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SOIL SURVEY OF IOWA

HENRY COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section
Soils



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Soil Survey Report No. 15
September, 1920
Ames, Iowa

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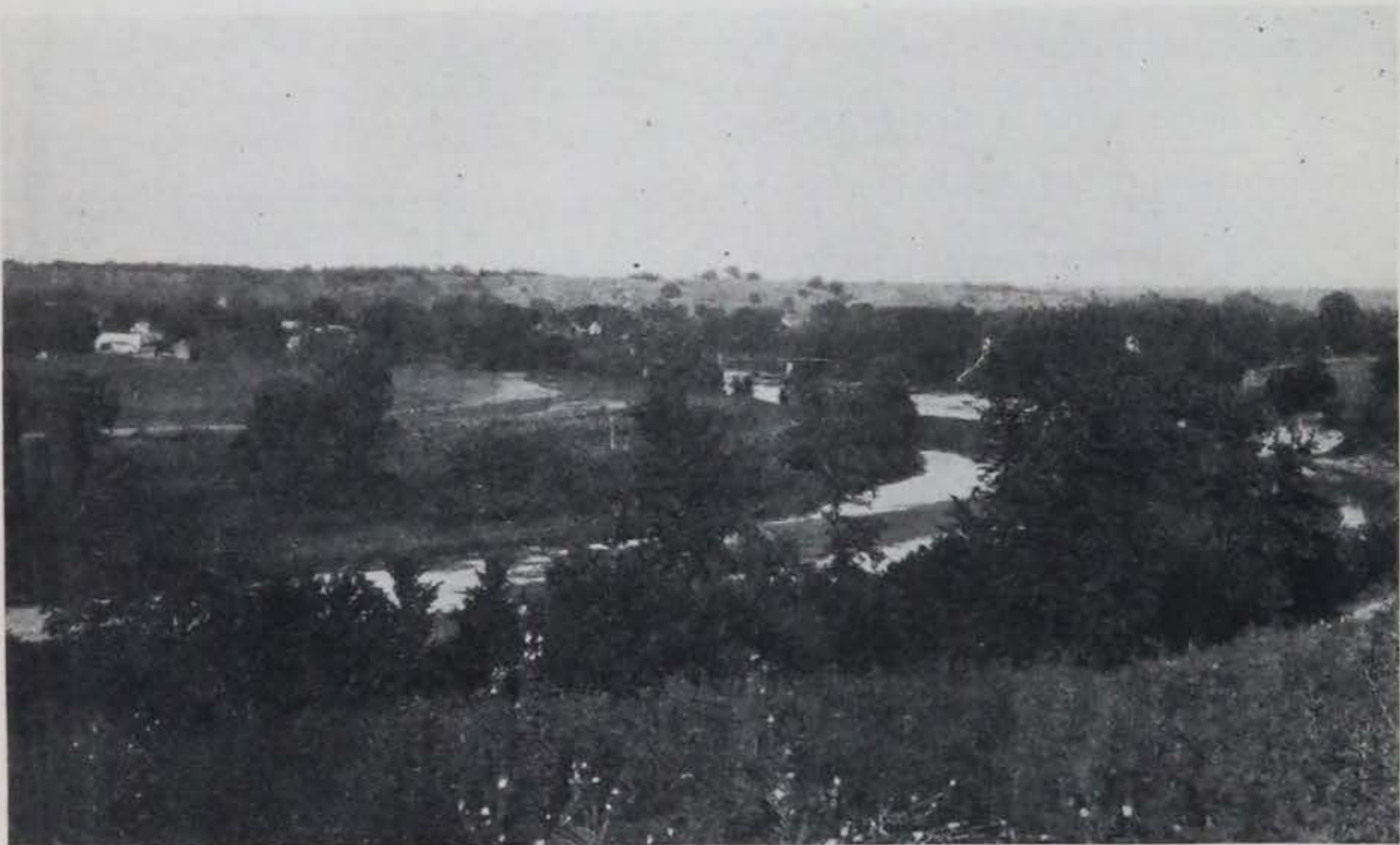
September, 1920

Soil Survey Report No. 15

SOIL SURVEY OF IOWA

Report No. 15---HENRY COUNTY

By W. H. Stevenson and P. E. Brown, with the assistance of L. W. Forman and T. H. Benton



Winding valley of Skunk river a mile wide, near town of Lowell

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HENRY COUNTY SOILS*

By W. H. Stevenson and P. E. Brown, with the assistance of L. W. Forman and
T. H. Benton

Henry county is located in southeastern Iowa in the second tier of counties north of the Missouri state line and the second tier west of the Illinois state line. It is entirely within the Mississippi loess soil area and by far the largest percent of its soils are derived from loess. The area of the county is 427 square miles or 273,280 acres. Of this 242,642 acres, or 88.7 percent, is in farm land. The total number of farms is 1,718 and the average size is 141.2 acres. The following figures taken from the Iowa Year Book of Agriculture for 1918, show the utilization of the farm land of the county:

Acreage in general farm crops.....	131,040
Acreage in pasture	95,879
Acreage in farm buildings, feed lots, and public highways.....	8,929
Acreage in waste land	588
Acreage in crops not otherwise listed.....	1,570

General farming is the type of agriculture practiced most extensively in Henry county and there is a large production of grain. The livestock industry is very important, however, and the tendency at present is toward livestock farming, with emphasis on beef and pork production. Dairying is gradually increasing in importance, and poultry is produced on most farms as a minor industry, with some commercial production at various points. Gardens and orchards are usually maintained, principally to supply the home demand. Apples, plums and pears are the chief fruits grown. There are one or two commercial orchards and a few carloads of apples are shipped out of the county each season. The growing of truck crops has received some attention but has been largely confined to supplying the local city and village demand.

The acreage in waste land in the county is not large, but methods of treatment should be adopted to reclaim such land. The causes of infertility are various and special treatments to be followed in the case of individual soil types will be given later in this report. Advice regarding the handling of such land in special cases will be given by the Soils Section of the Iowa Agricultural Experiment Station upon request.

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

Corn is the most extensively grown and the most valuable crop in the county, over 26 percent of the total farm land being devoted to it. Average yields of 47.4 bushels per acre are secured. About one-half the corn produced is sold, the remainder being fed, largely to hogs and cattle, much of it as ensilage, for the county has a large number of silos.

Oats rank second in acreage and value, 13.5 percent of the farm land of the county being utilized for this crop. Average yields of 52.5 bushels per

*See Soil Survey of Henry county by A. H. Meyer of the U. S. Department of Agriculture, and T. H. Benton of the Iowa Agricultural Experiment Station.

TABLE I. ACREAGE, YIELD AND VALUE OF CROPS GROWN IN HENRY COUNTY*

Crop	Acres	Percentage of total farm land of county	Bushels or tons per acre	Total bushels or tons	Average price	Total value of crop
Corn	64,814	26.70	47.4	3,074,991	\$1.23	\$3,782,339
Aats	32,744	13.50	52.2	1,711,499	.64	1,711,360
Spring wheat	1,134	.40	18.3	20,738	1.99	42,269
Winter wheat	3,463	1.42	21.7	75,215	2.02	151,934
Barley	347	.14	31.8	11,040	.89	9,826
Rye	1,474	.60	11.7	17,297	1.48	28,600
Potatoes	312	.12	90.5	28,214	1.32	27,242
Tame hay	26,680	10.90	1.4	37,469	19.57	734,368
Alfalfa	72	.02	2.7	199	23.93	4,762
Pasture	95,879	39.50	.....	.....	.....	.....

acre are secured. A large portion of the crop is fed on the farms, the remainder being shipped out of the state.

The production of hay in Henry county is considerable, the crop consisting chiefly of timothy and clover mixed. The average yield is 1.4 tons. Both timothy and clover are grown alone to some extent, and occasionally for seed. The hay crop sometimes consists of other tame grasses or of millet. Practically the entire hay crop is fed to cattle and work stock and only a small amount is sold.

Wheat is grown in the county to some extent, the winter varieties being used most generally. The average yield of winter wheat is 21.7 bushels. The yield of spring wheat is somewhat smaller.

Potatoes are grown on a small scale and yields of 90.5 bushels per acre are secured. The production is insufficient to meet the home demand and a considerable quantity is shipped in annually.

Rye and barley are grown on small areas and are relatively unimportant crops. Alfalfa has been produced successfully on several areas and yields of 2.7 tons per acre have been secured. With proper preparation of the seed bed, especially with the use of lime and inoculation, there should be no difficulty in securing a good growth of this crop.

The character and extent of the live stock industry in Henry county are shown in the following figures taken from the Iowa Year Book of Agriculture for the year 1918:

Horses (all ages)	10,797
Mules (all ages)	623
Swine (on farms July 1, 1918).....	66,110
Cattle (cows and heifers kept for milk).....	6,169
Cattle (other cattle not kept for milk).....	26,086
Cattle (total, all ages).....	34,119
Sheep (all ages, on farms).....	10,355
Sheep (total pounds of wool clipped).....	15,198

The raising of hogs is the most important livestock industry in the county, nearly every farmer fattening 20 to 30 head each year, while many of the larger farmers raise several hundred head. The beef cattle industry is receiving special attention in several communities, particularly in the vicinity of Olds, Wayland, and Mount Pleasant. Dairying is increasing in importance, and there are many dairy farms located near the towns and cities, altho as yet there is but one creamery in the county, at Mount Pleasant. Practically all farmers

*Iowa Year Book of Agriculture, 1918.

keep a few dairy cattle to supply the home demand. The breeding of draft horses is practiced to some extent but practically all the animals raised are utilized for the work on the farms of the county. Sheep raising is increasing in importance but at present is confined mainly to the southwestern part of the county. The largest source of income from the livestock industry in the county comes from the sale of hogs and beef cattle.

Land values in Henry county are quite variable, depending on improvements, topography, soil conditions, and location with reference to railroad facilities and to towns. The price usually ranges from \$75 to \$400 per acre, altho during the past year there has been a rather general increase over the previous figures and some farms have sold for considerably more than \$400 per acre.

The crop yields secured on most of the farms in Henry county and the incomes derived from the farms have in general been quite satisfactory but greater yields could be obtained in many cases and larger incomes could be secured if proper methods of soil treatment were practiced. The soils of the county are in general somewhat acid in reaction and the use of lime would undoubtedly bring about profitable increases in crop yields, especially in the case of legumes such as clover and alfalfa. Many of the soils, especially the lighter types, are in need of organic matter and the addition of farm manure proves very valuable. Even on the soils which are apparently better supplied with organic matter the use of farm manure brings about surprisingly large gains in crops. Some of the field experiments now under way in the county show very definite value from the application of manure. When farm manure is not available in sufficiently large amounts, green manure crops may be grown and turned under in the soils in order to supply the necessary organic matter. When legumes are used for such a purpose (and such crops are usually the most desirable) and thoro inoculation is accomplished, the nitrogen content of the soil may also be increased. The nitrogen present in most of the soils is not very low, but it is constantly decreasing and the use of leguminous green manure crops is often necessary **in addition** to farm manure in order to keep up the nitrogen supply.

The phosphorus content of the soils of the county is not high in any case and in several instances it is quite low. Phosphorus fertilizers will certainly be needed on the soils of the county at no very distant date and the indications at present point to the fact that their use might be of considerable value in some cases now. The field experiment on the State Farm at Mount Pleasant which has been under way for several years shows profitable increases in crops from the use of phosphorus fertilizers, and other field tests which have been started more recently already show the value from such materials. Rock phosphate and acid phosphate are being used in all these tests in the field in the effort to ascertain which material will prove the more economic. At the present time, the results are not sufficiently complete to permit of the drawing of definite conclusions. When the experiments which are scattered over the county on the more important soil types have been under way for a longer time, definite recommendations can be made based upon the results secured.

In the meantime, farmers are urged to test the two materials on their own soils and thus determine for their own conditions the kind of phosphate fer-

tilizer which is desirable. Tests on small areas on the farm will show which material should be used on that particular farm and that material may then be applied to large areas with the assurance of profit. Complete commercial fertilizers are not recommended for use on the soils of the county, for the reason that phosphate materials will probably give quite as satisfactory results at a less cost. If any complete fertilizer is shown to give profitable returns, however, there would be no objection to its use. When such materials are tested, comparisons should always be made with phosphate fertilizers.

Drainage is needed for some of the soils and in that case, it should be the first treatment practiced. The proper cultivation of the soil, the rotation of crops and the utilization of all crop residues produced on the farm are other methods of soil treatment which should be practiced in addition to those mentioned, if crop production is to be increased and the soils of the county kept permanently fertile.

THE GEOLOGY OF HENRY COUNTY*

The coverings of drift and loess which overlie the bedrock material in Henry county are so thick that they comprise the only geological formation which needs consideration in a study of the soils of the county.

Probably three great glaciers swept over this county during the glacial age but there is little evidence remaining of the first, or pre-Kansan, with the exception of layers of sand which are occasionally found between beds of boulder clay, in well borings. These sand deposits represent the interval occurring between the retreat of the pre-Kansan ice sheet and the invasion of the Kansan or second glacier.

Except for a narrow strip along the eastern edge of New London and Baltimore townships, the drift deposits in the county are the debris left by the Kansan glacier upon its retreat. In thick beds, the Kansan drift is a bluish clay, containing many small boulders and a few large ones. The upper layer of this drift to a depth of one to three feet is red or reddish-brown in color, owing to the oxidation which has occurred. The color gradually changes to a yellow and then to the typical blue of the original drift.

Just above the Kansan drift layer there occasionally occurs a layer of sand and gravel, known as the Buchanan gravels. These are water-laid deposits made directly following the laying down of the drift sheet.

In the eastern part of Baltimore and New London townships are found the remains of a third glaciation, the Illinoisan. The topography of the area mentioned is distinctly morainic, indicating the western edge of this glaciation. There is little difference in general characteristics between the Illinoisan drift and the Kansan except for the occurrence of a greater amount of certain rock materials.

The drift deposits as a whole have covered the rock material to varying depths, in some places as much as 175 feet of drift being found, and in all cases the layer of drift is quite deep.

Overlying the drift deposits there is found a layer of loess, a fine silt-like material deposited by the wind at some previous geological time when climatic

*Iowa Geological Survey, Vol. XII.

conditions were very different than at present. The entire area of the county was covered by this loess deposit and the upland soils of the county are therefore loessial in origin. The loess in an unweathered condition is a yellow to light-gray silt loam to silty clay loam but since its deposition, the weathering agencies have caused it to lose its original lime content and the accumulation of plant residues has brought about a considerable darkening in color. The depth of this loess layer is variable, in many places being rather thin, while in other instances it may extend to a depth of 25 feet.

In addition to the soils of loessical origin in the county there are several areas of terrace or second bottomland soils and of first bottom soils. These are formed by stream action and are extremely variable in character and in depth. They usually consist of mixtures of drift and loess, carried by the streams and deposited in layers of varying composition.

PHYSIOGRAPHY AND DRAINAGE

There are two rather distinct topographic areas in Henry county. One is the gently undulating prairie occurring in the northern and northeastern part of the county. Over a considerable portion of this area, the natural drainage is poor and tiling is frequently necessary. The level surface is broken by two old valleys, one-fourth to three-fourths of a mile in width and 15 to 20 feet in depth. These are occupied thruout most of their courses by Crooked creek. Along the county line east of New London, in this region, there are numerous rounded ridges and irregular hills.

Thruout the remainder of the county, the topography has been much modified by the action of the Skunk river, the principal stream of the county, and its various tributaries. These streams have in general cut thru the drift layer and in some instances have gone deep into the underlying rocks. As a result of this stream action, the topography of this section of the county is rolling to steeply rolling or hilly, with small, isolated, level areas, the largest of which occurs near Salem. The slopes to the main streams are steep and much cut up by erosion, while in the areas between the streams the slopes are more gentle. In general, the hilltops are flat and they are at about the same level thruout this section of the county. The southerly slopes are usually smooth and gentle, while those facing north are broken and rough.

In the southwestern part of Jefferson township and in the northwestern part of Trenton township, sand hills occur for several miles along the valley of the Skunk river. These hills are 20 to 40 feet in height and consist of almost pure sand which is yellow in color, known as the Knox fine sand, which is probably formed by the action of the wind. In section 21 of Tippecanoe township and section 4 of Salem township and in section 6 of Jefferson township are similar sand areas of the same origin.

Some small areas of flat terraces or second bottoms occur along Skunk river, Big Cedar creek and Little Cedar creek. These are 5 to 20 feet above the present flood plains and in general are eroded very slightly. The area of first bottom in the county is not extensive, due to the narrowness of the valleys along the larger streams. The bottomland in general is quite level in topography.

The drainage of Henry county is practically all accomplished by the Skunk river and its tributaries, the largest of which are Big Cedar creek, Big creek,

and Crooked creek. The Skunk river enters the county in the northwestern corner and with many windings, sometimes to the south and again to the east, it maintains a general southeasterly direction, passing out of the southeastern part of the county.

Big Cedar creek is the largest tributary of the Skunk river. It enters the county in the northwest corner of Salem township, follows a southeasterly

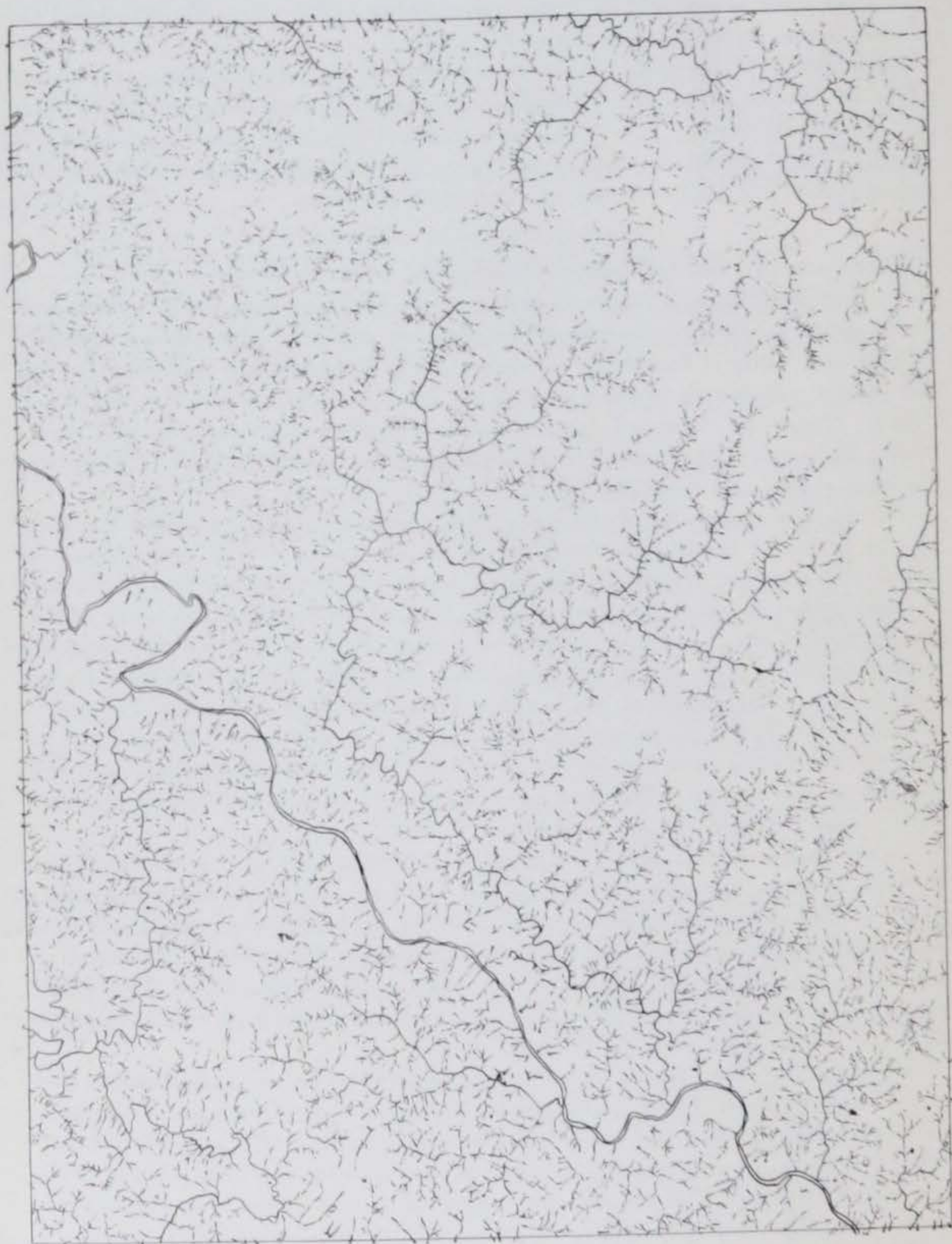


Fig. 1. Drainage map of Henry county

SOIL MAP OF HENRY COUNTY.

