UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 47

PIATT COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

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The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

IT IS A MATTER of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite charácterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil management in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for it represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due Mr. O. I. Ellis, who, as leader of the field party, was in direct charge of the mapping.

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PIATT COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

GEOGRAPHICAL FEATURES OF PIATT COUNTY

PIATT COUNTY is located near the center of Illinois about 25 miles north of the Shelbyville moraine, which, in this region, marks the dividing line between the dark-colored corn-belt soils to the north and the light-colored soils to the south. The county is about 34 miles north and south by about 15 miles east and west and occupies 432.72 square miles.

Climate

The climate of Piatt county is typical of that prevailing in the Mississippi valley region. It is characterized by a wide range in temperature between the extremes of winter and summer and by an abundant, well-distributed rainfall. The greatest range in temperature for any one year for the twenty-six year period 1903 to 1928, as recorded at Urbana, was 122 degrees in 1905 and again in 1918. The highest temperature was 103° in 1913; the lowest, 25° below zero in 1905. In 1921 the lowest winter temperature was 6° above zero. The summer temperature exceeded 100° during five years and the winter temperature fell below 10° below zero during fourteen years out of the twenty-six year period. The average date of the last killing frost in the spring is April 25; the earliest in the autumn is October 16. The average length of the growing season is 174 days, which is ample time to mature all the crops common to the region. Occasional early frosts result in soft corn when the preceding spring has been very wet and backward. Winter wheat is sometimes injured by sleet and ice, particularly on flat land.

The average annual rainfall for the twenty-six year period was 35.26 inches. The wettest year on record, 1927, had a rainfall of 55.64 inches; the driest year, 1914, had a rainfall of 24.68 inches.

Fig. 1 gives the average monthly rainfall for the twenty-six year period. An average monthly rainfall of more than 3 inches during the growing season would indicate that Piatt county soils receive enough water to maintain a proper moisture supply for the growing crops so that drouths would not occur. It should be borne in mind, however, that the total amount of precipitation is only one of the factors that control drouth; other important factors are humidity, rate of evaporation, rate at which rain falls, lapse of time between rains, and drainage conditions. However, the rainfall in this county is sufficiently well distributed that seldom is there a severe drouth. Occasionally twenty to thirty days pass without much rain so that crop yields are reduced and meadows and pastures are short, but the subsoil rarely becomes so dry that plant roots cannot procure some moisture.

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

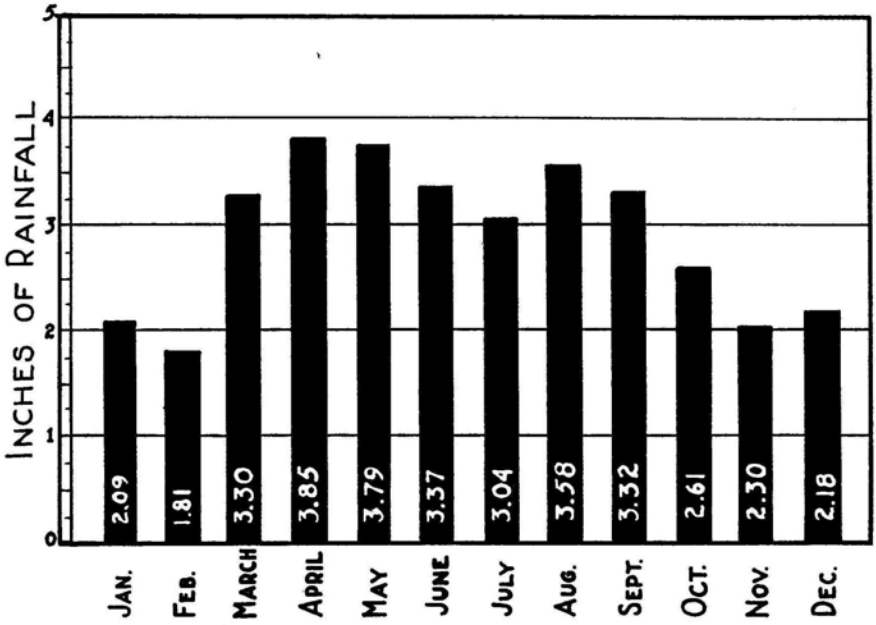

FIG. 1.—AVERAGE MONTHLY DISTRIBUTION OF RAINFALL IN PIATT COUNTY

Physiography and Drainage

Piatt county contains much nearly level land. The northeast corner is gently rolling where the Blue Ridge moraine, a part of the Champaign morainic system, cuts across the northeast corner of the county. Sangamon river traverses the central part of the county in a northeast-southwest direction and is bordered on either side by a narrow belt of gently rolling land. The Cerro Gordo moraine crosses the county parallel to, and on the south side of, Sangamon river. Both of these morainal areas are gently rolling and contain but few slopes sufficiently steep to erode badly if well managed. The remainder of the county contains much land that is so nearly level as to have poor natural drainage.

The southern part of the county, south of the Cerro Gordo moraine, drains into streams of the Kaskaskia river system, while the portion of the county north of this ridge drains into Sangamon river, either directly or thru its tributaries. Dredge ditches have been constructed in the flatter portions of the county to serve as outlets for tiling systems and to carry the large volume of run-off. No soil is known to occur in Piatt county which will not underdrain satisfactorily. The heavy, low-lying areas underdrain more slowly than the more open soils, but their high potential productivity fully justifies the expense of placing the lines of tile close enough together to provide adequate underdrainage. The accompanying drainage map shows the natural drainage of the county and the morainal ridges.

The elevation of Piatt county ranges between 668 and 793 feet. The highest point is in the northeast corner of the county and the lowest in the southeast.

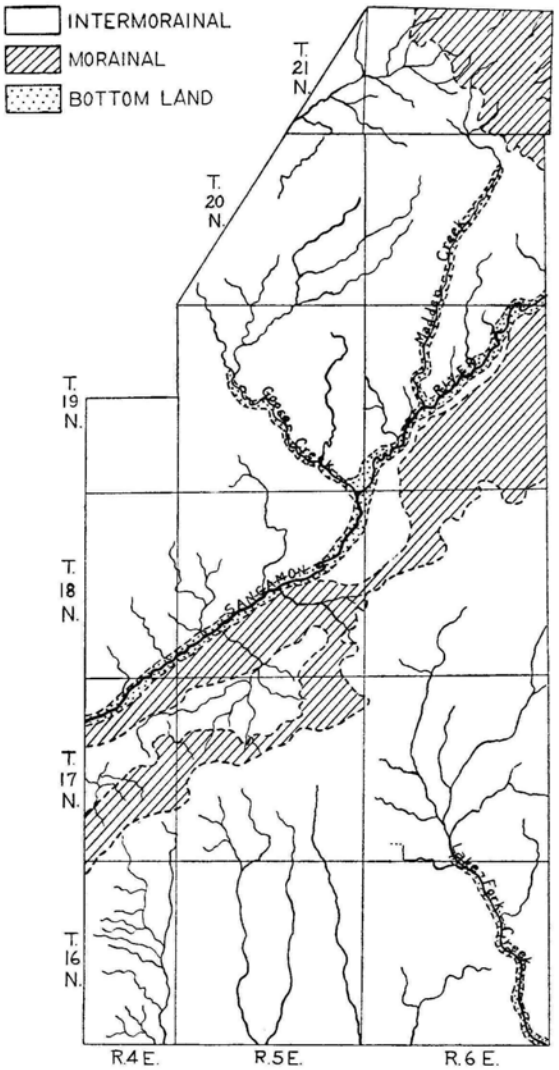

FIG. 2.—DRAINAGE MAP OF PIATT COUNTY SHOWING STREAM COURSES, BOTTOM LANDS, AND MORAINAL AND INTER-MORAINAL AREAS

Settlement and Development

The first settlers in Piatt county were from the Southern states, many of them coming by way of Ohio or Indiana. Having come from forested states, it was years before they learned that the prairies could be cultivated. The poor drainage of much of the prairie land was, no doubt, an important factor in retarding their cultivation. Much artificial drainage had been provided by 1883 and with the extension of the drainage systems the rich, black prairie soils were rapidly brought under the plow.

Monticello was laid out and named in 1837. In 1841 Piatt county was formed from parts of Macon and DeWitt counties, and Monticello was chosen as the county seat.

