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# SOIL SURVEY OF IOWA APPANOOSE COUNTY

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Soil Survey Report No. 53  
June, 1928  
Ames, Iowa

June, 1928

Soil Survey Report No. 53

# SOIL SURVEY OF IOWA

Report No. 53—APPANOOSE COUNTY SOILS

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

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### RESEARCH BULLETINS

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

By W. H. STEVENSON and P. E. BROWN with the assistance of C. L. ORRBEN, L. W. FORMAN,  
H. R. MELDRUM and A. J. ENGLEHORN

Appanoose County is located in southeastern Iowa in the fourth tier of counties west of the Mississippi River and adjoins the state of Missouri on the south. It is entirely in the Southern Iowa loess soil area, and about one-half of the soils

of the county are of loessial origin, the remainder being of drift origin and representing areas from which the loessial soil has been removed by erosion.

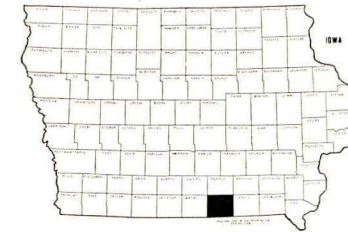


Fig. 1. Map showing the location of Appanoose County.

The total area of the county is 531 square miles, or 328,320 acres. Of this area 314,059 acres, or 92.6 percent, is in farm land. The total number of farms is 2,242, and the average size of the farms is 140 acres. The farms are operated by 1,516 owners, 192 relative renters, 414 renters and 120 both owners and

renters. The following figures from the Iowa Yearbook of Agriculture for 1926 show the utilization of the farm land of the county:

Acreage in general farm crops .....	144,234
Acreage in farm buildings, public highways and feed lots .....	11,781
Acreage in pasture .....	153,469
Acreage in waste land not utilized for any purpose .....	3,968
Acreage in farm wood lots used for timber only .....	2,286
Acreage in farm land lying idle .....	3,426
Acreage in crops not otherwise listed .....	1,833

### THE TYPE OF AGRICULTURE IN APPANOOSE COUNTY

The type of agriculture followed in Appanoose County at the present time consists mainly of a system of general farming, including the growing of corn and small grain combined with the raising of livestock. Very little grain farming is done in the county, and a number of the farms are operated on a strictly livestock basis. A great majority of the farmers, however, combine grain production and livestock raising. It is generally agreed that the livestock system of farming or the general system will more readily permit the maintenance of soil productivity. These systems of farming are, therefore, more popular. Specialized farming is practiced only on farms located near large towns where there is a ready market for the product. The general farm income of the county is derived from the sale of corn, small grain, livestock, dairy products, eggs and poultry. Small quantities of tree fruits, honey and cane sorghum are produced and sold locally.

There is not an extensive area of waste land in the county but a considerable acreage is listed as not being utilized for any crop production. It is not possible to make general recommendations for the reclamation of waste areas, as the causes of infertility are so variable. Later in this report, however, under the

\* See soil survey of Appanoose County by C. L. Orrben, of the Iowa Agricultural Experiment Station, and W. W. Strike, of the U. S. Department of Agriculture. Field operations of the Bureau of Soils, 1923.

TABLE I. AVERAGE YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN APPANOOSE COUNTY, IOWA\*

Crop	Acreage	Percent of total farm land of county	Bushels or tons per A.	Total bushels or tons	Average price	Total value of crops
Corn .....	55,008	17.50	26.80	1,474,214	\$ 0.54	\$796,075
Oats .....	25,238	8.00	21.00	538,389	0.35	188,436
Winter wheat .....	906	0.28	13.00	11,778	1.20	14,133
Rye .....	108	0.03	20.00	2,160	0.82	1,771
Clover hay .....	1,649	0.52	1.93	3,183	15.60	49,654
Timothy hay .....	23,460	7.40	1.06	24,868	12.25	304,633
Timothy and clover hay (mixed) .....	21,517	6.90	1.29	27,757	14.60	405,252
Alfalfa hay .....	419	0.13	2.62	1,098	19.50	21,411
Wild hay .....	607	0.19	0.90	546	12.50	6,825
Soybeans .....	879	0.27	.....	.....	.....	.....
Potatoes .....	83	0.02	67.00	5,561	1.70	9,453
Timothy seed .....	14,053	4.40	3.50	48,976	2.60	127,337
Clover seed .....	167	0.05	0.62	103	16.25	1,673
Sweet clover .....	101	0.03	.....	.....	.....	.....
Pasture .....	153,469	48.80	.....	.....	.....	.....

\* Iowa Yearbook of Agriculture, 1926.

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

#### THE CROPS GROWN IN APPANOOSE COUNTY

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

Corn is the most important crop grown in the county, being produced on 17.5 percent of the total farm land. Average yields of 26.8 bushels per acre are secured. Reid's Yellow Dent and Boone County White are the principal varieties grown, and Silver King, Iowa Silvermine, Bloody Butcher and strains or mixtures of these varieties are also produced. Some corn is cut green for silage and early fall feeding, and some is cut when the grain is mature. When mature, the corn is shocked in the field to be husked later, and the stalks are fed to the livestock as roughage. Most of the crop is husked by hand and stored in the crib until fed or shelled and sold. A large part of the corn is utilized for feeding purposes on the farms.

The hay crop is second in importance in the county, timothy and clover mixed being grown on 6.9 percent of the total farm land; average yields are 1.29 tons per acre. Timothy hay alone is grown on 7.4 percent of the total farm land, yielding 1.06 tons per acre. Clover hay is grown alone on 0.52 percent of the total farm land, yielding 1.93 tons per acre. The value of the hay crop is considerable, the timothy and clover mixed being of the highest value. Some timothy is grown for seed, and some clover is also grown for seed, altho only a limited area of the latter crop is utilized for seed. There is a small acreage in wild hay in the county, but this crop is of minor importance.

Oats are grown quite generally in the county, being produced on 8 percent of the total farm land. Average yields amount to 21 bushels per acre. The total

value of the oats crop is considerable. The principal varieties are Iowa 103, Iowa 105, Green Russian, Iowar, Iogren and Early Champion. The oats produced are used as feed for work animals, cattle, hogs and sheep. Only a small portion of the crop is sold.

Wheat is an important cash crop in the county but is grown only to a limited extent. The principal varieties are Turkey and Kanred. All of the wheat grown is marketed at the local elevators and shipped from there to the terminals.

Some alfalfa is grown, and average yields of 2.62 tons per acre are secured. The value of the crop is considerable, and alfalfa might be more extensively grown with profit to the farmers of the county. When the soil is well limed and the crop is inoculated, very satisfactory yields of alfalfa may be secured. It is a particularly valuable crop for use on the dairy farms.

Soybeans are grown in the county and very satisfactory yields are secured. Sweet clover is grown only to a limited extent but is becoming more and more valuable for pasture purposes. Sweet clover is very desirable for use in the county and may be grown very satisfactorily, provided the soil is well limed. It makes excellent pasture and forage. Some rye is grown in the county, but the crop is of minor importance. Potatoes are grown on practically every farm in sufficient amounts to supply the home demand. Small acreages are also devoted to barley, buckwheat, millet, flax and sorghum.

Some fruit growing is practiced in the county; apple orchards are maintained on many farms. The yields, however, are not satisfactory, owing to the fact that the orchards are neglected. Some pears, plums, cherries, grapes and small bush fruits are grown on most farms, serving to supply the home demand and the local markets.

#### THE LIVESTOCK INDUSTRY IN APPANOOSE COUNTY

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

Horses .....	7,400
Mules .....	1,500
Cattle, all .....	27,000
Hogs .....	33,100
Sheep .....	28,900

The raising and feeding of hogs is the most important livestock industry in the county. From 25 to 125 hogs are raised each year on the average sized farm. Duroc Jerseys are the favorite breed, altho some Hampshires, Chester Whites and Poland Chinas are also found. A large part of the farm income is derived from the raising and feeding of hogs, and in a number of cases the farms are devoted exclusively to hog raising.

Cattle raising and feeding is the second livestock industry of importance. On some of the larger farms several hundred head of cattle are pastured and fed annually. The average farmer feeds one or two carloads each year. Herefords are the most popular breed, but small herds of purebred Shorthorns and Angus are also kept. The cattle and hogs are marketed at Ottumwa, Chicago, Omaha, Kansas City or St. Louis.

Dairying is practiced to some extent in the county, and dairy animals are maintained on practically all farms. The largest dairy herds are found in the vicinity of Centerville. Creameries, milk stations and cheese factories are located at convenient points to receive the dairy products and transfer them to the central stations from which they are sold wholesale or retail. Dairying has become an industry of considerable importance in the county and much of the income of the county is derived from this source.

Horses and mules are raised on some farms, chiefly to supply work animals. There are small flocks of sheep and in individual cases the income from the sheep industry is considerable. Sheep raising is of particular importance on the rougher areas. Poultry raising is practiced extensively thruout the county, chiefly, however, to supply the home demands. There is considerable profit from the sale of poultry products and the income on many farms might be increased to a considerable extent thru a proper development of the poultry industry.

#### SOIL FERTILITY IN APPANOOSE COUNTY

While the yields of general farm crops secured in Appanoose County are fairly satisfactory, very much larger crops might often be secured thru the proper method of soil management.

In a number of cases the soil types of the county are not so well drained as they should be in order to provide for the most satisfactory crop yields. Where the land is too wet for the best crop growth, the installation of tile is very necessary. There are areas in the Grundy silt loam on the loessial upland, and especially on the more level to depressed areas of the Grundy silty clay loam, where tiling would be of particular value. There are also areas in the Putnam silt loam, the Marion silt loam and the Edina silt loam on the loessial uplands, where drainage would be distinctly worth while. The Bremer and Calhoun soils on the terraces are also frequently in need of tiling. The heavier Wabash types on the bottoms are in need of drainage. In individual areas of the various types the installation of tile would lead to a better condition for crop growth, and much larger crop yields might be secured.

The soils of the county are all acid in reaction and hence in need of lime for the best growth of general farm crops, particularly of legumes. It is very necessary, therefore, that the soils of this county be tested for lime needs and that the amount of lime needed be applied. Only by this treatment will it be possible to secure the most satisfactory crop yields. Farmers should have their soils tested for acidity or lime needs, and lime should be applied regularly, if maximum crops are to be secured.

A number of the soils are rather low in organic matter and nitrogen and are light in color. Other types are better supplied with organic matter and are darker in color. On the light colored soils it is particularly important that some fertilizing material supplying organic matter and nitrogen be applied, in order to insure more satisfactory crop yields. But even on those soils which are dark in color, and hence better supplied with these constituents, the use of fertilizers supplying organic matter is very necessary at regular intervals in order to maintain the supply. Applications of farm manure are of large value on the light colored soils of Appanoose County. Manure will also bring about very large and profitable crop increases on the darker colored and apparently richer soils.

It is the most valuable fertilizing material that can be used on the soils of the county and large increases in the yields of general farm crops will always follow its application. The turning under of leguminous crops will undoubtedly prove of large value on many of the types occurring in the county and especially on the lighter colored soils. The practice of green manuring may be of value also, however, on the heavier darker colored types. Green manuring is very desirable and profitable to supplement the use of farm manure which in many cases is inadequate to supply the needs of all the soils on the farms regularly. The proper utilization of crop residues also aids materially in building up and maintaining the supply of organic matter in the soil.

The content of phosphorus is rather low in the soils of the county, and it is apparent, therefore, that applications of some phosphorus fertilizer will be needed in the very near future. It would seem, furthermore, that a phosphate might be used with profit on many of these soils at the present time. Tests which have been carried out on some of the more extensive types occurring in the county have indicated large profits from the addition of a phosphate fertilizer. It would seem very desirable, therefore, that farmers in this county test the value of phosphorus fertilizers on their own soils under their particular farm conditions. Either superphosphate or rock phosphate should be used. Tests which have been carried out have indicated that either phosphate may prove of distinct value. In some cases the superphosphate has seemed somewhat preferable but in other instances the rock phosphate has given quite as good results. Farmers are urged to test both phosphates on their own farms and determine for their conditions which phosphorus carrier will prove the more profitable. It would seem that in general the soils of this county would respond in a very profitable way to the use of one or the other of the phosphorus fertilizers.

The use of commercial nitrogenous fertilizers and commercial potassium fertilizers cannot generally be recommended on the soils of the county at the present time. Nitrogen may be added to these soils quite readily by the proper growing and use of leguminous crops as green manures and thru the careful preservation and application to the land of all the farm manure produced and the turning under of all crop residues. Only in individual cases for special crops, would it seem that commercial nitrogen or potassium fertilizers could be used profitably. There is, in general, a large content of potassium in the soils, and the addition of more potassium would not seem to be necessary for general farm crops. Small amounts of commercial nitrogen or commercial potassium as top dressings for certain crops might be desirable in some cases. Tests of both fertilizers should be carried out on a small scale before any extensive applications are made.

The use of complete commercial fertilizers may be desirable in individual cases in this county. The tests which have been carried out on some of the more important soil types have indicated considerable crop increases from the use of complete fertilizers but have not shown as large a profit from the application as when a phosphate fertilizer has been employed. It would seem, therefore, that for general farm crops the phosphate fertilizers would be more desirable. However, tests of complete commercial fertilizers may be carried out on small areas and compared with a phosphate fertilizer, and if the results secured show the complete fertilizer to be profitable, applications may be made to extensive

# SOIL MAP OF APPANOOSE COUNTY IOWA

Thomas D. Rice, Inspector Northern Division. Soils surveyed by C. L. Orben of the Iowa Agricultural Experiment Station, and W. W. Strike of the U. S. Dept. of Agriculture.

U. S. DEPT. OF AGRICULTURE, BUREAU OF SOILS  
H. G. Knight, Chief. Curtis F. Marbut, in charge Soil Survey

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

## LEGEND

### Drift Soils

<b>79</b>	<b>65</b>
Shelby loam	Lindley loam

### Loess Soils

<b>64</b>	<b>66</b>
Grundy silt loam	Putnam silt loam

<b>67</b>	<b>211</b>
Marion silt loam	Edina silt loam

<b>80</b>	<b>115</b>
Clinton silt loam	Grundy silty clay loam

### Terrace Soils

<b>42</b>	<b>88</b>
Calhoun silt loam	Bremer silt loam

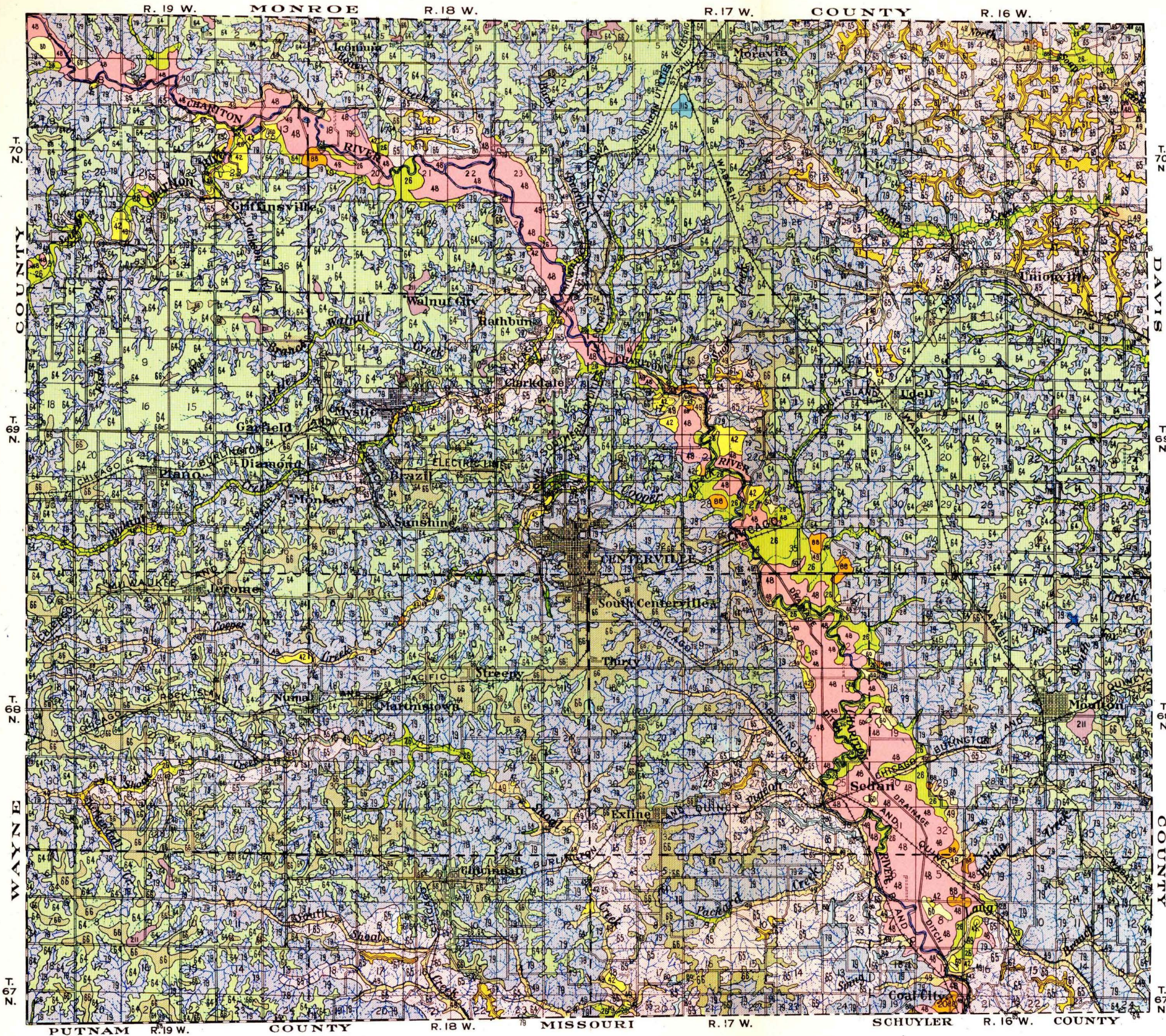
<b>60</b>	<b>48</b>
Waukesha loam	Wabash silty clay loam

<b>26</b>	<b>49</b>
Wabash silt loam	Wabash loam

<b>212</b>
Crawford loam

SCALE: 1 INCH TO 2½ MILES

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of the county. The soils of the Shelby and Lindley series are derived mainly from the Kansan drift. The Lindley soils are partly of loessial origin but are largely made up of Kansan material. The areas where these types occur undoubtedly represent areas in which the surface covering of loess later laid down over the drift has been entirely or partly removed thru erosion.