U. S. DEPT. OF AGRICULTURE
Bureau of Soils
Milton Whitney, Chief
Curtis F. Marbut, in charge Soil Survey

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

Thomas D. Rice, Inspector, Northern Division.
Soils surveyed by A. H. Meyer, of the U. S.
Department of Agriculture, in charge, and T. H.
Benton, of the Iowa Agricultural Experiment
Station.

LEGEND

Drift Soils

<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #d3d3d3; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">64</div> <p style="text-align: center; margin: 0;">Grundy silt loam</p>	<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #90ee90; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">115</div> <p style="text-align: center; margin: 0;">Grundy silty clay loam</p>
<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #90ee90; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">80</div> <p style="text-align: center; margin: 0;">Clinton silt loam</p>	<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background: repeating-linear-gradient(45deg, transparent, transparent 2px, #ccc 2px, #ccc 4px); display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">80A</div> <p style="text-align: center; margin: 0;">Clinton silt loam (broken phase)</p>
<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #ffff99; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">65</div> <p style="text-align: center; margin: 0;">Lindley loam</p>	<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #ffff00; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">67</div> <p style="text-align: center; margin: 0;">Marion silt loam</p>

<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #f5deb3; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">33</div> <p style="text-align: center; margin: 0;">Knox fine sand</p>
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Terrace Soils

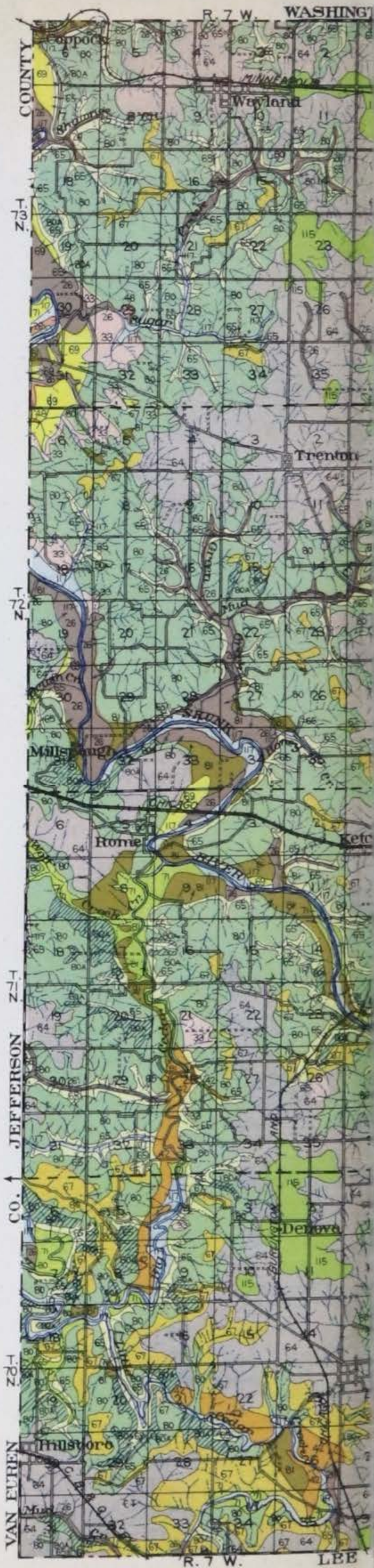
<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #ffff00; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">69</div> <p style="text-align: center; margin: 0;">Buckner very fine sandy loam</p>	<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #ff8c00; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">42</div> <p style="text-align: center; margin: 0;">Calhoun silt loam</p>
<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #808000; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">81</div> <p style="text-align: center; margin: 0;">Jackson silt loam</p>	

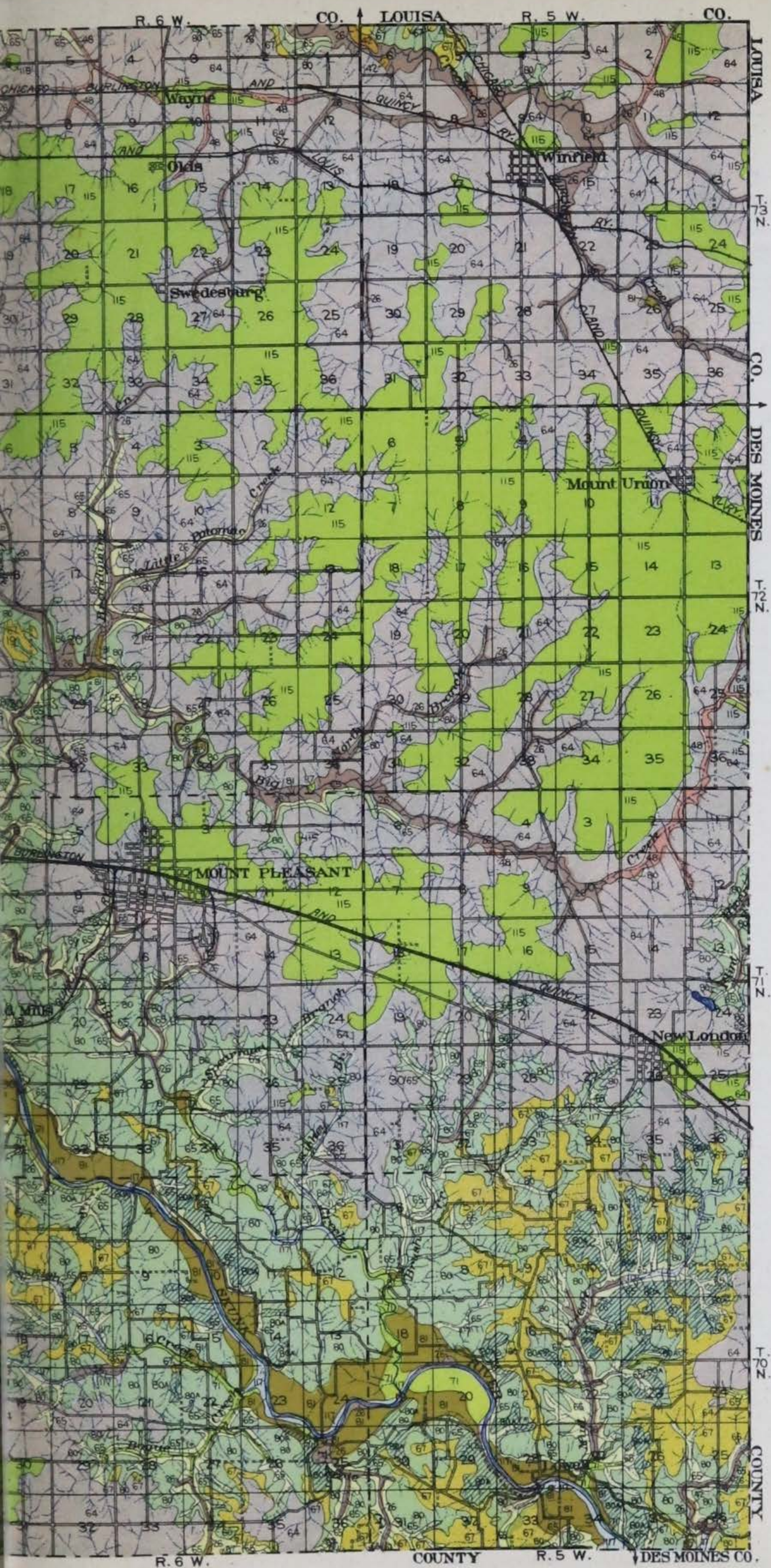
Swamp and Bottomland Soils

<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #808080; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">26</div> <p style="text-align: center; margin: 0;">Wabash silt loam</p>	<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #f08080; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">48</div> <p style="text-align: center; margin: 0;">Wabash silty clay loam</p>
<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #90ee90; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">71</div> <p style="text-align: center; margin: 0;">Genesee silt loam</p>	<div style="border: 1px solid black; width: 60px; height: 30px; margin: 0 auto; background-color: #add8e6; display: flex; align-items: center; justify-content: center; margin-bottom: 5px;">117</div> <p style="text-align: center; margin: 0;">Genesee fine sandy loam</p>

Scale: 1 Inch 2½ Miles.

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CO. LOUISA

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CO.

LOUISA

T. 73 N.

CO.

DES MOINES

T. 72 N.

T. 71 N.

T. 70 N.

COUNTY

R. 6 W.

COUNTY

R. 5 W.

DES MOINES CO.

course for some distance and then joins with Little Cedar creek. It then turns northward and, after considerable winding, joins the Skunk river near Rome. This creek drains the southwestern part of the county.

Big creek is the second largest tributary to the Skunk river. It rises in the eastern part of Canaan township and flows westward into Marion township. There it unites with several small branches and finally with Linn and Little Potomac creeks from the north. It then turns southward and flows parallel with the Skunk river for some distance, finally joining this river in Baltimore township. This creek brings about the drainage of the east central portion of the county.

Crooked creek flows across the northeastern corner of the county and with its many branches it brings about the drainage of that part of the county.

The drainage system of the county as a whole is shown in the accompanying map. With the exception of the area in the northeastern part of the county, separating the district drained by Crooked creek and that draining into the Skunk river, artificial drainage is not necessary in Henry county. In the area mentioned, however, which is largely made up of Grundy silty clay loam, the drainage conditions are poor and satisfactory crop growth may often be entirely dependent upon adequate drainage. This may be accomplished readily and should be the first treatment followed in farming such land.

THE SOILS OF HENRY COUNTY

The soils of Henry county are grouped into three classes according to their origin and location: Loess soils, terrace soils and swamp and bottomland soils. Loess soils are fine, dust-like deposits made by the wind at a time when climatic conditions were very different than at present. Terrace soils are old bottomlands which have been raised above overflow by a decrease in the volume of the stream or by a deepening of the stream channel. Swamp and bottomland soils are those which occur in low-lying, poorly drained areas or along streams, and they are subject to more or less frequent overflow.

The extent of these groups of soils in Henry county is shown in table II.

By far the largest portion of the county, over 91 percent of the total area, is covered by the loess soils. The terrace and swamp and bottomland soils are much less extensive in area. The terrace types cover only 3.1 percent of the total area of the county, while the swamp and bottomland types cover only a slightly larger area, 5.6 percent.

In topography the loess soils are exceedingly variable, ranging from almost level, in the case of the Grundy silty clay loam, to strongly rolling or hilly, in the case of the Clinton silt loam. The drainage of the loess soils is also quite variable. In most cases the natural drainage is satisfactory, but in some in-

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

Soil group	Acres	Percent of total area of county
Loess soils	249,536	91.3
Terrace soils	8,704	3.1
Swamp and bottomland soils	15,040	5.6
Total.....	273,280	



Fig. 2. Field of oats on Grundy silty clay loam near Mt. Union

stances, as for example many times on the Grundy silty clay loam, tiling is absolutely necessary for satisfactory crop production. The terrace soils are level to gently rolling and in general are well drained. In the Calhoun silt loam, however, artificial drainage is often needed. The bottomland types are level in topography and are subject to overflow. They are usually in need of drainage and in many cases the tiling of such soils and protection from overflow are the first and only treatments needed now to make them very productive.

There are 14 distinct soil types in Henry county and these, with the broken phase of the Clinton silt loam, make a total of 15 separate soil areas. There are eight loess types, three terrace types and four bottomland soils. These various soil types are distinguished on the basis of certain definite characteristics which are described in the appendix to this report. The type names which are given to the individual soils denote certain group characteristics which will be described later. The areas of the different soil types in the county are given in table III.

The Grundy silt loam is the most extensive loess soil in the county and the largest individual type. It covers over 39 percent of the total area of the county. The Clinton silt loam is somewhat smaller in extent than the Grundy but it is also extensive in area. With the broken phase, which is small in extent, the Clinton silt loam covers 26.9 percent of the total area of the county. The Grundy silty clay loam is the third largest type in the county, covering 14.9 percent of the total area of the county. These three types constitute the most extensive upland soils in the county, the Grundy soils occupying the more or less level to gently undulating uplands, while the Clinton soils are found on the more rolling to rough areas.

The other soils in the county are all comparatively small in area, but many of them are of considerable interest locally because they are less productive in

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN HENRY COUNTY

Soil No.	Soil type	Acres	Percent of total area of county
LOESS SOILS			
64	Grundy silt loam	107,584	39.4
80	Clinton silt loam	66,560)	
80a	Clinton silt loam (broken phase)	6,912)	26.9
115	Grundy silty clay loam	40,768	14.9
67	Marion silt loam	13,294	4.8
65	Lindley loam	13,056	4.8
33	Knox fine sand	1,152	0.4
66	Putnam silt loam	210	0.1
TERRACE SOILS			
81	Jackson silt loam	5,056	1.8
42	Calhoun silt loam	2,304	0.8
69	Buckner very fine sandy loam	1,344	0.5
SWAMP AND BOTTOMLAND SOILS			
26	Wabash silt loam	7,296	2.7
117	Genesee fine sandy loam	4,096	1.5
71	Genesee silt loam	2,688	1.0
48	Wabash silty clay loam	960	0.4

many cases and are in need of special treatment. The Marion silt loam and the Lindley loam occur in many small areas and are often quite unproductive. They each cover 4.8 percent of the total area of the county, and are larger in extent than any of the terrace or bottomland types. The Knox fine sand and the Putnam silt loam are minor in extent, covering only 0.4 and 0.1 percent of the total area of the county, respectively. They are both relatively unimportant, therefore, but especially in the case of the Knox fine sand, they are in need of careful handling to make them satisfactorily productive.

The terrace types are all small in area. The Jackson silt loam is the largest and it covers only 1.8 percent of the total area of the county. The Calhoun silt loam and the Buckner very fine sandy loam, the two remaining terrace types, are both small in extent, covering only 0.8 and 0.5 percent of the county, respectively.

The swamp and bottomland types are also all small in area. The Wabash silt loam is the largest, covering 2.7 percent of the total area of the county. The Genesee fine sandy loam and the Genesee silt loam are smaller in extent and cover 1.5 and 1.0 percent of the total area of the county respectively. The Wabash silty clay loam is the smallest bottomland type, occurring in several narrow areas along the streams and subject to overflow. This type occupies only 960 acres, or 0.4 percent of the area of the county.

The occurrence of these individual soil types in the county is shown on the map and the description of each type, together with recommendations regarding the treatments needed in each case, are given later in the report.

THE FERTILITY IN HENRY COUNTY SOILS

In order to determine the plant food content of the various soil types in the county, samples were drawn from all the soils in the county with the exception of the Putnam silt loam, which is very minor in extent. The larger types were sampled in triplicate, while the minor types were represented by only one sam-

ple. The samples were all taken with the greatest care that they should be representative of the types and that any variations due to local conditions or special treatments should be eliminated. The samplings were made at three depths, 0 to 6 2-3 inches, 6 2-3 to 20 inches, and 20 to 40 inches, representing the surface soil, the subsurface soil, and the subsoil, respectively.

The total phosphorus, total nitrogen, total organic carbon, inorganic carbon and limestone requirement, was determined on all samples. The official methods were followed in the case of the phosphorus, nitrogen and carbon determinations and the Veitch method was used for the determination of the limestone requirement. The results given in the tables are the averages of the duplicate determinations on all samples of each type. When more than one sample was taken, the results are the averages of four or six determinations.

THE SURFACE SOILS

The results of the analyses of the surface soils appear in table IV. They are calculated on the basis of 2,000,000 pounds of surface soil per acre. The phosphorus content of the soils of the county is somewhat variable, ranging from 916 to 1953 pounds per acre. In general, however, the amounts present are rather low and it would seem that phosphorus fertilizers should be distinctly profitable. There is no apparent relation between the various soil groups and their phosphorus content. The bottomland soils average somewhat higher than those of the other groups, which is undoubtedly a result of the smaller crop production and hence smaller removal of phosphorus from these soils. The terrace soils are rather low in phosphorus, but this is also true of some of the upland loess soils. In general it seems that the sandy soils are lower in this element than the loams and silt loams, while the silty clay loams are still better supplied with phosphorus.

