewhat shallower. Below 14 inches and to a depth of about 24 inches there is a blue-black plastic sticky waxy tough clay. From 24 to 40 inches the subsoil is a dark grayish-brown, olive-gray or dark gray sticky plastic impervious clay. Below 40 inches there is a gray to olive-gray, or slate-gray sticky clay stained with rusty-brown and black.

Only a small portion of the land in this type has been drained, and until drainage is accomplished crop yields are low. The uncultivated areas support a rank growth of slough grass which is utilized for hay or pasture. When well drained the land becomes highly productive and is used for growing corn. It is not so satisfactory for small grains as they are apt to lodge. The soil must be carefully handled too, because if it is worked when too wet it will be sticky and roll up and on drying it will form clods which break down slowly. The use of farm manure in small amounts will be valuable on this soil, especially after it is thoroughly drained, to stimulate the production of available plant food. It will also help the physical condition in the soil. Large applications, however, should not be made. The soil is acid and must be limed for the best growth of legumes and other general farm crops. The use of a phosphate fertilizer would also help, and tests of rock phosphate and superphosphate are recommended.

**Waukesha Loam (Wm) (60)**

The Waukesha loam is a minor type, covering 0.1 percent of the total area. It occurs in a number of small areas along the English and Skunk rivers, on the high terraces. It is found mainly in Iowa, English River and Lime Creek townships.

The surface soil of the Waukesha loam is a dark brown to a dark grayish-brown loam extending to a depth of about 10 inches. The next layer between 10 and 24 inches is a yellowish-brown heavy loam to silt loam. Below 24 inches and to a depth of 30 inches there is a slightly heavier textured soil, a light silty clay loam in most cases, and the color is yellowish-brown. Below 30 inches the subsoil is a silty clay loam yellowish-brown to gray in color with some brown and black iron stains.

This soil is all cultivated and yields of general crops are much the same as on the Waukesha silt loam. It will be improved materially in fertility by liberal additions of organic matter in the form of farm manure or leguminous green manures. It is acid and must be limed for the best growth of crops and particularly legumes. It will also respond to the use of a phosphate fertilizer, and tests of rock phosphate and superphosphate are desirable.

**O’Neill Fine Sandy Loam (Of) (110)**

The O’Neill fine sandy loam is a minor type, covering only 0.1 percent of the total area. It occurs on 128 acres of land, practically all of which lie on the north side of the Skunk River, northeast of Brighton.

The surface soil of the O’Neill fine sandy loam to a depth of 10 inches is a light brown fine sandy loam, loose and quite incoherent. From 10 to 30 inches there is a light brown loose fine sandy loam to fine sand. Below 30 inches the
subsoil is a pale yellowish-brown incoherent sand with some streaks of gray.

This type is a drouthy soil, and crop yields are low. It is chiefly in need of organic matter to make it more retentive of moisture and more productive. Liberal applications of farm manure and the turning down of legumes as green manures would prove very beneficial. The type is acid and must be limed for the best growth of general farm crops and especially legumes. The use of a phosphate fertilizer would help, and tests of superphosphate would be worth while.

SWAMP AND BOTTOMLAND SOILS

There are 4 bottomland soils in the county, classified in the Wabash, Cass and Genesee series. Together they cover 12.6 percent of the total area.

Wabash Silt Loam (W) (26)

The Wabash silt loam is the largest of the bottomland soils and the fourth largest individual soil type in the county. It covers 9.5 percent of the total area. It occurs along practically all the streams ranging in width from a few hundred feet to almost a mile in the different areas. The largest individual areas of the type occur in the three northern townships along the English River and in Brighton and Clay townships, in the southern part of the county along the Skunk River.

The surface soil of the Wabash silt loam is a brown to dark brown heavy silt loam containing some fine sand. The texture is not uniform and the sand content varies, being higher near the streams and lower in sand further away from the stream channels. Below 12 inches and down to about 36 inches there is a dark grayish-brown to grayish-black heavy clay. Below 36 inches the subsoil is a slate-black heavy plastic clay, very sticky when moist, and baking hard when dry. There are many variations in the soil in different areas. The dark surface color often extends to 38 or 47 inches. The texture of the subsoil varies from a heavy silt loam to a clay within short distances.