The Wabash railroad was constructed thru the county in 1855 and 1856, and the railroad between Monticello and Champaign was put into operation in 1870 and extended to Decatur two years later.

Piatt county is now well provided with rail transportation. No farm in the county is over seven miles from a shipping point. State concrete highways traverse the county, as shown on the soil map. The dirt roads are in general well kept, many of them being oiled.

Agricultural Production

The early agriculture in Piatt county was confined largely to small fields cleared in the timber along Sangamon river. Attempts to produce small grains on the prairie were not at first successful because of the rank growth resulting in lodging of the oats and rusting of the wheat. As drainage was provided and the excess of nitrogen and organic matter in the soil was reduced, these difficulties became less acute.

The principal crops grown in Piatt county in the present day are those common to the corn belt. The following figures (taken from Circular 385, Illinois Crop and Livestock Statistics, Illinois Department of Agriculture and U. S. Department of Agriculture cooperating) give the acreage, production, and yield per acre of the more important crops for 1928.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	111,800	4,695,600 bu.	42.0 bu.
Winter wheat	3,800	45,600 bu.	12.0 bu.
Spring wheat	7,600	76,000 bu.	10.0 bu.
Barley	7,630	160,230 bu.	21.0 bu.
Rye	90	1,170 bu.	13.0 bu.
Oats	61,900	2,290,300 bu.	37.0 bu.
White potatoes	250	21,250 bu.	85.0 bu.
Sweet potatoes	15	1,690 bu.	112.6 bu.
Soybeans (alone)	12,000	.....	.....
Soybeans (with other crops)	3,000	.....	.....
Alfalfa (cut for hay)	800	.....	.....
Sweet clover	17,000	.....	.....
Tame hay	10,400	14,560 tons	1.4 tons
Wild hay	35	39 tons	1.1 tons

The above figures are for but a single year, that of 1928. Yields will fluctuate from year to year and for this reason the average yield over a period of years more accurately represents conditions. The U. S. Department of Agriculture gives the following average yields for the eighteen-year period 1911 to 1928: corn, 38 bushels; wheat, 19 bushels; oats, 34 bushels; hay, 1.2 tons. Thus it appears upon comparing the figures for the single year 1928 with these long-time averages that 1928 was a rather favorable year for corn and oats but an exceptionally poor one for wheat.

An important crop of rather recent introduction is the soybean. The great interest in soybeans in this section of the country is shown by the fact that in 1928 there were 12,000 acres in Piatt county devoted to soybeans alone, and on 3,000 other acres soybeans were grown with other crops. The great value of sweet clover as a soil-building and pasture crop is becoming more and more appreciated, as attested by the 17,000 acres devoted to this crop.

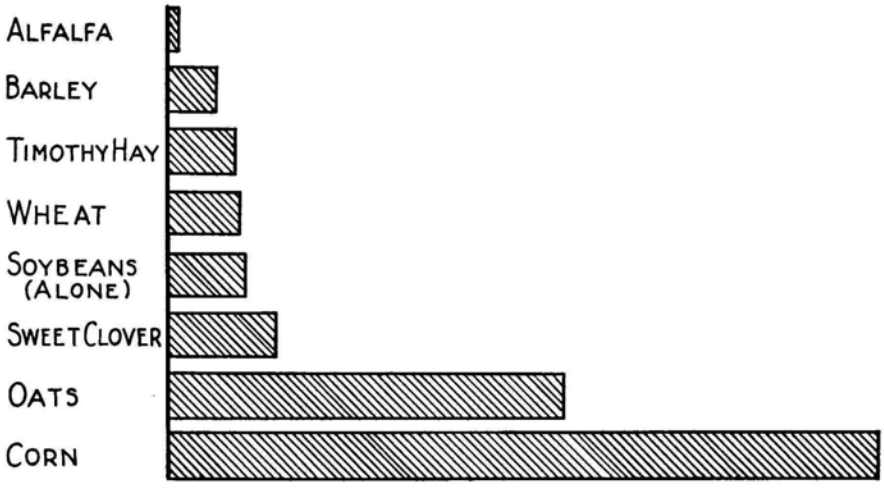

FIG. 3.—RELATIVE ACREAGE OF DIFFERENT KINDS OF FIELD CROPS IN PIATT COUNTY, 1928

It is of interest to note the prominent place being taken by two crops of rather recent introduction, the soybean and sweet clover. (Based on Circ. 385, Ill. Crop and Livestock Statistics, Ill. Dept. Agr. and U.S.D.A. cooperating.)

Fruit and vegetable crops are of little commercial importance in Piatt county. Stock raising was important from an early date. The character of the livestock interests in the county in 1928 is shown by the following figures taken from Circular 385, Illinois Crop and Livestock Statistics, mentioned above:

Animals and Animal Products	*Number*	*Value*
Horses	8,630	$733,500
Mules	1,330	118,300
Cattle (total)	13,170	723,100
Dairy cows	5,660	418,200
Hogs	45,830	641,600
Sheep	3,070	32,300

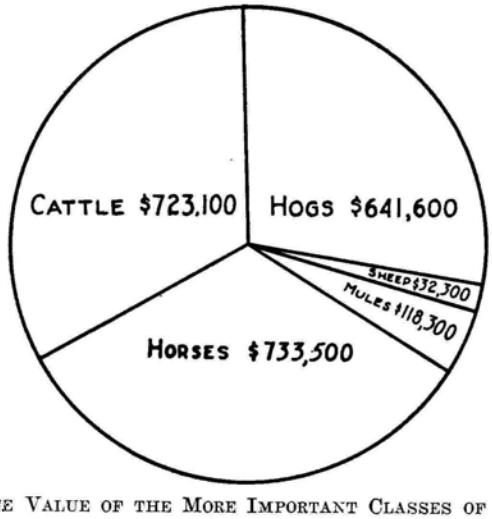

FIG. 4.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN PIATT COUNTY

FORMATION OF PIATT COUNTY SOILS

Sources of Soil Materials

Piatt county is covered by a thick deposit of glacial till. The surface of the county prior to glacial times was broken, but the preglacial topography had no influence on present surface conditions, for the deposit of till exceeds 200 feet in thickness over most of the county. The ice sheets, as they passed over the region, rubbed down the hills and filled the valleys, and upon their retreat left a nearly level till plain broken only by the Blue Ridge moraine in the northeast corner of the county and the Cerro Gordo moraine extending in a southwest-northeast direction thru the central part of the county.

The first glacier known to have advanced across the area now occupied by Piatt county is called the Illinoian. This glacier was an immense ice sheet which came from the north and covered most of Illinois. Following the retreat of this glacier there was a long period during which soil was formed on the till left by the Illinoian ice and also on loess deposited at a later time on the Illinoian till. Following this long interglacial stage, another immense ice sheet known as the Wisconsin advanced across the area. The present soils of Piatt county were formed in large part from the till left by the Wisconsin glacier. In a few areas a thin blanket of loess appears to have been deposited on the till, and where such is the case the soils were developed from the loess and are pebble-free.

Over much of the county there seems to have been a local reworking of the soil material by the wind, producing a loess-like cover. Because of the thickness of this deposit the soils developed from it have been classified with the loess soils rather than with the drift soils, tho strictly speaking they are not loess soils.

Flowing water reworked the glacial till and the loess in places, leaving deposits in the form of bottoms, terraces, and outwash plains from which the soils of these areas developed. All of these materials were high in carbonates at the time they were deposited and this fact has an important bearing on the character of the soils developed from them. The till was made up of a great variety of rocks, including limestone. These rocks were ground into various sized particles, including the very finest as well as gravel and stones, and these particles were mixed together, giving a material well supplied with all the elements of plant food. Loess is the "rock flour" produced by the grinding action of the ice sheet. This flour-like material was carried into the bottomlands by glacial streams flowing from the front of the glacier and was then picked up by the wind and deposited over the upland. It is an excellent soil-forming material, rich in the elements of plant food and of such texture that soils developed from it are easy to work. The water-deposited material was laid down in large amounts as outwash plains, terraces, and bottom lands during the retreat of the Wisconsin ice sheet. The transposition of soil material thru washing from the higher- to the lower-lying land has been in progress ever since the retreat of the glacier, and this process is still going on. The rate of this washing was relatively slow prior to the bringing of the land

under cultivation, because of the protection afforded by the timber or by the dense prairie grass. Since the land has been brought under the plow, washing on the more pronounced slopes has been so rapid as to be harmful. Its effect is evidenced by the yellowish color of the surface soil on the slopes which are washing rapidly, and is reflected in the lower crop yields on these areas. Part of the material washed from the higher land is deposited locally on the lower areas resulting in the formation of very youthful soils with little development of the horizons or strata which characterize mature soils.