In most cases the differences in phosphorus content are not very great and as the amount present in all cases is rather small, phosphorus will certainly be

TABLE IV. PLANT FOOD IN HENRY COUNTY, IOWA, SOILS
Pounds per acre of two million pounds of surface soil (0-6 2/3")

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
LOESS SOILS						
64	Grundy silt loam	1,354	3,912	54,073	0	2,602
80	Clinton silt loam	1,219	3,223	37,466	327	1,840
80a	Clinton silt loam (broken phase) ..	1,792	1,501	21,002	258	2,802
115	Grundy silty clay loam	1,372	5,408	68,873	0	1,334
67	Marion silt loam	1,296	3,226	40,472	0	1,768
65	Lindley loam	1,037	2,396	29,940	0	2,402
33	Knox fine sand	977	551	13,110	0	1,201
TERRACE SOILS						
81	Jackson silt loam	942	3,108	48,450	0	2,431
42	Calhoun silt loam	1,475	3,056	41,130	0	2,502
69	Buckner very fine sandy loam ..	916	1,243	8,880	0	2,145
SWAMP AND BOTTOMLAND SOILS						
26	Wabash silt loam	1,792	5,544	70,320	0	1,201
117	Genesee fine sandy loam	1,024	1,569	18,885	0	1,201
71	Genesee silt loam	1,158	2,036	25,160	2,080	Basic
48	Wabash silty clay loam	1,953	5,682	72,460	0	800

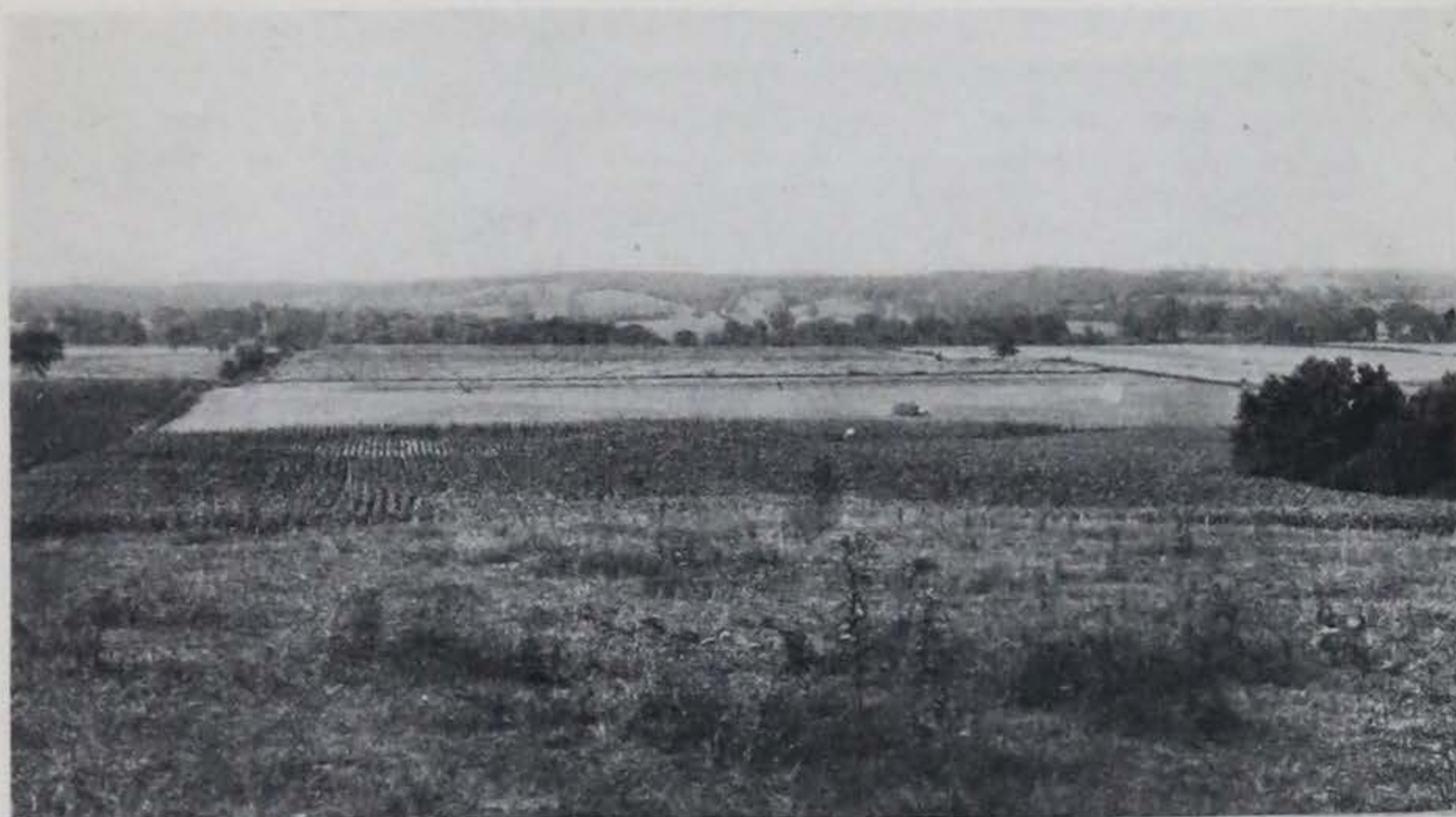


Fig. 3. Terrace soil, Jackson silt loam. The narrow bottomland along the river is indicated by the fringe of trees

needed in the near future if the soils are to be kept fertile. The application of a soluble phosphate might indeed prove of value in some cases at present. Tests should be made on small areas for they constitute the only definite means of determining the value of phosphorus now. Later, definite recommendations will be made based on the field experiments now under way.

The nitrogen content of the various soils in the county is in general considerably higher than the phosphorus. The bottomlands and the Grundy silty clay loam show especially large amounts of this element, while in the Knox fine sand it is extremely low. There is apparently no relation between the various soil groups in nitrogen supply, but the soil type does seem to influence to a considerable extent the amount of nitrogen present. As in the case of phosphorus, the sandy soils are low in nitrogen, while the silt loams and silty clay loams are rather well supplied.

In general the nitrogen present in the soils of the county is not low and only in a few cases is there an actual deficiency. This does not mean, however, that nitrogen should not be considered in systems of permanent fertility. Regular applications of nitrogenous materials should be made if the nitrogen supply in the soil is to be kept up. The use of farm manure, green manures and crop residues is the natural method of supplying nitrogen. Farm manures and crop residues, however, do no more than return a portion of the nitrogen removed by the crop. Leguminous green manures, on the other hand, if well inoculated, as they should be, will add nitrogen because of their ability to utilize nitrogen from the atmosphere. Legumes used as green manures also supply organic matter and hence have a double value.

The organic carbon present in soils is a measure of the amount of organic matter present and a large amount of organic carbon indicates a considerable amount of nitrogen. The color of the soil indicates fairly accurately the amount of organic matter present and usually gives a rough idea of the nitrogen supply.



Fig. 4. Terrace of Calhoun silt loam. Erosion of the hills in the background has exposed the drift. The soil is Lindley loam

The heavier soil types and those darker in color generally contain more organic carbon and more nitrogen than the light textured, light colored types.

In Henry county the bottomland soils are, on the average, better supplied with organic carbon than the upland types, just as they are with nitrogen. In some instances, however, individual upland types are high in organic matter. This is true, for example, of the Grundy silty clay loam. About the same relations prevail among the soil types in the case of the organic carbon content as were noted in the case of nitrogen. It may be said in general that the organic matter supply of the upland soils of the county is not particularly abundant and the application of fertilizing materials supplying organic matter is desirable. The use of farm manure is of particular value, as has been shown by many experiments and much farm experience. Frequently large increases in yields are secured by the application of manure alone and its value in increasing crop production should, therefore, be emphasized. When farm manure is not available for use in sufficient amounts, leguminous green manures should be turned under in the soil to keep up the organic matter supply.

Henry county soils are in general lacking in inorganic carbon. Only in three cases was there sufficient present in the samples to show a test, and in two of these, the amount was very small. In the Genesee silt loam, however, there was a rather considerable amount. In all the types, with the exception of this one mentioned, the Veitch test showed a limestone requirement, indicating a general need of applications of lime if the best growth of crops is to be secured, especially of legumes. The acidity in these soils will undoubtedly increase as cropping continues and if lime is not applied, crop production will be gradually reduced. The amount of lime to use should be determined by special tests.

Every soil should be tested before lime is applied, as there is a wide variation in the lime requirement of different soils. The results given in the table should

TABLE V. PLANT FOOD IN HENRY COUNTY, IOWA, SOILS
Pounds per acre of four million pounds of subsurface soil (6 2/3"-20")

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
LOESS SOILS						
64	Grundy silt loam	1,670	5,327	72,573	0	4,461
80	Clinton silt loam	1,442	2,384	24,900	0	4,804
80a	Clinton silt loam (broken phase) ..	1,374	1,783	18,740	0	5,604
115	Grundy silty clay loam	1,295	5,781	75,045	0	1,067
67	Marion silt loam	1,373	2,014	26,661	0	8,274
65	Lindley loam	1,010	1,948	24,680	0	8,008
33	Knox fine sand	1,064	816	10,720	0	1,600
TERRACE SOILS						
81	Jackson silt loam	1,603	3,001	62,460	0	6,063
42	Calhoun silt loam	1,340	3,904	34,116	224	11,440
69	Buckner very fine sandy loam	1,885	1,622	20,040	0	4,290
SWAMP AND BOTTOMLAND SOILS						
26	Wabash silt loam	3,832	8,384	97,200	0	1,600
117	Genesee fine sandy loam	1,374	2,162	23,580	0	3,603
71	Genesee silt loam	1,944	3,738	67,264	4,496	Basic
48	Wabash silty clay loam	2,196	6,528	146,048	252	800

be regarded merely as an indication of the needs of the soils and applications should not be based upon the results of these tests. The Soils Section will test samples for acidity without charge and will make recommendations regarding the amount of lime needed to put the soil in the best reaction for crop production.

THE SUBSURFACE SOILS AND THE SUBSOILS

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

The plant food present in the lower soil layers exerts some influence on the fertility or "life" of the soil, but unless the amount of a particular element

TABLE VI. PLANT FOOD IN HENRY COUNTY, IOWA, SOILS
Pounds per acre of six million pounds of subsoil (20"-40")

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
LOESS SOILS						
64	Grundy silt loam	1,966	3,924	48,240	0	4,690
80	Clinton silt loam	2,000	2,569	22,820	480	7,439
80a	Clinton silt loam (broken phase) ..	3,273	1,900	17,340	660	8,406
115	Grundy silty clay loam	1,778	3,202	48,022	938	Basic
67	Marion silt loam	2,505	2,639	21,480	0	13,212
65	Lindley loam	1,302	1,735	16,158	522	14,212
33	Knox fine sand	1,353	624	9,060	0	2,400
TERRACE SOILS						
81	Jackson silt loam	2,384	3,265	58,260	0	7,407
42	Calhoun silt loam	1,340	2,790	33,078	0	23,595
69	Buckner very fine sandy loam	2,020	1,686	37,800	0	6,435
SWAMP AND BOTTOMLAND SOILS						
26	Wabash silt loam	5,196	8,688	92,280	0	2,400
117	Genesee fine sandy loam	2,383	1,658	27,828	402	5,404
71	Genesee silt loam	2,547	4,472	56,982	3498	Basic
48	Wabash silty clay loam	2,334	5,927	73,314	486	1,200

is very much higher or very much lower than in the surface soil, the needs of the soil as indicated by the analyses of the surface soil are little modified. It is evident from tables V and VI that the plant food in the subsurface soils and subsoils of Henry county is very little different from that in the surface except for the decrease normally to be expected. It is hardly necessary, therefore, to consider these results in detail.

The conclusions reached from the results of the analyses of the surface soils are very largely confirmed. Phosphorus fertilizers might prove of profit now and they certainly will be needed in the near future, as there is no phosphorus supply in the lower soil layers. The organic carbon and nitrogen supply in these soils is not extremely low, yet neither is it very high in most cases; hence, the use of fertilizing materials supplying these elements is very desirable.

There is no large supply of lime in the lower soil layers except in the case of the Genesee silt loam; hence, lime will be needed on most of the soils of the county. With the exception of the soil type just mentioned, the subsurface samples and the subsoil samples with the exception of the Grundy silty clay loam, are all acid, and in this latter case there is no large supply of lime present. It is evident that the lime needs of the soil can not be met by any supply from below. The soils of the county should certainly be tested at regular intervals if the proper reaction is to be maintained and the best crop growth secured.

GREENHOUSE EXPERIMENTS

In order to learn something regarding the fertilizer needs of the soils of Henry county and to get some idea of the value of applying the various fertilizing materials, four greenhouse experiments were carried out on three of the soil types, three in 1918 and the fourth in 1919.

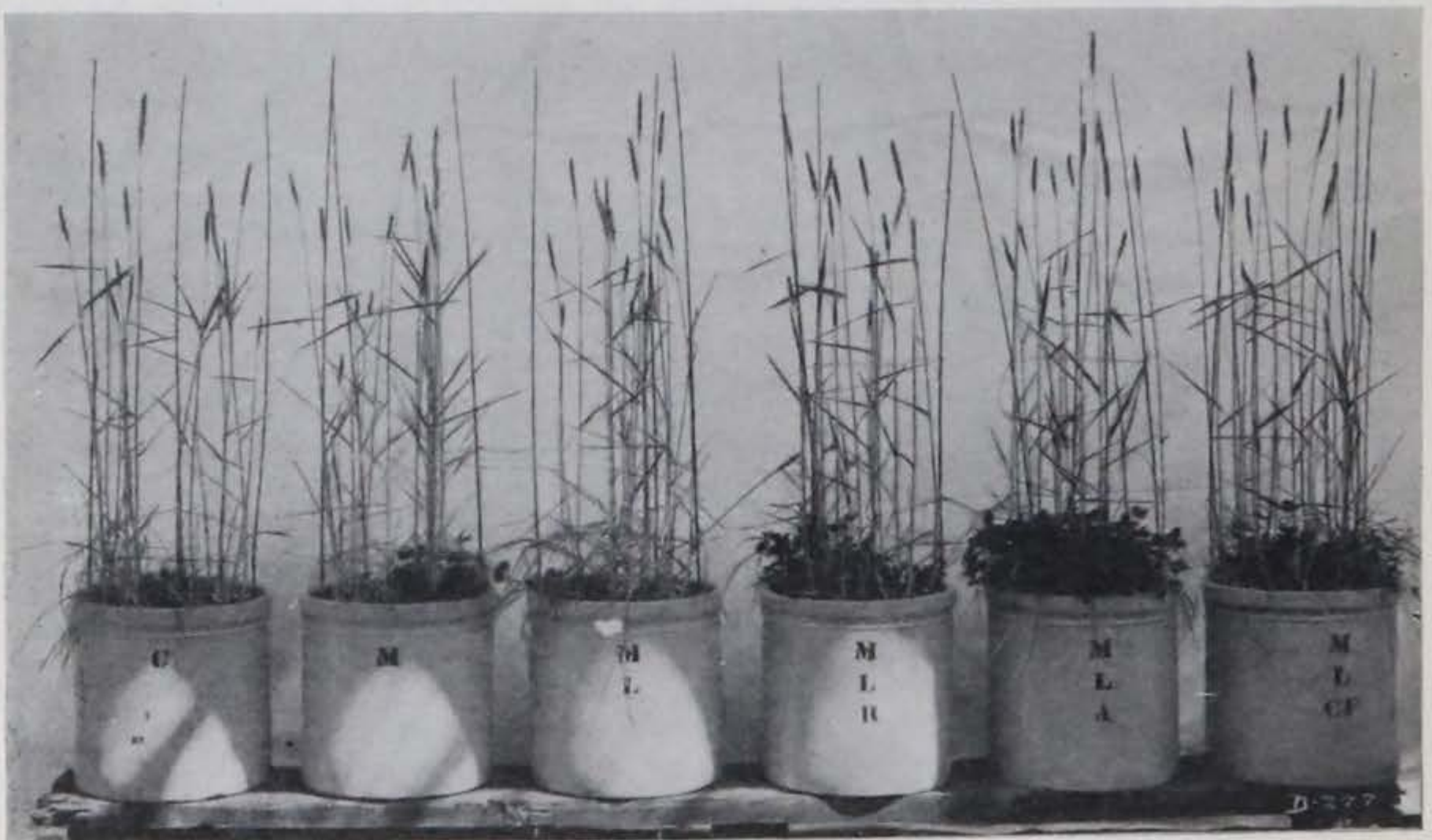


Fig. 5. Wheat on Marion silt loam



Fig. 6. Clover pot culture on Marion silt loam

The soils used were the Marion silt loam, the Clinton silt loam, and the Grundy silty clay loam. The soil treatments were the same in all the experiments and consisted in the application of manure, lime, rock phosphate, acid phosphate and a complete commercial fertilizer. The amounts used were the same as employed in the field experiments now under way. Hence, the results of the greenhouse tests may be considered indicative of the results to be expected in the field.

Manure was applied at the rate of 8 tons per acre. Lime was added in an amount sufficient to neutralize the acidity as indicated by the Veitch test and 2 tons additional were supplied to put the soil in the best condition for the growth of crops. Rock phosphate was applied at the rate of 2,000 pounds per acre, acid phosphate at the rate of 200 pounds per acre and a standard 2-8-2 brand of complete commercial fertilizer at the rate of 300 pounds per acre. Wheat and clover were grown in all of these experiments, the clover being seeded about a month after the wheat was up. The wheat yields were very unsatisfactory in all cases except one. They proved so irregular that the results are not given in the tables except in the case of the Marion silt loam. The clover yields, however, show some interesting effects from the treatments and the results may be considered to indicate the effect of these materials on clover in the field.

The results of the experiment on the Marion silt loam are given in table VII, the results being the averages of the duplicate pots. Manure brought about a distinct increase in the yield of wheat and a still further increase was noted by the addition of lime with the manure. The phosphate fertilizers showed no definite effect on this crop but the commercial fertilizer brought about a small increase. In the case of clover, however, the effect of treat-

TABLE VII. GREENHOUSE EXPERIMENT
Marion silt loam—Henry county

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	8.50	8.0
2	Manure	10.20	17.0
3	Manure+Lime	11.85	12.0
4	Manure+Lime+Rock phosphate	11.45	25.0
5	Manure+Lime+Acid phosphate	11.10	39.0
6	Manure+Lime+Commercial fertilizer.	12.22	36.0



Fig. 7. Clover pot culture on Clinton silt loam

ment were much more noticeable. The applications of manure more than doubled the yield. Lime with manure showed no increase over the manure alone. Rock phosphate used with lime and manure gave an increase in the yield of clover, but a much larger increase was obtained with acid phosphate and only a slightly smaller effect with the commercial fertilizer. The yield with acid phosphate was over twice as large as with the manure alone and the same was true of the commercial fertilizer.

These results show quite definitely that manure is a very valuable material for use on this soil and that the application of a phosphate fertilizer may bring about a large increase in the yields of clover. This soil type is deficient in organic matter and also low in phosphorus and the results indicate that these materials would prove of special value in making the type more productive.

The results of the experiment on the Clinton silt loam are given in table VIII, the average yields of clover only being shown. The data given in this table show a beneficial effect from the use of manure and a very distinct increase from the application of lime. Rock phosphate used with manure and lime showed no influence. The same was true of the commercial fertilizer. Acid phosphate, however, brought about an increase in the crop yield, indicating that phosphorus fertilizers might be of value on this soil type. The effect of manure is very evident and this material should certainly be used. Phosphate fertilizers should also be tested in order to determine the possibility of their beneficial effect.

The results of the greenhouse experiment on the Grundy silty clay loam in 1918 are given in table IX. Again the yield of clover only was secured. It will be noted that the application of manure brought about a large increase and lime with manure also gave a very considerable increase. The rock phosphate used with manure and lime showed no effect, but the acid phosphate

TABLE VIII. GREENHOUSE EXPERIMENT
Clinton silt loam—Henry county

Pot No.	Treatment	Weight of clover in grams
1	Check	35.0
2	Manure	40.0
3	Manure+Lime	56.0
4	Manure+Lime+Rock phosphate	49.0
5	Manure+Lime+Acid phosphate	63.0
6	Manure+Lime+Commercial fertilizer	56.0

TABLE IX. GREENHOUSE EXPERIMENT
Grundy silty clay loam—Henry county—1918

Pot No.	Treatment	Weight of clover in grams
1	Check	40.0
2	Manure	53.0
3	Manure+Lime	66.5
4	Manure+Lime+Rock phosphate	66.5
5	Manure+Lime+Acid phosphate	80.0
6	Manure+Lime+Commercial fertilizer	79.0

increased the yield considerably over the manure and lime and the commercial fertilizer showed just about the same effect as the acid phosphate.

It is apparent from these results that manure is of considerable value on this soil, probably due very largely to its physical effect and to the introduction of bacteria. The soil is high in organic matter and is a heavy type in which bacterial action is probably rather restricted. The increase in crop yield may be a direct result of the better air conditions in the soil and the larger production of available plant food. Lime is shown to be of value and whenever this soil type is acid, it should certainly be treated with the required amount of lime. Rock phosphate showed no influence in the short time of the experiment, but might have given some effect if the experiment had been continued over a longer period. The beneficial effect of acid phosphate is particularly noticeable and serves to indicate that phosphate fertilizers may be particularly valuable on this soil. It would seem from these results that there would be no greater benefit from the use of commercial fertilizer than from acid phosphate.

The second greenhouse experiment on this same soil type was carried out in 1919 and the results are given in table X. Again the large beneficial effect of manure may be noted. Lime did not show up here as it did in the sample

TABLE X. GREENHOUSE EXPERIMENT
Grundy silty clay loam—Henry county—1919

Pot No.	Treatment	Weight of clover in grams
1	Check	40.82
2	Manure	72.57
3	Manure+Lime	65.76
4	Manure+Lime+Rock phosphate	77.11
5	Manure+Lime+Acid phosphate	69.80
6	Manure+Lime+Commercial fertilizer	86.18



Fig. 8. Clover pot culture on Grundy silty clay loam

tested the preceding year, due perhaps to a difference in the reaction of the two samples. Rock phosphate showed a small gain over manure and lime, but acid phosphate showed no effect. Commercial fertilizer, however, brought about a distinct increase in the yield of clover.