Less than one-fourth of the type is under cultivation as the soil is subject to overflow, and crop yields are quite uncertain. The narrow areas are not
farmed and support a sparse growth of trees and in places a good bluegrass sod. In some areas weeds and brush reduce the pasture value of the land. Where provision is made to prevent overflow by the building of dikes and levees, especially where the broader areas of the type occur, corn and other farm crops are grown quite successfully. Corn yields are as high as on the best corn soils. Unless protected from overflow and well-drained, however, this soil is better utilized for permanent pasture. When cultivated and used for general farm crops, it would be benefited by small applications of farm manure, especially on newly drained areas, to stimulate the production of available plant food. The soil is acid in reaction and must be limed for the best growth of crops. The use of a phosphate fertilizer would be of value and tests of rock phosphate and superphosphate are desirable.

Genesee Silt Loam (Gf) (71)

The Genesee silt loam is the second largest bottomland soil, covering 1.6 percent of the total area. It occurs in numerous areas along the Iowa River and the English River in Iowa, English River and Lime Creek townships, and along the Skunk River in Clay Township. There are other small areas along some of the smaller streams.

The surface soil of Genesee silt loam to a depth of about 15 inches is a dark gray to light gray or almost white silt loam containing some fine sand. There are many brown, rusty-brown and black iron stains giving the soil a brownish cast. Below 15 inches the soil is a more solid gray in color with less lighter gray layers between the darker gray material and the soil is somewhat more compact, becoming a heavy silt loam to a silty clay loam. There is considerable iron staining in this layer. From 33 to 60 inches the subsoil is a gray silty clay loam to silty clay with some iron stains. There are many variations in the soil in the different areas. Layers of dark colored soil are often found between almost white material. Small patches of sandy or silty clay material occur within short distances. There is considerable variation also in the depth of the surface soil and in the color of the various layers.

This soil is subject to overflow and it is not often farmed. It supports a thin stand of bluegrass and a thick stand of trees, mainly elm, cottonwood, willow, ash, birch, maple and basswood. If the soil were cultivated it would need first of all to be protected from overflow. Then it would be benefited by liberal applications of farm manure and the turning under of legumes as green manures. The addition of lime would be necessary as the soil is acid in reaction. The use of a phosphate fertilizer would help materially, and tests of superphosphate would be desirable. In general, it is doubtful if this soil should be brought
under cultivation as it is not a productive type and it would be better in most cases to use it for whatever pasture can be secured.

**Cass Fine Sandy Loam (Cf) (130)**

The Cass fine sandy loam is a minor type, covering 0.8 percent of the total area. It occurs in Iowa and English River townships along the English River and in Marion Township along Crooked Creek and in smaller areas along some of the other streams of the county.

The surface soil of the Cass fine sandy loam is a brown porous fine sandy loam extending to a depth of about 12 inches. Below this point the soil is a lighter brown fine sand with some silt and some dark organic matter coloring from above. Below 24 inches the subsoil is a yellow and gray pure sand. Frequent overflows change the texture of the soil. Small areas of light colored soils, sandy soils, fine sands and loams have been included with the type as mapped.

None of the type is farmed and the greater part is sparsely forested with scattered elms, oaks, maple, walnut, cottonwood, willow, basswood, wild plum, crab apple and red haw. Bluegrass makes a thin growth and rather poor pasture. Weeds and brush lower the pasture value of the soil. It is probably better to keep this soil in pasture for what it will produce as it is subject to frequent overflow and is a poor soil from the productive standpoint. If it were protected from overflow it would need to be built up in fertility to be made productive. Liberal use of farm manure and the turning under of legumes as green manures, the use of lime and the application of superphosphate would be needed.

**Wabash Silty Clay Loam (Wc) (48)**

The Wabash silty clay loam is a minor type in the county, covering 0.7 percent of the total area. It occurs in numerous areas along the English River, the Skunk River and Davis Creek. The largest areas of the type are found in Iowa Township, in Lime Creek Township and in Clay Township along the Skunk River north and northeast of Rubio.