At a later geological time, when climatic conditions were quite different than at present, the entire surface of the land was covered by a layer of fine silt-like material known as loess. The deposit was evidently made by the wind and the silt like material was laid down quite uniformly over the previous topographic features of the county. The depth of the original loess deposit is problematical, but it seems likely that it was from 18 to 25 feet in thickness. At the present time the depth of the loess covering varies from 1 to 18 feet. Extensive erosion has occurred in many sections and a large part of the original loess covering has been washed away. The original loess material was a yellow to light gray silt loam, but thru the accumulation of plant residues there has been a gradual darkening of the color and in general the loess material at the present time is dark brown to black. This is the characteristic color of the Grundy soil of the loessial uplands. The Tama and Putnam soils of the loessial upland are also dark in color. The Clinton and Marion soils, however, have been developed on the loessial upland under a timbered condition and hence there has not been such a large accumulation of organic matter from plant residues, and the soils are light in color. The Grundy, Tama and Putnam soils, on the contrary, being developed under prairie conditions, show a considerable darkening in color, owing to the accumulation of the plant remains.

Some second bottomlands or terraces occur in the county, and while they are found only to a rather limited extent the areas are of considerable importance. The bottomland soils are extensively developed thruout the county. Both of these groups of soils are more or less variable in character and depth, depending upon the action of the streams which deposited them. They usually consist of mixtures of drift and loess material which have been carried by the streams and deposited in layers of varying composition.

#### PHYSIOGRAPHY AND DRAINAGE

There are two distinct topographic features in the county. The broad, level plains on the wide upland interstream areas represent the remnant of the original plains which occurred in the county. This level plain has been cut by the streams which flow thru the county. Erosion has occurred to a considerable extent along the streams, and the topography near the various drainageways is rolling to strongly rolling and broken. The Chariton River has cut a deep wide valley thru the level country. On the north side of the river which enters the county from the northwest the slopes are very steep, while those facing the south as well as those formed by the smaller tributaries are long and gentle with rounded ridges. Soap Creek, North Soap Creek and the numerous tributaries to these streams in the northeastern part of the county have cut deep gorges, leaving steep rugged slopes with narrow sharp ridges of upland and V-shaped valleys. Stream beds are from 50 to 150 feet below the original plains. Similarly, in the western part of the county, deep channels have been formed by the South Chariton River and Walnut, Cooper and Shoal Creeks.

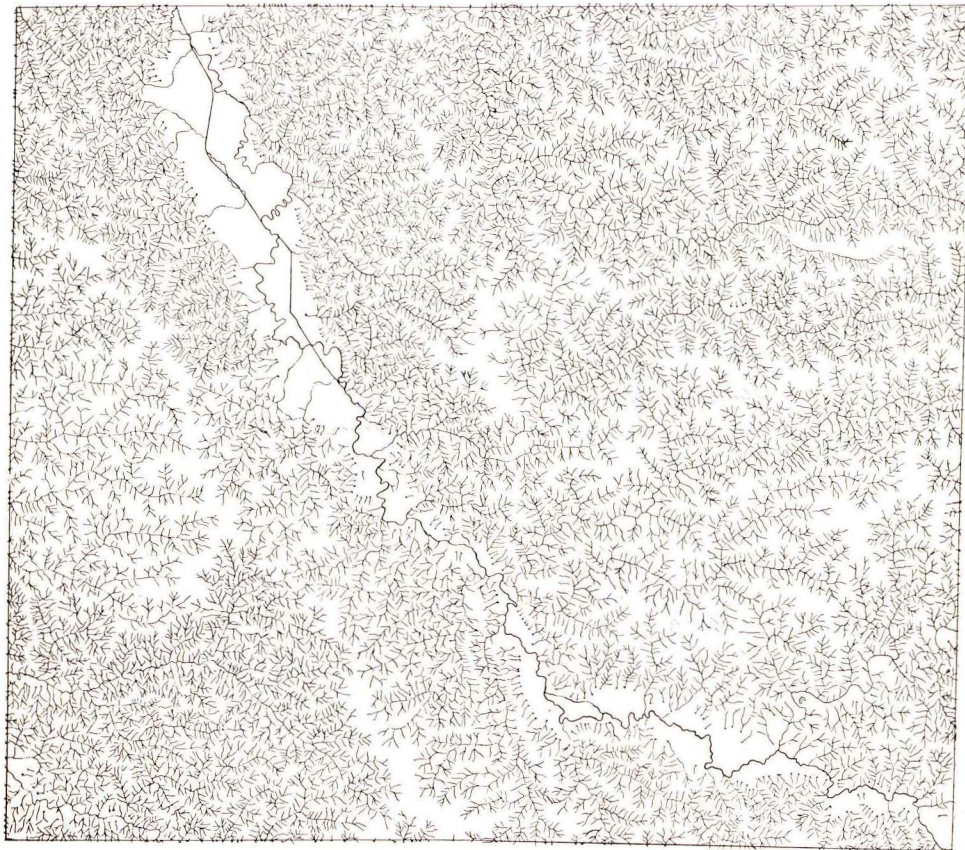


Fig. 2. Map showing the natural drainage of Appanoose County.

The narrow channels and sharp ridges formed by the branching tributaries of the various creeks show the extensive effects of the erosion which has occurred in the southern part of the county. In the northern half of the county, further away from the Chariton River valley, the topography is much less rugged. The valleys are U-shaped and the slopes long and gentle. In these sections erosion has not been so active, and the upland areas are more level to rolling in topography.

In general, then, the topographic condition of the county may be said to vary from the more nearly level to gently undulating areas in the interstream uplands thru the more gently rolling to strongly rolling lands at further distances from the main streams and finally to the rough to broken areas occurring in the immediate vicinity of the larger streams.

The drainage is brought about by the Chariton River and its tributaries, which drains into the Missouri River system. Soap Creek and North Soap Creek drain the northeastern part of the county and these, with Fox River which drains the east central part of the county, belong to the Mississippi River system. The divide which separates the drainage into the two systems extends across the northwestern part of the county from Moravia to Moulton. The Wabash Railway follows the crest of this divide. The Chariton River flows in a winding

course over broad flood plains, the first bottoms narrowing to barely a fourth of a mile in width about four miles north of Centerville and broadening out above and below that point, are in some places  $2\frac{1}{2}$  miles in width. Remnants of old terraces from 8 to 20 feet above the first bottoms, adjacent to the bluffs, may be seen where smaller tributaries flow into the main streams. The first bottomlands bordering the creeks occur in narrow strips which rarely exceed one-fourth of a mile in width.

The natural drainage system of the county is adequate, as is indicated by the accompanying map. The main streams with their tributaries and intermittent drainageways extend into practically all parts of the county, with the exception of a limited area on the level upland divides. Drainage on some of these level uplands by the installation of tile would be of considerable value in such areas. Artificial drainage is particularly necessary in some of the level areas of the Grundy silt loam, the Marion silt loam, the Putnam silt loam and the Edina silt loam. Some of the terrace types will also be benefited by drainage, and on the bottomlands drainage is frequently needed, especially on the heavier textured soils after the types have been protected from overflow.

### THE SOILS OF APPANOOSE COUNTY

Appanoose County soils are grouped into five classes according to their origin and location—drift soils, loess soils, terrace soils, swamp and bottomland soils and residual soils. Drift soils consist of deposits left by the glaciers and they contain materials varying widely in composition, including much sand and frequently boulders. Loess soils are fine dust-like deposits made by the wind at a time when climatic conditions were very different than they are at present. Terrace soils are old bottomlands that have been raised above overflow by a decrease in the volume of the streams which deposited them, or by a deepening of the river channel. Swamp and bottomland soils occur in low-lying, poorly drained areas along streams which overflow. Residual soils are derived from the native bedrock material which underlies them.

The occurrence of these groups of soils in Appanoose County is shown in table II. Over 50 percent of the total area of the county is covered by the drift soils. Loess soils are second in extent and cover 35.7 percent of the total area. There is a small area in terrace soils, amounting to 1.1 percent of the total area of the county. Bottomland soils are developed considerably in the county, covering 12.2 percent of the total area. There is a limited area of residual soil in the county, covering 0.1 percent of the total area.

There are 15 individual soil types in the county, 2 drift soils, 6 loess types, 3 terrace soils, 3 swamp and bottomland soils and 1 residual soil. These various soils are distinguished on the basis of certain definite characteristics which are described in the appendix to this report. The type names given to the individual soils denote certain group characteristics which will be described later. The areas of the different soil types are given in table III.

The Shelby loam is the largest individual soil type and the most extensively developed drift soil in the county. It covers 40.1 percent of the total area. The Lindley loam is the second largest drift soil in the county and the third most extensively developed type, covering 10.8 percent of the total area. The Grundy silt loam is the largest individual loess soil and the second most extensively de-



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

Soil group	Aeres	Percent of total area of county
Drift soils .....	166,912	50.9
Loess soils .....	117,056	35.7
Terrace soils .....	3,712	1.1
Swamp and bottomland soils .....	40,384	12.2
Residual soils .....	256	0.1
Total.....	328,320	.....

veloped type. It covers 25.8 percent of the total area. The Putnam silt loam is the second largest loess soil and the fourth most extensively developed type, covering 7.3 percent of the county. The remainder of the loess types are minor in extent. The Marion silt loam covers 1.5 percent of the county. The Edina silt loam covers 0.4 percent, the Clinton silt loam 0.6 percent and the Grundy silty clay loam 0.1 percent. The terrace types are all minor in area; the Calhoun silt loam, the largest, covering only 0.6 percent of the total area. The Bremer silt loam covers 0.3 percent and the Waukesha loam 0.2 percent of the county. The swamp and bottomland soils are extensively developed. The Wabash loam, the largest bottomland type covers 4.4 percent of the county and is the fifth largest type. The Wabash silty clay loam covers 4.2 percent and the Wabash silt loam 3.6 percent of the total area. The one residual soil is of minor importance in the county, covering only 0.1 percent of the area.

The various topographic features of the soils of the county are distinctive, and there is a definite relationship between the topography and the various soil

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN APPANOOSE COUNTY

Soil No.	Soil type	Aeres	Percent of total area of county
DRIFT SOILS			
79	Shelby loam .....	131,584	40.1
65	Lindley loam .....	35,328	10.8
LOESS SOILS			
64	Grundy silt loam .....	84,800	25.8
66	Putnam silt loam .....	23,808	7.3
67	Marion silt loam .....	5,056	1.5
211	Edina silt loam .....	1,152	0.4
80	Clinton silt loam .....	1,984	0.6
115	Grundy silty clay loam .....	256	0.1
TERRACE SOILS			
48	Calhoun silt loam .....	2,048	0.6
88	Bremer silt loam .....	896	0.3
60	Waukesha loam .....	768	0.2
SWAMP AND BOTTOMLAND SOILS			
48	Wabash silty clay loam .....	13,952	4.2
26	Wabash silt loam .....	11,968	3.6
49	Wabash loam .....	14,464	4.4
RESIDUAL SOILS			
212	Crawford loam .....	256	0.1
	Total.....	328,320	.....

types which are mapped. The Shelby loam and the Lindley loam on the drift uplands are much more strongly rolling to hilly in topography than are the loessial uplands. The Grundy silt loam is level to very gently undulating in topography. The Putnam and Marion soils and the Edina silt loam are very similar. The Clinton silt loam is rolling to strongly rolling in topography. The Grundy silty clay loam is level to flat or depressed. On the terraces there is very little topographic variation. Similarly on the bottoms the soils are level to flat in topography with very little relief evident. The Crawford loam on the residual upland is rather strongly rolling to rough in topography.

#### THE FERTILITY IN APPANOOSE COUNTY SOILS

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

The total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirements were determined for all the samples. The official methods were followed in the case of the nitrogen, phosphorus and carbon determinations and the Truog qualitative test was used for the determination of the limestone requirement. The results given in the tables are the averages of the results of duplicate determinations on all samples of each type.

#### THE SURFACE SOILS

The results of the analyses of the surface soils are given in table IV. They are calculated on the basis of 2,000,000 pounds of surface soil per acre.

The phosphorus content of the soils of this county varies from 754 pounds in the Lindley loam on the drift uplands to 1952 pounds in the Wabash silt loam on the bottomlands. No striking relationships between the phosphorus content of the soils and the various soil groups are shown, except that the average of the drift soils is much lower than that of the other soil groups. The bottomland soils will average somewhat higher than the terrace or upland types. This might be expected inasmuch as there has been less crop growth and hence a smaller removal of plant food constituents from the lower soil layers. The loess soils on the average are better supplied with phosphorus than the drift upland types. This would be expected because of the nature and composition of the drift soils and the origin of these types. The soils occurring on the drift uplands are naturally poorer in plant food constituents and lower in fertility than those found on the richer loessial uplands. Furthermore, they are loams in texture, while the loessial upland types are silt loams, or silty clay loams.

Some relationships are evident between the phosphorus content of the soils and the soil series in which the types have been classified. Thus on the drift uplands the Shelby soils are better supplied than the Lindley; on the loessial uplands the Grundy soils are the richest in phosphorus, the Edina soils coming second, followed by the Putnam, Clinton and Marion. On the terraces the Bre-

TABLE IV. PLANT FOOD IN APPANOOSE COUNTY, IOWA, SOILS  
Pounds per acre of 2 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
DRIFT SOILS						
79	Shelby loam .....	875	3,400	37,678	.....	4,000
65	Lindley loam .....	754	1,280	14,111	.....	5,000
LOESS SOILS						
64	Grundy silt loam .....	1,418	3,947	43,768	.....	2,667
66	Putnam silt loam .....	956	2,240	33,800	.....	3,000
67	Marion silt loam .....	821	1,560	18,653	.....	8,000
211	Edina silt loam .....	1,198	3,480	37,624	.....	4,000
80	Clinton silt loam .....	889	2,120	24,851	.....	4,000
115	Grundy silty clay loam....	1,185	4,720	56,604	.....	.....
TERRACE SOILS						
42	Calhoun silt loam .....	1,239	1,880	32,285	.....	3,000
88	Bremer silt loam .....	1,791	2,960	53,156	.....	2,000
60	Waukesha loam .....	996	3,720	41,324	.....	4,000
SWAMP AND BOTTOMLAND SOILS						
48	Wabash silty clay loam..	1,845	4,120	50,926	.....	4,000
26	Wabash silt loam .....	1,952	4,040	50,436	.....	4,000
49	Wabash loam .....	1,414	3,120	40,726	.....	3,000
RESIDUAL SOILS						
212	Crawford loam .....	1,037	5,280	57,854	.....	.....

mer soils are the richest, followed by the Calhoun and Waukesha. Evidently the characteristics which serve to distinguish the various soil series—color of the surface soil, topographic position and character of the subsoil—are all significant. The types which are darker in color in the surface soil are richer in phosphorus than the light colored soils, thus the Shelby types are richer than the lighter colored Lindley types. The Grundy soils are richer than the other loessial upland types and darker in color. The Putnam and Edina soils are richer than the Marion and Clinton and they are darker in color than the latter types. The Bremer soils are the richest on the terraces and are darker in color. The topographic condition is also significant. Soils which are level to gently rolling in topography are richer in phosphorus than are the more strongly rolling types. Thus the Grundy, Putnam and Edina soils of the loessial upland are richer than the Clinton, and the Shelby soils are higher than the Lindley types. On the terraces the Bremer soils are the richest because they are more nearly level to flat or even depressed in topography. The subsoil character is also significant, those types with sandy to gravelly subsoils are more poorly supplied with plant food constituents.