Process of Soil Development

The various kinds of soil material, whether deposited directly from the glacier, reworked by the wind, or transported by water, all began immediately to undergo change thru the action of weathering forces. The simpler forms of vegetation grew first, these being followed by the higher plants as conditions for their growth became favorable. In the region now included in Piatt county all the conditions were favorable for the accumulation of organic matter over a large proportion of the land. A grass vegetation developed and occupied most of the area, and this condition, together with the high lime and high moisture contents of the soil, favored the accumulation of organic matter and the development of dark-colored soils. A relatively small total area along Sangamon river and in the southeastern corner of the county was occupied by a timber vegetation, which resulted in the development of light-colored soils.

As time went on and weathering continued, the soils as we now know them began to take form. Layers or horizons, often spoken of as surface, subsurface, and subsoil, became distinguishable. The soils of the county are still youthful in the sense that the various parts of the profile are not yet fully developed. In some of the low-lying areas fresh-water shells are still abundant, indicating the short length of time which has elapsed since these areas were swampy. The construction of dredge ditches and the installation of tile have changed the low-lying, swampy areas into highly productive farm land. As time goes on and leaching progresses, the youthful soils in this county will take on the features of maturity and will inevitably become less productive. This change, however, from youth to maturity is extremely slow. So far as the present generation and many generations in the future are concerned, the soils of Piatt county will remain productive unless depleted thru poor soil management methods.

About 94 percent of the soils in Piatt county are dark-colored. These soils were originally high in organic matter and are still well supplied with this important constituent except where no provision has been made in the farming plan for its replenishment and on slopes which have eroded rapidly. The dark-colored soils owe their dark color and high organic-matter content to the prairie grasses which grew there prior to occupation by the white man. The fibrous roots of the grasses were preserved from rapid decay by the swampy conditions in the low lands and by the covering of fine soil and mat of grass stems and leaves on the higher land which partially excluded the oxygen. The mat of grass stems and leaves was at times partially destroyed

by prairie fires and by decay, but it was constantly being renewed and by its protecting action contributed to the accumulation of organic matter in the soil.

Light-colored soils occupy about 6 percent of the total area of the county. These soils are light-colored because they were occupied by a timber vegetation. The conditions in a forest are not favorable for the accumulation of organic matter in the soil. The tree roots are large, and when the tree dies they decay rapidly and completely. The leaves and other debris falling on the surface are exposed to rapid decay and to destruction by timber fires and therefore contribute but little to the organic-matter supply of the soil.

When virgin soil is first plowed up and put under cultivation, the rate at which the organic matter decays is greatly accelerated. Prairie soil when first plowed may contain in some cases more organic matter than is actually necessary for good productivity, but timber soil has such a limited amount of organic matter that its depletion thru cultivation becomes harmful. Special attention must now be given to increasing the amount of this valuable soil constituent in these light-colored soils if the best results are to be expected.

THE SOIL MAP

Basis of Soil Classification

In the soil survey the "type" is the unit of classification. Each soil type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or horizons, which constitute

FIG. 5.—STUDYING THE SOIL PROFILE
Deep natural exposures are made use of in studying the soil profile.

the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. The topography and the kind and character of the vegetation are easily observed features of the landscape which are very useful indicators of soil character. A knowledge of the geological origin and formation of the soil material of the region that is being mapped often makes possible an understanding of the soil conditions which occur.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which such characteristics show considerable variation. When these variations are considered to have sufficient significance, and the areas involved are sufficiently large, type separations are made. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Naming the Soil Types

In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a somewhat definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of more than one stratum and it is impossible to describe each stratum in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

To assist in designating soil types, a number is assigned to each type. These numbers are not only a convenience in referring to the respective types but they are especially useful in designating very small areas on the map and as a check in reading the map colors.

TABLE 1.—SOIL TYPES OF PIATT COUNTY, ILLINOIS

Soil type No.	Type name	Area in square miles	Area in acres	Percent of total area
36	Light Brown Silt Loam	8.69	5 562	2.08
38	Light Brown Sandy Loam	.20	128	.04
41	Brown Silt Loam	195.89	125 369	45.27
56	Brown Silt Loam On Drift	16.12	10 317	3.72
22	Reddish Brown Silt Loam On Drift	8.11	5 190	1.87
59	Brown Silt Loam On Calcareous Drift	1.11	710	.25
66	Black Clay Loam On Drab Clay	163.90	104 896	37.87
64	Black Clay Loam On Calcareous Drift	8.54	5 465	1.97
18	Brownish Yellow-Gray Silt Loam	9.07	5 805	2.09
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	5.37	3 437	1.24
16	Brownish Yellow-Gray Silt Loam On Tight Clay	.22	141	.05
8	Eroded Gravelly Loam	2.03	1 300	.47
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	.20	128	.04
135	Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel	.32	205	.07
51	Deep Dark Brown Silt Loam	.25	160	.05
107	Deep Black Clay Loam	.68	435	.15
77	Deep Brown Silt Loam	.09	58	.02
76	Black Mixed Loam	.09	58	.02
73	Brown Mixed Loam	11.84	7 577	2.73
	Total area	432.72	276 941	100.00

Table 1 gives the list of the soil types as mapped in Piatt county, the area of each in square miles as well as in acres, and also the percentage that each type constitutes of the total area of the county.

The accompanying colored map, shown in two sections, gives the location and boundary of each soil type and indicates the position of streams, roads, railroads, and town sites.

DESCRIPTION OF SOIL TYPES

Based on the principles explained above, the soils of Piatt county have been differentiated under nineteen soil types. A brief description of the outstanding characters, together with a few suggestions for the practical management of each type, are given in the following paragraphs.

Light Brown Silt Loam (36)

Light Brown Silt Loam is a relatively unimportant type in Piatt county, occupying a total of only 8.69 square miles, or slightly over 2 percent of the area of the county. It occurs only on slopes or high ground where drainage has always been good and where there has been an accumulation of wind-blown material. It does not occupy the steeper slopes because on such slopes erosion has removed the loess-like material. It occurs on areas sufficiently sloping and high enough to have been well drained but not so sloping that there was much erosion prior to bringing the land under cultivation.

In addition to occupying a characteristic topographic position, the areas of this type are so located as to have received wind-blown material from adjacent low land or silty wash from adjacent higher land. Glacial till is rarely found at depths less than 40 inches from the surface and is commonly found deeper than 50 inches.

The type is characterized by a light brown surface soil which is silty and friable. The surface is 7 or 8 inches deep and passes into a more yellowish material with a reddish cast, which in turn rests on a slightly compact but friable, reddish brown subsoil at a depth of 18 or 20 inches. This subsoil horizon is not very well defined but usually is about 12 to 14 inches thick. Below this subsoil layer, the material becomes much more friable and contains some gray material mixed with the yellow. At depths varying from 40 to about 60 inches, gravelly-sandy glacial till is encountered. This material was deposited by the Wisconsin ice sheet.

Management.—Light Brown Silt Loam is an easy soil to farm, and if reasonable attention is given to keeping it supplied with nitrogen and organic matter it is a productive soil. Failure to practice a good rotation soon results in lowered yields and loss of soil by erosion. This type varies somewhat in acidity, depending on the manner in which it has been farmed and on its location with regard to wash from higher slopes. Ordinarily two tons of limestone, if the stone does not contain too large a proportion of coarse particles, will sweeten the soil sufficiently to grow good red clover and fair sweet clover. After the nitrogen and organic matter have been taken care of by means of a good rotation well handled,

attention should be given to further improvement by the use of fertilizers. If little manure is available, trial might well be made of either rock phosphate or superphosphate for wheat. The use of either of these materials should benefit the corn crop indirectly thru increased clover growth. Experimental results at present available do not indicate that profitable crop increases in general farming can be expected to follow the use of a complete mixed fertilizer on this soil type.

Light Brown Sandy Loam (38)

Light Brown Sandy Loam is a minor type occupying a total of only two-tenths of a square mile. It differs from Light Brown Silt Loam in having a sandy rather than a silty texture. Where a small patch of this type occurs near the farm dwelling, it may be used for melons or garden crops, for which it is well adapted. The type, unless used for some special purpose, should be managed as recommended for Light Brown Silt Loam (36).