These results may be considered to confirm those of the previous year and the general conclusion seems justified that this soil will respond profitably to manuring and liming and probably also to phosphorus fertilizers. Definite conclusions regarding the value of the addition of these materials should be based on field results rather than on greenhouse experiments, however, and for the present it is urged that farmers test the use of phosphate fertilizers on their own soils and determine which material is more profitable. The field experiments which follow throw some light on this question, but individual tests are necessary before definite conclusions should be drawn.

FIELD EXPERIMENTS

Several field experiments are now under way in Henry county and while most of them have not run for long periods of time, some interesting data have already been secured. These tests were all planned with the idea of determining the value of various methods of soil treatment. They are laid out on land which is thoroly representative of the most important individual soil types in the county. They are permanently located by the installation of corner stakes and care is taken in the application of fertilizers and in the harvesting of the crops to be certain that the results secured are accurate.

On each field there are one or more series of plots which have been arranged to include tests under the livestock system of farming and under the grain system. In the former, manure is applied, while in the latter, crop residues are utilized as a source of organic matter. The other applications tested are limestone, rock phosphate, acid phosphate and a complete commercial fertilizer. The manure has been applied in all cases at the rate of 8 tons per acre once in a 4 year rotation. Limestone has been applied in a sufficient amount to neutralize the acidity of the soil and supply 2 tons additional. Rock phosphate is applied at the rate of 2,000 pounds per acre once in the rotation, while acid phosphate is applied at the rate of 200 pounds per acre annually. A standard 2-8-2 complete commercial fertilizer has been used at the rate of 300 pounds per acre annually. In the case of the grain system plots, where the crop residues are employed in place of manure, the second crop of clover is plowed under in all cases. The corn stalks are cut with a disc and plowed under and the threshed straw from the small grain is returned to the soil.

In all the experiments there are 13 plots, 3 of which are untreated, or check plots. These are numbered 1, 7, and 13. Plots 1 to 7 inclusive are therefore included in the livestock system, while plots 7 to 13 are in the grain system.

The first field was laid out near New London in 1914 and the plots are 128 feet, 2 inches, by 68 feet, or 1-5 of an acre in size. They are separated by 4 feet division strips. The second field, at Mt. Pleasant, was laid out in 1915 in duplicate series. These plots are 156 feet, 6 inches, by 28 feet, or 1-10 of an acre in size. The data secured to date on the New London and Mt. Pleasant fields are given for the full series, but in the experiments started in

1917, the data for the livestock system only are presented inasmuch as there has been no opportunity as yet for any utilization of crop residues.

In the New London field the corn yield in 1914 is not given and in the Mt. Pleasant field the crop yields in 1915 and 1916 are not included. These results for the first years of the experiments are eliminated because of the irregularity in the soil conditions, which led to such variations in crop yields as to leave the effect of treatment in question.

THE MT. PLEASANT FIELD

The results obtained on the Mt. Pleasant field are given in table XI. This field is located on the Grundy silt loam, the largest soil type in the county, and the results secured for the years 1917, 1918 and 1919 on the two series of plots show some interesting results of treatment. In the case of the corn and oats crop, the yield on the check plot is determined by averaging the 3 check yields. With the clover, however, this can only be done in the livestock system plots. In the grain system plots the checks are the average of plots 7 and 13, which adjoin the crop residue treated plots, and are the average of the first cutting yields only. It has been necessary to eliminate the oat yield in one instance, owing to the very evident error which must have occurred in obtaining the weight of the sample.

In one or two cases the effects of treatment are not evident, or at least, they are not what would be expected, probably due to unavoidable irregularities in the soil conditions in the plots. For instance plot 2, treated with manure, shows a slightly lower yield of corn than the average checks, a slightly lower yield of oats than the checks and a slightly lower yield of clover than the checks. This variation occurs especially in the 100 series, but is also noted in the 200 series.

In general, however, the effects of the application of fertilizing materials is really very definite and attention should especially be called to the effect

TABLE XI. MT. PLEASANT FIELD EXPERIMENT
Grundy silt loam

Plot No.	Treatment	1917		1918		1919	
		100 corn	200 oats	100 oats	200 clover	100 clover	200 corn
1	Check	48.1	93.1	73.7	7883	8300	57.3
2	Manure	37.5	85.0	75.1	9650	7580	66.3
3	Manure, Limestone	52.2	90.0	74.8	10600	7990	74.1
5	Manure, Limestone, Acid phosphate....	73.6	97.5	85.1	12575	12950	75.3
4	Manure, Limestone, Rock phosphate...	66.0	107.5	76.5	11450	9860	78.6
6	Manure, Limestone, Commercial fertilizer	76.8	97.5	80.8	10850	13870	66.5
7	Check*	48.1	93.1	73.7	4575	4380	57.3
8	Crop residues	50.8	91.3	81.3	5650	4600	65.3
9	Crop residues, Limestone	47.1	92.5	93.2	4250	4450	71.0
10	Crop residues, Limestone, Rock phosphate	52.7	100.0	96.4	5985	5700	75.1
11	Crop residues, Limestone, Acid phosphate	54.7	92.5	99.9	6545	6420	81.1
12	Crop residues, Limestone, Commercial fertilizers	52.8	107.5	93.6	5390	6300	78.5

*The check yields given under 7 are the same as under 1 in the case of the corn and oats—the figures being the averages of the three check plots. In the case of the clover however the yields in 7 are the average of the first clover crop on plots 7 and 13—the second being turned under on the crop residue plots. The clover yields in 1 however are the average of both clover crops on all three check plots.

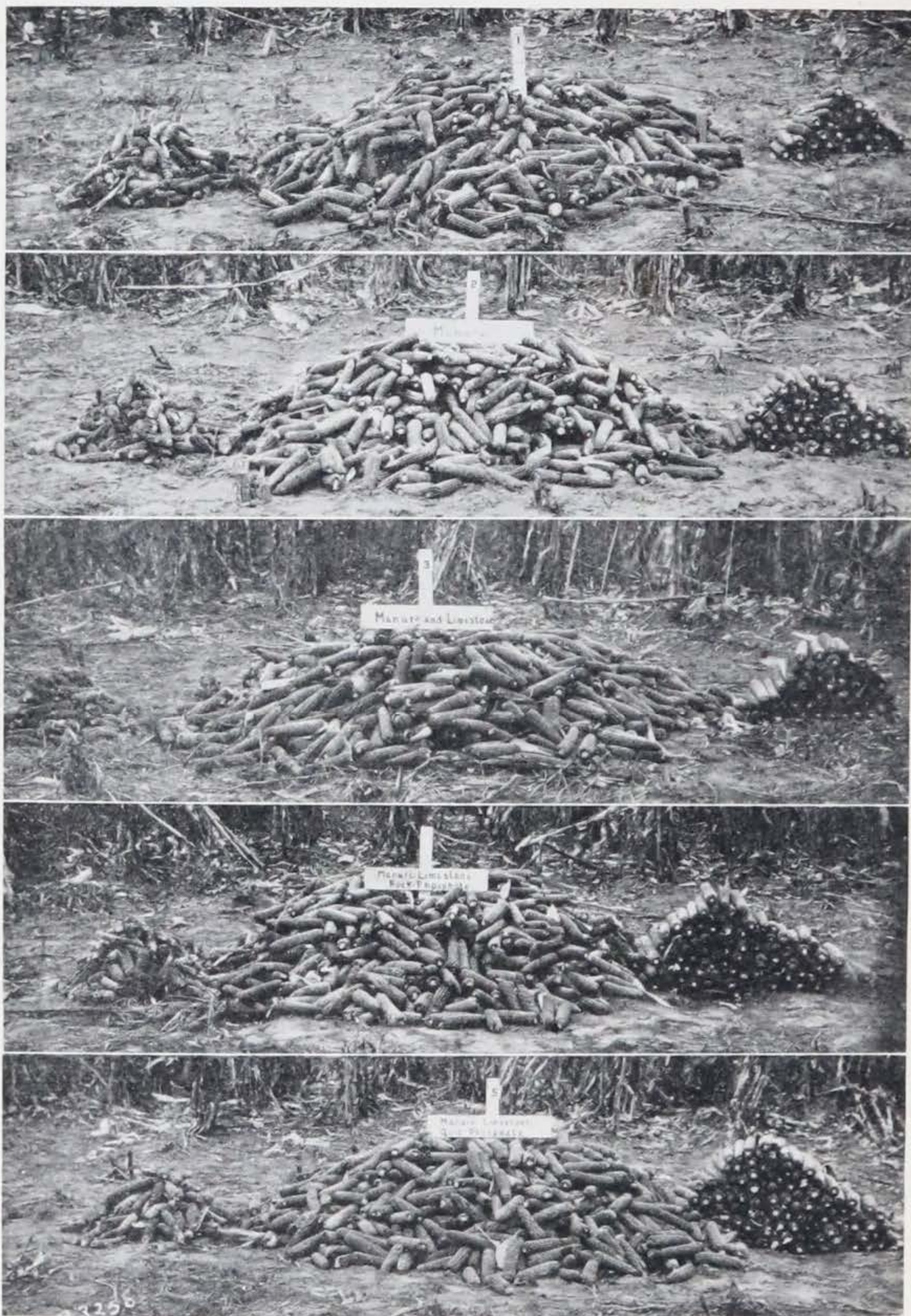


Plate I. Field Experiment at Mt. Pleasant on Grundy silt loam—livestock system, 1919. Yield of corn per acre, check plot, 55.7; with manure, 66.3; manure and limestone, 74.1; manure, limestone and rock phosphate, 78.6; manure, limestone and acid phosphate, 75.3. Center piles, good, marketable corn; to the right, seed corn; to the left, nubbins. Check plot No. 1 shown. Results in the text are the average of all checks (1, 7 and 13).

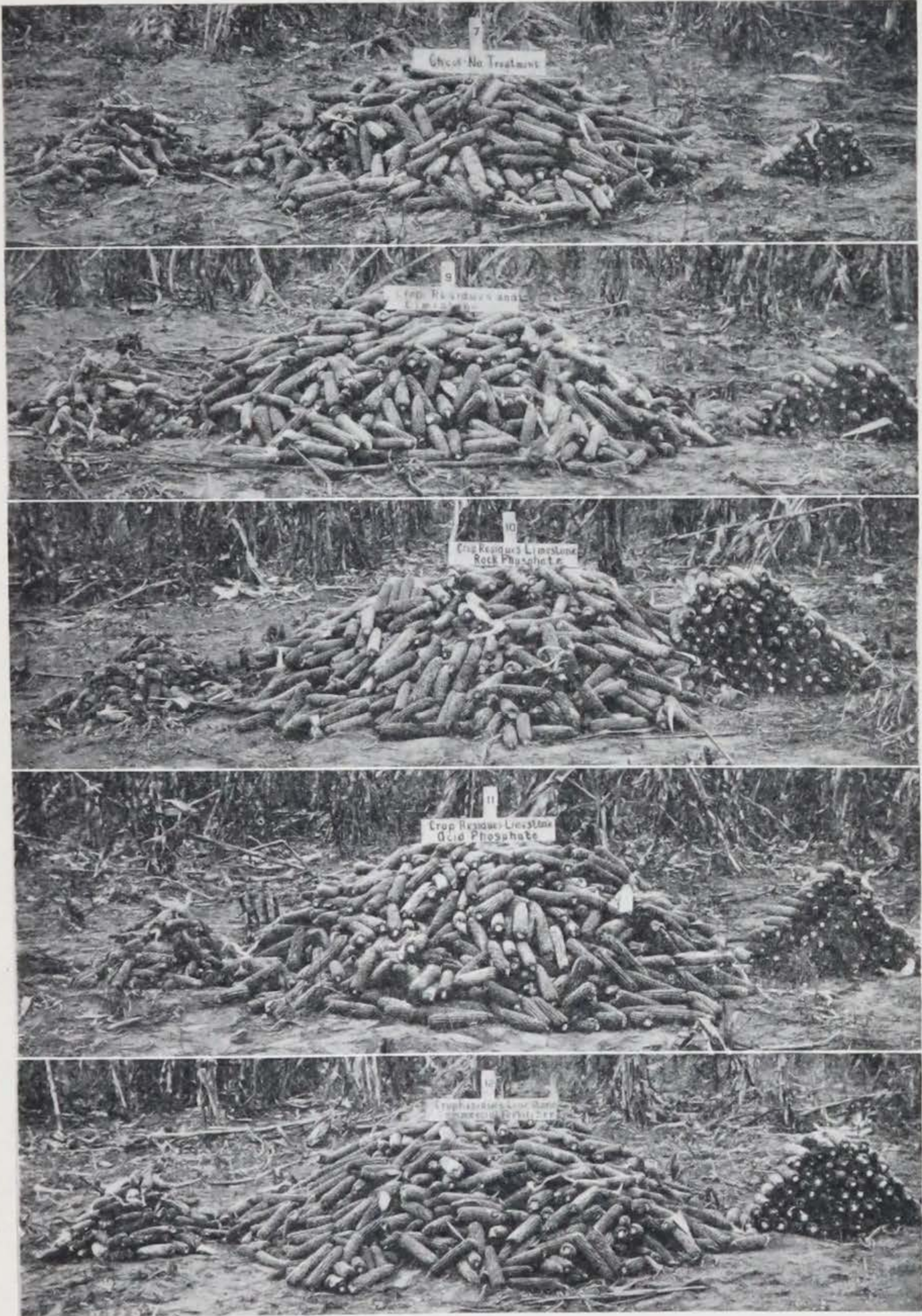


Plate II. Field experiment at Mt. Pleasant on Grundy silt loam—grain system, 1919. Yield of corn per acre, check plot, 50.6; with crop residues and limestone, 65.3; crop residues, limestone and rock phosphate, 71.0; crop residues, limestone and acid phosphate, 75.1; crop residues, limestone and commercial fertilizer, 78.5. Center piles, good marketable corn; to the right, seed corn; to the left, nubbins. Check plot No. 7 shown. Results in the text are the average of all checks (1, 7 and 13).

of the phosphate fertilizers. It will be noted that the rock phosphate and the acid phosphate brought about considerable increases in yields of corn, oats, and clover in each test, both under the livestock system and under the grain system. The results are hardly complete enough, however, to permit of definite conclusions regarding the relative merits of these two materials. In some cases the rock seems to be a little better, but in most instances the acid phosphate seems to show the larger gains. The differences, however, are not very large and unless succeeding years' results enlarge considerably the gains from the acid phosphate, it is hardly likely that the material will prove to be as economically profitably as the rock phosphate. From these results, however, it would seem quite evident that some phosphate fertilizer should be used on the Grundy silt loam and farmers are urged to test the two materials side by side in order to determine which is the more valuable for their particular conditions.

The complete commercial fertilizer with few exceptions showed no superiority over acid phosphate and in some instances it gave a smaller effect than the rock phosphate. It would seem, therefore, that the larger cost of the complete fertilizer would hardly be warranted on this particular type of soil and quite as satisfactory results may be secured by using one or the other of the cheaper phosphate materials.

Owing to the irregular soil conditions in plot 2, already mentioned, the application of manure does not show up so well as would be expected nor so well as is commonly the case in general farm practice. The clover yield in 1918 shows a large increase from the use of manure, however, and the corn in 1919 also shows the effect of manure. There is no question but that manure is a very valuable fertilizing material for use on this soil and it should be applied in as large amounts as practicable to insure the continued fertility of the soil. Lime shows some increase in crop yields, particularly in the case of clover, and this would indicate the need of testing the Grundy silt loam to determine its reaction and the amount of lime required to put it in a basic condition.

The experiment has not been continued long enough for the crop residues to give much effect. The corn yield in 1919, however, showed a distinct increase on the crop residue plots where the second crop of clover was plowed under. The yield for the next two or three years should show even more definite effects from this method of handling the clover crop. These results as a whole give a good indication of the requirements of the Grundy silt loam for increased and continued fertility, indicating as they do the value of manure, lime, and a phosphate fertilizer.

THE NEW LONDON FIELD NO. 1

The second field experiment on the Grundy silt loam was carried out on a farm two miles north of New London. The results of the experiment are given in table XII. The experiment was started in 1914, but the yield of corn for that year is not given in the table, owing to the irregularities in the soil, which were much the same as those occurring in the Mt. Pleasant field. Again the yield of the untreated plot or check plot is determined by averaging plots 1, 7 and 13 and this average only is recorded in the table.

TABLE XII. FIELD EXPERIMENT

New London Field No. 1

Grundy silt loam—Henry county*

Plot No.	Treatment	Oats	Clover	Corn	Corn
		bushels per acre 1915	tons per acre 1916	bushels per acre 1917	bushels per acre 1919
1	Check (Av. of plots 1, 7 and 13).....	58.3	2.2	50.0	51.5
2	Manure	63.6	2.9	61.7	52.9
3	Manure+Lime	69.2	3.0	64.8	55.2
4	Manure+Lime+Rock phosphate	69.7	2.8	63.7	60.0
5	Manure+Lime+Acid phosphate	72.0	2.8	68.6	64.0
6	Manure+Lime+Commercial fertilizer	78.9	2.5	55.0	56.5
8	Crop residues	64.2	1.9	47.7	50.1
9	Crop residues+Lime	66.4	2.2	51.3	57.8
10	Crop residues+Lime+Rock phosphate	70.0	2.4	59.5	58.0
11	Crop residues+Lime+Acid phosphate	60.6	2.1	56.4	52.4
12	Crop residues+Lime+Commercial fertilizer.....	86.8	3.0	53.2	47.3

*The yield of corn for 1918 was not secured.

In a general way the results secured in this experiment confirm the indications observed in the experiment at Mt. Pleasant. The effect of the application of manure is much more evident, however, in this test, considerable increases in crop yields being noted each year. The application of lime increased the yields of every crop grown, showing a surprising effect upon corn and oats, as well as the expected effect upon clover.

The phosphate fertilizers in general increased the yields of all of the crops. There are some exceptions to this general rule, in a few instances no beneficial effects being secured either from the rock phosphate or the acid phosphate. The data in this experiment are hardly sufficient to warrant conclusions regarding the relative value of the two materials. In the live-stock system plots, acid phosphate seemed somewhat superior but on the crop residue plots there not only seemed to be no superior value but the results were somewhat smaller than those secured from the rock phosphate.

Again it should be emphasized that the value of these two materials will depend very largely upon the cost and the cheaper rock phosphate may actually prove more economical than the more quickly acting acid phosphate. These results, like the former, therefore, indicate the desirability of farmers testing the phosphate fertilizer on the Grundy silt loam and, by using the two materials mentioned, determining for their own conditions which is the more economical. The complete commercial fertilizer in one or two cases showed up a little better than the phosphate fertilizer but in general it was not as effective in increasing crops as were the phosphate materials.

These results on this field confirm those obtained at Mt. Pleasant and altho the data is not as definite as will be secured in the next few years, yet the indications point strongly to the value of the use of lime and phosphate fertilizers in making this soil more productive.

THE ROME FIELD

In table XIII there appear the results secured in 1918 and 1919 on the field experiment on the Clinton silt loam located near Rome. The plots under the grain system are not included in this data inasmuch as the results are extremely irregular and no clover has been turned under as yet. While this is a new field

TABLE XIII. FIELD EXPERIMENT
Clinton silt loam—Henry county—Rome field

Plot No.	Treatment	Oats, bushels per acre 1918	Clover, tons per acre 1919
1	Check	34.0	1.75
2	Manure	46.7	1.80
3	Manure+Lime	44.6	2.10
4	Manure+Lime+Rock phosphate	46.5	1.70
5	Manure+Lime+Acid phosphate	44.6	2.60
6	Manure+Lime+Commercial fertilizer	48.8	2.30
7	Check	35.9	1.75

and the results which are given on the livestock system are rather meager, yet there are some indications of the effects of treatment which it is interesting to note. Beneficial effects of manure are shown quite distinctly in the case of the oats and also in the case of clover. Lime gave an increase on the clover but had practically no influence on the oats. Acid phosphate had considerable effect on the clover and the commercial fertilizer showed up almost as well. The commercial fertilizer also increased the oat yield but only to a small extent. Rock phosphate showed no effect on either crop. This is probably due to the fact that this soil is rather poorly supplied with organic matter and there has been an insufficient amount of available phosphorus produced. This soil is not very well supplied with this element and it might be expected that phosphate fertilizers would prove of some value.