There is some evidence of the effect of the texture of the soil on the phosphorus content, but very few comparisons are possible from the analyses of the soils of this county, as only in a few cases are different types of the same series mapped. On the loessial upland the Grundy silt loam and the silty clay loam are both mapped. The silt loam in this case is somewhat better supplied with phosphorus than the silty clay loam, which is contrary to the usual conditions. The differences are not very large. On the bottomland the Wabash silt loam

is a little higher than the Wabash silty clay loam, which, again, is somewhat contrary to the usual results, but the differences are small and not important. The Wabash loam is more poorly supplied with phosphorus than are the finer textured types. In general it would seem from these results that the soils which are finer in texture are better supplied with phosphorus. Ordinarily silty clay loams are richer in plant food than silt loams, silt loams are better supplied than loams, loams are richer than sandy loams and sands.

There is evidently no large content of phosphorus in any of the soils in Appanoose County, and phosphorus fertilizers will certainly be needed on these types in the very near future, even if they are not of value at the present time. The results of the experiments which have been carried out on the soils of this county and will be discussed later in this report indicate that applications of certain phosphorus fertilizers will be of value on these soils at the present time.

There is a rather considerable variation in the nitrogen content of the various soils, the amounts present ranging from 1,280 pounds in the Lindley loam on the drift uplands up to 4,720 pounds in the Grundy silty clay loam on the loessial upland. As has been noted in the case of the phosphorus, there is little evidence of any relationship between the nitrogen content of the soils and the various soil groups. The bottomland types are a trifle richer on the average in this constituent than the upland soils, owing to the fact that there has been less crop growth and less removal of plant food from these bottomland soils. The loessial uplands on the average are better supplied than the drift uplands. The difference, however, is not large enough to be significant.

There does seem to be a relationship between the nitrogen supply of the soils and the various soil series. Those characteristics which serve as a basis for distinguishing soil series are apparently reflected in the nitrogen content. The color of the soil is significant, for soils which are darker in color are usually richer in nitrogen. The Shelby soils are richer than the Lindley on the drift upland. The Grundy soils are richer than the other types on the loessial upland; followed by the Edina soils and these in turn by the Putnam types. The Clinton come next, and finally the Marion soils which are the lightest in color and the lowest in nitrogen. On the terraces the Bremer and Waukesha soils are richer in nitrogen and are darker in color than are the Calhoun types. The topographic position is likewise of considerable significance. Those types which are more nearly level to flat in topography like the Grundy, Putnam and Edina soils are higher in nitrogen than are the more rolling to rough soils like the Clinton. The Shelby soils are richer than the Lindley. The character of the subsoil is also important; the types having heavier subsoils are generally richer in nitrogen.

The relationship of the nitrogen content to the soil texture is evidenced in only one or two cases in this county. The Grundy silty clay loam of the loessial upland is richer in nitrogen than the Grundy silt loam, the Wabash silty clay loam is the highest in nitrogen among the Wabash types, followed in turn by the Wabash silt loam and the Wabash loam. Evidence is thus supplied that the texture of the soil will affect the nitrogen content. The finer textured types are richer in nitrogen than coarse textured soils, silty clay loam are richer than

silt loams and these are better supplied than loams which in turn are richer than fine sandy loams or sands.

While some of the soils in this county seem to be fairly well supplied with nitrogen, a number of types are rather low in this constituent, especially the lighter colored soils. On these types the application of fertilizing materials supplying nitrogen is very desirable at the present time, and large crop increases will be secured from the application of such fertilizers to these soils. On all the soils in this county, however, it is very important that fertilizing materials supplying nitrogen be applied regularly if the content of this constituent is to be kept up. The utilization of all the manure produced on the farm will aid considerably in keeping up the supply of nitrogen in the soil, and this material, when applied in liberal amounts, will bring about large crop increases on the various soils of the county. The crop residues will also aid in keeping up the nitrogen content of the soils and they should all be returned to the land. The use of leguminous crops as green manures is the best and cheapest means of increasing the nitrogen content of the soils, and green manuring is a valuable substitute for farm manure in maintaining the nitrogen content of the soil, or green manures may serve as a supplement to farm manure.

The content of organic carbon or organic matter in the soils of the county varies in much the same way as was noted in the case of nitrogen. The Lindley loam on the drift upland is the lowest in this constituent, containing 14,111 pounds and the Grundy silty clay loam on the loessial upland is the highest, containing 56,604 pounds per acre. These are the same types that showed the lowest and highest content of nitrogen, respectively.

The same relationships noted in the case of nitrogen are apparent between the soil groups and the content of organic carbon. Generally the bottomland soils are slightly higher in organic carbon than are the upland and terrace types, as might be expected from their character. The drift soils, on the average, are lower in organic matter than are the loessial upland types. The terrace soils show about the same content as the loessial uplands and are slightly lower in organic matter than are the bottomland types.

The relationships of the various soil series which are represented in the county and the organic matter content are quite definitely shown. The same factors which have been noted in the case of phosphorus and nitrogen will affect the content of organic carbon. Thus the color of the soil is of prime importance. Soils which are dark in color, like the Grundy, Edina and Putnam, are richer than the light colored soils, like the Clinton and Marion. The Shelby soils are richer than the Lindley types, and the Bremer and Waukesha are better supplied with organic matter than are the Calhoun soils. Those types which are more nearly level to flat in topography, like the Grundy, Putnam and Edina soils, are richer in organic matter than are the more strongly rolling to rough soils, like the Clinton. The Shelby is better supplied than the Lindley and it is not so strongly rolling to rough in topography. The subsoil conditions are important as those types with heavier subsoils are richer in organic matter.

The relationship between organic carbon and texture is evident in two cases. The Grundy silty clay loam is richer in organic matter than the Grundy silt loam, and the Wabash silty clay loam is richer than the Wabash silt loam, which

in turn is better supplied than the Wabash loam. It seems again that those types which are fine textured are generally better supplied with organic matter and other plant food constituents. Silty clay loams are ordinarily richer in organic matter than are silt loams, and these in turn are better supplied than loams which are richer than are the sandy types.

While no striking deficiency in organic matter is evident in most of the soils in Appanoose County, in some cases there is a rather noticeable deficiency. On the light colored soils and those which are more strongly rolling to rough in topography the supply of organic matter is inadequate to provide for the best conditions in the soils for maximum crop growth. On such soils applications of fertilizing materials supplying organic matter are very necessary but on all the soils of the county the additions of such fertilizing materials will be of value. The application of farm manure is of large value on the light colored soils but it will also bring about large crop increases on the darker colored types which are apparently better supplied with this constituent. The practice of green manuring is very desirable on many of the soils of the county as a supplement to the use of farm manure, or as a substitute for that material. The utilization of crop residues will also aid materially in maintaining the supply of organic matter in the soils of this county.

The relationship between the content of nitrogen and organic carbon in soils, gives a rough indication of the rate at which decomposition is going on in the soils and hence the rate at which available plant food is being produced. In some of the soil types in this county there is evidence of insufficient decomposition and an inadequate production of available plant food. Thus on the Shelby loam and Lindley loam on the drift uplands, on the Marion silt loam, the Edina silt loam and the Clinton silt loam on the loess uplands, and on the Waukesha loam on the terraces and the Crawford loam on the residual uplands, there is indication that the production of available plant food may be inadequate to meet crop needs. On these soils the application of farm manure will be of particularly large value in stimulating the production of available plant food. It is the most important material that can be used for this purpose, and large increases in crop yields may be secured from its application on these types.

No inorganic carbon content was found in any of the soil types in Appanoose County. All are acid in reaction and show a lime requirement. The figures given in the tables should be considered, however, as merely indicative of the lime needs of these soils. Soil types vary widely in acidity and need for lime, and even samples of the same type from different fields show considerable variations in lime requirement. It is very necessary, therefore, that samples be secured from any area before lime is applied and that these samples be tested for lime needs before an application is made. Only in this way will it be possible to supply the necessary amount of lime for the best crop growth on the soil. It is apparent from the figures given here that the soils of this county are all acid in reaction and applications of lime will certainly be needed on these types if the best growth of general farm crops, particularly of legumes, is to be secured.

#### THE SUBSURFACE SOILS AND SUBSOILS

The results of the analyses of the subsurface soils and subsoils are given in

tables V and VI. They are calculated on the basis of 4,000,000 pounds of sub-surface soil and 6,000,000 pounds of subsoil per acre.

An examination of the data given in these tables indicates that the conclusions drawn from the analyses of the surface soils will not be modified to an appreciable extent by study of the analyses of the lower soil layers. There is no large content of any individual plant food constituents in the lower soil layers nor is there any striking deficiency in any of the elements. There is little need, therefore, for considering these analyses in detail. In general they may be considered to confirm the conclusions drawn from the analyses of the surface soils.

The phosphorus content of the soils of the county is not high and in most cases it is strikingly deficient. It is evident, therefore, that phosphorus fertilizers will be of value on these soils in the very near future and may be used profitably in many cases at the present time.

The supply of organic matter and nitrogen is low in some of the soil types and it is not extremely high in any of them. The amounts present in some cases are inadequate for the best crop growth at the present time. It is very necessary, therefore, that some fertilizing material supplying organic matter and nitrogen be used on some of the soils at the present time, and such treatment will be needed on all the soil types in the county in the future, if the supply of organic matter is to be maintained. The proper use of farm manure, the turning under of leguminous crops as green manures and the utilization of all crop residues are strongly recommended for the soils of this county to build up and keep up the supply of organic matter and nitrogen.

There is no content of lime in any of the lower soil layers, except in the case

TABLE V. PLANT FOOD IN APPANOOSE COUNTY, IOWA, SOILS  
Pounds per acre of 4 million pounds of subsurface soil (6 2/3"-20")

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
DRIFT SOILS						
79	Shelby loam .....	1,992	4,080	50,681	.....	4,000
65	Lindley loam .....	1,320	1,840	17,234	.....	7,000
LOESS SOILS						
64	Grundy silt loam .....	1,813	3,613	44,261	.....	3,600
66	Putnam silt loam .....	1,670	3,280	35,401	.....	6,000
67	Marion silt loam .....	1,588	1,520	16,690	.....	8,000
211	Edina silt loam .....	1,778	3,440	42,835	.....	3,000
80	Clinton silt loam .....	1,670	2,160	19,189	.....	8,000
115	Grundy silty clay loam....	2,128	6,480	83,300	.....	.....
TERRACE SOILS						
42	Calhoun silt loam .....	2,316	2,460	37,306	.....	3,000
88	Bremer silt loam .....	2,694	4,480	55,705	.....	1,000
60	Waukesha loam .....	1,992	4,240	60,602	.....	4,000
SWAMP AND BOTTOMLAND SOILS						
48	Wabash silty clay loam....	3,016	6,080	70,995	.....	4,000
26	Wabash silt loam .....	3,314	7,200	78,839	.....	2,000
49	Wabash loam .....	2,262	4,800	62,721	.....	4,000
RESIDUAL SOILS						
212	Crawford loam .....	1,992	4,000	67,573	.....	.....

TABLE VI. PLANT FOOD IN APPANOOSE COUNTY, IOWA, SOILS  
Pounds per acre of 6 million pounds of subsoil (20"-40")

Soil No.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
DRIFT SOILS						
79	Shelby loam .....	2,745	6,240	40,860	.....	4,000
65	Lindley loam .....	1,535	2,400	25,035	.....	8,000
LOESS SOILS						
64	Grundy silt loam .....	2,530	4,120	48,152	.....	3,000
66	Putnam silt loam .....	2,343	4,560	52,811	.....	6,000
67	Marion silt loam .....	2,826	2,880	33,354	.....	8,000
211	Edina silt loam .....	2,424	4,440	49,347	.....	4,000
80	Clinton silt loam .....	2,949	1,920	28,471	.....	8,000
115	Grundy silty clay loam....	2,667	3,360	54,855	.....	.....
TERRACE SOILS						
42	Calhoun silt loam .....	3,594	3,240	33,027	.....	4,000
88	Bremer silt loam .....	3,069	5,760	53,916	.....	2,000
60	Waukesha loam .....	2,100	4,560	50,492	.....	3,000
SWAMP AND BOTTOMLAND SOILS						
48	Wabash silty clay loam..	3,999	8,040	100,620	.....	4,000
26	Wabash silt loam .....	3,717	6,240	65,721	.....	1,000
49	Wabash loam .....	2,625	3,360	58,896	.....	4,000
RESIDUAL SOILS						
212	Crawford loam .....	No sample				

of the Crawford loam which is a residual soil resting on limestone. All the types which show an acid reaction in the surface soil are therefore in need of applications of lime for the best crop growth. It is highly important that all the soils of this county, except the Crawford loam on the residual uplands, be tested for lime needs and that lime be applied regularly in the rotation if the best legume crops are to be grown and if the most satisfactory yields of general farm crops are to be secured.

#### GREENHOUSE EXPERIMENTS

Two greenhouse experiments were carried out on soils from Appanoose County in an attempt to learn something of the needs of the soils and to secure indications of the value of various fertilizing materials. These experiments were carried out on the Shelby loam and the Marion silt loam, two of the more important soil types in the county. In addition to these experiments, the results secured in the greenhouse tests on the Grundy silt loam from Jefferson County, the Grundy silt loam from Clarke County, the Clinton silt loam from Wapello County, the Shelby loam from Clarke County, the Marion silt loam from Henry County and the Grundy silty clay loam from Henry County are included, as these soil types are the same as those occurring in Appanoose County and the results secured indicate rather definitely what may be expected of the same soil types in this county.

The treatments used in all these experiments included manure, lime, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. These materials were applied in the same amounts in which they are

used in the field and the results of the greenhouse tests are definitely indicative of what may be expected in the field.

Manure was applied at the rate of 10 tons per acre, lime was added in sufficient amounts to neutralize the acidity of the soil, rock phosphate was applied at the rate of 2,000 pounds per acre, superphosphate at the rate of 200 pounds per acre, the standard 2-8-2 or 2-12-2 complete commercial fertilizer at the rate of 300 or 267 pounds per acre and muriate of potash at the rate of 25 pounds per acre. Wheat and clover were grown in all the experiments, the clover being sown after the wheat had been up about a month. In some of the tests only the wheat yields are given, the yield of clover not being secured.

#### RESULTS ON THE SHELBY LOAM

The results secured on the Shelby loam from Appanoose County are given in table VII. The application of superphosphate increased the yield of wheat quite appreciably and brought about an enormous increase in the yield of clover. Lime with the superphosphate gave a further increase in wheat but showed only a slight effect on the clover. The application of manure gave about the same crop yield as that secured under the treatment of limestone and superphosphate in the case of the wheat, but the manure gave a larger crop yield than did the superphosphate and lime in the case of the clover. The addition of the superphosphate with manure increased the yield of wheat and brought about a very appreciable increase in the yield of clover. Lime with the manure and superphosphate showed a further increase in the yield of wheat but had very little effect on the clover. Muriate of potash with the manure, lime and superphosphate showed an increase in the yield of wheat but had little effect on the clover.

These results indicate that this soil type will respond very profitably to applications of manure, and liberal applications of this material should be made. The type is acid in reaction, and additions of lime are very necessary and will bring about increases, not only in the yields of legume crops but also in the grain crops of the rotation as well. The use of a phosphate fertilizer is very desirable on this soil, and tests of superphosphate and rock phosphate should be carried on under field conditions. The superphosphate gave very profitable



Fig. 3. Clover in greenhouse experiment on Shelby loam, Appanoose County.

TABLE VII. GREENHOUSE EXPERIMENT, SHELBY LOAM, APPANOOSE COUNTY

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

returns in this experiment, but rock phosphate might prove quite as profitable when used in the field. The use of muriate of potash may be desirable in some cases on this soil, but tests under individual soil conditions should be carried out before extensive applications are made.

#### RESULTS ON THE MARION SILT LOAM

The data secured in the experiment on the Marion silt loam from Appanoose County are given in table VIII. The superphosphate brought about an increase in the yield of wheat and clover in this experiment. Lime with the superphosphate increased the yields still further, bringing about a very large increase in the case of the clover. The manure alone increased the wheat yields but to a less extent than did the superphosphate and lime, but it brought about a much larger increase in the clover than did the lime and superphosphate. Superphosphate with the manure greatly increased the wheat yield and brought about a pronounced increase in the yield of clover. Lime with the manure and superphosphate showed no effect in the case of the wheat but brought about a large increase on the yield of clover. Muriate of potash with the manure, lime and superphosphate showed an increased yield of wheat and brought about a very pronounced increase in the yield of clover.