Brown Silt Loam (41)

Brown Silt Loam is the most extensive type in Piatt county, occupying a total of 195.89 square miles, or 45 percent of the area of the county. It occupies intermediate topographic positions and has, for the most part, good surface drainage. The subsoil allows water to pass rapidly into the underdrainage, so that the drainage of this type can be said to be good altho tile must be installed thruout.

The surface soil is about 8 inches thick and has a dark brown color. The subsurface is a somewhat lighter brown than the surface, and the subsoil, which begins at about 18 inches, is a brownish yellow, somewhat compact, clay loam. Below a depth of 35 to 40 inches the material is friable and yellowish in color.

Management.—Erosion should not be a serious problem on this soil, altho, very material damage has been caused by sheet washing on many fields occupied by this type. If good farming methods are practiced, the loss from erosion should be small over most of the type. This soil was originally well supplied with organic matter and still is, except where destructive farming methods have been practiced thru a considerable period of time. Sweet clover or alfalfa will not grow on this type without a light application of limestone, but during favorable clover years red clover will make a fair crop without the addition of limestone. This soil responds well to manure but not so well as Type 36, Light Brown Silt Loam. Where manure is not available, rock phosphate should give profitable returns where clover is grown and used in part as a green manure.

Summarized results from the Bloomington experiment field are given on pages 29 to 33 and may be taken as indicating the returns that may be expected from the use of phosphates.

Brown Silt Loam On Drift (56)

Brown Silt Loam On Drift differs from Brown Silt Loam (41) chiefly in having sandy, gravelly drift near the surface. It occurs in the northeastern corner of the county and on the rolling areas along Sangamon river and occupies a total area of 16.12 square miles. The rolling topography on which this soil

occurs makes it subject to erosion; in fact erosion is responsible for its existence in that it has removed more or less of the original silty surface, thus bringing the sandy gravelly drift near to the present surface. On some slopes erosion has been so active that even the surface soil contains a large amount of gravel.

This type is characterized by a friable, rather coarse silt loam surface soil which is brown in color; a dull reddish brown, somewhat sandy and gravelly silt loam subsurface; and a reddish brown, slightly plastic and medium compact, sandy, gravelly silt loam subsoil. Calcareous material occurs at depths varying from 40 to 60 inches below the surface.

Management.—It is particularly important that a cropping system be adopted for this soil type, that will provide a vegetative cover during as much of the year as possible. The first thing to do in starting such a cropping system is to apply enough limestone so that sweet clover can be grown. Tests show that the lime requirement of this soil varies from 1 to 3 tons an acre with but few areas requiring the maximum amount. Before applying limestone to this soil, tests should be made to determine just how much is needed. Results from the Urbana experiment field indicate that rock phosphate can be used at a profit on this soil tho it would be advisable to grow one or two crops of clover, preferably sweet clover, before investing in this material. Tiling is not commonly practiced on this land but the wise use of tile will prove to be a good investment because of the assistance it gives in decreasing erosion.

Reddish Brown Silt Loam On Drift (22)

Reddish Brown Silt Loam On Drift occurs on rolling to rough topography along Sangamon river. It has supported some timber growth but not for a long enough time to give to it well-developed timber-soil features. This soil has a distinctly reddish cast thruout the profile developed because of its good drainage. Erosion is destructive on this soil.

The surface soil is shallow, has a grayish brown or yellowish brown color, and is often rather sandy because of sheet erosion. The deeper layers are reddish brown and have not developed into well-defined horizons. The fact that it is 50 inches or more to carbonates shows that leaching is rapid in this soil.

Management.—A considerable portion of this type is now used for pasture or timber and these uses should be continued since it erodes badly when farmed. This soil is somewhat peculiar in being more strongly acid in the deeper layers than in the surface. This characteristic appears to be very general over the entire area of the type and suggests that if limestone is applied to improve the pastures more should be applied than is indicated by the degree of acidity of the surface soil.

Brown Silt Loam On Calcareous Drift (59)

Brown Silt Loam On Calcareous Drift occupies a total area of only 1.11 square miles in Piatt county, and occurs only in the northeastern corner of the county on the Blue Ridge moraine. It is found on areas which have suffered the loss of enough soil material by erosion to bring the underlying calcareous drift within 35 inches or less of the surface. It differs from Brown Silt Loam On

Drift (56) chiefly in depth to calcareous material. It is somewhat less acid than Type 56 and is naturally adapted to growing alfalfa because of good drainage and the nearness of carbonates to the surface. Reference may be made to Type 56, page 15, for suggestions regarding the management of this soil.

Black Clay Loam On Drab Clay (66)

Black Clay Loam On Drab Clay is an extensive soil type in Piatt county, occupying a total of 163.9 square miles. It occurs only on low-lying areas and was formed under conditions of poor drainage. These conditions favored the accumulation of organic matter. In places, marl-like material occurs at varying depths below the surface.

The surface soil is black, and is plastic when wet. It is ten or twelve inches in depth, the lower three or four inches often having a waxy appearance. The subsurface is a waxy appearing, black or drabbish black, plastic clay loam. The subsoil, beginning at about 20 inches, is a drab or grayish drab plastic clay.

Management.—This soil type is potentially highly productive. Its characteristics are those imparted by conditions of poor drainage and its present crop-producing value depends on the thoroness with which these conditions have been corrected. The surface drainage of the type is poor, and water does not pass thru the subsoil as readily as it does in the soils previously described. This condition necessitates placing strings of tile not over six rods apart. The physical properties of this soil make it easily injured if worked when too wet or too dry. The moisture range within which it may be successfully worked decreases as the amount of organic matter decreases. It is especially important, therefore, to adopt a cropping system in which provision is made for regular additions of organic matter. This soil type is rarely acid and no assurance can be given that the use of any fertilizing material will return a profit. Drainage and organic matter are the two things which should be given attention at present and probably for many years to come.

Black Clay Loam On Calcareous Drift (64)

Black Clay Loam On Calcareous Drift has a total area of 8.54 square miles in Piatt county. It occupies depressions and is often surrounded by Type 66, just described. It differs from No. 66 in being calcareous at twenty to twenty-five inches below the surface. It is also more difficult to drain than No. 66 and is more likely to be alkaline. However, the same suggestions for management apply to this type that were given for No. 66.

Brownish Yellow-Gray Silt Loam (18)

Brownish Yellow-Gray Silt Loam is a light-colored timber soil occurring along Sangamon river and having a total area of about 9 square miles in this county. The topography of this type is undulating to gently rolling and both the surface drainage and underdrainage are good.

The surface soil is about 8 inches deep and is a grayish light brown silt loam. The subsurface soil is yellowish with a reddish cast and the subsoil, be-

ginning at about 18 inches, is yellowish brown with mottlings of gray and reddish brown. It is slightly compact and slightly plastic but easily permeable to water and roots.

Management.—This soil is medium-acid and is low in organic matter and nitrogen. It responds well to good farming, and following the application of limestone and the growing of sweet clover, produces good yields of corn. Fields which have had their originally small amount of organic matter further reduced by bad farming might well be put into a very short rotation including clover or in a longer rotation in which clover appears twice. No experiment field data are available for this soil type, and because of this fact no recommendations for treatment are made other than the application of limestone in amounts indicated by tests and the use of farm manure and crop residues including clover. After the nitrogen and organic-matter deficiencies have been taken care of, tests should be made with phosphates and other fertilizing materials.

Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay (17)

Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay differs from the type described immediately above, No. 18, because it has developed under conditions of poor drainage. It is found only on flat topography and has poor surface drainage and underdrainage.

The surface soil is a slightly brownish gray silt loam. This horizon, as well as all the horizons in the profile, contains numerous iron pellets. The subsurface, beginning at about 8 inches, is gray splotched with dark brown. The subsoil begins about 17 inches below the surface and is a drabbish gray, compact, medium-plastic clay. This plastic material continues to a depth of 30 to 35 inches, where the material becomes more friable.