These results indicate in general the value of manure in improving the fertility of the Clinton silt loam and of applications of lime and phosphate fertilizer to bring about the best growth of clover particularly. Results on these plots for the next few years will undoubtedly permit of more definite conclusions but the treatments suggested, particularly the use of manure and lime, are known to be of considerable value from farm practice. The use of a phosphate fertilizer should be determined by tests on a small scale in order to select that material which will be the most profitable.

THE MT. UNION FIELD

The results secured on the Grundy silty clay loam in Series I at Mt. Union are given in table XIV. The yield of corn was obtained in 1918 and the yield of wheat in 1919. Again only the livestock system plots are included for the reasons that were given before. It will be noted that manure gave a considerable increase in the yield of corn and in the yield of wheat. Lime showed some effect but only increased the crop to a small extent. Rock phosphate gave a small increase in the corn yield but had no effect on the wheat. Acid phosphate

TABLE XIV. FIELD EXPERIMENT
Grundy silty clay loam—Henry county
Mount Union field—Series I

Plot No.	Treatment	Corn bushels per acre 1918	Wheat bushels per acre 1919
1	Check	57.2	8.3
2	Manure	61.3	11.8
3	Manure+Lime	62.0	12.0
4	Manure+Lime+Rock phosphate	63.1	11.3
5	Manure+Lime+Acid phosphate	65.5	13.1
6	Manure+Lime+Commercial fertilizer	59.4	12.2
7	Check	57.4	10.2

TABLE XV. FIELD EXPERIMENT
 Grundy silty clay loam—Henry county
 Mount Union field—Series II

Plot No.	Treatment	Oats bushels per acre 1918	Clover and timothy tons per acre 1919
1	Check	65.8	2.28
2	Manure	72.1	3.22
3	Manure+Lime	74.2	2.65
4	Manure+Lime+Rock phosphate	74.2	2.89
5	Manure+Lime+Acid phosphate	72.1	3.33
6	Manure+Lime+Commercial fertilizer	78.5	3.07
7	Check	65.8	2.30

however, showed a distinct increase in both crops. The commercial fertilizer had no effect on either crop.

These results indicate a considerable beneficial effect from manure on this soil type, which is well supplied with organic matter, showing that there is a need for a stimulation in the production of available plant food in this soil. When the soil is acid lime should undoubtedly be applied and this application would be much more effective on the legume in the rotation than is apparent in these results on the grain crop. Phosphorus is not particularly high in this soil and the application of a phosphate fertilizer may prove distinctly profitable. Further results are needed to determine whether acid phosphate or rock phosphate should be employed. There are no indications of value from the use of the commercial fertilizer and it seems unlikely that it would prove of as much economic value as the phosphate materials.

The second series of this same field experiment on the Grundy silty clay loam at Mt. Union shows results which very largely confirm those in series I. The results of this experiment appear in table XV, and the crop yields of oats and clover and timothy are given. Manure again showed a very decided effect on crop growth. Lime showed some influence on the oat crop but there is no evidence of any effect on the clover and timothy. It seems probable that the yield on plot 2 is abnormally high so the absence of any effect of lime should not be taken to show that this soil does not need liming when it is acid. Farm experience has indicated the need of lime on this soil, especially when it is brought under more intensive cultivation. Neither rock phosphate nor acid phosphate showed any considerable effect on these crops except in the case of the acid phosphate on clover, where a very large benefit was evidenced. The commercial fertilizer gave some effect on both of these crops, smaller effect being shown than with the acid phosphate in the case of clover and timothy. Apparently the Grundy silty clay loam is particularly in need of applications of manure, lime and possibly also a phosphate fertilizer. This is a comparatively fertile soil type and with treatments as indicated can be made highly productive.

THE NEW LONDON FIELD NO. 2

The fourth field experiment established in 1917 in Henry county is near New London and is located on the Marion silt loam. It is known as the New London field No. 2. Results obtained from this field in 1918 and 1919 are given in table XVI. The beneficial effect of manure is shown quite distinctly in the case of both crops. Lime also gives evidence of some value. Rock phosphate and acid

TABLE XVI. FIELD EXPERIMENT
 Marion silt loam—Henry county
 New London field No. II

Plot No.	Treatment	Oats bushels per acre 1918	Clover and timothy tons per acre 1919
1	Check	38.2	2.92
2	Manure	42.5	3.44
3	Manure+Lime	48.8	3.30
4	Manure+Lime+Rock phosphate	65.8	2.96
5	Manure+Lime+Acid phosphate	73.3	2.50
6	Manure+Lime+Commercial fertilizer	68.0	2.70
7	Check	42.5	2.20

phosphate both brought about large increases in the yields of oats but for some reason showed no effect on the clover and timothy. The acid phosphate seemed to show some superior effect over the rock. The commercial fertilizer benefited the oats about the same as the phosphate materials and like them showed no influence on the clover and timothy. It had somewhat less effect than the acid phosphate and slightly more than the rock but the differences are hardly sufficient to warrant any definite conclusions. These results are indicative of the needs of the Marion silt loam, however, in showing benefits from the use of manure, lime and a phosphate fertilizer. This type is particularly deficient in organic matter and it would be expected that manure would prove especially valuable. Just which phosphate fertilizer should be used must be left to be determined by individual tests as in the case of the other soil types.

These field experiments are to be continued and the results secured in the next few years, it is hoped, will permit of more definite conclusions regarding the needs of the individual soil types. The data given in the tables are included in this report, however, because of the very striking indications which they give of the value of certain treatments. The results should not be interpreted too definitely nor too broadly at this time and as a general conclusion from the field experiments so far, it would be quite justifiable to call attention to the need of manure and lime on these soils and the probable value of applications of phosphate fertilizers. Farmers should also be urged to test these latter materials and determine whether rock phosphate or acid phosphate should be used.

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

The general treatments recommended in this report for the soils of the county are based upon the laboratory, greenhouse and field experiments reported in the previous pages. They are based also, however, upon the general experience of farmers and the suggestions made are only those which have been proven by practical experience to be of value.

The results of the field experiments which have been given are far from complete and several years additional results are necessary before absolutely definite conclusions from them may be drawn. This is especially true in the case of recommendations regarding the real merits of the two phosphate fertilizers.

The complete data from these tests will be published later in a supplementary report. A general statement may be given at this time, however, regarding the needs of Henry county soils.

LIMING

The need of lime on the soils of Henry county has been shown by many tests of field soils and the analyses of the typical soil types given earlier in this report. With one exception the soils are acid in reaction and should be supplied with lime if the best crop growth is to be secured. The acidity of the samples taken in this work was not nearly as large as has been found in other counties but with the one exception mentioned, where the soil was basic in reaction, there was no inorganic carbon present in the soil and hence the conclusion would be warranted that the acidity would increase rapidly with continued cropping. In the subsurface and subsoil samples, acidity was also indicated except in the Genesee silt loam, the type which was basic at the surface, and the Grundy silty clay loam, which showed a basic reaction in the subsoil. Even in this latter case, however, there was no appreciable amount of carbonate present in the soil. It is possible also that other samples of the Genesee silt loam might show acidity and this soil type should be tested for its reaction in order to be certain that the best crop growth, particularly of legumes, may be secured.

In general it may be said that the soils of this county are in need of liming and tests should be made in all cases now and also at regular intervals in the future, if satisfactory crop production is to be secured. Farmers may test their own soils for acidity but it will be more satisfactory if they will send a small sample to the Soils Section to have it tested more accurately, free of charge. Soils which are cropped tend to lose their lime content rather rapidly and it is necessary, therefore, that applications be made at certain definite times in the rotation. It is best to test the soil once in a four year rotation, preferably just prior to seeding to clover, and apply the lime needed at that time. In this way it is possible to keep the soil supplied with the proper amount of lime to prevent any accumulation of acidity, which has been shown by many experiments to reduce crop production.

The exact amount of lime to be used on any soil must be determined for that particular soil. The lime requirements of soils will vary widely and even average tests made on a large number of samples would not necessarily show how much lime should be used in the field on any particular soil. The results given earlier in this report likewise should not be considered to show definitely the needs of the particular soil types everywhere in the county, but they should be looked upon merely as indicating the average acidity of the types and the average lime requirement. Farmers should test for the lime requirement in the various fields on their farm and not apply lime according to the results of the test of a sample from one field. Further information regarding the loss of lime from soil, the need of lime for the best crop growth, the use of lime and other points connected with liming in general, are given in bulletin 151 and circular 58 of the Iowa Agricultural Experiment Station. The latter publication also indicates where limestone may be procured and the approximate cost of the material.

MANURING

Many of the soils in Henry county are quite low in organic matter and, while only a few are strikingly deficient, the need of manuring is quite generally evident thruout the county. Only in the case of the Grundy silty clay loam and two of the bottomland types is there any large amount of organic matter present. The greenhouse experiments on three of the soil types and the field experiments on four of the types have shown some very striking results from the application of farm manure. The practical experience of many farmers also gives rather definite proof that farm manure is an exceedingly valuable fertilizing material for use on the soils of the county. In view of its small cost and large production on the livestock farm, it proves a very profitable fertilizer and it should be used even when other fertilizers are employed, if these latter materials are expected to exert any large influence on crop production.

Farm manure apparently has a beneficial effect on all the soils in Henry county, showing unexpectedly large increases in crops even on those types which are well supplied with organic matter, and on the lighter colored soils its influence is very striking. The reason for its beneficial effect on this wide variety of soils under varying conditions is that it influences the physical, chemical and bacteriological conditions in the soil. It opens up heavy, impervious soils, making them less retentive of moisture, better aerated and in a better condition in general for the production of available plant food. It makes light, open soils more retentive of moisture, less open and porous and less apt to lose valuable plant food by leaching. The chemical effects of manure are due to the actual addition of plant food. It may contain a large portion of the plant food constituents contained in the feed of the animals and hence it serves to prolong the "life" of the soils by lengthening the period of time which will elapse before any one of the essential elements will become entirely deficient. Manure contains also a large amount of organic matter, which has an important influence on the chemical, physical and bacterial conditions of the soil. The number of bacteria in manure is enormous and the production of available plant food may be increased to a large extent by the mere introduction of organisms. The organic matter, however, also stimulates bacterial growth and manure often proves beneficial merely because of its influence in making plant food available. It is probably the bacterial effect of manure which accouts for its beneficial influence on the soil types which are well supplied with organic matter.

As manure is a waste product on the farm, very often its value is overlooked and it is not properly cared for before application to the soil and suffers considerable loss. Tests have shown that when manure is stored in uncovered heaps, exposed to the weather and the liquid portion is allowed to wash away, the loss of valuable constituents may amount to from 75 to 90 percent of the total value of the constituents present. Thus its effect in prolonging the life of the soil is reduced to a minimum. When properly stored and applied, however, the manure may return to the soil 75 to 80 percent of the plant food removed by the crops grown. Proper precautions should be taken on every farm to protect manure from loss. It may be stored in a covered yard or pit or in some other manner. No definite method of storing can be recommended for all conditions, but any method may be considered satisfactory which keeps the manure moist and

compact and protected from the weather. The value of manure in increasing crop production is so great, as has been indicated in the field experiments referred to and in practical tests on many farms, that the difficulty involved in the proper storing and the small expense necessitated are well worth while.

The average application of manure amounts to about 8 to 10 tons per acre once in a four-year rotation. This amount may be increased with profit in some cases, but in general it is not advisable to apply more than 16 to 20 tons per acre for ordinary farm crops. On the average farm, in fact, the production of manure is insufficient to permit of any excessive applications of the material, provided the amount produced is distributed uniformly over the farm. Manure alone cannot be considered, therefore, to keep up the fertility of the soil, but it goes a long way toward doing so.

In gardening or truck farming, where it is necessary to force a soil to a high productivity, very much larger amounts of manure may be used to advantage. In such cases, of course, it becomes a matter of the purchase of manure locally or from cities.

On the grain farm there is a very small production of manure and hence in this case some other means must be resorted to to supply the organic matter. Green manuring is the practice which should be employed in such instances. On the livestock farm, also, green manuring is needed in many cases to supplement the farm manure. Legumes or non-legumes may be used as green manures, but the former crops are considered preferable, inasmuch as when well inoculated they have the ability of taking nitrogen from the atmosphere and thus of increasing the amount of this constituent in the soil. From the standpoint of maintaining the nitrogen supply in the soil, the use of legumes as green manures is therefore essential. In some cases non-legumes may be used to advantage, if the addition of organic matter is of primary importance and the nitrogen supply is secondary. Many legumes are available for use as green manures and they may be grown under a wide range of conditions. It is therefore possible to choose one which will fit in with almost any rotation. In several instances in the field experiments, the beneficial effects of turning under the second crop of clover on the crop residue plots is very definitely shown by considerable increases in the succeeding crop. This practice may be considered as a partial substitute for green manuring. The clover seed may be removed without a serious reduction in its value as a green manure crop. It may also be a profitable practice under some conditions to seed a legume in the corn at the last cultivation and thereby provide for the introduction of nitrogen and organic matter in the soil. It may be said that in general green manuring may prove a valuable farm practice in Henry county, but it should not be followed carelessly nor blindly, for it may prove quite undesirable under improper conditions. Suggestions in cases of special soil conditions will be given by the Soils Section upon request.

There is a third means by which organic matter may be applied to the soil and that is by the proper utilization of crop residues, such as straw and stover. The value of these materials is very apt to be overlooked and they are often burned or otherwise destroyed instead of being returned to the soil. On the livestock farm they may be utilized for feed or bedding and returned to the soil mixed with the manure. The greatest effect from their use is probably secured by this

method of application because of the stimulation of the decomposition of the materials. In grain farming they may be applied directly, or they may be stored and allowed to decompose partially, but in either case they should all be returned to the soil, as it is particularly important in grain farming that the crop residues be used to keep up the organic matter supply. Crop residues also have some effect on the life of the soil because of the plant food which they contain, but their chief value lies in the organic matter which they supply. By the proper use of all residues, the careful storing and application of all manure produced and the utilization of leguminous crops as green manures, it will be possible to keep the soils of Henry county in a high state of fertility and in many cases at the present time the addition of these materials will bring about large increases in crop production.

THE USE OF COMMERCIAL FERTILIZERS

The analyses of the soils of Henry county showed that the phosphorus supply was not high and in several cases it was rather low. It would seem, therefore, quite probable that phosphorus fertilizers might prove of value in many cases. Even if they do not prove profitable at present, the analyses indicate that the materials will be needed in the near future as the phosphorus supply gradually decreases. The greenhouse experiments indicated the possibility of the beneficial effects from the use of rock phosphate or acid phosphate on clover, on three soil types. The field tests on four of the main types also gave indications of considerable influences from these materials on general farm crops. The relative effects of the rock phosphate and the acid phosphate were somewhat different in the different experiments and hence it is impossible to draw definite conclusions regarding these two materials. It seems evident, however, that acid phosphate may be more valuable for some crops on some soils, while rock phosphate will prove more valuable for other crops or for the same crops under different soil conditions. Farmers are urged to test these materials on their own farms and determine which should be used for their particular conditions.

In determining the relative value of these materials, it is essential that the cost be considered. Acid phosphate is much more expensive than rock; hence it must bring about a considerably larger effect than rock if it is to prove more profitable. Any farmer may test these materials by simple experiments and determine by measurement of the actual crop increases the profit from their use.

The general conclusion regarding the use of phosphorus fertilizers at the present time in Henry county may be summarized in the statement that there is every indication that the soils of the county will respond profitably to phosphorus fertilization.

The soils of Henry county are not strikingly deficient in nitrogen, but the amount of this constituent present is not high except in one or two instances. It is evident, therefore, that any system of permanent fertility must consider the need of adding nitrogen to the soil. Crop residues and farm manure supply nitrogen and they aid materially in keeping up the content of this constituent in the soil. Well inoculated legumes when used as green manures often prove a satisfactory means of increasing the nitrogen in the soil. Such materials have a double effect, in that they also supply organic matter. Commercial nitrogen-



Fig. 9. Applying raw rock phosphate

ous fertilizers cannot, therefore, be recommended at the present time as economical. In small amounts, as top dressings, they may prove of value by stimulating the early growth of some crops but in general, if used at all, they should be considered as supplementary to leguminous green manures. Tests of such materials should always be carried out on a small scale before any large applications are made, in order that definite information may be available regarding the value of the materials.

Analyses* of many of the soils of the state have shown a large supply of potassium and it is hardly likely that potassium fertilizers would prove profitable on any of the soils in Henry county. If the soil is kept in the best physical condition and well supplied with organic matter, there should be a sufficient production of available potassium to keep crops supplied. In other words, if the soil is prepared and kept in condition for the best crop growth, there should be no deficiency of available potassium. Potassium fertilizers might be used profitably in small amounts as top dressings and they might also prove highly valuable in trucking or market gardening. In growing general farm crops, however, it is rather unlikely that they would prove of value.

The use of complete commercial fertilizers is being tested in the field experiments in Henry county and from the results already secured, which are given earlier in this report, it seems evident that phosphorus fertilizers are quite as valuable in increasing crop yields as the more expensive complete brands. If nitrogen can be supplied more cheaply by the use of leguminous green manures and potassium is unnecessary, the conclusion would certainly seem to be warranted that a phosphorus fertilizer should prove more profitable than a complete brand. Farmers may test the value of complete fertilizers on their own soils at the same time that they test phosphate materials and, if some special

*Bulletin 150, Iowa Agricultural Experiment Station.

brand proves profitable under special conditions, it may be used without fear of injury to the soil. Such tests should be made on a small scale. The complete brand tested should be chosen from among those recommended by the fertilizer companies for the particular crop and general soil condition. There is no objection to the use of complete commercial fertilizers if they prove profitable, but in interpreting the results care should be taken to determine whether or not they are more profitable than the phosphate materials. In deciding upon their use, the cost of the two materials should be considered. At the present time it seems that phosphorus materials will probably prove profitable for use on the soils of Henry county and other materials can not be recommended.

DRAINAGE

Some of the soil types in Henry county are rather poorly drained and the installation of tile is one of the first treatments needed to make them productive. This is particularly true in the cases of the so-called gumbo soils, which include the Grundy silty clay loam and the Wabash silty clay loam. There are also, however, other types in the county that are occasionally in need of tiling in order to permit of the removal of excess moisture. The Marion silt loam, the Grundy silt loam, the Calhoun silt loam and the Wabash silt loam each contain areas where crop growth is not entirely satisfactory, due to improper moisture conditions. In all of these cases, and especially in the gumbo soils, the installation of tile drains has brought about large increases in crop yields. In fact, it is practically impossible to secure anything like satisfactory crops on these soils without draining. While the expense involved may be considerable it is always well warranted and it always proves profitable. No other soil treatment will prove effective on poorly drained land and no other treatment will take the place of drainage.