These results indicate that the Marion silt loam will respond in a very large way to applications of manure, lime and a phosphate fertilizer. The addition of manure is particularly necessary on this soil type which is low in organic matter. The type is acid in reaction, and additions of lime are very necessary for the best growth of general farm crops and particularly of legumes. Large increases in the yields of legume crops will follow its use. The application of a phosphate fertilizer is certainly very desirable, and tests of superphosphate on this soil under field conditions are recommended. Large increases in the yields of general farm crops will undoubtedly follow its application. The use of muriate of potash may be of profit on this soil but tests should be carried out under individual conditions before this material is applied to any extensive areas.

#### RESULTS ON GRUNDY SILT LOAM FROM JEFFERSON COUNTY

The results secured in the greenhouse experiment on the Grundy silt loam from Jefferson County are given in table IX. The application of manure increased the yield of wheat in this experiment in a very pronounced way, and a considerable gain in the clover was also noted. Lime with manure showed no effect on the wheat but brought about an increase in the yield of clover. The application of rock phosphate with the manure and lime increased the yield

TABLE VIII. GREENHOUSE EXPERIMENT, MARION SILT LOAM, APPANOOSE COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check .....	2.0	9.0
2	Superphosphate .....	4.4	13.1
3	Lime+superphosphate .....	6.0	19.8
4	Manure .....	4.9	24.3
5	Manure+superphosphate .....	8.6	29.0
6	Manure+lime+superphosphate .....	7.7	37.4
7	Manure+lime+superphosphate+potassium .....	8.3	42.3

of wheat and showed a gain also in the case of the clover. The superphosphate with the manure and lime increased the yield of wheat to a much greater extent than did the rock phosphate, and it brought about a much larger increase in the clover. The complete commercial fertilizer showed about the same effect as the superphosphate in the case of the wheat and had a slightly smaller effect on the clover.

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

RESULTS ON GRUNDY SILT LOAM FROM CLARKE COUNTY

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

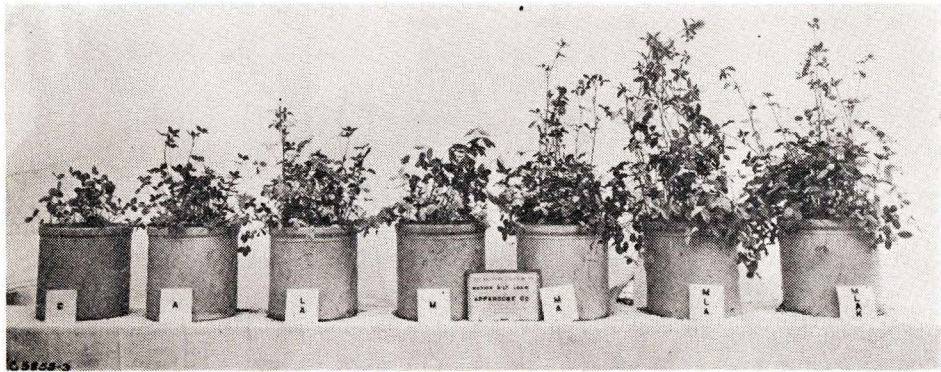


Fig. 4. Clover on Marion silt loam, Appanoose County.

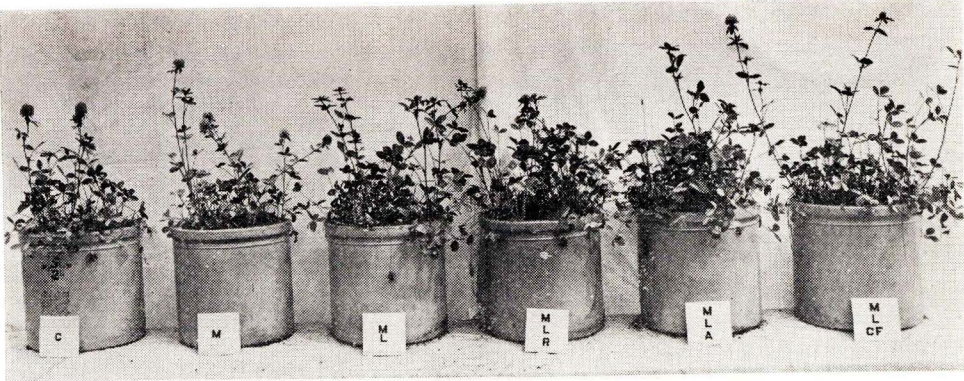


Fig. 5. Clover on Grundy silt loam, Jefferson County.

effects than the superphosphate and lime. The addition of superphosphate with manure gave a further increase in the yield of wheat but showed no effect on the clover. The application of limestone with the superphosphate and manure gave a very large increase in the yield of wheat and showed a very pronounced effect on the yield of clover. The addition of potassium with the superphosphate, manure and limestone, the application being made in the form of muriate of potash, showed no effect on the wheat but brought about a considerable increase in the clover yields.

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

RESULTS ON THE CLINTON SILT LOAM FROM WAPELLO COUNTY

The results secured on the Clinton silt loam from Wapello County are given

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

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

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

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

in table XI. Manure brought about a distinct influence on both the wheat and clover crops. The application of lime with the manure gave an increase in the wheat. Owing to abnormal conditions the yield of the clover crop was not secured. The rock phosphate showed a small effect on the wheat and on the clover. The superphosphate gave a distinct increase in both the wheat and clover yields. The complete commercial fertilizer increased the wheat yields somewhat less than the superphosphate, but the opposite was true with the clover. With the clover the commercial fertilizer showed the largest effect of any of the materials employed.

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

#### RESULTS ON THE SHELBY LOAM FROM CLARKE COUNTY

The data secured in the greenhouse experiment on the Shelby loam from Clarke County are given in table XII, only the yields of wheat being recorded. The application of superphosphate increased the wheat yields considerably. Lime with the superphosphate had no further effect on the wheat. Manure alone brought about a much larger increase than that occasioned by the lime and superphosphate. The addition of superphosphate with manure showed practically no effect on the yield of wheat. The further addition of limestone with



Fig. 6. Clover in greenhouse experiment on Clinton silt loam, Wapello County.



Fig. 7. Wheat on Clinton silt loam, Wapello County.

the manure and phosphate had no effect, while the inclusion of the muriate of potash with the treatment showed little effect on the crop yield.

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

#### FIELD EXPERIMENTS

There are no field experiments under way in Appanoose County, but experiments have been under way for a number of years in other counties in the same soil area on soils which are the same as those occurring in Appanoose County. Hence, the results which have been secured may be considered applicable to this county. The results secured on the Grundy silt loam on the Agency Field in Wapello County; on the Grundy silt loam on the Mount Pleasant Field, Series 100, in Henry County; on the same soil type on the Mount Pleasant Field, Series 200, in Henry County; on the Marion silt loam on the West Point Field No. 2, Series I, in Lee County; and on the Clinton silt loam on the Princeton Field in Scott County are given here.

These field experiments are carried out to determine the value of certain fertilizer treatments. They are laid out on land which is thoroly representative

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

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

of the particular soil type. The fields include 13 plots 155' 7" x 28' or one-tenth of an acre in size. They are permanently located by the installation of corner stakes, and all precautions are taken in the application of fertilizers and in the harvesting of the crops to secure accurate results.

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

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

## THE AGENCY FIELD

The data secured in the field experiment on the Grundy silt loam on the Agency Field in Wapello County are given in table XIII. The beneficial effects of manure on this soil are evidenced by the increases in crop yields which were secured in practically all seasons. The largest increases were shown in the oats

TABLE XII. GREENHOUSE EXPERIMENT, SHELBY LOAM, CLARKE COUNTY

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

in 1919, in the hay in 1921 and 1922, in the oats in 1925 and in the clover in 1927. The use of lime with the manure brought about crop increases in practically all seasons. The beneficial effects of the lime were particularly evident on the hay crop, but large increases were also shown on the corn and oats.

The rock phosphate with the manure and lime increased the crop yields in every season; in some cases very large effects being noted. The hay crop was particularly benefited by the rock phosphate and considerable increases were secured on the oats in 1919, on the corn in 1923 and on the wheat in 1926. The superphosphate showed larger effects than the rock phosphate in practically all seasons. There were no strikingly large differences, however, except in the case of the hay crop in 1922. In 1921 and 1923 the rock phosphate gave a slightly larger effect on the corn and in 1925 on the oats. The complete commercial fertilizer generally showed somewhat smaller effects than the superphosphate. Only on the hay crop in 1921 and on the clover in 1927 was there any greater effect from the complete fertilizer. In some cases the rock phosphate gave larger increases than did the complete fertilizer.

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

The application of rock phosphate gave increases in crop yields in practically every season. In some instances the increases were very distinct as on the hay crop in 1921, 1922 and 1927, and on the wheat in 1926. The superphosphate showed larger effects than the rock phosphate in several seasons. It had a smaller effect than the rock phosphate, however, on the clover in 1921, on the oats in 1925 and practically the same effect on the oats in 1919 and on the wheat in 1920. The complete commercial fertilizer gave very similar increases to those brought about by the superphosphate. Only in one case was there a striking difference. On the corn in 1923 the complete fertilizer showed no effect.

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

## THE MOUNT PLEASANT FIELD

The results secured on the Grundy silt loam on the Mount Pleasant Field, Series 100, in Henry County are given in table XIV. The application of manure



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

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

(1) Corn damaged slightly by hail in July and dry weather in August.

(2) Sample No. 7 lost in transit; wheat badly down. Light dressing of manure to all plots by mistake in winter of 1920. Lime applied in November.

(3) Pastured after first crop.

(4) Pastured after first crop.

(5) Wet weather prevented seeding of plots 11, 12 and 13.

(6) Mostly timothy.

has proved of value on this soil, as is indicated by the increased crop yields secured in most seasons. The beneficial effects of the manure appeared particularly on the corn in 1920 and on the oats in 1926. Small increases were secured on these crops in other seasons. The application of lime along with the manure brought about crop increases which were very large in some years. The corn in 1917 and 1920 showed very large increases due to the use of lime. The oats in 1922 showed a very large effect from the lime. Small increases were secured in practically all seasons from the use of lime on this soil.

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

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

The results secured on the Grundy silt loam on the Mount Pleasant Field, Series 200, are given in table XV. Here again the beneficial effects of manure were evident in the increased crop yields secured in every season. Large increases were noted on the oats in 1921, on the clover in 1926 and on the corn in 1927. The application of lime along with the manure increased the crop

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

Plot No.	Treatment	(1) 1916 Corn bu. per A.	(2) 1917 Corn bu. per A.	1918 Oats bu. per A.	1919 Clover tons per acre			(3) 1920 Corn bu. per A.	(4) 1921 Corn bu. per A.	(5) 1922 Oats bu. per A.	(6) 1923 Soybeans	1924 Corn bu. per A.	1925 Corn bu. per A.	(7) 1926 Oats bu. per A.	(8) 1927 Clover tons per A.
					First crop	Second crop	Total								
1	Check	27.4	36.0	72.3	2.22	1.65	3.87	34.5	54.3	35.9	.....	50.7	41.2	20.5	0.05
2	Manure	22.2	37.5	75.1	2.29	1.50	3.79	57.0	56.7	39.8	.....	54.0	35.9	30.4	0.40
3	Manure+lime	15.3	55.2	74.8	2.34	1.65	3.99	76.6	59.5	62.1	.....	58.7	40.6	35.9	0.64
4	Manure+lime+ rock phosphate	40.4	66.0	76.5	2.78	2.15	4.93	81.8	67.5	63.3	.....	66.0	50.6	47.3	1.46
5	Manure+lime+ superphosphate	55.9	73.6	85.1	3.72	2.75	6.47	77.7	72.8	70.1	.....	60.7	64.4	66.4	1.56
6	Manure+lime+ complete commercial fertilizer	54.1	76.8	80.8	3.68	3.25	6.93	67.5	64.9	70.6	.....	62.0	63.7	70.9	1.31
7	Check	47.9	60.1	76.5	2.20	2.20	4.40	65.6	60.7	56.1	.....	54.0	54.1	40.2	0.51
8	Crop residues	41.7	50.8	81.3	2.30	.....	.....	67.5	65.7	54.5	.....	52.0	55.0	40.6	0.80
9	Crop residues+ lime	30.3	47.1	93.2	2.22	.....	.....	80.6	66.1	49.0	.....	55.3	56.2	39.9	0.67
10	Crop residues+ lime+rock phos- phate	30.4	52.7	96.4	2.85	.....	.....	90.0	65.0	57.9	.....	57.7	56.5	38.8	1.09
11	Crop residues+ lime+super- phosphate	30.6	54.7	99.9	3.21	.....	.....	75.5	66.9	54.8	.....	59.3	57.2	48.4	1.43
12	Crop residues+ lime+complete commercial fer- tilizer	27.0	52.8	93.6	3.15	.....	.....	51.2	67.1	61.9	.....	59.7	58.1	47.3	1.28
13	Check	21.1	48.3	72.3	2.18	2.00	4.18	45.0	59.1	42.3	.....	50.0	52.8	30.6	0.35

(1) Season wet, corn weedy but of good quality.

(2) Short season, early frost.

(3) Cattle trampled plot 1.

(4) Corn not uniform.

(5) Three tons lime applied, oats thin and down. Smartweed bad in plots 11 and 12.

(6) No record on account of weeds.

(7) Low yield due to very dry season and considerable rust.

(8) Very poor stand on check plots.

TABLE XV. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY, MT. PLEASANT FIELD, SERIES 200

Plot No.	Treatment	1919 Corn bu. per A.	1920 Corn bu. per A.	(1) 1921 Oats bu. per A.	(2) 1922 Clover tons per A.	1923 Corn bu. per A.	1924 Corn bu. per A.	1925 Oats bu. per A.	(3) 1926 Clover tons per A.	1927 Corn bu. per A.
1	Check .....	55.7	48.1	36.9	1.6	61.3	49.3	50.9	0.10	33.8
2	Manure .....	66.3	51.2	46.9	1.9	77.3	58.0	55.0	0.60	44.4
3	Manure+lime .....	74.1	69.8	35.3	2.1	85.0	72.7	50.9	1.05	60.0
4	Manure+lime+rock phosphate .....	78.6	66.4	42.6	2.4	84.5	70.4	65.9	1.31	76.9
5	Manure+lime+super- phosphate .....	75.3	77.2	48.9	2.4	77.6	73.3	64.8	1.43	76.6
6	Manure+lime+complete commercial fertilizer .....	66.5	81.2	46.5	2.7	80.0	65.7	60.4	1.15	65.0
7	Check .....	50.6	64.0	33.7	2.1	58.3	44.3	47.1	0.52	40.6
8	Crop residues .....	65.3	75.5	43.1	2.3	64.6	35.3	47.6	0.52	47.5
9	Crop residues+lime .....	71.0	76.3	40.0	2.6	73.3	34.7	56.1	0.76	67.5
10	Crop residues+lime+ rock phosphate .....	75.1	75.1	43.8	2.5	69.0	38.0	52.5	0.86	59.7
11	Crop residues+lime+ superphosphate .....	81.1	85.1	43.5	2.5	68.0	40.7	63.2	0.96	53.8
12	Crop residues+lime+ com- plete commercial fertilizer .....	78.5	90.1	42.2	2.6	74.3	41.3	60.4	0.99	47.2
13	Check .....	65.8	64.1	31.1	1.7	60.3	39.3	43.8	0.39	33.1

(1) Three tons lime applied, oats lodged in spots.

(2) Two crops on all but crop residue plots.

(3) Plots 7 to 13 were partly burned off in April. Check plots badly infested with weeds.

yields in nearly all seasons. In some cases considerable increases were secured as for example on the corn in 1920 and 1924, on the clover in 1926, and on the corn in 1927.

The use of rock phosphate with the manure and lime gave increases in some seasons, showing up particularly well on the oats in 1921 and 1925, on the clover in 1922 and 1926, and on the corn in 1927. In general the effects were less evident and in some seasons were not shown at all on the corn. The superphosphate showed a greater effect than the rock phosphate in some seasons, especially on the corn in 1920, on the oats in 1921 and on the clover in 1926. In other seasons the effects were slightly less or similar to those brought about by the rock phosphate. The complete commercial fertilizer had larger effects than the superphosphate in one or two cases, notably on the corn in 1920 and on the clover in 1922. In most of the other seasons, however, the effects were less evident than those brought about by the superphosphate.

The influence of crop residues on crop growth was not great. The use of lime along with the crop residues showed beneficial effects on most of the crops. The clover in 1922 and 1926, was definitely increased. The corn was increased in 1923 and the oats in 1925 and the corn in 1927 showed a large effect from the use of lime. In other seasons the effects of the lime were small and not definite.