Management.—If this soil type is utilized for cropping, attention should first be given to drainage. Tile will draw but not readily; the strings should therefore be placed closer together than in a more open soil. The second step should be to test each field in detail for acidity. This soil is medium to strongly acid but varies somewhat in degree of acidity, hence the desirability of determining by means of detailed tests the exact amount of limestone needed. Following the application of limestone, sweet clover should be seeded and plowed down in the spring of its second year for corn. An objection to this practice is that, particularly on this soil, difficulty may be experienced in getting the plowing done early enough when the spring is wet.

Brownish Yellow-Gray Silt Loam On Tight Clay (16)

Brownish Yellow-Gray Silt Loam On Tight Clay occupies less than a quarter of a square mile in Piatt county and is of relatively low agricultural value. It is similar to No. 17, just described, but the gray color is more pronounced thruout the profile and the subsoil is more impervious. If this soil is farmed, the same general plan should be followed as that recommended for Type 17 except that drainage should be taken care of by means of furrows and open ditches.

Eroded Gravelly Loam (8)

Eroded Gravelly Loam is a minor type occupying a total area of only 2.03 square miles. It occurs in narrow strips on slopes along Sangamon river. Erosion has been sufficiently active on these slopes to remove any loess-like material and expose the glacial drift, which contains a large percentage of gravel. No soil profile has developed because the rate of removal by erosion is more rapid than the rate of soil development. The nature of the material varies somewhat on different slopes because of differences in the glacial drift, some slopes being more sandy or more gravelly than others.

Management.—Eroded Gravelly Loam is unsuited to general farming because of its gravelly nature and because erosion is too severe under tillage. It should be used for timber or pasture, and is well adapted to either of these uses.

Brownish Yellow-Gray Silt Loam Over Sand Or Gravel (134)

Brownish Yellow-Gray Silt Loam Over Sand Or Gravel is a light-colored terrace soil, occupying a total of only two-tenths of a square mile in Piatt county. It differs from type No. 18, the corresponding upland type described on page 17, chiefly in being underlain by sand or gravel. The description and management suggestions given for Type 18 may be applied to this type.

Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel (135)

Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel is a terrace formation and is underlain by sand or gravel. It is of minor importance in Piatt county, occupying only .32 of a square mile. It is not so good a soil as the preceding type, No. 134, but should be managed in the same way.

Deep Dark Brown Silt Loam (51)

Deep Dark Brown Silt Loam is a highly productive soil formed in low-lying areas where much silting-in has taken place. It occupies a total area of only .25 of a square mile in Piatt county. This soil is not acid, is well supplied with organic matter, and needs no fertilizer treatment. It is so youthful that well-defined surface, subsurface, and subsoil horizons have not yet been developed.

Deep Black Clay Loam (107)

Deep Black Clay Loam occurs along Lake Fork creek in the southeastern corner of the county. It is a silted-in type and is therefore deep and shows little horizon development. This soil is highly productive and requires no treatment other than the addition of organic matter as a means of maintaining a good physical condition.

Deep Brown Silt Loam (77)

Deep Brown Silt Loam differs from No. 51, Deep Dark Brown Silt Loam, described above, in having less organic matter. It occupies a total area of only 58 acres in Piatt county.

Black Mixed Loam (76)

Black Mixed Loam occupies so small an area in Piatt county as to be of minor importance. It is similar to Brown Mixed Loam (73) except that it contains much more organic matter. Therefore the reader is referred to Type 73, which is described immediately below.

Brown Mixed Loam (73)

Brown Mixed Loam is the important bottom-land soil in Piatt county. It occupies a total area of nearly 12 square miles. As its name implies, this type is not uniform. There is no well-defined horizon development. The land is productive unless subject to harmful overflow, as much of it is. Corn is the crop usually grown. No treatment need be applied to this soil since practically all of it overflows frequently enough to maintain its productive capacity.

CHEMICAL COMPOSITION OF PIATT COUNTY SOILS

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

This, of course is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that the composition of each is based on a different quantity of soil, as explained above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

TABLE 2.—PIATT COUNTY SOILS:[1] PLANT-FOOD ELEMENTS IN THE UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type[2]	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
36	Light Brown Silt Loam	49 180	4 230	1 010	670	36 350	7 450	7 830
41	Brown Silt Loam	55 740	4 710	1 040	700	34 810	8 310	10 440
56	Brown Silt Loam On Drift	50 600	4 430	1 070	.....	36 500	8 470	8 820
59	Brown Silt Loam On Calcareous Drift	47 390	4 210	1 000	.....	37 820	8 340	7 600
66	Black Clay Loam On Drab Clay	75 900	6 940	1 800	1 050	34 230	14 890	24 660
64	Black Clay Loam On Calcareous Drift	63 220	6 310	1 580	910	35 910	14 950	21 190
18	Brownish Yellow-Gray Silt Loam	23 800	2 100	760	520	35 820	5 860	7 050
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	25 740	2 230	790	440	33 470	5 320	7 150
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	27 050	2 270	1 130	420	37 000	5 920	7 750

[1]The samples representing the respective types were taken mainly in neighboring counties.
[2]No samples were taken of Types 107, 77, 76, and 73, on account of their heterogeneous character, nor of Nos. 38, 22, 16, 8, and 135, on account of their limited areas.

Dark-Colored Soils High in Organic Matter and Nitrogen

Among the outstanding features of the chemical make-up of these soils is the gradation in the quantity of organic matter as one passes from the dark- to the light-colored soils. The organic carbon, which constitutes about 50 percent of the organic matter and is used as a measure of organic matter, varies in the surface soil from 75,900 pounds an acre in Black Clay Loam On Drab Clay to less than one-third this amount, or 23,800 pounds in Brownish Yellow-Gray Silt

TABLE 3.—PIATT COUNTY SOILS:[1] PLANT-FOOD ELEMENTS IN THE MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type[2]	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
36	Light Brown Silt Loam	70 960	6 630	1 850	1 080	72 790	17 990	15 760
41	Brown Silt Loam	69 940	6 240	1 700	1 140	70 260	20 460	19 730
56	Brown Silt Loam On Drift	71 410	6 400	1 770	.....	74 440	21 520	17 930
59	Brown Silt Loam On Calcareous Drift	62 600	5 910	1 600	.....	79 730	21 170	15 320
66	Black Clay Loam On Drab Clay	69 270	6 620	2 690	1 400	70 760	31 870	41 910
64	Black Clay Loam On Calcareous Drift	59 300	5 900	2 500	1 200	72 620	33 190	37 810
18	Brownish Yellow-Gray Silt Loam	17 660	2 190	1 380	560	73 620	21 340	14 490
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	16 900	1 830	1 160	760	70 160	19 410	13 560
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	19 700	2 240	2 060	920	76 640	15 440	13 360

[1]The samples representing the respective types were taken mainly in neighboring counties.
[2]No samples were taken of Types 107, 77, 76, and 73, on account of their heterogeneous character, nor of Nos. 38, 22, 16, 8, and 135, on account of their limited areas.

TABLE 4.—PIATT COUNTY SOILS:[1] PLANT-FOOD ELEMENTS IN THE LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type[2]	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
36	Light Brown Silt Loam	45 800	4 260	2 100	1 140	114 680	39 080	27 320
41	Brown Silt Loam	35 370	3 780	2 250	1 020	108 240	46 900	42 220
56	Brown Silt Loam On Drift	36 010	4 080	2 260	.....	114 700	43 040	28 460
59	Brown Silt Loam On Calcareous Drift	34 810	3 720	1 870	.....	131 730	48 460	41 740
66	Black Clay Loam On Drab Clay	33 270	3 490	3 130	1 100	109 040	62 640	98 950
64	Black Clay Loam On Calcareous Drift	36 230	3 770	2 900	1 200	106 940	77 430	184 030
18	Brownish Yellow-Gray Silt Loam	10 960	2 580	2 300	550	112 300	45 360	31 300
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	20 320	2 550	2 340	1 140	110 950	40 240	28 090
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	15 000	2 130	3 180	720	106 860	33 330	22 380

[1]The samples representing the respective types were taken mainly in neighboring counties.
[2]No samples were taken of Types 107, 77, 76 and 73, on account of their heterogeneous character, nor of Nos. 38, 22, 16, 8, and 135, on account of their limited areas.

Loam. It will be noticed that the nitrogen content of these soils runs approximately parallel to the organic carbon, being about one-eleventh as high. This relationship is explained by the fact that nearly all the soil nitrogen is organic nitrogen, that is, it is a part of the organic matter. One of the important biological processes associated with the decay of organic matter is the conversion of the organic nitrogen into the inorganic form of nitrate, thus making it available to growing crops.