THE ROTATION OF CROPS

The results obtained in many experiments have shown that the continuous growing of any one crop reduces the fertility of the soil very rapidly; hence, it is always advisable that some sort of a rotation be practiced on every farm. Furthermore, experiments and farm experience have demonstrated that rotation of crops is actually more profitable than a continuous growing of any one crop, even if the latter is a money crop. Various rotations are in use thruout the state and while no special tests of them have been made in Henry county, a choice of one which will prove satisfactory from among those suggested may readily be made. In case those suggested do not seem to suit the conditions, minor modifications may be introduced as desired. The chief point to be observed, however, in choosing a rotation, is that it should contain a legume, as well as those crops which experience has shown are the most profitable. Keeping these points in mind, a rotation may be selected which will fit most any conditions.

1—FOUR OR FIVE-YEAR ROTATION

First year —Corn.

Second year —Corn.

Third year —Oats (with clover or with clover and timothy).

Fourth year—Clover (if timothy was seeded with the clover the preceding year, the rotation may be extended to five years. The last crop will consist principally of timothy).

2—FOUR-YEAR ROTATION WITH ALFALFA

First year —Corn.*Second year* —Oats.*Third year* —Clover.*Fourth year*—Wheat.*Fifth year* —Alfalfa (The crop may remain on the land five years. This field should then be used for the four-year rotation outlined above).

3—THREE-YEAR ROTATION

First year —Corn.*Second year* —Oats or wheat (with clover seeded in the grain).*Third year* —Clover (Only the grain and clover seed should be sold. In grain farming most of the crop residues such as corn stover and straw should be plowed under. The clover may be clipped and left on the land to be returned to the soil.)**THE PREVENTION OF EROSION**

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

Slowly falling rain may be very largely absorbed by the soil, provided it is not already saturated with water, while the same amount of rain in one storm will wash the soil badly. When the soil is thoroly wet, the rain falling on it will, of course, wash over it and much soil may be carried away in this manner to the detriment of the land.

Light, open soils which absorb water readily are not apt to be subject to erosion, while heavy soils, such as loams, silt loams and clays may suffer much from heavy or long-continued rains. Loess soils are apt to be injured by erosion when the topography is hilly or rough and it is this group of soils which is affected to the greatest extent in Iowa. Flat land is, of course, little influenced by erosion. Cultivated fields or bare bluffs and hillsides are especially suited for erosion, while land in sod is not affected. The character of the cropping of the soil may, therefore, determine the occurrence of the injurious action. The careless management of land is quite generally the cause of erosion in Iowa. In the first place, the direction of plowing should be such that the dead furrows run at right angles to the slope, or, if that is impracticable, the dead furrows should be "plowed in" or across in such a manner as to block them. Fall plowing is to be recommended whenever possible as a means of preventing erosion. Only when the soil is clayey and absorption of water is very slow will spring plowing be advisable. The organic matter content of soils should be kept up by the addition of farm manure, green manures and crop residues if soil subject to erosion is to be properly protected. By the use of such materials the absorbing power of the soil is increased and they also bind the soil particles together and prevent their washing away as rapidly as might otherwise be the case. By all these treatments the danger of erosion is considerably reduced and expensive methods of control may be rendered unnecessary.

There are two types of erosion, sheet washing and gullying. The former may occur over a rather large area and the surface soil may be removed to such an extent that the subsoil will be exposed and crop growth prevented. Sheet washing often occurs so slowly that the farmer is not aware of the gradual removal

of fertility from his soil until it has actually resulted in lower crop yields. Gullying is more striking in appearance, but it is less harmful and it is usually more easily controlled. If, however, a rapidly widening gully is allowed to grow unchecked, an entire field may soon be made useless for farming purposes. Fields may be cut up into several portions and the farming of such tracts is costly and inconvenient.

Several of the soils in Henry county are injured considerably by a destructive action of erosion. The Clinton silt loam in particular is apt to be badly washed in some localities. Occasionally the Lindley loam, Jackson silt loam and Grundy silt loam are badly eroded. It is of interest, therefore, and of considerable importance in the county to consider briefly the causes of erosion and the methods which may be employed to prevent or control washing.

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

EROSION DUE TO DEAD FURROWS

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

"Plowing In." It is quite customary to "plow in" the small gullies that result from these dead furrows and in level areas where the soil is deep, this "plowing in" process may be effective. In the more rolling areas, however, where the soil is rather shallow, the gullies formed from dead furrows may not be entirely filled up by "plowing in." Then it is best to supplement the "plowing in" with a series of "staked in" dams or earth dams.

"Staking In." The method of "staking in" is better, as it requires less work and there is less danger of washing out. The process consists in driving in several series of stakes across the gully and up the entire hillside at intervals of from 15 to 50 yards, according to the slope. The stakes in each series should be placed three to four inches apart and the tops of the stakes should extend well above the surrounding land. It is then usually advisable to weave some brush about the stakes, allowing the tops of the brush to point up-stream. Additional brush may also be placed above the stakes, with the tops pointing up-stream, permitting the water to filter thru, but holding the fine soil.

Earth Dams. Earth dams consist of mounds of soil placed at intervals along the slope. They are made somewhat higher than the surrounding land and act in much the same way as the stakes used in the "staking in" operation. There are some objections to the use of earth dams, but in many cases they may be quite effective in preventing erosion in dead furrows.

SMALL GULLIES

Gullies result from the enlargement of surface drainageways and they may occur in cultivated land, on steep hillsides, in grass or other vegetation, in bottomlands, or at any place where water runs over the surface of the land. Small gullies may be filled in a number of ways, but it is not practicable to fill them by dumping soil into them; that takes much work and is not lasting.

"Staking In." The simplest method of controlling small or moderate sized gullies and the one that gives the most general satisfaction is the "staking in"

operation recommended for the control of dead furrow gullies. The stakes should vary in size with the size of the gully, as should also the size and quantity of brush woven about the stakes. A modification of the system of "staking in" which has been used with success in one case consists in using the brush without stakes. The brush is cut so that a heavy branch pointing downward is left near the top. This heavy branch is caught between a fork on the lower part of the brush pile, or hooked over one of the main stems and driven well into the ground. Enough brush is placed in this manner to extend entirely across the gully with the tops pointed down stream instead of up stream, which keeps it from being washed away readily by the action of a large volume of water. A series of these brush piles may be installed up the course of the gully and with the regular repair of washouts or undercuttings, may prove very effective.

The Straw Dam. A simple method of preventing erosion in small gullies is to fill them with straw. This may be done at threshing time with some saving of time and labor. The straw is usually piled near the lower part of the gully, but if the gully is rather long or branching, it should be placed near the middle or below the junction of the branches, or more than one dam should be used. The pile should be made so large that it will not wash out readily when it gets smaller thru decomposition and settling. One great objection to the use of straw is the loss of it as feed, as a bedding material and as a fertilizer. Yet its use may be warranted on large farms which are operated on an extensive scale, because of the saving in time, labor and inspection.

The Earth Dam. The use of an earth dam or mound of earth across a gully may be a satisfactory method of controlling erosion under some conditions. It will prove neither efficient nor permanent, however, unless the soil above the dam is sufficiently open and porous to allow of a rather rapid removal of water by drainage thru the soil. Otherwise large amounts of water may accumulate above the dam and wash it out. In general it may be said that when not provided with a suitable outlet under the dam for surplus water, the earth dam cannot be recommended. When such an outlet is provided, the dam is called a "Christopher" or "Dickey" dam.

The Christopher or Dickey Dam. This modification of the earth dam consists merely in laying a line of tile down the gully and beneath the dam, an elbow, or a "T" being inserted in the tile just above the dam. This "T", called the surface inlet, usually extends two or three feet above the bottom of the gully. A large sized tile should be used in order to provide for flood waters and the dam should be provided with a cement or board spillway or runoff to prevent any cutting back by the water flowing from the tile. The earth dam should be made somewhat higher and wider than the gully and higher in the center than at the sides to reduce the danger of washing. It is advisable to grow some crop upon it, such as sorghum, or even oats or rye, and later seed it to grass. Considering the cost, maintenance, permanency and efficiency, the Christopher or Dickey dam, especially when arranged in a series of two or more, may be regarded as the best method of filling ditches and gullies and as especially adapted to large gullies.

The Stone or Rubble Dam. Where stones abound, they are frequently used in constructing dams for the control of erosion. With proper care in making such

dams, the results in small gullies may be very satisfactory, especially when tile openings have been provided in the dam at various heights. The efficiency of the stone dam depends rather definitely upon the method of construction. If it is laid up too loosely, its efficiency is reduced and it may be washed out. Such dams can be used only very infrequently in Iowa.

1. *The Rubbish Dam.* The use of rubbish in controlling erosion is a method sometimes followed and a great variety of materials may be employed. The results are in the main rather unsatisfactory and it is a very unsightly method. Little effect in preventing erosion results from the careless use of rubbish even if a sufficient amount is used to fill the cut. The rubbish dam may be used, however, when combined with the Dickey system, just as the earth dam or stone dam, provided it is made sufficiently compact to retain sediment and to withstand the washing effect of the water.

The Woven Wire Dam. The use of woven wire, especially in connection with brush or rubbish, has sometimes proved satisfactory for preventing erosion in small gullies. The woven wire takes the place of the stakes, the principle of construction being otherwise the same as in the "Staking in" system. It can only be recommended for shallow, flat ditches and in general other methods are somewhat preferable.

Sod Strips. The use of narrow strips of sod along natural surface drainage-ways may often prevent these channels from washing into gullies, as the sod serves to hold the soil in place. The amount of land lost from cultivation in this way is relatively small as the strips are usually only a rod or two in width. Bluegrass is the best crop to use for the sod, but timothy, red top, clover or alfalfa may serve quite as well and for quick results sorghum may be employed if it is planted thickly. This method of controlling erosion is in common use in certain areas and it might be employed to advantage in many other cases.

The Concrete Dam. One of the most effective means of controlling erosion is by the concrete dam, provided the Dickey system is used in connection with it. They are, however, rather expensive. Then too, they may overturn if not properly designed and the services of an expert engineer are required to insure a correct design. Owing to their high cost and the difficulty involved in securing a correct design and construction, such dams cannot be considered as adapted to general use on the farm.

Drainage. The ready removal of excess water may be accomplished by a system of tile drainage properly installed. This removal of water to the depth of the tile increases the water absorbing power of the soil and thus decreases the tendency toward erosion. Catch wells properly located over the surface and consisting of depressions or holes filled with coarse gravel and connected with the tile, help to catch and carry away the excess water. In some places tiling alone may be sufficient to control erosion, but generally other means are also required.

LARGE GULLIES

The erosion in large gullies which are often called ravines may in general be controlled by the same methods as in the case of small gullies. The Christopher dam, already described, may also serve in the case of large gullies. The precautions to be observed in the use of this method of control have already

been described and emphasis need only be placed here upon the importance of carrying the tile some distance down the gully to protect it from washing. The Dickey dam is the only method that can be recommended for controlling and filling large gullies and it seems to be giving very satisfactory results at the present time.

BOTTOMLANDS

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

Straightening and Tiling. The straightening of the larger streams in bottomland areas may be accomplished in any community and while the cost is considerable, large areas of land may thus be reclaimed. In the case of small streams, tiling may be the only method necessary for reclaiming useless bottomland and it often proves very efficient.

Trees. Erosion is sometimes controlled by rows of such trees as willows, which extend up the drainage channels. While the method has some good features, it is not generally desirable. The row of trees often extends much further into cultivated areas than is necessary and tillage operations are interfered with. Furthermore the trees may seriously injure the crops in their immediate vicinity because of their shade and because of the water which they remove from the soil. In general it may be said that in pastures, bottomlands and gulches the presence of trees may be effective in controlling erosion, but a row of trees across cultivated land or even extending out into it, cannot be recommended.

HILLSIDE EROSION

Hillside erosion may be controlled by certain methods of soil treatment which are of value, not only in preventing the injurious washing of soils but in aiding materially in securing satisfactory crop growth.



Fig. 10. Serious erosion in Clinton silt loam

Use of Organic Matter. Organic matter or humus is the most effective means of increasing the absorbing power of the soil and, hence, proves very effective in preventing erosion. Farm manure may be used for this purpose, or green manures may be employed if farm manure is not available in sufficient amounts. Crop residues such as straw, corn stalks, etc., may also be turned under to increase the organic matter content. In general it may be said that all means which may be employed to increase the organic matter content of soils will have an important influence in preventing erosion.

Growing of Crops. The growing of crops, such as alfalfa, that remain on the land continuously for a period of two years or more, is often advisable on steep hillsides. Alsike clover, sweet clover, timothy and red top are also desirable for use in such locations. The root system of such crops as these holds the soil together and the washing action of rainfall is reduced to a marked extent.

Contour Discing. Discing around a hill instead of up and down the slope or at an angle to it, is frequently very effective in preventing erosion. This practice is called "contour discing" and has proven quite satisfactory in many cases in Iowa. Contour discing is practiced to advantage on stalk ground in the spring, preparatory to seeding small grain, and also on fall plowed land that is to be planted to corn. It is advisable in contour discing to do the turning row along the fence, up the slope, first, as the horses and disc when turning will pack and cover the center mark of the disc, thus leaving no depression to form a water channel.

Deep Plowing. Deep plowing increases the absorptive power of the soil and hence decreases erosion. It is especially advantageous if it is done in the fall, as the soil is then put in condition to absorb and hold the largest possible amount of the late fall and early spring rains. It is not advisable, however, to change from shallow plowing to deep plowing at a single operation, as too much subsoil may be mixed with the surface soil and the productive power of the soil will be reduced. A gradual deepening of the surface soil by increasing the depth of plowing will be of value both in increasing the feeding zone of plant roots and in making the soil more absorptive and, therefore, less subject to erosion.

INDIVIDUAL SOIL TYPES IN HENRY COUNTY*

LOESS SOILS

There are seven loess soils in Henry county and these, together with the broken phase of the Clinton silt loam, make up eight loess soil areas in the county. These soils are classified in the Grundy, Clinton, Marion, Lindley, Knox and Putnam series.

GRUNDY SILT LOAM (64)

The Grundy silt loam is by far the largest individual soil type in the county. It covers an area of 107,584 acres, or 39.4 percent of the total area. It occurs in all parts of the county, covering many extensive individual areas. Thruout the entire northeast portion of the county it is the chief soil type, being associated in that section with the more level to depressed Grundy silty clay loam.

The surface soil is a dark brown to nearly black heavy silt loam 10 to 15

*The descriptions of the individual soil types given in the Bureau of Soils report have been rather closely followed in this section of the report.

inches in depth. It grades gradually into a friable, heavy silt loam or silty clay loam, brown to dark brown in color and frequently possessing faint mottlings of brown and suggestions of a gray coloration. In the southern part of the county, the type generally contains this gray layer, while in the northern part it is found only infrequently. At 18 to 20 inches this intermediate layer changes abruptly into a gray silty clay mottled with yellow, yellowish-brown or rusty brown. With increasing depths the color becomes lighter, while the texture becomes more compact, hard and impervious. The subsoil is frequently so tough that it is known locally as hardpan. In general, however, the soil may be readily cultivated and little difficulty is experienced from the imperviousness of the subsoil.

In topography this type is undulating to gently rolling and in the more rolling areas some erosion has occurred. Drainage is usually well established, but in some instances tiling is necessary. This is particularly true in the areas where the subsoil is extremely impervious. Poor drainage is more common in the southern part of the county and tiling is more generally needed there than is the case on the type in the northern part.

The Grundy silt loam is practically all under cultivation. It has been estimated that only about 5 percent of the type is not cultivated. The larger portion of the land in this type is devoted to corn, the remainder being largely in oats, clover and timothy. Corn yields on the average 45 to 60 bushels per acre and in favorable seasons may go somewhat higher. Oats yield 35 to 40 bushels per acre and the crop is second in importance to corn. Wheat is not grown extensively, but yields of 20 to 30 bushels per acre are secured. Clover and timothy mixed constitute the chief hay crop grown on this soil. Some alsike clover, millet and sorghum are also grown. Little alfalfa is grown, but with a clearer knowledge of improved methods of preparing for this crop, the acreage will undoubtedly be increased. A little barley and rye are also produced, but they are of minor importance.

The Grundy silt loam is a very productive type, but the crop yields on it may be increased thru proper methods of treatment. While it is not particularly low in organic matter, applications of farm manure prove distinctly profitable. The soil is slightly acid in reaction and for the best growth of crops, particularly of legumes, such as clover and alfalfa, lime should be applied. This material may bring about distinct gains in crop yields. The soil is not very well supplied with phosphorus and the field tests indicate that applications of rock phosphate or acid phosphate may prove profitable. Even if these materials are not of value at the present time, they will certainly be needed in the near future. In some areas the type is in need of drainage to remove the excessive moisture which often accumulates and in other sections there has been considerable washing. In these places some method of preventing erosion should be practiced.

CLINTON SILT LOAM (80)

The Clinton silt loam is the second largest soil type in Henry county. It covers 66,560 acres and, together with the broken phase, which is rather small in acreage, makes up 26.9 percent of the total area of the county. It occurs in narrow, irregular areas on each side of the Skunk river valley, varying in these locations

from one to two miles in width. It is found in narrow strips along each side of Big Cedar and Little Cedar creeks. Small areas also occur along many of the larger drainageways.

The surface soil is a light brown to grayish-brown silt loam. This extends to a depth of 8 to 12 inches, at which point it grades into a layer of yellowish-brown or yellowish-gray silty clay mottled with yellowish-brown. This intermediate layer is usually 4 to 8 inches in depth and changes abruptly into a yellowish-gray silty clay mottled with yellowish-brown and rusty brown. This subsoil is very plastic when wet and compact and hard when dry.

In topography the Clinton silt loam is rolling to steeply rolling or hilly. Much of the area in this type has been badly washed and there are many gullies which need attention. Care must be taken in handling this type to prevent a serious washing away of the surface soil. In many cases special methods of reclamation are needed to make the type properly productive. Drainage is good thruout the type.

Originally this soil was practically all forested with a growth of bur oak, black oak, black and shagbark hickory, elm and evergreen. About 25 percent of the type is still in forest, but it is gradually being cleared and cultivated. The chief crops grown are corn, oats, clover and timothy. Average yields of 30 to 40 bushels per acre of corn are secured. Oats yield 30 to 35 bushels per acre on the average. Clover and timothy produce 1½ to 2 tons per acre under ordinary conditions. Alfalfa, Sudan grass and millet are also grown in a small way for hay. Potatoes, sorghum and many vegetables are grown for home consumption. Fruit is grown to a small extent on nearly every farm, apples and pears being produced for home use.

This soil is materially less fertile than the Grundy silt loam. It is low in organic matter, as indicated by its light color. Analyses also show a rather reduced amount of organic carbon and nitrogen. Applications of farm manure prove distinctly valuable on this soil, as indicated by the greenhouse and some field experiments carried out on the same type. It is acid in reaction and applications of lime would be necessary to permit of the proper growth of clover and other legumes. It is low in phosphorus and should respond to applications of phosphorus fertilizers. Experiments thus far secured indicate this to be true. Further tests are necessary before definite recommendations can be made regarding the kind of phosphorus fertilizer to use. This soil is particularly in need of reclamation from the frequent gullies and washed areas and in many cases the first treatment necessary to make it more productive is to prevent the washing away of the surface soil. After this is accomplished the next treatment needed is the incorporation of organic matter. Applications of farm manure are particularly valuable and when this material is not available, leguminous green manures may be used as a substitute.

CLINTON SILT LOAM (broken phase) (80a)

This phase of the Clinton silt loam is rather minor in extent covering only 6,912 acres or 2.6 percent of the total area of the county. Much of the badly eroded portions of the Clinton are included under this phase. It is found in narrow strips and small patches along the slopes to the larger streams in the

western and southern parts of the county. It occurs in association with the typical Clinton and is very similar to it, except that the surface soil is very much shallower. It is much the same as the Clinton silt loam in color and texture, but in many cases there is practically no surface soil remaining and in some localities, the heavy, compact subsoil is exposed at the surface. In general these eroded areas are covered with a growth of weeds and grass.