The use of rock phosphate proved of value on practically all of the crops grown. In some cases the increases were not large, and in one or two instances no increases at all were secured. The superphosphate showed larger effects than the rock phosphate in practically all seasons. The influence was much greater on the corn in 1920, on the oats in 1925 and on the clover in 1926. In the other

seasons the effects were about the same, or slightly less than those brought about by the rock phosphate. The complete commercial fertilizer showed a larger effect than the superphosphate in one or two cases but in general the differences were small and there was no evidence of a superiority of the commercial fertilizer over the superphosphate.

The results secured in the two experiments on the Mount Pleasant Field on the Grundy silt loam, confirm those secured on the same soil type on the Agency Field. They show definitely the beneficial effect of applications of manure to this soil and the large increases in yields of general farm crops which may be secured from the application of this fertilizer. The value of lime is definitely indicated in these results, and the desirability of testing the soil and applying the lime which is shown to be necessary according to the test is evident. A phosphate fertilizer is strongly recommended for this soil. In some cases the superphosphate proves more profitable, while in other instances the rock phosphate seemed to give quite as large effects. Tests of both materials under individual farm conditions are urged. The use of the complete commercial fertilizer did not seem to be any more effective than the use of superphosphate, hence, it would be less desirable for use.

THE WEST POINT FIELD NO. 2

The results secured on the Marion silt loam on the West Point Field No. 2, Series I, in Lee County are given in table XVI. The application of manure to this soil type usually brought about striking increases. In 1922 the yield of clover and timothy was more than doubled. In several cases the yields of

TABLE XVI. FIELD EXPERIMENT, MARION SILT LOAM, LEE COUNTY, WEST POINT FIELD, NO. II, SERIES I

Plot No.	Treatment	(1) 1918 Oats bu. per A.	1919 Clover tons per A.	(2) 1920 Corn bu. per A.	(3) 1921 Oats bu. per A.	(4) 1922 Clover and Timothy tons per A.	1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Clover tons per A.	1926 Corn bu. per A.	1927 Corn bu. per A.
1	Check .....	46.7	1.45	24.5	27.7	1.20	43.4	38.8	1.08	37.3	Corn cut for fodder
2	Manure .....	55.2	1.59	43.0	28.7	2.70	62.6	66.4	1.57	56.0	
3	Manure+lime .....	55.2	1.87	37.2	28.7	2.80	62.4	66.8	1.73	60.2	
4	Manure+lime+rock phosphate .....	51.3	1.91	45.5	38.4	3.00	68.5	66.4	1.92	53.1	
5	Manure+lime+super- phosphate .....	55.2	2.60	41.5	42.9	3.60	69.3	76.6	2.03	52.9	
6	Manure+lime+complete commercial fertilizer .....	55.2	2.85	46.5	46.6	3.60	69.8	86.4	2.01	58.6	
7	Check .....	38.2	1.63	33.5	32.5	1.60	49.6	40.3	1.02	41.1	
8	Crop residues .....	34.0	1.50	27.0	27.4	1.70	46.9	41.0	1.26	36.2	
9	Crop residues+lime .....	38.2	1.55	30.5	30.2	1.90	48.0	41.0	1.35	30.4	
10	Crop residues+lime+ rock phosphate .....	36.1	2.07	32.0	35.0	2.60	48.5	54.4	1.41	25.6	
11	Crop residues+lime+ superphosphate .....	38.2	2.68	30.5	24.4	3.20	54.9	56.9	1.45	28.5	
12	Crop residues+lime+ com- plete commercial fertilizer .....	51.3	2.73	27.0	42.3	2.90	56.4	53.0	1.72	38.4	
13	Check .....	34.0	1.65	25.5	27.4	2.40	51.7	35.2	1.20	36.8	

(1) Four tons lime, November, 1917.

(2) Wet spring made crop poor.

(3) Three tons lime September. Plots 3 and 11 low yields due to injury to samples.

(4) Stand of clover irregular.

oats were almost doubled and in one or two instances this was true with the corn. On all the crops the very beneficial effect of manure was evident. The use of lime with manure brought about small but definite increases in the crops in practically all seasons. The application of rock phosphate with the manure and lime brought about increases in crop yields in practically all cases. Sometimes very considerable increases were secured, as in the case of the clover and timothy in 1922, the clover in 1925, the corn in 1920 and the oats in 1921. In most other seasons increases were secured. The crop was poor and irregular in 1926, hence the yields in that season should not be considered of significance. Superphosphate with manure and lime brought about much larger increases than the rock phosphate in several cases. The larger beneficial effects were evidenced on the clover in 1919, on the clover and timothy in 1922, on the oats in 1924 and on the clover in 1925. In most of the other seasons there was a slightly larger effect from the superphosphate. The complete commercial fertilizer gave a somewhat greater effect than the superphosphate in one or two cases, but the differences, with the exception of the oats in 1924, were not large enough to be of great significance. Generally the increases were very similar to those brought about by the superphosphate.

Very little influence of the crop residues was evident on the different crops grown on this soil. Only in the case of the clover in 1925 was there any significant evidence of a beneficial effect. The use of lime with the crop residues increased the crop yields in practically every season; in some cases very considerable increases being secured. The application of rock phosphate with the crop residues and lime gave considerable increases in the yield of clover in 1919, in the clover and timothy in 1922 and in the oats in 1924. In several other seasons definite increases in yields were secured. The superphosphate brought about much greater results than the rock phosphate on the clover in 1919 and on the clover and timothy in 1922. In several other seasons larger effects from rock phosphate were evidenced but only in one case was the yield lower with the superphosphate, which was due to an injury to the samples of oats taken on the plot. The complete commercial fertilizer showed somewhat larger effects than the superphosphate in several seasons. The oats in 1918, the clover in 1925 and the corn in 1926 were increased considerably more by the complete fertilizer than by the superphosphate, but in three or four seasons the superphosphate proved somewhat superior.

These results indicate that the Marion silt loam will respond in a very profitable way to applications of manure, lime and a phosphate fertilizer. The addition of liberal amounts of manure to this type, which is light in color and low in organic matter, is very desirable for the best growth of crops.

Large increases in yields of general farm crops will follow the use of manure on this soil. Where manure is not available in sufficient amounts, leguminous green manures should be employed and would certainly bring about profitable crop increases. The application of lime is necessary, as the soil is acid. Lime will bring about very favorable results on the legumes and generally on other farm crops of the rotation. Rock phosphate and superphosphate both brought about crop increases, the superphosphate seeming to be somewhat superior in most cases. The complete commercial fertilizer at times gave somewhat larger

effects than the superphosphate, particularly with the crop residues and lime under the grain system of farming. With manure and lime, the superphosphate seems preferable because it brought about quite as large increases and it is less expensive to apply.

#### THE PRINCETON FIELD

The results secured on the Clinton silt loam on the Princeton Field, Series I, in Scott County are given in table XVII. The application of manure increased the crop yields on this soil in nearly every season. In some cases very considerable increases were secured, as for example on the wheat in 1925, on the corn in 1923 and 1927 and on the clover in 1922 and 1926. The use of lime with manure increased still further, the yields of crops on this soil. The beneficial effects were particularly evident on the clover in 1922 and 1926 and on the corn in 1927. Increases in the yields of wheat, oats and corn were also secured in practically every season. In some cases the effects on these same crops were surprisingly large. The addition of rock phosphate with the manure and lime increased the yields of crops in most seasons; the gains, however, were not generally large. The superphosphate with the manure and lime gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of the superphosphate were not any greater than those brought about by the rock phosphate. The oats in 1924 and the clover in 1926, showed the largest effects from the addition of superphosphate. The complete commercial fertilizer with the manure and lime gave somewhat greater effects than the super-

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

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

- (1) Three tons lime applied August, 1917. Yield on plot 8 an error.
- (2) Clover poor and plowed up.
- (3) Plot 11 many missing hills, low yields.
- (4) Yields on plots 13 and 14 lost due to error.
- (5) Stand of wheat very thin due to extreme dry spring.

phosphate in most seasons, but in other cases the beneficial influence was less and in no case was there any considerable gain from the use of the complete fertilizer over that brought about by the addition of superphosphate.

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

The rock phosphate with the crop residues and lime increased the crop yields in all but one season. In the case of the clover crop the increases were very distinct. On the other crops grown smaller increases were secured. The corn in 1927, however, showed a very large gain from the application. The largest beneficial effects of the lime were shown on the clover in 1922 and 1926 and on the corn in 1919, 1920, 1923 and 1927.

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

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

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

The laboratory, greenhouse and field tests which have been discussed indicate in a general way the fertilizer treatments desirable for use on the soils of this

county. Some general recommendations may, therefore, be given regarding the needs of the soils of the county and the treatments which might be expected to prove of value. The suggestions which are offered are based on the experiences of many farmers as well as on the results of the experimental work carried out on the main soil types occurring in this county and in other counties. No suggestions are offered, but such as have proved practical by experience and any of the treatments recommended may be put into effect on any of the soils of the county. In the case of certain abnormal soils where special treatments are required, specific recommendations will be made later in this report under the discussion of the individual soil types. The recommendations given here refer in general to the normal soils of the county.

#### **LIMING**

The tests which have been made of the soils of the county have shown that they are all acid in reaction and therefore, in need of lime. The figures given earlier in this report for the lime requirements of the soil types indicate only roughly the needs of the various soils. Soils vary widely in acidity and lime requirement and even soils of the same type from different fields will often show different needs for lime. Even average figures, then from a number of tests will not show absolutely accurately the lime needs of a soil type wherever it may occur. Only by testing the soil from each individual field will it be possible to determine accurately the needs of that soil. Only by such tests will it be possible to apply the proper amount of lime to the area. Farmers may test their own soils for acidity and lime requirement but it will usually be more satisfactory for them to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge.

Most satisfactory crop yields will not be secured on acid soils. While some crops will grow fairly well under acid conditions, in general the yields will not be as large as they should be, and in many cases the crop will prove poor and unprofitable. With legumes, such as sweet clover, alfalfa and red clover, an acid soil may cause a crop failure. It is very important, therefore, that lime be applied to acid soils if the yields of general farm crops and especially of legumes are to prove most satisfactory. In the experiments discussed earlier in this report, striking crop increases were secured from the applications of lime to some of the main soil types of the county. The beneficial effects were shown on the Grundy silt loam, the Shelby loam, the Marion silt loam and the Clinton silt loam. Increases in crop yields would also undoubtedly be obtained on the other soil types occurring in the county. The use of lime on the acid soils of this county has been shown by tests and by practical experience to be distinctly profitable, and farmers generally recognize the fact that they cannot hope to secure the best legume yields if they do not lime. Farmers are also coming to realize that the lime benefits the other crops grown in the rotation, often to a very large extent.

Not only is it necessary that all the soils of this county be tested for lime needs now, and that lime be applied as required, but such tests must be made at regular intervals in the future if the supply of lime is to be kept up and the soil is to be maintained in the best condition for crop growth. One test and one addition

of lime is not sufficient for all time. It is preferable that the soil be tested for acidity and lime needs just preceding the seeding of the legume of the rotation. The lime may then be applied where it will bring about the greatest effect and where it is most needed. The beneficial effects will not be restricted to the legume but will be evident on the succeeding grain crops also.

Further information regarding the use of lime on soils, losses of lime by leaching and other points connected with liming will be found in Extension Service Bulletin 105 of the Iowa Agricultural Extension Service.

### MANURING

Many of the soils in Appanoose County are not well supplied with organic matter, as is indicated by their light color and low fertility. On the more level to gently undulating upland soils where the color is darker the need for organic matter is not so evident, and crop yields on these darker colored soils are more satisfactory. On the Shelby loam and Lindley loam on the drift uplands, on the Edina, Marion and Clinton silt loams on the loessial uplands and on the Calhoun silt loam on the terraces there is special need at the present time for the addition of fertilizing materials supplying organic matter. On all the soils of the county, however, the application of organic matter will prove of value now and will be needed regularly if the supply is to be kept up.

The best and cheapest means of increasing and maintaining the supply of organic matter in soils is by the use of farm manure. On the livestock farm the manure produced should be carefully preserved and applied to the land. It has large value from the standpoint of its effect on crop yields. The increases which it will occasion in the yields of general farm crops when it is applied to the soils of Appanoose County, have been indicated by the data discussed earlier in this report. The Grundy silt loam, the Shelby loam, the Marion silt loam and the Clinton silt loam all showed a striking response from the application of manure. The other soil types would undoubtedly show just as large and in some cases even greater effects. The liberal application of farm manure to all the soils of the county is strongly recommended, and farmers should see to it that all the manure produced is carefully preserved and properly applied to the land regularly if they would secure the best crop yields and keep their land permanently productive.

The turning under of all crop residues is an aid in the maintaining of the supply of organic matter in the soil. On the livestock farm the residues may be used for feed or bedding and returned to the land with the manure. On the grain farm they may be stored and allowed to partially decompose before being applied, or they may be applied directly to the land. The use of crop residues is particularly necessary on the grain farm where little or no farm manure is produced, but it is also very desirable on the livestock farm.

The use of leguminous crops as green manures is a means of supplying organic matter to soils. On the grain farm it is the only practical means of increasing and keeping up the content of organic matter. Green manuring is also a desirable practice on many livestock farms to supplement farm manure. Often the production of farm manure is inadequate to supply the needs of all the soils on the farm and in such cases green manures are necessary. When leguminous crops are used as green manures they have a double value due to the fact that

when well inoculated, as they should be, they not only add organic matter to the soil but they also supply nitrogen which they have secured from the atmosphere. The practice of green manuring may be followed with profit on many of the soils of Appanoose County at the present time. On the lighter colored types the effects will be particularly large and where farm manure is not available for application the value of green manures will be the greatest. But the practice should not be followed carelessly or blindly, as undesirable results may occur if the green material does not decompose properly. Farmers in this county should keep up the supply of organic matter in their soils by the proper use of farm manure, green manures and crop residues.

### THE USE OF COMMERCIAL FERTILIZERS

The total content of phosphorus is rather low in most of the soils of Appanoose County, according to the analyses which have been given earlier. It is apparent, therefore, that the supply of this essential plant food is insufficient for the best crop growth for any long period of years. Phosphate fertilizers will certainly be needed in the very near future and may be of value in many cases at the present time. When the total content of an element becomes as low as is the phosphorus in the soils of this county, the supply of available plant food is sure to be very much reduced and the need of supplying the element in an available form thru the use of a fertilizer is evident. It has been shown earlier that the use of phosphate fertilizers may prove distinctly profitable on some of the soils of the county now.

Both rock phosphate and superphosphate have been used in the tests referred to above, and very similar increases have generally been secured. It is impossible at the present time, therefore, to say which phosphate will prove more profitable under the various soil conditions occurring in this county. In some cases the superphosphate proved superior but in other instances the rock phosphate was quite as effective. The superphosphate is more expensive than the rock phosphate but it is applied in smaller amounts. It provides the element phosphorus in an available form and hence has a much quicker effect on crop yields. This is particularly true on the lighter colored soils which are more poorly supplied with organic matter. On such types the use of superphosphate is particularly desirable. On the other hand rock phosphate costs less but must be applied in larger amounts, and the element phosphorus must be changed into an available form before it can have any effect. Rock phosphate will generally be slower in influence, and the beneficial effects may not appear until the second or third year after application. Frequently, however, on soils well supplied with organic matter the rock phosphate will bring about very profitable increases in the yields of general farm crops.

Farmers are urged to test both phosphates on their own soils and thus determine for their particular conditions which will prove more profitable. Simple tests may be readily carried out on any farm. Many farmers are conducting such tests on their farms at the present time and are securing results which are proving of value not only to themselves but also to other farmers who are located on the same soil types. Directions which may be followed in carrying

out such experiments are given in Circular 97 of the Iowa Agricultural Experiment Station.

A number of the lighter colored soil types occurring in Appanoose County are rather deficient in nitrogen and in need, therefore, of applications of some fertilizing material supplying nitrogen. None of the soils, however, are so well supplied that nitrogen may be overlooked when planning systems of permanent fertility. Nitrogen is constantly removed from soils by the growth of crops and by washing out in the drainage water, and hence the supply constantly diminishes. Even when there is sufficient present, therefore, to meet the needs of present crops, some means must be taken to return nitrogen constantly or the supply will soon become deficient. On all the soils of this county, then, fertilizing materials supplying nitrogen must be used regularly, and in some cases the application of such materials is very necessary now.

The cheapest and best means of increasing and maintaining the nitrogen content of soils is by the use of leguminous crops as green manures. When well inoculated, such crops take a large part of the nitrogen which they contain, from the atmosphere and hence when they are turned under in the soil there may be a large increase in the content of nitrogen. Green manuring is of double value on soils as organic matter is supplied as well as nitrogen. The practice is of particular value, therefore, on the light colored soils but is also worthwhile on the darker colored soils.