Phosphorus and Sulfur Associated With Organic Matter

Two other chemical elements, phosphorus and sulfur, both essential for plant growth, are associated with the organic matter of the soil tho less completely so than is nitrogen. Altho variations occur with different soils, it is estimated that in general one-fourth to one-third of the total phosphorus in ordinary soils exists as organic phosphorus. Less is known of the proportion of the sulfur found in organic forms. However, the amount of organic matter in a soil is a rough index of the abundance of these various elements, all of which are associated in a greater or less degree. Thus, Types 64 and 66 are the highest in organic carbon, with more than 60,000 pounds an acre. These types contain somewhat more than 6,000 pounds an acre of nitrogen, 1,500 to 1,800 pounds of phosphorus, and about 1,000 pounds of sulfur. A second group of soils is represented by Types 36, 41, 56, and 59. These average about 50,000 pounds an acre of organic carbon, about 4,500 pounds of nitrogen, 1,000 pounds of phosphorus, and 700 pounds of sulfur. The lowest group, represented by Types 17, 18, and 134 contains from one-half to two-thirds as high a percentage of these four related elements as the soils of the second group.

In passing to the middle and lower soil strata, the organic matter, together with these associated elements, decreases in amount, the decrease being less in the case of phosphorus and sulfur, which exist in part in mineral form.

The quantities of sulfur in the various soils are considerably lower than those of phosphorus. While crops in general take more sulfur than phosphorus from the soil, the atmospheric supply prevents sulfur deficiencies from developing. The sulfur dioxid which escapes into the air in the burning of wood and coal is brought to the earth dissolved in rain water, the amount added to the soil ranging in different parts of the state from one to three or more pounds of sulfur an acre a month.

Potassium Content Comparatively Uniform

The potassium content of Piatt county soils shows relatively less variation from type to type than any other element studied. The average amount in the surface soil is approximately 35,770 pounds an acre, and the entire range thru all the types in the county is from 33,470 to 37,820 pounds an acre. The potassium concentration in the soil at different depths likewise shows very little variation, averaging 36,720 pounds an acre in the middle stratum, and 37,600 pounds in the lower, when the figures are converted to the basis of 2 million pounds per acre.

Wide Variations in Calcium and Magnesium

Variations in the calcium and magnesium content of Piatt county soils are almost as great as those in the organic matter, as can be seen from Tables 2, 3, and 4.

Aside from the calcium which may be in solution in the soil water, soil calcium exists primarily in three forms. *Calcium-aluminum silicates* are complex soil minerals which decompose but slowly and furnish but scant amounts of soluble calcium for plant growth. This is the form which predominates in most soils, particularly those which are highly acid. Calcium may be deficient as a plant-food element in such soils, so that the supplying of this element may be one of the benefits of liming. Calcium also occurs in association with the soil colloids (the finest of the clay particles), where it is absorbed; this is known as *replaceable calcium,* and is much more easily obtainable by growing plants than the mineral form above mentioned. It is found more abundantly in the soils which are non-acid or only slightly acid. Soil types are occasionally found that grow sweet clover luxuriantly because of the abundance of replaceable calcium which they contain, even tho they may be distinctly acid. *Calcium carbonate,* the form contained in limestone, is the third form of calcium in soils. It occurs only in alkaline (sweet) soils. Of the three forms of calcium this is the most readily dissolved in the soil water; it is carried down to lower levels, where it tends to accumulate. The depth at which carbonates are found varies with the amount of leaching to which the soil has been subjected. While calcium carbonate is not present in the surface soils of Piatt county, it may be encountered within the upper 40 inches in a few soil types.

As the calcium and the magnesium in the soil water are carried downward, magnesium is more readily absorbed than calcium by the soil colloids, so that

with increasing depth there is an increasing proportion of magnesium to calcium. This change is the more pronounced in mature soils. For example, in Type 17 the ratios of magnesium to calcium in the upper, middle, and lower strata are, respectively, .74, 1.43, and 1.43. That is, in the surface soil there is only about three-fourths as much magnesium as calcium, while in the second and third strata there is about one and one-half times as much magnesium as calcium. In youthful soils, where the leaching has been less intense or less prolonged, the ratio of magnesium to calcium shows little or no increase in the lower levels. For instance, in Black Clay Loam On Drab Clay the ratios of magnesium to calcium are, in the three respective strata, .60, .76, and .63.

From these observations, it is obvious that some of the various processes involved in soil development are definitely reflected in the chemical properties of the soil itself. These, in turn, may be related to agricultural utilization and fertility requirements.

Local Tests for Soil Acidity Often Necessary

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate (as in some subsoils of Piatt county), others will contain none, but on the other hand, may actually have a lime requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made during the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and they give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests therefore furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 14 to 20. To have a sound basis for the application of limestone, the owner or operator of a farm will usually find it desirable to determine the lime requirements of each of his different fields. The section in the Appendix dealing with the application of limestone (page 41) is pertinent and should be read in this connection.

Chemical Combinations of Plant-Food Elements in Relation to Their Availability

It has been seen that a given plant-food element exists in the soil in various forms, or chemical combinations. Thus the soil phosphorus is partly organic and partly in several different inorganic, or mineral, combinations. These various forms differ from each other in the rates at which they become available to growing crops. Again, calcium has been observed to be present sometimes as

calcium carbonate, which is quickly available in the soil, but it is generally more abundant as *replaceable calcium,* a form which is not so active yet is more or less available; and it is also present as *calcium-alumino-silicate* minerals, which decompose very slowly. Statements of similar import might be made concerning nitrogen, sulfur, and other elements. Moreover, the proportions in which the different forms of a given element occur vary in different soils. When the importance of the rate at which plant-food elements become available is considered in the light of these facts, it becomes apparent that a knowledge of the total amounts of these various elements present in a soil cannot be a very definite guide as to the need for applications in the form of fertilizers.

Service of Chemical Investigations in Soil Improvement

The chemical investigations carried out in connection with the soil survey, of which the analyses here reported are a part, are of value chiefly in two ways: In the first place, they reveal at once outstanding deficiencies or other chemical characteristics which alone would affect soil productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual composition are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is probable that the results of chemical soil analyses are frequently misused when attempts are made to interpret small differences in the amount of a certain plant-food element as indicative of corresponding differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus an acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as indicating that there will be a corresponding difference in response to phosphate fertilization. Again, 100 pounds of active nitrogen an acre added by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds of nitrogen an acre. As an example of the direct use of the results of chemical investigations the case of the need for potassium fertilization in peat soils as revealed by chemical analysis may be cited; another case is the determination of the lime need of soils by chemical tests.

The second place in which chemical methods are useful is in the more detailed study of soils. The processes of soil development leave their imprint both in the physical conformation of a soil and in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in variations in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes, and chemical investigations are undertaken with the aim of aiding in the classification of soils as well as making possible more accurate prediction of their agricultural value and fertility needs and their response to different methods of management.

FIELD EXPERIMENTS ON SOIL TYPES SIMILAR TO THOSE IN PIATT COUNTY

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in this soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system, but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots

have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

Following is a key to the symbols used in describing soil treatments and reporting results from their use.

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated, (sP=superphosphate, bP=bone meal, rP=rock phosphate, slP=slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

DIXON FIELD

A summary of the results from the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Piatt county. (See discussion of Light Brown Silt Loam, page 14). This field includes about 21 acres and is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops were, for the most part, maintained up to 1922 according to the general plan described on pages 26 and 27. The most important modification of the plan has been the discontinuance, within the last

FIG. 6—CLOVER ON UNTREATED LAND, DIXON FIELD
A cutting of red-clover hay obtained from an untreated plot. Compare with the crop shown in Fig. 7.

few years, of the applications of limestone, phosphate, and straw residues, after the total quantity of limestone applied had reached the average amount of 8 tons an acre and the total phosphate 4 tons an acre.

Table 5 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure. The average annual increase due to the use of manure alone has amounted to over 19 bushels of corn an acre, more than 14 bushels of oats, 6½ bushels of wheat, nearly ¾ of a ton of clover, and ¼ of a ton of soybean hay.

Organic manure in the form of crop residues has also produced increases in yields altho not to the extent of those produced by animal manure.