The surface soil of the Wabash silty clay loam to a depth of 18 inches is a very dark brown to almost black plastic silty clay loam. The texture is not uniform, and the color varies in alternate thin layers from gray to black. Below 18 inches the color does not change to any extent, but the texture becomes heavier approaching a silty clay. At about 40 inches the subsoil is a slate-gray heavy clay with some mottling. The depth of the surface soil is extremely variable. The black color often extends to a depth of 4 feet or more before the gray subsoil is encountered. Areas of lighter colored soils have been included because of their small extent. In some cases the percentage of silt is high and in other areas the texture approaches a clay.

The land is utilized for pasture, as it mostly supports a luxuriant growth of bluegrass and slough grass. There are some scattered timber and dense underbrush in some areas. The type is subject to overflow and is poorly drained. If it were to be cultivated it must be protected from overflow and thoroughly drained. It would then need some farm manure to put it into condition for crop production, some lime to correct the acidity and some phosphate fertilizer. With these treatments it could be made highly productive.
APPENDIX

THE SOIL SURVEY OF IOWA

What soils need to make them highly productive and to keep them so, and how their needs may be supplied, are problems which are met constantly on the farm today. To enable every farmer to solve these problems for his local conditions, a complete survey and study of the soils of the state has been undertaken, the results of which will be published in a series of county reports. This work includes a detailed survey of the soils of each county, following which all the soil types, streams, roads, railroads, etc., are accurately located on a soil map. This portion of the work is being carried on in cooperation with the Bureau of Soils of the United States Department of Agriculture.

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

Following the survey, systems of soil management which should be adopted in the various counties and on the different soils are worked out, old methods of treatment are emphasized as necessary or their discontinuance advised, and new methods of proved value are suggested.

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.

THE Principal Soil Areas of IOWA

Map showing the principal soil areas in Iowa.
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 entirely 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 from the 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 stones. The three loess areas in the state, the Missouri, the Mississippi and the Southern Iowa, are distinguished by differences in texture and appearances, 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 any 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 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 eumulose.
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:

<table>
<thead>
<tr>
<th>Organic Matter</th>
<th>All partially destroyed or decomposed vegetable and animal matter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stones</td>
<td>over 32 mm.*</td>
</tr>
<tr>
<td>Gravel</td>
<td>32—2.0 mm.</td>
</tr>
<tr>
<td>Very coarse sand</td>
<td>2.0—1.0 mm.</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>1.0—0.5 mm.</td>
</tr>
<tr>
<td>Medium sand</td>
<td>0.5—0.25 mm.</td>
</tr>
<tr>
<td>Fine sand</td>
<td>0.25—0.10 mm.</td>
</tr>
<tr>
<td>Very fine sand</td>
<td>0.10—0.05 mm.</td>
</tr>
<tr>
<td>Silt</td>
<td>0.05—0.00 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inorganic Matter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stones—over 32 mm.*</td>
<td></td>
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<td>Fine sand—0.25—0.10 mm.</td>
<td></td>
</tr>
<tr>
<td>Very fine sand—0.10—0.05 mm.</td>
<td></td>
</tr>
<tr>
<td>Silt—0.05—0.00 mm.</td>
<td></td>
</tr>
</tbody>
</table>

**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.

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

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

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

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

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

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

**Gravels**—More than 50 percent very coarse sand.

**Stony Loams**—A large number of stones over 1 inch in diameter.

**METHODS USED IN THE SOIL SURVEY**

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

As has been indicated, the completed map is intended to show the accurate location and boundaries, not only of all soil types, but also of the streams, roads, railroads, etc. The first step, therefore, is the choice of an accurate base map, and any official map of the county may be chosen for this purpose. Such maps are always checked to correspond correctly with the land survey. The location of every stream, road and railroad on the map is likewise carefully verified and corrections are frequently necessary. When an accurate base map is not available the field party must first prepare one.

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

When one section is completed, the party passes to the next section and the location of all soil types, streams, etc., in that section is then checked with their location in the adjoining area just mapped. Careful attention is paid to the topographic features of the area, or the “lay of the land,” for the character of the soils is found to correspond very closely to the conditions under which they 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 inspections and by consultation with those in charge of the work at the Bureau of Soils and at the Iowa Agricultural Experiment Station. When the entire county is completed, all section maps or field sheets are assembled and any variations or questionable boundaries are verified by further observations of the particular area.

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