The proper use of farm manure will aid materially in maintaining the supply of nitrogen in soils and the utilization of crop residues will also prove of help in this connection. By these means and by the turning under of legumes as green manures, the nitrogen supply may be maintained without the use of expensive nitrogenous fertilizers. Commercial nitrogenous fertilizers cannot be recommended for general use in the county at the present time. They may be used in small amounts as top dressings for certain crops with profitable effects. For truck and garden crops the use of nitrogenous fertilizers may be of considerable value. They should not be used, however, for general farm crops until tests have been carried out on small areas and the value of the fertilizer has been definitely proved.

Many analyses which have been made of the soils of the state have shown that there is a large supply of potassium present and apparently commercial potassium fertilizers are not needed. If the production of available potassium is kept up, there should be sufficient of this element in the soils of this county to meet the needs of crops. The maintenance of proper soil conditions, such as good drainage and cultivation, abundance of organic matter, the presence of lime and plenty of other plant food constituents will ordinarily lead to the adequate production of available potassium to meet the needs of crops. The use of commercial potassium fertilizers cannot be recommended on the soils of this county at the present time for general farm crops. In small amounts as top dressings they may prove of value and occasionally may give returns with certain crops. Tests should always be carried out, however, on small areas before a potassium fertilizer is applied to any extensive area, in order that the actual profit from the application may be determined. For special crops, such as truck or garden crops, the use of a potassium fertilizer may be of large value.

Complete commercial fertilizers supply all three essential plant food constituents, nitrogen, phosphorus, and potassium. Their value on Iowa soils, however, probably lies mainly in their phosphorus content. There is an abundance of potassium in the soils, and nitrogen may be most cheaply supplied by the use of legumes as green manures. It would seem, therefore, that a phosphate fertilizer might be used more profitably. Complete fertilizers are much more expensive than superphosphate and hence they must bring about much larger increases in crop yields to prove as profitable for use. In the experiments which have been discussed earlier in this report, the complete commercial fertilizer used in the tests did not bring about any larger increases in crops than those occasioned by the superphosphate and hence did not give nearly as large economic returns. The general use of complete fertilizers on the soils of this county cannot be recommended, therefore, at the present time. Special brands which have been prepared for use with individual truck crops may prove profitable, but for general farm crops complete commercial fertilizers should not be used until they have been compared with superphosphate on small areas. If the complete fertilizer proves more profitable than the superphosphate, applications may then be made to extensive areas with the assurance of profit. There is no objection to the use of complete commercial fertilizers—it is merely a question of using that material which gives the best returns.

### DRAINAGE

The map given earlier in this report shows the rather extensive natural drainage system of the county. The major streams, tributaries and intermittent drainageways, extend into practically all parts of the county. There are some areas, however, in individual soil types where the drainage is not entirely adequate and in such areas the installation of tile would be very desirable. There are areas in the Grundy silt loam, the Marion silt loam and the Grundy silty clay loam on the loessial uplands where tiling would be of considerable value. In fact much of the Grundy silty clay loam is poorly drained and the first treatment needed by that type for it to be satisfactorily productive is the laying of tile. The Bremer and Calhoun soils on the terraces and the Wabash soils on the bottoms would also be benefited materially by drainage. These latter types, the Wabash, are also in need of protection from overflow, if they are to be made productive. When that is accomplished, then drainage may be brought about to advantage.

Whenever soils are too wet, satisfactory crop yields will not be secured regularly, and in wet seasons very poor crops will be obtained. The first treatment needed for such land is the installation of tile. The cost of tiling may be considerable, but the results secured always warrant the outlay. The addition of fertilizers or the use of any other treatments will be of little or no value on land which is too wet. Farm experience and many experiments have demonstrated the value of tiling wet land. Farmers should tile all poorly drained areas on their farms in order to secure the most satisfactory crop yields.

### THE ROTATION OF CROPS

The beneficial effects of following a crop rotation system are quite generally recognized. If one crop is grown continuously on an area a very rapid reduction

in the fertility of the land will take place, and the yields will grow smaller and smaller until finally the crop will become unprofitable. Even if crops which are of smaller money value are included in the rotation, the total value of all the crops grown over a period of years will be greater when a rotation is followed. This is due to the fact that the yields of crops are so quickly reduced under a continuous cropping system. Experiments have shown that it is much more profitable to follow a rotation. Farmers should not let the greater money value of some crop lead them into the practice of growing that crop continuously with the idea that they will be making more profit. Their soils will quickly lose fertility and the crop yields will rapidly decline.

No special rotation experiments have been carried out in Appanoose County, but a number of rotations are being used successfully in various parts of the state and from among these some one may be chosen which will fit in with almost any farm condition. Farmers in this county should see to it that a good rotation is adopted on their farms, since it is one of the fundamental practices necessary for the maintenance of fertility. From among the rotations suggested below, some one may be selected or some other rotation may be chosen and prove of value. Almost any rotation may serve, provided it contains a legume and the money crop.

#### 1. SIX-YEAR ROTATION

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

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

#### 2. FOUR OR FIVE-YEAR ROTATION

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

#### 3. FOUR-YEAR ROTATION WITH ALFALFA

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

#### 4. FOUR-YEAR ROTATIONS

*First year*—Wheat (with clover)  
*Second year*—Corn  
*Third year*—Oats (with clover)  
*Fourth year*—Clover

*First year*—Corn  
*Second year*—Wheat or oats (with clover)  
*Third year*—Clover  
*Fourth year*—Wheat (with clover)

*First year*—Wheat (with clover)  
*Second year*—Clover  
*Third year*—Corn  
*Fourth year*—Oats (with clover)

#### 5. THREE-YEAR ROTATIONS

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

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

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

#### THE PREVENTION OF EROSION

Erosion is the carrying away of the surface soil by the free movement of water over the surface of the land, known as sheet erosion, or the washing away of the soil with the formation of gullies, gulches or ravines.

Erosion occurs to some extent in the soils of Appanoose County. On the drift uplands the Shelby loam and the Lindley loam are much eroded. On the loess uplands the Clinton silt loam is badly washed in many areas. There are individual eroded areas in some of the other upland soil types. Wherever the destructive effects of erosion occur, some means of prevention and control of the action must be adopted.

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

Small gullies may be filled by the "staking in" operation, or by the use of straw dams, earth dams, Christopher or Dickey dams, Adams dams, stone dams, rubbish dams, woven wire dams or concrete dams. Gullies may be prevented by thoro drainage or by the use of sod strips. Large gullies may be controlled or prevented in a similar manner. Erosion in bottomlands is prevented by straightening the streams, by tiling and by planting trees up the drainage channels. Hillside erosion is controlled by the use of organic matter, by growing cover crops, by contour discing, by terracing, by deep plowing and by the use of sod strips.\*

#### INDIVIDUAL SOIL TYPES IN APPANOOSE COUNTY\*\*

There are 15 individual soil types in Appanoose County and these are divided into five groups: drift soils, loess soils, terrace soils, swamp and bottomland soils and residual soils.

#### DRIFT SOILS

The two drift soils in the county are classified in the Shelby and Lindley series. Together they cover 50.9 percent of the total area.

\* See Bulletin 183. Soil Erosion in Iowa. Iowa Agricultural Experiment Station and Extension Service Bulletins 93, 94, 95, 96, Agr. Extension Service, Iowa State College.

\*\* Descriptions given in this section of the report very closely follow those in the Bureau of Soils Report.

## SHELBY LOAM (79)

The Shelby loam is the largest individual soil type and the most extensively developed drift soil. It covers 40.1 percent of the total area. It is developed in all parts of the county on the slopes and ridges adjacent to the stream channels. It is found separating the more level to gently undulating upland areas of the Grundy silt loam, the Putnam silt loam and the Edina silt loam from the bottomlands and the intermittent drainageways. The most extensive areas of the type are found in the southern part of the county in the rougher, more hilly and eroded sections.

The surface soil of the Shelby loam to a depth of 4 to 8 inches is a dark grayish-brown finely granular friable loam containing some fine sand. The subsoil is a yellowish-brown granular silty clay loam. In some areas there is a layer separating the dark colored surface soil from the yellowish-brown subsoil which is somewhat lighter in color than the surface soil and gradually grades into the light colored subsoil. Below 18 to 24 inches the subsoil consists of a mixture of glacial drift made up of fragments of many kinds of rock, usually reddish-brown or yellowish-brown in color and spotted with red, brown or gray. The texture is a silty clay, but the subsoil contains considerable quantities of sand, gravel and boulders. Small pockets of sand and gravel occur here and there and boulders are frequently found thruout the soil and subsoil.

There are many variations in the texture of the surface soil. In some areas it consists of a mixture of silt loam, loam and sandy loam on the same hillside. At the tops of the hills the silt loam predominates. Farther down the slopes loams occur more frequently, and at the base of the slopes the texture is frequently a sandy loam. Small areas of the Shelby silt loam and Shelby sandy loam are included with the Shelby loam, inasmuch as they are too small to show on the map. On the cultivated slopes where erosion has been particularly active, much of the surface material has been completely washed away. The underlying yellowish-brown gritty clay is exposed, sometimes becoming a reddish-brown in color. At the base of the slopes the dark brown color of the soil sometimes continues to a depth of from 8 to 15 inches.

In topography the Shelby loam is strongly rolling to hilly. Drainage is good to excessive.

About one-half of the type is under cultivation, the remainder being utilized as hay and pasture land. In many of the ravines along the streams the tree growth consists of elm, hickory, oak, walnut, basswood and ash. Bluegrass and redtop grow well on this soil and furnish excellent feed. General farm crops grown include corn, small grain and hay. The yields of corn vary considerably. On the thinner areas the average yield is low and 30 bushels is a good yield. On the ridges and more gently rolling areas yields as high as 50 to 60 bushels per acre are secured. Oats yield from 15 to 25 bushels per acre. Some wheat is grown. Yields of hay range from one to two tons per acre, the hay consisting chiefly of clover and timothy mixed.

The Shelby loam is subject to serious erosion in many areas and the small grain crops and hay crops are grown more extensively than corn as there is less danger of erosion with these crops. Much of the land in Shelby loam should certainly not be cultivated, as it is too rough and erosion would be too extensive

for the land to be used for cultivated crops. Protection from erosion is the treatment most needed by practically all areas of the Shelby loam, and great care should be taken in selecting the crop to be grown and in planning a rotation of crops to be sure that the land is protected from erosion. Even on the more gently rolling areas sheet erosion may occur to a serious extent if proper precautions are not taken.

On the cultivated areas the needs of the Shelby loam to make it more productive include, first of all, the liberal incorporation of organic matter. Farm manure should be applied in large amounts, and beneficial effects on the yields of general farm crops will be secured thru its liberal application. If this material is not available for use, leguminous crops should be used as green manures in order to build up the content of organic matter and to make the soil better able to absorb moisture and less subject to erosion. The type is acid in reaction, and additions of lime are very necessary to bring about large increases in the yields of general farm crops. The application of a phosphate fertilizer is very desirable on this soil, and tests of superphosphate are recommended. In the experiments referred to earlier in this report evidence is given of the value of applications of farm manure, lime and superphosphate to this soil. It is apparent from these results that large increases in crop yields may be secured thru the utilization of these fertilizing materials.

## LINDLEY LOAM (65)

The Lindley loam is the second largest drift soil in the county and the third most extensively developed type. It is found in numerous areas in various parts of the county, being most extensively developed in Union Township in the north-eastern corner of the county along Soap Creek and North Soap Creek. There is also a rather extensive development of the type in the southern townships, particularly in Wells, Caldwell, and Pleasant Townships. Small areas of the type are developed in the central townships, along the Chariton River, Walnut Creek and Snort Creek.

The surface soil of the Lindley loam is a brownish-gray, loose, friable, shallow loam extending to a depth of 5 inches. Below this point there is a mixture of sand, gravel, small boulders and clay, yellowish-brown in color mottled with reddish-brown. This subsoil material extends to a depth of 20 to 28 inches. Below this point there is less sand and gravel present. Black and dark rusty iron concretions occur thruout the subsoil. In some places where the underlying drift has been exposed to weathering the subsoil is a reddish-brown in color.

There is considerable variation in the depth of the surface soil due to the erosion which has occurred. In some areas the surface covering has been completely removed, and the yellowish-brown subsoil has been exposed.

In topography the Lindley loam is rough to strongly rolling and broken, and the drainage is good to excessive.

The type is used principally for pasture and hay land. It supports a rather dense growth of trees such as oak, elm, hickory, walnut, butternut and basswood and an undergrowth of hazel brush, buck brush, hackberry scrub oak and thorn apple. Only a very small part of the type is used for the production of cultivated crops. On these areas general farm crops are grown; corn yielding from 20 to 40 bushels per acre, oats from 13 to 20 bushels and hay from one



to two tons. The steeper slopes should undoubtedly be left in grass and the land used for pasture. If cultivated, much of the Lindley loam would be seriously injured by erosion and the surface soil would be gradually removed. Only the more level areas should be cultivated. The type is, in general, best suited for pasture purposes.

When cultivated, the Lindley loam should receive liberal applications of farm manure to build up its organic matter content, or leguminous crops should be turned under as green manures. It is acid in reaction, and the application of lime is necessary for the best growth of leguminous crops. This soil is low in phosphorus content, and the use of a phosphorus fertilizer is desirable. Tests of superphosphate on this soil are strongly recommended. When used for pasture purposes, it is very important that precautions be taken to maintain a good pasture, and proper methods of handling of the pasture should be followed.\*

### LOESS SOILS

The 6 loess soils in the county are classified in the Grundy, Putnam, Marion, Edina and Clinton series. Together they cover 35.7 percent of the total area.

#### GRUNDY SILT LOAM (64)

The Grundy silt loam is the largest individual loess soil and the second most extensively developed type in the county. It covers 25.8 percent of the total area, and occurs in extensive areas on the more level to gently rolling upland in all parts of the county. The largest developments of the type are found, however, in the northern part of the county where large areas occur in Jones, Independence, Walnut, Chariton, Taylor, Douglas, Udell and Washington Townships. The type is also developed in the other townships to a smaller extent.

The surface soil of the Grundy silt loam is a very dark grayish-brown, friable silt loam extending to a depth of about 12 inches. It is mellow when dry but sticky and almost black when wet. In the lower part of the surface soil faint gray splotches appear. Between 12 and 17 inches the material is a silty clay loam slightly browner in color than the surface soil. From 17 to 25 inches the soil is a heavy clay, dark brown in color on the exterior of the particles but somewhat gray to yellow or brown in the interior. The coloring is evidently due to a coating of organic matter which has moved down from the surface soil. At the lower depths there is a small amount of this dark covering of organic matter on the particles and the soil material takes on a mottled appearance. There are numerous small dark iron concretions. The texture of this lower soil material is a heavy, plastic silty clay but it is somewhat lighter than the layer above. Below this subsoil material the slightly weathered substratum consists of a yellow silty clay loam. Iron stains and concretions give it a blotched appearance. Below 6 feet the texture becomes somewhat heavier and less silty and the color becomes a gray, or mottled with yellow or rusty brown.

Included with areas of the Grundy silt loam are small patches of the Putnam silt loam which are too small to show on the map. A number of these areas occur on the high interstream divide between the Chariton and Fox Rivers, north of Plano and northwest of Walnut City.

\* Circular 89, "The Pasture Problem in Iowa." Iowa Agricultural Experiment Station.

The Grundy silt loam occurs on the more level to gently rolling loessial upland in the northern part of the county and it covers many of the interstream areas entirely. In the southern part of the county the areas are smaller and occur as narrow strips between the areas of Shelby loam on the slopes and the Putnam silt loam on the flat or undulating divides.

Drainage conditions in the Grundy silt loam are somewhat variable. On the more level areas drainage is rather poor and artificial drainage is necessary. The heavy compact subsoil often retards the movement of moisture and makes the areas of the type poorly drained. On the more rolling areas drainage is adequate. Where the topography is more strongly rolling, some erosion has occurred.

Practically all of the Grundy silt loam is in cultivation, and general farm crops are grown. The average yield of corn is 40 bushels per acre, the yields ranging from 30 to 65 bushels. The yields of oats range from 15 to 35 bushels per acre, the yields of wheat from 12 to 25 bushels per acre and the yields of hay from 1 to 2½ tons per acre.

The Grundy silt loam will respond in a very large way to applications of farm manure, and liberal amounts of this material should be applied. Large increases in the yields of general farm crops may be secured by the use of this material. The turning under of leguminous crops as green manures would also be of value on this type. The soil is acid in reaction, and additions of lime are very necessary, especially for the best growth of legumes. It will also bring about considerable increases, however, in the yields of general farm crops. The addition of a phosphate fertilizer will also be of value on this soil, and tests of superphosphate and rock phosphate are recommended. The experiments which have been referred to earlier in this report have shown increases in crop yields from the use of both of these phosphates. Definite recommendations as to which phosphate should be employed cannot, therefore, be given. Farmers are urged to test both superphosphate and rock phosphate on their own soils under their particular farm conditions. Thus they may determine which material will prove more profitable for use.