TABLE 5.—DIXON FIELD: SUMMARY OF CROP YIELDS
Average annual yields, 1912-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *14 crops*	Corn *18 crops*	Oats *17 crops*	Barley *1 crop*	Clover[1] *11 crops*	Soybeans *5 crops*
1	0	20.8	37.1	48.2	43.3	(1.79)	(1.50)
2	M	27.3	56.4	62.4	46.4	(2.47)	(1.75)
3	ML	31.3	61.2	66.3	55.2	(2.67)	(1.87)
4	MLP	34.1	63.7	68.0	58.3	(2.80)	(1.91)
5	0	22.3	41.8	54.1	49.5	(1.49)	(1.27)
6	R	25.1	48.8	57.2	53.8	(1.56)	(1.43)
7	RL	28.5	56.6	62.1	54.5	(1.89)	(1.40)
8	RLP	32.5	58.0	64.4	59.0	(2.12)	(1.38)
9	RLPK	33.6	61.9	63.9	56.9	(2.24)	(1.42)
10	0	20.7	40.8	51.2	45.4	(1.90)	(1.46)

[1] Including some seed evaluated as hay.

FIG. 7.—CLOVER ON TREATED LAND, DIXON FIELD

A cutting of red-clover hay produced under the residues-limestone-phosphate treatment. Here we have a yield of 1,319 pounds, more than two and one-third times the yield on the untreated land.

Limestone in addition to organic manures has, with a single exception, effected more or less improvement. On the whole it has become increasingly profitable, so that in the last rotation period it has returned a net profit of $5.50 per ton of limestone in the manure system and $7.00 in the residues system.

Rock phosphate, as usual, shows up to best advantage when used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

Altho potassium has produced an average increase of about 4 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905 they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For twenty years all the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 6 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

TABLE 6.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average annual yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
	For limestone				
	L over 0	− 3.5	4.1	− 2.4	(.06)
	LRbPK over RbPK	5.4	10.3	1.1	− (.02)
	For residues				
	LR over L	6.0	1.5	3.8	(.08)
	LRbP over LbP	4.8	11.7	4.0	− (1.35)
	LRK over LK	2.4	3.3	2.0	− (.08)
	LRbPK over LbPK	3.3	5.9	5.9	− (1.63)
	For phosphorus				
	LbP over L	14.3	9.6	21.6	(1.74)
	LRbP over LR	13.1	19.8	21.8	(.31)
	LbPK over LK	14.7	13.7	19.0	(1.54)
	LRbPK over LRK	15.6	16.3	22.9	− (.01)
	For potassium				
	LK over L	4.7	− 1.2	1.4	(.10)
	LRK over LR	1.1	.6	− .4	− (.06)
	LbPK over LbP	5.1	2.9	− 1.2	− (.10)
	LRbPK over LRbP	3.6	− 2.9	.7	− (.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops, on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of

about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There was a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts. The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues, including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre-rates per rotation: bone meal, 1,000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1,000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rotation application of these phosphates is made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 7 indicates the arrangement of these modified plots and also gives the results of the six years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated excepting in the case of the new phosphate applications, for which the regular annual acre-rate is charged. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $15, superphosphate at $32, bone meal at $48, potash estimated as potassium sulfate at $70, and residues at 75 cents an acre.

TABLE 7.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop yields and values 1924-1929—Bushels or (tons) and dollars per acre

Plot No.	Soil treatment		1924	1925	1926	1927	1928	1929	Average annual acre-value		
	Previous	Present	Oats	Clover	Wheat	Corn	Corn	Oats	Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	49.0	62.8	$28.59	$ .75	$27.84
1-S	0	0	58.4	(2.54)	19.5	41.0	33.4	60.3	28.04	.....	28.04
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	52.2	60.6	34.19	6.49	27.70
2-S	L	RL	53.2	(.75)	18.7	46.0	35.2	51.6	22.95	1.69	21.26
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	64.6	57.2	36.60	3.57	33.03
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	59.6	66.9	37.95	4.89	33.06
4-N	LP (bone)	RLP bone)[1]	57.6	(1.81)	37.3	60.0	49.6	58.4	33.67	6.49	27.18
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	60.0	65.0	36.59	5.17	31.42
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	56.2	57.2	33.59	6.17	27.42
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	55.6	65.3	36.90	7.49	29.41
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	55.8	66.9	37.57	6.49	31.08
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	60.4	73.4	39.13	5.17	33.96
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	58.4	64.1	37.29	6.17	31.12
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	62.8	69.4	39.82	7.49	32.33
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	56.2	64.1	36.02	9.09	26.93
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	63.0	70.9	36.91	7.77	29.14
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	60.4	67.2	39.95	9.09	30.86
9-S	RKLP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	62.6	71.6	39.75	7.77	31.98
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	51.2	60.3	34.87	8.15	26.72
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	58.0	68.4	35.31	6.83	28.46
11-N	([3])	RP (rock)	70.4	(1.68)	45.3	61.8	47.4	60.6	36.06	2.63	33.43
11-S	([3])	RP (super)	60.0	(1.78)	44.5	63.0	57.2	69.7	37.24	3.95	33.29

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also, that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

In answering the question whether other carriers of phosphorus would be as effective as bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S, where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may therefore have an advantage in this respect over the bone-meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11). In some years on some plots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present the majority are in favor of superphosphate, but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these comparisons the two materials are not applied in amounts proportionate to equal cost as in other cases reported. Here 200 pounds an acre a year of superphosphate figured at $3.20 are applied against 500 pounds of rock phosphate valued at $3.75 an acre a year.

For light on the question of the residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, and where the south halves have received no bone meal since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

1. The results indicate an outstanding phosphorus hunger.
2. This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.
3. There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

MORROW PLOTS

As representing the soil type Brown Silt Loam, the field experiments on the Morrow plots, which have been continued for more than half a century, will be of special interest.

The Morrow plots are located on the campus of the University of Illinois. This series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. In 1925 the phosphates were evened up to a total of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate and their application discontinued. In 1904 ground limestone was applied at the rate of 1,700 pounds an acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons an acre. From 1903 until 1920 legumes were seeded in the corn on the south half

FIG. 8.—CORN ON THE MORROW PLOTS IN THE THREE-YEAR ROTATION
Both of these plots are under a good crop rotation of corn, oats, and clover. No soil treatment is applied to the plot at the left, while that at the right receives manure, limestone, and phosphate. The one is yielding at the rate of 49 bushels an acre, the other at 67 bushels.

of each plot. Legumes, chiefly red clover until 1918 and sweet clover since that time, have been seeded in the oats on the south half of Plot 4.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparison are brought out in Table 8. In the first place we find in the untreated, continuous-corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production. The averages for the three-year system on the untreated land show a slight increase in corn yield, a small decrease in oats, and a considerable reduction in clover.

Crop rotation has noticeably improved the yields over continuous corn growing. The three-year rotation has been more effective than the two-year rotation in maintaining yields over the entire period. The two-year rotation, however, has been gaining on the three-year rotation in recent years probably because of the influence of sweet clover.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization. Thruout the season the crops growing on the treated soil are usually

TABLE 8.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average annual yields—Bushels or (tons) per acre

Years	Soil treatment	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
1888 to 1903		*16 crops*	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
	None	39.7	41.0	44.0	48.0	47.6	(2.03)
1904 to 1929		*26 crops*	*13 crops*	*13 crops*	*9 crops*	*9 crops*	*8 crops*
	None	24.7	34.2	34.0	49.3	46.3	(1.49)
	MLP	40.0	60.9	59.2	67.2	64.1	(2.83)

at a more advanced stage of development than those growing on the untreated soil. In corn this shows up at husking time in drier, sounder ears than those found on the untreated land.

An important principle of soil management is demonstrated in these experiments; namely, that the best results are not obtained thru crop rotation alone nor thru soil fertilization alone, but it is the combination of these two practices that brings out the highest possibilities for production.

The practices in rotation and soil treatment which have been the most effective in increasing the crop-producing capacity of the soil have also been in this case the most profitable financially. These better practices not only have increased the yields but they have made possible a greater economy in production, an important factor in increasing farm profits.

For further information concerning these long-time soil experiments, the reader is referred to Bulletin 300, "Lessons from the Morrow Plots," where these investigations are described and discussed in detail.

HARTSBURG FIELD

More than one-third of the area of Piatt county is occupied by soil somewhat similar to the Black Clay Loam upon which the Hartsburg experiment field is located. This field is situated in Logan county just east of the town of Hartsburg and has been in operation since 1911.