Most of the type is in timber and is used for pasture. Owing to the danger of washing and gullying when the soil is cultivated, it is little used for cropping purposes. Its value is largely determined by the amount of pasture which it provides.

GRUNDY SILTY CLAY LOAM (115)

This is the third largest soil type in the county, covering 40,768 acres or 14.9 percent of the total area of the county. It is a very extensive upland type, occurring particularly in association with the Grundy silt loam in the northeast and southwest parts of the county. The largest development of this type is found between Crooked creek and Big creek. Another extensive area occurs just north and east of Mt. Pleasant. There are also a few small areas scattered thru the northeast and southwest parts of the county.

The surface soil of the Grundy silty clay loam is a black silty clay loam 6 to 8 inches in depth. It grades into a pitch black, plastic, tenacious silty clay. At a depth varying from 18 to 24 inches, there is a change to a blue or yellowish-gray silty clay mottled with yellow, yellowish-brown and rusty brown.

This soil is locally known as "gumbo", because of the difficulty which it frequently causes in farming operations. The term "gumbo" is not a recognized name for a particular class of soils, according to any accepted scheme of soil classification. It is a popular name for a group of soils which possess characteristics well known and dreaded by farmers. It is very different from the gumbo referred to in geological reports, which includes almost impervious gray or yellow clay subsurface soils. The soil that Iowa farmers call "gumbo" is a heavy, "greasy", black clay soil, occurring in flat areas, either river bottoms or level uplands. It is usually inky black and is stickier and bakes more easily than any other type of soil in the state. If such soil is plowed when too wet it balls up before the plow point in such a way that the implement cannot be made to stay in the ground. On the other hand, if it becomes too dry it will turn up in clods which cannot be worked down during the whole season. Where such clods are formed, freezing and thawing is the only process which will restore the loose, mealy structure. This soil can, however, be put into excellent tilth, with a fine, mealy appearance, and kept so during the entire season, provided it is not cultivated when too wet.

The Grundy silty clay loam is an upland gumbo and while the entire area of the type is not typical gumbo, it is all heavy and impervious in the subsoil and must be carefully handled. In topography the type is level to flat or depressed. The natural drainage is very poor and the first treatment which the soil needs is the removal of the excessive moisture thru proper tiling.

This soil is now all under cultivation, corn being the most important crop grown. Over three-fourths of the area in this type is estimated to be devoted

to this crop. Average yields of 50 bushels per acre are reported, while, in many cases much larger yields than this may be secured. Oats are second in importance to corn and yield 35 to 40 bushels per acre. Clover and timothy mixed constitute the chief hay crop and satisfactory yields of these crops are grown. The type is not well adapted for the growth of potatoes and similar crops.

The needs of the Grundy silty clay loam are chiefly for drainage as is true in the case of all "gumbo" soils. Tile should generally be laid 8 or 10 rods apart to secure thoro drainage. When properly tilled out this type is very productive. It is well supplied with organic matter and nitrogen as indicated in the analyses. It will be noted in the greenhouse and field experiments, however, that even in spite of its high content of organic matter, applications of farm manure have proven distinctly profitable. In fact, this material has shown up better than any of the other treatments practiced. It may be noted also that while the phosphorus supply is not extremely low, phosphorus fertilizers seem to be of value and applications of these materials would probably prove profitable. They will certainly be needed in the near future. This soil is slightly acid in reaction and will need a small application of lime. The greatest care must be taken in handling it. Fall plowing is very desirable and the use of clover or some other green manure also improves the physical condition of the type. In general it may be said that this soil may be made as productive or even more productive than the surrounding upland if it is properly drained, manured and cultivated.

MARION SILT LOAM (67)

The Marion silt loam is of rather extensive occurrence in Henry county, covering 13,294 acres or 4.8 percent of the county. It occurs associated with the Clinton silt loam, chiefly on flat topped hills and narrow level strips of upland. It is also found in areas separating the Clinton and Grundy silt loams. The largest development of this type is found in Baltimore township, but there are many other small areas scattered thruout the southern part of the county, and a few in the northern part.

The surface soil is a light gray to almost white, floury silt loam, which extends to a depth of 4 to 8 inches. At that point there occurs a layer of a still lighter-colored, compact, flour-like silt loam, sometimes faintly mottled with rusty brown. This white layer is the characteristic feature of the Marion soils. At depths varying from 15 to 18 inches it changes abruptly into a bluish-gray or yellowish-gray silty clay which is mottled with yellowish-brown and rusty brown. The subsoil is very impervious when wet, and tenacious, tough, and hard when dry. This type is low in organic matter and because of its light color is locally called "white ash" or "chalk" land.

The Marion silt loam was originally a forested soil, but at the present time it is practically all under cultivation and is devoted to the production of general farm crops. Corn is the most important, yielding 15 to 40 bushels per acre. Oats is of secondary importance, yielding 20 to 30 bushels per acre. Wheat, barley, rye, and millet are also grown to some extent. Clover and timothy mixed constitute the chief hay crop.

This soil is low in organic carbon and nitrogen and is very much in need of the application of organic matter. The greenhouse and field experiments both

showed very definite increases in crops by the addition of farm manure. This material should undoubtedly be applied in as large amounts as practicable to build the soil up to a higher productivity. It is acid in reaction and lime should be applied as needed. It is low in phosphorus and the greenhouse and field experiments show evidences of considerable value from the application of rock phosphate and acid phosphate. The soil is apt to be in need of drainage and when this is true, the first treatment needed to make it productive is proper tiling.

LINDLEY LOAM (65)

The Lindley loam is a comparatively minor type in Henry county covering 13,056 acres or 4.8 percent of the total area of the county. It occurs in small areas scattered thruout the Clinton silt loam. It is usually found on slopes lying between the bottomland and the loess upland. The areas consist of narrow strips and they occur mainly along the larger, more or less steep, slopes.

The surface soil is a reddish-brown to light brown silty loam to loam, extending to a depth of 8 to 12 inches. In some places the soil contains considerable silt and there are included in the type a few areas of silt loam which were too small to map separately. The subsurface soil is a light brown or reddish-brown, tenacious, gritty clay. There is little change until a depth of 28 to 30 inches is reached, where the subsoil becomes brownish-yellow in color, somewhat mottled with light gray, and the texture is somewhat lighter.

In topography the Lindley loam is rough and, occurring as it does on the slopes, it is subject to considerable erosion. Gullies 5 to 15 feet in depth are frequently found and when not checked, may extend for considerable distance back into the uplands. In places on the steeper slopes, the surface soil has been very largely removed and the heavy texture of the subsoil is frequently exposed.

This type is not in general cultivation, owing to its topographic position, and is generally used for pasture. On the steeper slopes there is frequently a growth of oak, hickory and elm. On the more gentle slopes, general farm crops are sometimes grown satisfactorily. Corn in such places yields 20 to 40 bushels and oats 20 to 35 bushels per acre. Clover and blue-grass also do well.

The chief need of the Lindley loam, whether it is used for pasture or for cropping purposes, is the prevention of erosion. Wherever gullies are formed, some one of the methods mentioned earlier in this report should be adopted to check their growth and to fill them. The steep slopes should probably be kept in permanent pasture in order to prevent the formation of gullies. In the cultivated areas the soil should receive liberal applications of farm manure in order to build it up in organic matter and nitrogen. In case farm manure is not available, green manuring should be practiced. It is also acid and in need of lime. The phosphorus content is low and applications of phosphorus fertilizers are desirable, if not absolutely necessary.

KNOX FINE SAND (33)

The Knox fine sand is a very minor type in the county, covering only 1,152 acres or 0.4 percent of the total area of the county. It is found in small areas along the eastern bank of the Skunk river in Jefferson and Trenton townships

and along the eastern bank of Big Cedar creek. The surface soil is a light brown, loamy fine sand to fine sand, to a depth of 8 to 12 inches. Below this point the soil becomes a yellowish-brown fine sand which at 24 inches grades into a brownish-yellow sand.

In topography the Knox fine sand is gently rolling to rolling and the drainage is excessive, owing to the loose, open structure. Yields of general farm crops on this type are generally low, owing to injury by drought. About 80 percent of the type is under cultivation and, except for a few areas northwest of Trenton where watermelons and muskmelons are grown, general farm crops are produced.

This soil is extremely low in organic matter, nitrogen and phosphorus. It is also subject to more or less blowing and extensive leaching. It is very much in need, therefore, of large applications of barn yard manure in order to build up the organic matter and nitrogen content and to make it more retentive of moisture and less subject to blowing. The use of leguminous green manures would also prove of much value and green manuring should be used, particularly in case farm manure is not available in sufficient amounts. The phosphorus content is low and phosphorus fertilizers should undoubtedly be used in order to bring about more satisfactory crop growth. The soil is also acid in reaction and should receive an application of lime.

PUTNAM SILT LOAM (66)

The Putnam silt loam is of very minor extent in the county, covering only 210 acres or 0.1 percent of the total area of the county. It occurs in several very small areas along the northern boundary of the county. The surface soil is a grayish-brown silt loam, extending to a depth of 8 to 14 inches. From this point to a depth of 20 or 22 inches, there is a gray to dark gray silty clay loam. Below this layer the soil changes abruptly to a clay loam or a silty clay, dark brown in color, mottled with yellowish-brown, rusty brown and bluish-gray. This soil is very much the same as the Marion mapped in this county and a separation is made in order to join up with the surveys in adjoining counties. In production it is about the same as the Marion and its needs to make it more productive are applications of manure, lime, and phosphate fertilizers.

TERRACE SOILS

There are three terrace types in the county, classified in the Jackson, Calhoun, and Buckner series. The areas covered by these types are all small and the total extent of the terrace soils in the county amounts to only 8,704 acres or 3.1 percent of the entire area.

JACKSON SILT LOAM (81)

The Jackson silt loam is the most extensive terrace type covering 5,056 acres or 1.8 percent of the total area of the county. It occurs on low terraces along the Skunk river, chiefly south and southwest of Rome, following the course of the river to the county line south of Lowell. The surface soil is a light brown, smooth silt loam, 8 to 12 inches in depth, passing gradually into a yellowish-brown, silty clay loam to silty clay. The subsoil is rather compact. In a few

places the surface material approaches a very fine sandy loam or fine sandy loam in texture. There are included in this type small areas of a dark colored silt loam which might have been separated out as the Bremer silt loam. These areas were, however, too small in extent for such a separation to be made. In them the soil is a dark gray heavy silt loam 12 to 15 inches in depth, grading into a very dark gray silty clay, somewhat mottled with rusty brown. At 28 to 30 inches the subsoil changes to a gray or light gray, with considerable mottling. In places the surface soil is almost black.

The typical areas of this type are rather level in topography and the drainage is everywhere adequate. In some places there has been some erosion and the type has been somewhat modified by washing. In the dark colored variation mentioned above, the topography is also level and, owing to the heavier texture of the subsoil, the drainage is apt to be deficient. In these areas practically no washing has occurred.

Nearly all of the Jackson silt loam is under cultivation. Corn yields 40 to 50 bushels per acre and oats 35 to 40 bushels. Hay crops also yield satisfactorily. On the darker colored, heavier areas, the soil is more generally devoted to corn and yields of 45 to 60 bushels per acre are secured. Some oats and some hay are grown also on these areas and the yields are very much the same as on the typical soil.

The needs of the typical Jackson to make it more productive, are protection from washing, the addition of organic matter, either as farm manure or green manure, the application of lime to remedy acidity conditions, and probably also the application of phosphorus fertilizers. On the heavier areas erosion is not of importance, but drainage is quite necessary. The other treatments mentioned should all be followed on these darker colored areas to insure better crop production.

CALHOUN SILT LOAM (42)

The Calhoun silt loam is a minor terrace type covering 2,304 acres or 0.8 percent of the total area of the county. It occurs chiefly along Little Cedar creek and Big Cedar creek. Two areas are found, also, along Crooked creek. The surface soil is a brownish-gray to light gray, floury silt loam, extending to a depth of 8 to 10 inches. At this point there is found a light gray to almost white silt loam, which continues to about 20 inches. There an abrupt change occurs into a tenacious, plastic, yellowish-gray silty clay, mottled with yellowish-brown and rusty brown.

This type occurs 10 to 15 feet above the bottomlands and it is level in topography. Drainage is not well established and frequently tiling would be of value. Most of the type is under cultivation, corn, oats, and hay being the chief crops grown. Corn yields 25 to 40 bushels per acre, oats 30 to 40 bushels and clover and timothy 1 to 2 tons.

This soil is in need particularly of more organic matter and would be benefited by liberal applications of farm manure or the turning under of leguminous green manures. It is acid and in need of lime, and phosphorus fertilizers will be needed in the near future if they do not prove of value now. In most cases drainage is quite necessary.

BUCKNER VERY FINE SANDY LOAM (69)

This is a minor terrace type, covering 1,344 acres or 0.5 percent of the total area of the county. It occurs on terraces along the Skunk river in the western part of the county, the largest area being found northwest of Trenton.

The surface soil to a depth of 12 to 15 inches, is a brown to dark brown, very fine, sandy loam. In places the color is almost black. The subsoil is an open, friable and very fine sandy loam, yellowish-brown in color. With this type there is included an area of Buckner loam in sections 6 and 7 of Jefferson township. This area was not separated, owing to its small extent.

In topography this type is nearly level or only slightly undulating, but drainage is excessive and the type is usually droughty. In some instances there has been more or less blowing and drifting of the surface soils.

The Buckner very fine sandy loam is practically all under cultivation and in favorable seasons general farm crops, as well as truck crops, grow well. Corn and oats are the chief crops grown, but watermelons and strawberries give excellent yields. This type is very low in organic matter, nitrogen and phosphorus, and it is particularly in need of large applications of farm manure or leguminous green manures to put it in better condition for crop growth. Phosphorus fertilizers would also prove of considerable value.

SWAMP AND BOTTOMLAND SOILS

There are four swamp and bottomland types in Henry county belonging in the Wabash and Genesee series. Together they cover 15,040 acres or 5.6 percent of the total area of the county.

WABASH SILT LOAM (26)

The Wabash silt loam is the most extensive bottomland type, covering 7,296 acres or 2.7 percent of the total area of the county. It occurs in the bottomlands along Crooked creek, Big creek, Skunk river, and the smaller streams of the county.

The surface soil is a nearly black, heavy, smooth silt loam, extending to a depth of about 18 inches. The underlying material is a slightly heavier and more compact silt loam, usually somewhat lighter in color, altho often the color of the soil changes very little in the 3-foot section.

In topography the soil is generally flat and normally the drainage is poor. The straightening of the streams has improved the drainage conditions, however, and when not overflowed this soil is highly productive.

About 65 percent of the type is under cultivation and areas are constantly being cleared and brought under the plow. Along the smaller streams much of the original timber growth remains. This consists of cottonwood, willow, elm, black walnut and ash. Corn is the chief crop grown on the cultivated areas and yields of 50 to 60 bushels per acre are secured. In favorable seasons, yields of 90 bushels per acre have been secured. Oats yield 30 to 40 bushels per acre.

The soil is chiefly in need of better drainage and protection from overflow to make it more productive. Small applications of farm manure might also prove of value in some instances. The phosphorus supply is not high and phos-

phorus fertilizers will be needed in the near future. The soil is acid and in need of lime.

GENESEE FINE SANDY LOAM (117)

This is the second largest bottomland type in the county covering 4,096 acres or 1.5 percent of the total area. It is found chiefly along the banks of the Skunk river and in the first bottoms of the smaller streams.

The surface soil is a light brown to brown fine sandy loam, underlaid at 12 to 15 inches by a yellowish-brown to rusty brown fine sandy loam with light gray mottlings in the lower part. In the areas along Big Cedar creek and along Skunk river in the southeastern part of the county, the soil is really a very fine sandy loam and would have been mapped separately except that the area is so small. Here the soil is a brown, very fine sandy loam, 15 to 18 inches deep, underlaid by a lighter colored material, lighter in texture.

In topography the typical soil is flat and subject to frequent overflow, but between stages of high water the drainage is adequate, owing to the sandy character of the subsoil.

Very little of the type is under cultivation, the chief crop grown being corn, which yields 40 to 55 bushels per acre. The soil is very low in organic matter and nitrogen and should receive liberal applications of farm manure or leguminous green manures to make it more productive. It is acid in reaction and lime should be applied. With these treatments and protection from overflow, the soil may be used for the growth of general farm crops with entire success.

GENESEE SILT LOAM (71)

The Genesee silt loam is a minor bottomland soil, covering 2,688 acres or 1.0 percent of the total area of the county. It is found chiefly in the bottoms along Skunk river, Big Cedar creek, Little Cedar creek and their tributaries.

In topography this type is flat, but between the times of high water, it is adequately drained, owing to its sandy subsoil. The greater part of the soil is under cultivation, corn and oats being the chief crops grown. Corn yields 40 to 60 bushels per acre and oats 30 to 40 bushels.

This soil is chiefly in need of additions of organic matter such as farm manure or leguminous green manures, to bring about greater crop production. It is not high in phosphorus content and phosphorus fertilizers would undoubtedly prove of value. The sample of this soil tested was basic in reaction and showed a lime content. Other samples of the type might be acid, however, and tests should always be made to insure the best growth of crops.

WABASH SILTY CLAY LOAM (48)

This is a very minor bottomland type, covering only 960 acres or 0.4 percent of the total area of the county. It occurs along Big Creek and the head waters of Crooked creek in the eastern and northeastern parts of the county.

The surface soil is a black silty clay loam, 6 to 8 inches in depth, which grades gradually into a black silty clay loam to silty clay. Below 24 inches it is a dark gray, silty clay, faintly mottled with brown or rusty brown. The subsoil is plastic and sticky when wet and hard and granular when dry. This type is known locally as "gumbo" and it is representative of bottomland gumbo. In

topography it is flat to depressed and is naturally poorly drained. It is rarely overflowed except after very heavy rains.

Practically all of the type is under cultivation, corn, oats, and hay being produced. Corn is the most important crop, yielding 40 to 60 bushels per acre. Oats are apt to lodge. Clover and timothy, which are grown for hay, ordinarily yield 2 to 2 1-2 tons per acre.

This soil is particularly in need of drainage to make it more productive. Tile should be laid rather close together and a suitable outlet provided if thoro drainage is to be secured. Fall plowing is of value and the application of small amounts of farm manure or the turning under of leguminous green manures would also prove of value. The soil is fairly well supplied with organic matter, but the small applications suggested are of value in improving its physical condition. With proper care in handling, especially in avoiding plowing when too wet, very satisfactory crop yields may be secured, as the type is naturally very 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 Iowa 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 soil types in the large soil areas.

Following the survey, systems of soil management which should be adopted in the various counties and on the different soils are worked out, old methods of treatment are emphasized as necessary or their discontinuance advised, and new methods of proven value are suggested. The published reports as a whole will outline the methods which the farmers of the state must employ if they wish to maintain the fertility of their soils and insure the best crop production.