The experiments which have been carried out on this soil, together with much farm experience, make it evident that the yields of general farm crops may be very materially increased thru proper methods of soil treatment. The drainage of the soil should be provided for, if it is not already adequate. The turning under of farm manure or leguminous green manures will be of value; the use of lime and a phosphate fertilizer may be depended upon to bring about large crop increases.

#### PUTNAM SILT LOAM (66)

The Putnam silt loam is the second largest loess soil and the fourth most extensively developed type. It is found on the loessial uplands in numerous areas in various parts of the county. The most extensive developments of the type occur, however, in Vermillion, Bellair, Pleasant and Caldwell Townships. It is also rather extensively developed in small areas in the other southwestern townships, and small areas occur in some of the northern and northeast central townships.

The surface soil of the Putnam silt loam is a dark grayish-brown smooth

friable silt loam extending to a depth of 4 to 8 inches. It is underlaid by a more compact ashy gray velvety or floury silt loam layer, usually about 8 inches thick but varying from 6 to 14 inches in thickness. On the more level areas of the type this light colored layer is usually deeper and more pronounced than on the slightly rolling areas. In places it lies within the plow depth and causes the white spots so common in areas of the type. Below this layer there is a yellowish-brown clay loam or clay mottled with gray and rusty brown. The subsoil is tough and compact in structure and contains iron concretions. At a depth of 30 or 40 inches the subsoil material grades into a mottled gray and yellow clay. It contains numerous iron stains and concretions in most places.

In topography the Putnam silt loam is slightly rolling. It is found on the uplands between the streams, usually associated with the Grundy silt loam. Drainage is generally poor on the type, and artificial drainage is necessary for the best crop yields.

Practically all of the Putnam silt loam is under cultivation and is utilized for the production of general farm crops. The yields of corn range from 30 to 55 bushels per acre, oats from 15 to 20 bushels per acre, wheat from 10 to 22 bushels per acre and hay from 1 to 2 tons per acre.

The first need of the Putnam silt loam to make it more productive is adequate drainage. When this has been accomplished, the soil will respond in a very large way to applications of farm manure. The turning under of liberal amounts of farm manure or the addition of leguminous crops as green manures would be of large value on this soil. The type is acid, and additions of lime are necessary to correct the acidity and provide the best conditions for the growth of legumes. The use of a phosphorus fertilizer is very desirable on this soil, and tests of superphosphate are strongly recommended.

#### MARION SILT LOAM (67)

The Marion silt loam is the third largest loess type in the county, covering 1.5 percent of the total area. It is found in a number of small areas, chiefly in the northeastern townships. The largest development of the type is in Union Township and in the northern part of Udell Township. It is found on the ridges between Soap Creek and North Soap Creek north of Unionville. It also occurs along the Chariton River south of Iconium, east of this river and north of the Douglas Township line and east of the river along the Ridge road in Sections 14, 15 and 16 of Wells Township. Narrow strips of the Clinton silt loam are included with this soil because of their small extent.

The surface soil of the Marion silt loam is a light grayish-brown or gray very fine floury silt loam, extending to a depth of 6 to 10 inches. Below this point is a very fine powdery compact silt loam material lighter in color than the surface soil and having the appearance of a distinct white subsurface layer. Iron stains and concretions occur in this layer. At depths varying from 15 to 20 inches the subsoil consists of a tough compact waxy clay, grayish-brown to brownish-yellow in color with rusty colored mottlings and iron concretions. In some areas where the soil has been washed away, especially on the narrow ridges and slopes, the glacial material is found within 3 feet of the surface soil.

In topography the Marion silt loam is smooth to undulating and drainage is fair to good. Originally the type was forested with oak, elm, hickory, birch

and an undergrowth of buck brush, hazel brush, scrub oak and thorn apple. It was a forested soil but has been entirely cleared and some fields have been under cultivation for many years. The entire acreage of Marion silt loam is now used for the production of general farm crops. Corn yields range from 25 to 40 bushels per acre, oats from 15 to 25 bushels per acre, wheat from 10 to 20 bushels per acre and hay from 1½ to 2½ tons per acre.

The yields of crops on the Marion silt loam may be materially increased thru proper methods of soil treatment. Normally the yields are rather low. The application of farm manure is very desirable on this soil as it is low in organic matter and particularly in need of some material supplying organic matter. Liberal applications of farm manure should be made to the type, and, if farm manure is not available for use, leguminous crops should be turned under as green manures. The soil will be increased in productivity materially thru the incorporation of organic matter. The type is acid in reaction, and additions of lime are very necessary for the best growth of legumes. Lime will also bring about increases in the yields of general farm crops. The addition of a phosphate fertilizer is very necessary on this soil and tests of superphosphate are strongly recommended. The experiments which have been referred to earlier in this report have indicated the large value from the application of farm manure, lime and phosphorus to this soil.

#### EDINA SILT LOAM (211)

The Edina silt loam is the fifth largest loess soil, covering 0.4 percent of the total area. It is found in a number of small areas, the principal ones occurring just east of Walnut City and east of Moulton. Other small bodies, some of which are included with the adjacent soils on the map, are found thruout the county within areas of the Grundy and Putnam soils on the more level upland plain.

The surface soil of the Edina silt loam is a very dark grayish-brown finely granular silt loam extending to a depth of 4 to 10 inches. Below this point there is a gray granular heavy silt loam layer from 4 to 8 inches in thickness. At a depth of about 20 inches the subsoil is a heavy clay which appears almost black and resembles the heavy subsoil of the Grundy soils. The particles are yellowish-brown, reddish-brown or rusty brown inside but are covered with a coating of brown or black. This dark coating of the particles disappears with depth and below 24 to 30 inches mottlings appear on the soil particles. The substratum at a depth of about 4 feet consists of a light grayish-brown or light olive brown friable silty clay loam. Streaks and spots of iron stains are common thruout this layer and in places thin beds of an iron accumulation are found. Included in the areas of the Edina silt loam are small areas of Putnam silt loam which could not be shown separately on the map.

In topography the Edina silt loam is level to slightly depressed. The natural drainage of the type is poor.

Practically all of the soil is under cultivation, and yields of general farm crops secured are very similar to those obtained on the Grundy and Putnam soils.

The type is in need, first of all, of adequate drainage to be made most satisfactorily productive. When drainage has been brought about the type will respond to liberal applications of farm manure. The turning under of leguminous crops as green manures will also be of value. The type is acid in reaction,

and additions of lime are very necessary for the best growth of legumes. Lime will also bring about considerable increases in the yields of general farm crops. The use of a phosphate fertilizer is very necessary on this soil, and tests of superphosphate are strongly recommended. The indications obtained from tests which have been carried out are that a phosphate fertilizer will prove very desirable when applied to this soil.

#### CLINTON SILT LOAM (80)

The Clinton silt loam is the fourth largest loess type, covering 0.6 percent of the total area. It is found in a number of small areas. The chief developments occur in Union Township north of Unionville, in Caldwell Township east of Exline and in Chariton Township north of Rathbun. Other small areas of the type are found. It occurs in association with the Marion soils, being usually developed between areas of the Marion silt loam on the ridges and the Lindley loam on the slopes. The area in Caldwell Township east of Exline is developed directly in association with the Lindley loam.

The surface soil of the Clinton silt loam is a grayish-brown or gray friable silt loam 4 to 6 inches in depth. The subsoil is a mottled yellowish-brown and gray, tough compact silty clay loam extending to a depth of 24 to 30 inches. This compact subsoil is underlaid by a more friable silty clay loam material which becomes more silty at the lower depths. Iron stains are present in many cases below 30 inches. In topography the Clinton silt loam is hilly to rough and drainage is good to excessive.

Most of the type is utilized for pasture and hay land. About 60 percent is forested with oak, elm, ash, birch, hickory and an underbrush of hazel brush, buck brush, gooseberry, wild rose and thorn apple. Only a small area of the type is cultivated. On this area general farm crops are grown.

When cultivated the chief need of the Clinton silt loam is for protection from erosion, as very serious damage is occasioned by erosion because of the rough and hilly topography of the type. It will respond to applications of farm manure and liberal amounts of this material should be applied in order to build up the organic matter content. The turning under of leguminous crops as green manures would also be of value on this soil. The type is acid and additions of lime would be of large value, especially for the growth of legumes. The application of a phosphate fertilizer would be worth while and tests of superphosphate are strongly recommended.

#### GRUNDY SILTY CLAY LOAM (115)

The Grundy silty clay loam is a minor type, covering only 0.1 percent of the total area. It is found only in a few very small areas. The two areas largest in size occur in Taylor Township southwest of Moravia. Other small areas are found in other parts of the county.

The surface soil of the Grundy silty clay loam is a black heavy silty clay loam sticky and tenacious when wet but breaking up into fine granules when dry. Below 8 inches the texture changes to a silty clay. The dark brown to black color persists to a depth of 12 to 18 inches. The color of the soil becomes lighter at the lower depths. At about 30 inches there is an abrupt change to a grayish-yellow, gray, or mottled gray and yellow silty clay loam or silty clay with many

iron concretions. This material gradually changes to the grayish-yellow silty clay loam of the parent loessial material.

In topography the Grundy silty clay loam is flat to depressed. Drainage is poor. When the areas are satisfactorily drained and the seasonal conditions are good, the yields of general farm crops are quite satisfactory. Corn yields will range from 50 to 70 bushels per acre, oats from 20 to 35 bushels per acre, wheat from 12 to 30 bushels per acre and hay from 1½ to 2 tons per acre.

The chief need of this soil to make it more productive is adequate drainage. When well drained, the type will respond to small applications of farm manure to stimulate the production of available plant food. Large applications of farm manure should not be made to this soil, as it is already high in organic matter content. The type is acid in reaction, and additions of lime are necessary for the best growth of legumes. This material will also bring about increases in the yields of other general farm crops. The addition of a phosphate fertilizer would be worth while on this soil, and tests of superphosphate and rock phosphate are recommended. The experiments which have been carried out on this soil have indicated large value from the use of both of these phosphates but have not permitted of a definite conclusion on the relative value of the two materials. Tests under individual farm conditions are therefore, recommended.

#### TERRACE SOILS

The three terrace soils in the county are classified under the Calhoun, Bremer and Waukesha series. Together they cover 1.1 percent of the total area.

#### CALHOUN SILT LOAM (48)

The Calhoun silt loam is the largest individual terrace soil covering 0.6 percent of the total area. It is found in numerous small areas in various parts of the county, being developed chiefly along the Chariton River. The largest development of the type is found along this river northeast of Centerville and in Independence Township north and west of Griffinsville. Small areas of the type are mapped along Walnut, Cooper and Shoal Creeks in the western part of the county and along Soap Creek and North Soap Creek in the northeastern corner.

The surface soil of the Calhoun silt loam is a grayish-brown or gray fine friable smooth silt loam 6 to 8 inches in depth, grading into a more compact light gray or white powderish silt loam mottled with rusty colored iron stains. At a depth of 18 or 22 inches the subsoil consists of a mottled gray, brown and rusty brown, compact, waxy, impervious clay loam or clay, containing many black iron concretions. There are variations in texture of the surface soil in different localities. On the south bank of the Chariton River north of Griffinsville are two small knolls on which the soil is a loamy sand and on the west side of the road the same terrace is a heavy silt loam somewhat darker in color than the typical Calhoun. A small terrace north of Numa along Cooper Creek has a very sandy texture but it is included with the Calhoun silt loam. Small patches of soil containing some very fine sand are commonly found in areas of the Calhoun silt loam.

The Calhoun silt loam occurs on terraces which vary from 8 to 20 feet above overflow, and, with the exception of the area north of Griffinsville which is rolling, the land is level and poorly drained.

Practically all of the Calhoun silt loam is under cultivation and devoted to the production of general farm crops. Corn is the chief crop grown and yields from 30 to 55 bushels per acre; oats yield from 20 to 30 bushels per acre. Clover and timothy hay do well, yielding from 1 to 2 tons of hay per acre.

The chief need of this soil to make it more productive is adequate drainage. When this has been accomplished the soil will respond to the addition of organic matter, and liberal applications of farm manure are recommended. The turning under of leguminous crops as green manures would also be of value. The type is acid in reaction, and additions of lime are very necessary for the best growth of legumes. The application of a phosphate fertilizer would undoubtedly be of value on this soil, and tests of superphosphate are recommended.

#### BREMER SILT LOAM (88)

The Bremer silt loam is a minor type, covering only 0.3 percent of the total area. It is found in the southern part of the county along the lower Chariton River; the most extensive areas being mapped along the edge of the river bottoms five miles east of Centerville and west of the river near Coal City and in the town of Dean. Several small areas are also shown on the map. In a number of cases the acreage was too small to show on the map, and these areas of the soil are included with the adjacent bottomland.

The surface soil of the Bremer silt loam is a dark brown to black heavy silt loam 10 to 18 inches in depth. Below this point there is a layer of a dark gray heavy compact impervious subsoil, mottled with brown and rusty brown and having iron concretions in the lower part. The land is level to slightly undulating in topography and this together with the impervious nature of the subsoil makes the drainage poor. Practically the entire acreage is devoted to the growing of corn, and very satisfactory crop yields are secured. Small grains tend to produce a rank growth of straw and little grain. The more poorly drained areas are utilized as hay lands.

The chief need of the Bremer silt loam to make it better and more satisfactorily productive is adequate drainage. When this has been accomplished, more satisfactory crop yields may be secured. The type is acid, and additions of lime will be necessary for the best growth of legumes. The application of a phosphate fertilizer would be desirable, and tests of rock phosphate and superphosphate are recommended.

#### WAUKESHA LOAM (60)

The Waukesha loam is a minor type, covering only 0.2 percent of the total area. It is found on the terraces along the Chariton River, lying well above overflow. The largest area of the type occurs south of the river in Sections 6 and 7 of Independence Township. Numerous small areas are mapped along both sides of the river thruout its course; the more extensive of these lying southeast of Sedan and west of Dean, within the first bottom plains and on small knolls rising from 5 to 8 feet above the surrounding land.

The surface soil of the Waukesha loam is a dark brown loose friable loam extending to a depth of 8 to 12 inches. The subsoil is a compact yellowish-brown loam or silt loam becoming somewhat lighter at the lower depths. At a depth of 36 inches the material is almost yellow, lighter textured and more friable.

In topography this type is level to undulating, but drainage is good. The greater part of the land is under cultivation, and general farm crops are grown. The yields of corn range from 40 to 60 bushels per acre and oats from 15 to 35 bushels per acre. Some hay is grown.

The type will respond to applications of farm manure when general farm crops are produced. Considerable increases in the yields of crops may be secured from the application of this fertilizing material. The type is acid and in need of lime to bring about increases in the yields of legumes and also benefit general farm crops grown on this soil. The application of a phosphate fertilizer would undoubtedly be of value, and tests of superphosphate and rock phosphate are recommended.

### SWAMP AND BOTTOMLAND SOILS

There are three swamp and bottomland soils in the county, classified in the Wabash series. Together they cover 12.2 percent of the total area of the county.

#### WABASH SILTY CLAY LOAM (48)

The Wabash silty clay loam is the second largest bottomland soil and the sixth most extensively developed type. It covers 4.2 percent of the total area. It occurs on wide bottomlands separating the terraces and the streams and in places these areas extend two or three miles in width. It is most extensively developed in the northwestern and southeastern townships along the Chariton River.

The surface soil of the Wabash silty clay loam is a dark brown to black sticky, plastic silty clay loam extending to a depth of 8 to 30 inches. The subsoil is a gray, compact, waxy, plastic and impervious clay mottled with brown and rusty brown. A few small areas of clay and clay loam too small to indicate on the map are included with this type and a lighter textured surface soil occurs near the streams.

In topography the soil is level to gently sloping, and drainage is poor, owing to the level topography and the impervious character of the soil and subsoil.

About 65 percent of the soil is under cultivation, the remainder supporting a growth of cottonwood, elm, maple, birch, swamp oak and hickory and being utilized as pasture land. Corn is the chief crop grown, yielding about 45 bushels per acre. The growing of corn is, however, entirely dependent upon seasonal conditions as frequently the entire crop is lost thru floods. Small grains are not grown successfully as they have a tendency to produce a rank growth of straw and very little grain. The low wet areas of the type are used for hay lands and many areas serve for pasture purposes. Considerable acreages of the soil have been reclaimed by the establishment of a deep drainage ditch which straightens the channel of the Chariton River from near Centerville to the southern boundary of the county.

The chief need of this soil to make it more satisfactorily productive is adequate drainage. After this has been accomplished very satisfactory crop yields may be secured. It is necessary, to insure crop yields on this type, that it be well protected from overflow. Thoro drainage will be of little value on the land unless protection from overflow is provided. After being protected from overflow and adequately drained, the soil will respond to additions of lime for the

best growth of leguminous crops, and the addition of a phosphate fertilizer would undoubtedly be of value. Tests of superphosphate and rock phosphate are strongly recommended.

#### WABASH SILT LOAM (26)

The Wabash silt loam is the third largest bottomland soil, covering 3.6 percent of the total area. It is developed on the bottomland along many of the streams in the county; the largest areas occurring on the higher flood plains along the Chariton River. Narrow strips, one-fourth to one-half mile in width are developed along the larger creeks of the county.

The surface soil of the Wabash silt loam is dark brown to almost black friable silt loam from 8 to 14 inches in depth. This is underlaid by a gray and brown or yellowish-brown clay loam or clay showing iron concretions and more or less stained with iron oxide.

There is a variation in the texture of the surface soil, and in some places there is a considerable proportion of very fine sand mixed with the silt. The transition from the Wabash silt loam to the Wabash loam is so gradual that it is often difficult to establish boundary lines between these types and occasionally they have been drawn rather arbitrarily. In topography the type is level to undulating, and drainage is fairly well developed.

Most of the Wabash silt loam is under cultivation. The very narrow strips mapped along the small streams are forested and are too small to be utilized for any purpose other than pasture. General farm crops are grown on the cultivated areas. Corn yields from 30 to 60 bushels per acre and oats from 30 to 35 bushels.

In many areas the drainage of the type is the first treatment needed to make it most satisfactorily productive, and in some areas it is also necessary that the type be protected from overflow. Small applications of farm manure would be of value in order to stimulate the production of available plant food in this type. The turning under of leguminous crops as green manure would also be of value on this soil. The type is acid and additions of lime are necessary for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly increase crop yields, and tests of superphosphate and rock phosphate are recommended.

#### WABASH LOAM (49)

The Wabash loam is the most extensively developed bottomland type, covering 4.4 percent of the total area. It occurs in narrow strips along the smaller streams and at the base of the slopes of the upland approaching the bottomlands along the Chariton River and others of the larger streams.

The surface soil of the Wabash loam is a dark brown loose friable mellow loam from 6 to 12 inches in depth. The upper part of the subsoil is a brown and gray silt loam more compact than the surface soil, containing a high percentage of very fine sand. The lower portion of the subsoil is a mottled gray and drab, compact heavy impervious clay.

Eighty percent of this narrow bottomland is covered with a forest growth and is used only for pasture purposes. On the cultivated areas corn yields range

from 25 to 50 bushels per acre, oats from 20 to 30 bushels and mixed timothy and clover hay from 1 to 2½ tons per acre.

The chief need of this soil is protection from overflow, if satisfactory yields of general farm crops are to be grown. Applications of farm manure would be of value in bringing about increases in crop yields, and the application of lime would undoubtedly prove of value, especially on the legume crops grown. The use of a phosphate fertilizer is recommended on this soil, and tests of superphosphate and rock phosphate should be carried out under individual farm conditions.

#### RESIDUAL SOILS

The one residual soil in the county is classified as the Crawford loam.

#### CRAWFORD LOAM (212)

The Crawford loam is a minor type, covering only 0.1 percent of the total area. It occurs in several small areas, the most extensive being found near the towns of Centerville, Rathbun and Clarkdale. In some places the areas of the Crawford loam are very small and they are indicated on the map by rock outcrop symbols. The soil on the slopes along the lower course of Cooper Creek above the junction of the Chariton River consists largely of Crawford loam.

The surface soil of the Crawford loam is a very shallow dark brown or black loam 4 inches in depth. This is underlaid by a tough compact waxy, greasy or soapy reddish-brown or chocolate-brown clay. At depths varying from 22 to 26 inches lime rock is encountered. The texture of the surface material is variable, ranging from a loam to a clay loam. These areas of different texture could not be separated on the map as they are too small.

The Crawford loam is unimportant agriculturally because it can be used only as pasture land; steep rugged slopes and outcrops of limestone making cultivation impractical. The soil occurs in conjunction with the Shelby loam and the Grundy silt loam and is used only for pasture.

# APPENDIX

## THE SOIL SURVEY OF IOWA

What soils need to make them highly productive and to keep them so, and how their needs may be supplied, are problems which are met constantly on the farm today.

To enable every farmer to solve these problems for his local conditions, a complete survey and study of the soils of the state has been undertaken, the results of which will be published in a series of county reports. This work includes a detailed survey of the soils of each county, following which all the soil types, streams, roads, railroads, etc., are accurately located on a soil map. This portion of the work is being carried on in cooperation with the Bureau of Soils of the United States Department of Agriculture.

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

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

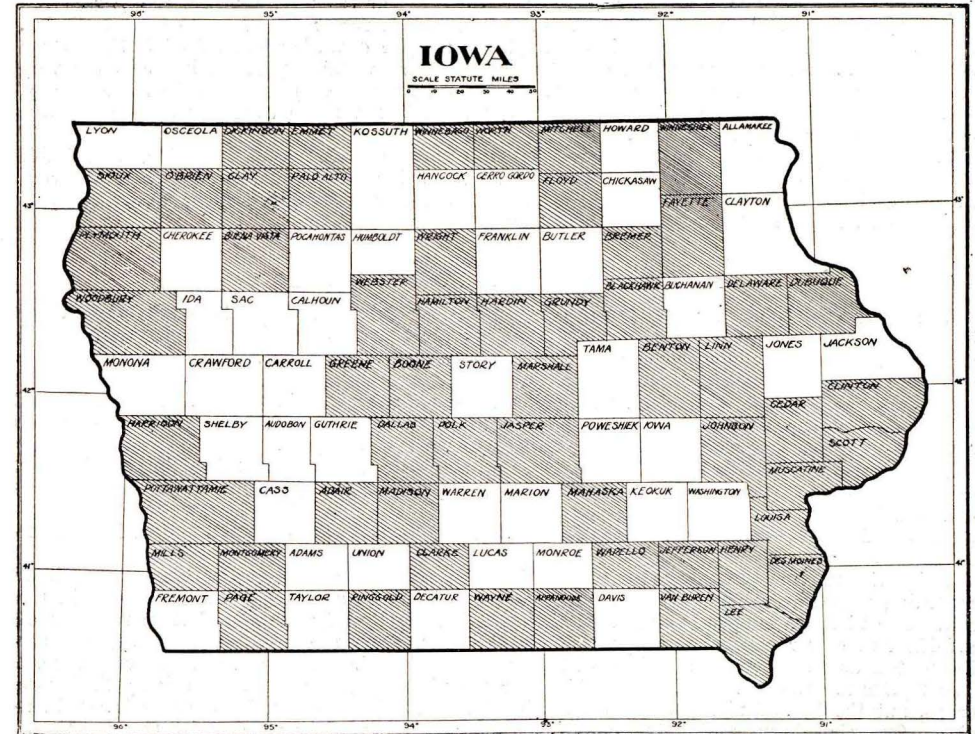


Fig. 8. Map of Iowa showing the counties surveyed.

## PLANT FOOD IN SOILS

Fifteen different chemical elements are essential for plant food, but many of these occur so extensively in soils and are used in such small quantities that there is practically no danger of their ever running out. Such, for example, is the case with iron and aluminum, past experience showing that the amount of these elements in the soil remains practically constant. Furthermore, there can never be a shortage in the elements which come primarily from the air, such as carbon and oxygen, for the supply of these in the atmosphere is practically inexhaustible. The same is true of nitrogen, which is now known to be taken directly from the atmosphere by well-inoculated legumes and by certain microscopic organisms. Hence, altho many crops are unable to secure nitrogen from the air and are forced to draw on the soil supply, it is possible by the proper and frequent growing of well-inoculated legumes and their use as green manures, to store up sufficient of this element to supply all the needs of succeeding non-legumes.

## THE "SOIL DERIVED" ELEMENTS

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

## AVAILABLE AND UNAVAILABLE PLANT FOOD

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

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

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

## REMOVAL OF PLANT FOOD BY CROPS

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

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

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

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

TABLE I. PLANT FOOD IN CROPS AND VALUE  
Calculating Nitrogen (N) at 16c (Sodium Nitrate (NaNO<sub>3</sub>)), Phosphorus (P) at 12c (Superphosphate), and Potassium (K) at 6c (Potassium Chloride (KCl)).

Crop	Yield	Plant Food, Lbs.			Value of Plant Food			Total Value of Plant Food
		Nitrogen	Phos-phorus	Potas-sium	Nitro-gen	Phos-phorus	Potas-sium	
Corn, grain	75 bu.	75	12.75	14	\$12.00	\$1.52	\$0.84	\$14.37
Corn, stover	2.25 T.	36	4.5	39	5.76	0.54	2.34	8.64
Corn, crop	.....	111	17.25	53	17.76	2.07	3.18	23.01
Wheat, grain	30 bu.	42.6	7.2	7.8	6.81	0.86	0.46	8.13
Wheat, straw	1.5 T.	15	2.4	27	2.40	0.28	1.62	4.30
Wheat, crop	.....	57.6	9.6	34.8	9.21	1.14	2.08	12.43
Oats, grain	50 bu.	33	5.5	8	5.28	0.66	0.48	6.42
Oats, straw	1.25 T.	15.5	2.5	26	2.48	0.30	1.56	8.28
Oats, crop	.....	48.5	8	34	7.76	0.96	2.04	14.70
Barley, grain	30 bu.	23	5	5.5	3.68	0.60	0.33	4.61
Barley, straw	0.75 T.	9.5	1	13	1.52	0.12	0.78	2.42
Barley, crop	.....	32.5	6	18.5	5.20	0.72	1.11	7.03
Rye, grain	30 bu.	29.4	6	7.8	4.70	0.72	0.46	5.88
Rye, straw	1.5 T.	12	3	21	1.92	0.36	1.26	3.54
Rye, crop	.....	41.4	9	28.8	6.62	1.08	1.72	9.42
Potatoes	300 bu.	63	12.7	90	10.08	1.25	5.40	17.00
Alfalfa, hay	6 T.	300	27	144	48.00	3.24	8.64	59.88
Timothy, hay	3 T.	72	9	67.5	11.52	1.08	3.95	16.55
Clover, hay	3 T.	120	15	90	19.20	1.80	5.40	16.40

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

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

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

## REMOVAL FROM IOWA SOILS

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

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

## PERMANENT FERTILITY IN IOWA SOILS

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

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

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

#### CULTIVATION AND DRAINAGE

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

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

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

#### THE ROTATION OF CROPS

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

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

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

#### MANURING

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

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

By using all the crop residues, all the manure produced on the farm, and giving well-

inoculated legumes a place in the rotation for green manure crops, no artificial means of maintaining the humus and nitrogen content of soils need be resorted to.

#### THE USE OF PHOSPHORUS

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

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

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

#### LIMING

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

All Iowa soils should therefore be tested for acidity before the crop is seeded, particularly when legumes, such as alfalfa or red clover, are to be grown. Any farmer may test his own soil and determine its need of lime, according to simple directions in Bulletin No. 151, referred to above.

As to the amount of lime needed for acid soils as a general rule sufficient should be applied to neutralize the acidity in the surface soil and then an additional amount of one or two tons per acre.

#### SOIL AREAS IN IOWA

There are five large soil areas in Iowa, the Wisconsin drift, the Iowan drift, the Missouri loess, the Mississippi loess and the Southern Iowa loess. These five divisions of the soils of the state are based on the geological forces which brought about the formation of the various soil areas. The various areas are shown in the map, fig. 9.

With the exception of the northeastern part of the state, the whole surface of Iowa was in ages past overrun by great continental ice sheets. These great masses of ice moved slowly over the land, crushing and grinding the rocks beneath and carrying along with them the material which they accumulated in their progress. Five ice sheets invaded Iowa at different geological eras, coming from different directions and carrying, therefore, different rock material with them.

The deposit, or sheet, of earth debris left after the ice of such glaciers melts is called "glacial till" or "drift" and is easily distinguished by the fact that it is usually a rather stiff clay containing pebbles of all sorts as well as large boulders of "nigger heads." Two of these drift areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift was laid down at a much earlier period and is somewhat poorer in plant food than the



Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

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

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

THE SOIL SURVEY BY COUNTIES

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

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

GENERAL SOIL CHARACTERISTICS

Soil types possess more or less definite characteristics which may be determined largely in the field, 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

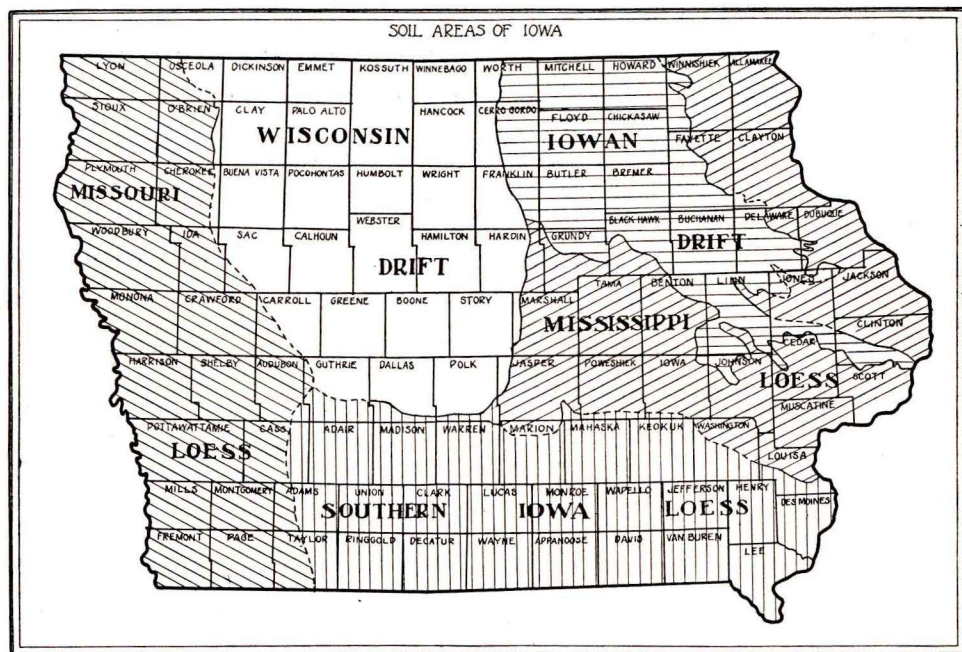


Fig. 9. Map showing the principal soil areas in Iowa.

the type boundaries. In some cases, however, there is a graduation from one type to another and then the boundaries may be fixed only with great difficulty. The error introduced into soil survey work from this source is very small and need cause little concern.

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

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

The common soil constituents may be given as follows:†

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

SOILS GROUPED BY TYPES

- The general groups of soils by types are indicated thus by the Bureau of Soils.
- Peats*—Consisting of 35 percent or more of organic matter, sometimes mixed with more or less sand or silt.
  - Peaty Loams*—15 to 35 percent organic matter mixed with much sand and silt and a little clay.
  - Mucks*—25 to 35 percent of partly decomposed organic matter mixed with much clay and some silt.
  - Clays*—Soils with more than 30 percent clay, usually mixed with much silt; always more than 50 percent silt and clay.
  - Silty Clay Loams*—20 to 30 percent clay and more than 50 percent silt.
  - Clay Loams*—20 to 30 percent clay and less than 50 percent silt and some sand.
  - Silt Loams*—20 percent clay and more than 50 percent silt mixed with some sand.
  - Loams*—Less than 20 percent clay and less than 50 percent silt and from 30 to 50 percent sand.
  - Sandy Clays*—20 percent silt and small amounts of clay up to 30 percent.
  - Fine Sandy Loams*—More than 50 percent fine sand and very fine sand mixed with less than 25 percent very coarse sand, coarse sand and medium sand, much silt and a little clay; silt and clay 20 to 50 percent.
  - Sandy Loams*—More than 25 percent very coarse, coarse and medium sand; silt and clay 20 to 50 percent.
  - Very Fine Sand*—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.
  - Fine Sand*—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.
  - Sand*—More than 25 percent very coarse, coarse and medium sand, less than 50 percent fine sand, less than 20 percent silt and clay.
  - Coarse Sand*—More than 25 percent very coarse, coarse and medium sand, less than 50 percent of other grades, less than 20 percent silt and clay.
  - Gravelly Loams*—25 to 50 percent very coarse sand and much sand and some silt.
  - Gravels*—More than 50 percent very coarse sand.
  - Stony Loams*—A large number of stones over one inch in diameter.

METHODS USED IN THE SOIL SURVEY

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

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

As has been indicated the completed map is intended to show the accurate location and boundaries, not only of all soil types but also of the streams, roads, railroads, etc.

The first step, therefore, is the choice of an accurate base map and any official map of the county may be chosen for this purpose. Such maps are always checked to correspond correctly with the land survey. The location of every stream, road and railroad on the map is likewise carefully verified and corrections are frequently necessary. When an accurate base map is not available the field party must first prepare one.

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

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

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

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

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