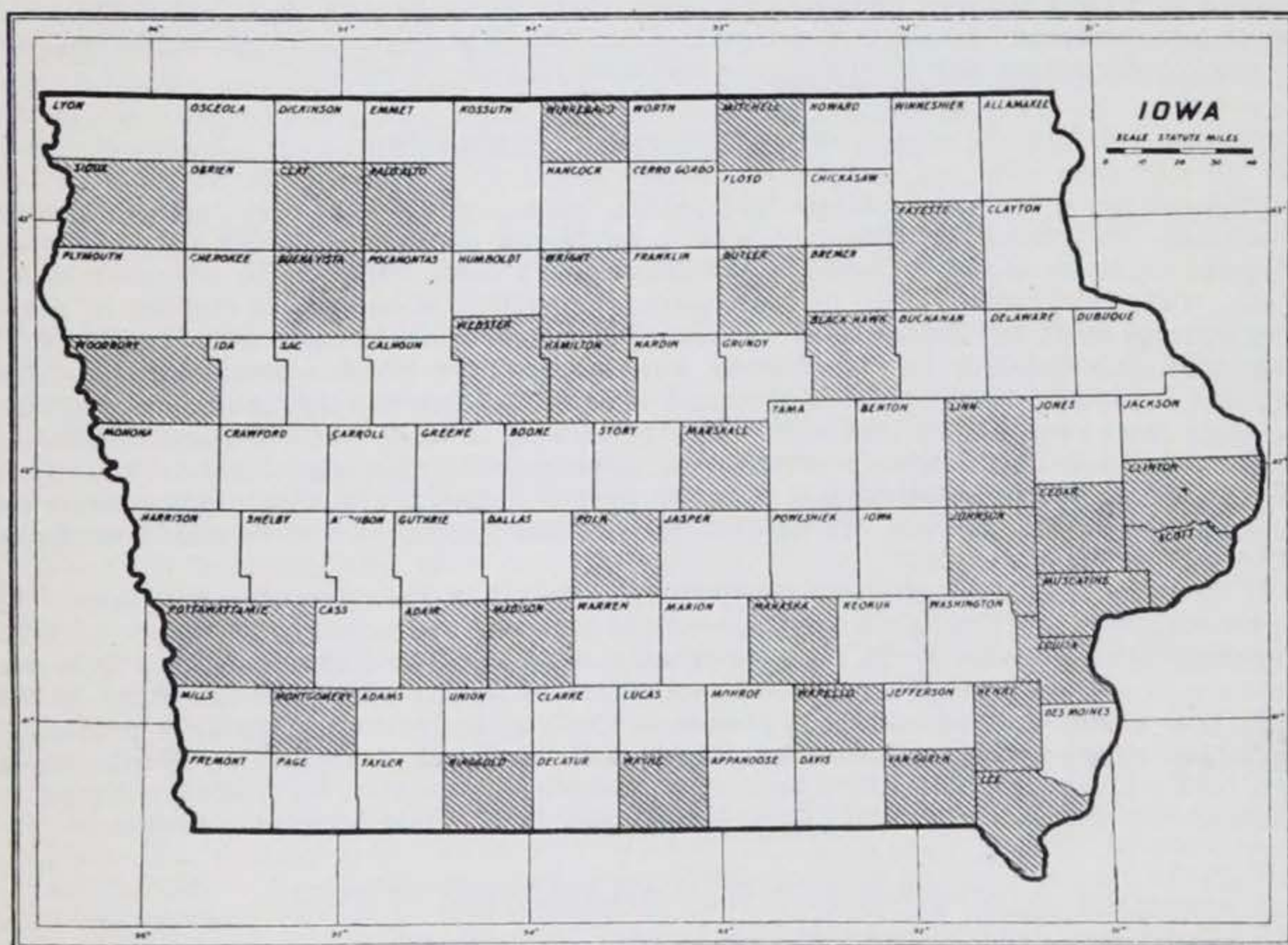


Fig. 11. Map showing the principal soil areas in Iowa

The various counties of the state will be surveyed as rapidly as funds will permit, the number included each year determined entirely by the size of the appropriation available for the work. The order in which individual counties will be chosen depends very largely upon the interest and demand in the county for the work. Petitions signed by the residents, and especially by the farmers or farmers' organizations of the county, should be submitted to indicate the sentiment favorable to the undertaking. Such petitions are filed in the order of their receipt and aid materially in the annual selection of counties.

The reports giving complete results of the surveys and soil studies in the various counties will be published in a special series of bulletins, as rapidly as the work is completed. Some general information regarding the principles of permanent soil fertility and the character, needs and treatment of Iowa soils, gathered from various published and unpublished data accumulated in less specific experimental work will be included in or appended to all the reports.

PLANT FOODS IN SOILS

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

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

Knowledge of the nitrogen content of soils is important in showing whether sufficient green manure or barnyard manure has been applied to the soil. Commercial nitrogenous fertilizers are now known to be unnecessary where the soil is not abnormal, and green manures may be used in practically all cases. Where a crop must be "forced," as in market gardening, some nitrogenous fertilizer may be of value.

THE "SOIL DERIVED" ELEMENTS

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

If the amounts of any of these soil-derived elements in soils are very low, they need to be supplied thru fertilizers. If considerable amounts are present, fertilizers containing them are unnecessary. In such cases if the mechanical and humus conditions in the soil are at the best, crops will be able to secure sufficient food from the store in the soil. For example, if potassium is abundant, there is no need of applying a potassium fertilizer; if phosphorus is deficient, a phosphate should be applied. If calcium is low in the soil, it is evident that the soil is acid and lime should be applied, not only to remedy the scarcity of calcium, but also to remedy the injurious acid conditions.

AVAILABLE AND UNAVAILABLE PLANT FOOD

Frequently a soil analysis shows the presence of such an abundance of the essential plant foods that the conclusion might be drawn that crops should be properly supplied

for an indefinite period. However, application of a fertilizer containing one of the elements present in such large quantities in the soil may bring about an appreciable and even profitable increase in crops.

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

Bacteria and molds are the agents which bring about the change of insoluble, unavailable material into an available form. If conditions in the soil are satisfactory for their vigorous growth and sufficient total plant food is present, these organisms will bring about the production of enough soluble material to support good crop growth. The soil conditions necessary for the best growth and action of bacteria and molds are the same as those which are required by plants. The methods necessary to maintain permanent soil fertility will, therefore, insure satisfactory action of these organisms and the sufficient production of available plant food. The nitrogen left in the soil in plant and animal remains is entirely useless to plants and must be changed to be available. Bacteria bring about this change and they are all active in normal soils which are being properly handled.

Phosphorus is found in soil mainly in the mineral known as apatite and in other insoluble substances. Potassium occurs chiefly in the insoluble feldspars. Therefore, both of these elements, as they normally occur in soils, are unavailable. However, the growth of bacteria and molds in the soil brings about a production of carbon dioxide and organic acids which act on the insoluble phosphates and potassium compounds and make them available for plant food.

Calcium occurs in the soil mainly in an unavailable form, but the compounds containing it are attacked by the soil water carrying the carbon dioxide produced by bacteria and molds and as a result a soluble compound is formed. The losses of lime from soils are largely the result of the leaching of this soluble compound.

Sulfur, like nitrogen, is present in soils chiefly in plant and animal remains, in which form it is useless to plants. As these materials decompose, however, so-called sulfur bacteria appear and bring about the formation of soluble and available sulfates.

The importance of bacterial action in making the store of plant food in the soil available is apparent. With proper physical and chemical soil conditions, all the necessary groups of bacteria mentioned become active and a vigorous production of soluble nitrogen, phosphorus, potassium, calcium and sulfur results. If crops are to be properly nourished care should always be taken that the soil be in the best condition for the growth of bacteria.

REMOVAL OF PLANT FOOD BY CROPS

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

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

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

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

TABLE I. PLANT FOOD IN CROPS AND VALUE

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

Crop	Yield	Plant Food, Lbs.			Value of Plant Food			Total Value of Plant Food
		Nitrogen	Phosphorus	Potass'm	Nitrog'n	Phosphorus	Potass'm	
Corn, grain	75 bu.	75	12.75	14	\$12.00	\$1.53	\$0.84	\$14.37
Corn, stover	2.25 T.	36	4.5	39	5.76	0.54	2.34	8.64
Corn, crop	.....	111	17.25	53	17.76	2.07	3.18	23.01
Wheat, grain	30 bu.	42.6	7.2	7.8	6.81	0.86	0.46	8.13
Wheat, straw	1.5 T.	15	2.4	27	2.40	0.28	1.62	4.30
Wheat, crop	.....	36.6	9.6	34.8	9.21	1.14	2.08	12.43
Oats, grain	50 bu.	33	5.5	8	5.28	0.66	0.48	6.42
Oats, straw	1.25 T.	15.5	2.5	26	2.48	0.30	1.56	8.28
Oats, crop	.....	48.5	8	34	7.76	0.96	2.04	14.70
Barley, grain	30 bu.	23	5	5.5	3.68	0.60	0.33	4.61
Barley, straw	0.75 T.	9.5	1	13	1.52	0.12	0.78	2.42
Barley, crop	.....	32.5	6	18.5	5.20	0.72	1.11	7.03
Rye, grain	30 bu.	29.4	6	7.8	4.70	0.72	0.46	5.88
Rye, straw	1.15 T.	12	3	21	1.92	0.36	1.26	3.54
Rye, crop	.....	41.4	9	28.8	6.62	1.08	1.72	9.42
Potatoes	300 bu.	63	12.7	90	10.08	1.52	5.40	17.00
Alfalfa, hay	6 T.	300	27	144	48.00	3.24	8.64	59.88
Timothy hay	6 T.	72	9	67.5	11.52	1.08	1.95	16.55
Clover hay	3 T.	120	15	90	19.20	1.80	5.40	16.40

kept up by the use of leguminous green manure crops, phosphorus and potassium must be supplied by the use of expensive commercial fertilizers.

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

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

REMOVAL FROM IOWA SOILS

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

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

The loss of fertility is great enough to demand serious attention. Careful consideration should certainly be given to all means of maintaining the soils of the state in a permanently fertile condition.

PERMANENT FERTILITY IN IOWA SOILS

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

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

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

CULTIVATION AND DRAINAGE

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

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

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

Many acres of land in the Wisconsin drift area in Iowa have been reclaimed and made fertile thru proper drainage, and one of the most important farming operations is the laying of drains to insure the removal of excessive moisture in heavy soils.

The loss of moisture by evaporation from soils during periods of drought may be checked to a considerable extent if the soil is cultivated and a good mulch is maintained. Many pounds of valuable water are thus held in the soil and a satisfactory crop growth secured when otherwise a failure would occur. Other methods of soil treatment, such as liming, green manuring and the application of farm manures, are also important in increasing the water-holding power of light soils.

THE ROTATION OF CROPS

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

*Bulletin 150, Iowa Agricultural Experiment Station.

Probably the chief reason why the rotation of crops is beneficial may be found in the fact that different crops require different amounts of the various plant foods in the soil. One particular crop will remove a large amount of one element and the next crop, if it be the same kind, will suffer for a lack of that element. If some other crop, which does not draw as heavily on that particular plant food, is rotated with the former crop, a balance in available plant food is reached.

Where a cultivated crop is grown continuously, there is a much greater loss of organic matter or humus in the soil than under a rotation. This fact suggests a second explanation for the beneficial effects of crop rotations. With cultivation, bacterial action is much increased and the humus in the soil may be decomposed too rapidly and the soil injured by the removal of the valuable material. Then the production of available plant food in the soil will be hindered or stopped and crops may suffer. The use of legumes in rotations is of particular value since when they are well inoculated and turned under they not only supply organic matter to the soil, but they also increase the nitrogen content.

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

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

MANURING

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

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

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

Farm manure is composed of the solid and liquid excreta of animals, litter, unconsumed food and other waste materials, and supplies an abundance of organic matter, much nitrogen and millions of valuable bacteria. It contains, in short, a portion of the plant food present in the crops originally removed from the soil and in addition the bacteria necessary to prepare this food for plant use. If it were possible to apply large enough amounts of farm manure, no other material would be necessary to keep the soil in the best physical condition, insure efficient bacterial action and keep up the plant food supply. But manure cannot serve the soil thus efficiently, for even under the very best methods of treatment and storage, 15 per cent of its valuable constituents, mainly nitrogen, are lost. Furthermore, only in a very few instances is enough produced on a farm to supply its needs. On practically all soils, therefore, some other material must be applied with the manure to maintain fertility.

Crop residues, consisting of straw, stover, roots and stubble, are important in keeping up the humus, or organic matter content of soils. Table I shows that a considerable portion of the plant food removed by crops is contained in the straw and stover. On all farms, therefore, and especially on grain farms, the crop residues should be returned to the soil to reduce the losses of plant food and also to aid in maintaining the humus content. These materials alone are, of course, insufficient and farm manure must be used when possible, and green manures also.

Green manuring should be followed to supplement the use of farm manures and crop

residues. In grain farming, where little or no manure is produced, the turning under of leguminous crops for green manures must be relied upon as the best means of adding humus and nitrogen to the soil, but in all other systems of farming also it has an important place. A large number of legumes will serve as green manure crops and it is possible to introduce some such crop into almost any rotation without interfering with the regular crop. It is this peculiarity of legumes, together with their ability to use the nitrogen of the atmosphere when well inoculated, and thus increase the nitrogen content of the soil, which gives them their great value as green manure crops.

It is essential that the legumes used be well inoculated. Their ability to use the atmospheric nitrogen depends on that. Inoculation may be accomplished by the use of soil from a field where the legume has previously been successfully grown and well inoculated, or by the use of inoculating material that may be purchased. If the legume has never been grown on the soil before, or has been grown without inoculation, then inoculation should be practiced by one of these methods.

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

THE USE OF PHOSPHORUS

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

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

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

LIMING

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

All Iowa soils should therefore be tested for acidity before the crop is seeded, particularly when legumes, such as alfalfa or red clover, are to be grown. Any farmer may test his own soil and determine its need of lime, according to simple directions in bulletin 151, referred to above.

SOIL AREAS IN IOWA

There are five large soil areas in Iowa, the Wisconsin drift, the Iowan drift, the Missouri loess, the Mississippi loess and the Southern Iowa loess. These five divisions of the soils of the state are based on the geological forces which brought about the formation of the various soil areas. The various areas are shown in the map, fig. 12.

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 or "nigger-heads." Two of these drift areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift soil was laid down at a much earlier period and is somewhat poorer in plant food than the Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

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

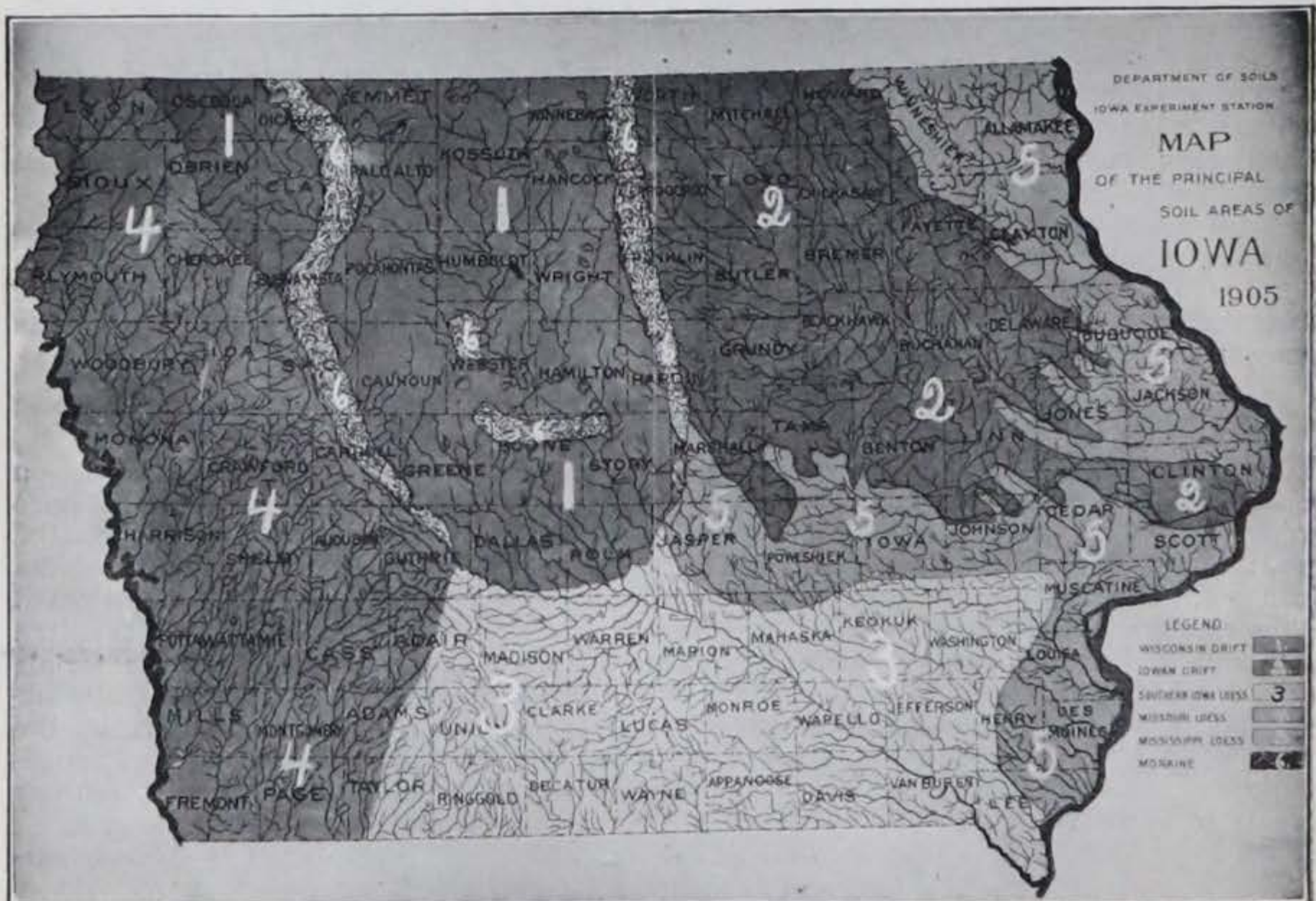


Fig. 12. Map showing the principal soil areas in Iowa

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

THE SOIL SURVEY BY COUNTIES

It is apparent that a general survey of the soils of the state can give only a very general idea of soil conditions. Soils vary so widely in character and composition, depending on many other factors than their source, that definite knowledge concerning their needs can be secured only by thoro and complete study of them in place in small areas. Climatic conditions, 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 soil areas separated on the basis of their geological origin. In other words, while the unit in the general survey is the geological history of the soil area, in the soil survey by counties or any other small area, the unit is the soil type.

GENERAL SOIL CHARACTERISTICS

Soil types possess more or less definite characteristics which may be determined largely in the field, altho some laboratory study is necessary for final disposition. Usually the line of separation between adjoining soil types is quite distinct and it is a simple matter to locate the type boundaries. In some cases, however, there is a gradation from one type to another and then the boundaries may be fixed only with great difficulty. The error introduced into the 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 Agricultural Experiment Station in its Soil Report No. 1:

1. The geological origin of the soil, whether residual, glacial, loessial, alluvial, colluvial or cumulose.
2. The topography or lay of the land.
3. The structure or depth and character of the surface, subsurface and subsoil.
4. The physical or 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 natural drainage.
8. The agricultural value based upon its natural productiveness.
9. Native vegetation.
10. The ultimate chemical composition and reaction.

The common soil constituents may be given as follows:†

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

SOILS GROUPED BY TYPES

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

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

*25 mm. equals 1 in. † Bur. of Soils Field Book. ‡ Loc. cit.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Gravels—More than 50 per cent very coarse sand.

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

METHODS USED IN THE SOIL SURVEY

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

As has been indicated, the completed map is intended to show the accurate location and boundaries, not only of all the 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 type, which fact is readily ascertained, and in that case the mapping may proceed rapidly.

When one section is completed, the party passes to the next section and the location of all soil types, streams, etc., in that section is then checked with their location in the adjoining area just mapped. Careful attention is paid to the topographical 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 type are verified also by inspection by and consultation with those in charge of the work at the Bureau of Soils and at the Iowa Agricultural Experiment Station. When the entire county is completed, all the section maps 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 road map of the county.

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