The field is laid off in five series of ten plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The crops were handled mainly as described on pages 26 and 27 until 1918, when it was planned to remove one hay crop and one seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that time the return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922, after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 6, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure, whether in the form of crop residues or stable manure. The behavior of limestone is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it has caused some increase in practically all crops, while with residues its effect on several of the crops appears negative.

TABLE 9.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average annual yields 1913-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *15 crops*	Barley *1 crop*	Corn *26 crops*	Oats *18 crops*	Clover *8 crops*	Soy-beans *2 crops*	Alfalfa *8 crops*	Stubble clover *3 crops*
1	0	24.6	35.4	46.4	47.8	(1.86)	(1.29)	(3.47)	(.62)
2	M	27.6	44.2	56.5	52.1	(2.21)	(1.64)	(3.67)	(.82)
3	ML	33.6	50.0	63.8	57.8	(2.35)	(1.82)	(3.91)	(.74)
4	MLP	35.4	50.0	62.8	56.9	(2.43)	(1.92)	(4.19)	(.83)
5	0	28.0	42.7	51.2	46.8	(1.66)	25.8	(3.33)	(.58)
6	R	31.1	47.5	62.9	52.4	(2.00)	26.8	(3.78)	(.96)
7	RL	28.8	53.3	66.6	50.9	(1.99)	28.4	(3.45)	(.72)
8	RLP	33.0	46.9	66.9	54.7	(2.04)	26.1	(4.04)	(.93)
9	RLPK	32.6	55.6	65.4	54.1	(1.99)	26.4	(4.16)	(1.04)
10	0	29.1	45.8	51.7	47.4	(2.09)	(1.69)	(3.20)	(.54)

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect except on the one barley crop.

APPENDIX

PRINCIPLES OF SOIL MANAGEMENT

Clear thinking on the complex problems of soil management must start with a realization that there are many different kinds of soils, each differing from the others in soil characters. The fertilizer, management, and cropping requirements of each kind of soil are not yet fully worked out, altho knowledge regarding the agricultural significance of the various soil types recognized in the soil survey is rapidly accumulating.

Soils are dynamic, exceedingly complex, natural bodies made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, soils cannot be considered as reservoirs into which given quantities of an element or elements of plant food can be poured with the assurance that they can be expected to respond uniformly to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance to favor the growth of higher plants and of beneficial microorganisms.

It is obvious that in order to fulfill these conditions no single system of soil treatment can be laid down for all situations. The long-time records from numerous soil experiment fields scattered over Illinois demonstrate strikingly that different soils require different management practices. Some soils are naturally so productive that no fertilizer treatment yet tried has succeeded, on a paying basis, in raising the crop yields over their natural capacity. On the other hand, there are other soils so poor that altho under proper treatment the yield can be increased many fold, the plane of production under the best management known is still so low that it is questionable whether it pays to farm the land at all. Between these two extremes all grades of productivity are found. A further significant fact brought out in a study of these experiment fields is that a given piece of land seldom responds to soil treatments in the same manner thruout its history. The most efficient treatment during one rotation period does not necessarily remain the most efficient in another period.

Thus it appears that soil management is a complex matter even when considered from only one side of the problem, namely, that of producing crops. In addition to these complexities connected with production, however, are those having to do with the everchanging economic conditions by which market prices are affected. Whether a certain yield produced by a given soil treatment will be profitable depends directly upon the price of produce as well as upon the cost of the treatment, and every farmer knows only too well something of the violent fluctuations in market prices that have taken place in recent years. Furthermore, costs of fertilizing materials change from time to time, and these changes do not necessarily run parallel with the fluctuations in value of farm products.

With these facts in mind it is not difficult to understand that, from the standpoint of financial profits, a soil-management practice perfectly recommendable this year may become wholly unprofitable in another year and, vice versa, a practice that is unprofitable under present conditions may become highly profitable at another time.

The above remarks suggest something of the difficulty of prescribing definite recommendations for specific soil treatments and of the futility of making blanket recommendations to cover the requirements of all soils and all crops at all times. In mentioning these difficulties there is no intention to discourage efforts at planning programs of soil improvement; the purpose, rather, is to set forth some of the uncertainties involved and, in particular, to warn against hasty conclusions based upon scanty experience or superficial observation.

In spite of the many complexities involved in the problem of soil improvement, there are certain broad, underlying principles that are basic and that must be taken into consideration in laying out any improvement program. Underlying the permanent and profitable productivity of the soil is the maintenance of good physical condition, favorable biological activity, a suitable soil reaction, and an adequate supply of available plant-food elements during the growing season. The chief practices which accomplish these ends are—

1. Adequate drainage
2. Protection from erosion
3. Application of limestone where necessary
4. A good cropping system, including suitable legumes for soil improvement
5. Provision for active organic matter by returning regularly animal and plant manures
6. Purchase of mineral plant-food elements to supply deficiencies

PROVIDING ADEQUATE DRAINAGE

Adequate drainage is recognized as essential for the consistent production of satisfactory crops. Crops vary, however, in their ability to endure poor drainage. Alsike clover, for example, is better adapted to wet land than is red clover. Some bottom lands produce excellent summer crops but cannot be used for winter crops because of flooding. Altho such lands may not be well drained, it is often possible to raise good crops of corn on them year after year, because, as a result of frequent overflow, they receive periodically a fresh deposit of soil material. Such a practice on poorly drained upland would not be feasible. Upland soils, with few if any exceptions, require a well-planned cropping system if they are to be utilized most efficiently, and such a system is difficult to follow unless adequate drainage is provided.

Soils differ in permeability and consequently in their response to the installation of tile. There are soils in the southern and southwestern parts of Illinois, occupying a large total area, which cannot be drained successfully with tile because they have an impervious, clay-pan subsoil. In the east-central part of the state there is a soil occupying a considerable area which does not underdrain well because of an impervious glacial drift which comes to within 30 inches or less of the surface.

The soils of Illinois may well be artificially underdrained with the exception of those noted above. The soils which cannot be underdrained must be drained by means of open ditches and furrows or by means of a combination of open ditches, furrows, and tile provided with manholes thru which the water may enter the tile. In some soils the efficiency of the tile may be greatly increased by starting to fill the tile ditches with top-soil instead of with the more impervious material taken from the bottom of the ditches.

There are some soils in Illinois that cannot be satisfactorily drained either by tile or by open ditches. There should be no attempt to utilize such soils for general farming purposes.

PROTECTING SOIL FROM EROSION

The erosion problem is a serious one in Illinois. We are accustomed to think of erosion as being harmful only on rough and strongly rolling land. This seems, however, to be far from the truth.

The land surface subject to erosion in Illinois might be considered to include three groups of soils based on steepness of slope. The first group might be characterized as being subject to destructive erosion. Land of this character is located, for the most part, adjacent to streams and comprizes a total area in the state of some 7,000 square miles. Land subject to destructive erosion, is for the most part unsuited to general farming. If used for this purpose, erosion is so difficult to control that the returns do not justify the expense involved. Some of the land of this character may be used for orcharding and some of it may be used for permanent pasture but a large proportion of it is suitable only for timber.

A second group of erodible soils may be considered to include land suitable, under proper protection, for permanent pasture and orcharding but unsuited to general farming because of the steepness of the slopes resulting in destructive erosion if tilled. Land of this general character includes some 8,000 square miles. Terracing is recommendable on land of this character as affording a relatively inexpensive and an effective means of reducing erosion. There will be times however when erosion will be severe on land of this general character even on fields where the best known methods of control are being used.

Generally speaking the two groups mentioned above comprize land of relatively low agricultural value, as this term is commonly understood. If, however, certain of these soils are used for purposes for which they are adapted, they may be of considerable or, in some cases, of high value.

A third group comprizes the gently rolling to rolling land thruout the northern two-thirds of the state. Some 25,000 square miles may be included in this group. This land has a high value for general farming but is subject to harmful erosion and much of it is being seriously damaged thru the removal of surface soil by running water. The erosion problem presented by this third group is probably of more serious concern than that presented by either of the other two because of the high value of the land involved. Erosion can be controlled on a large proportion of this land by means of a good cropping system. Provision should be made for a protecting cover of vegetation particularly in the fall and spring. Cornstalks rolled down at a right angle to the slope are very effective in

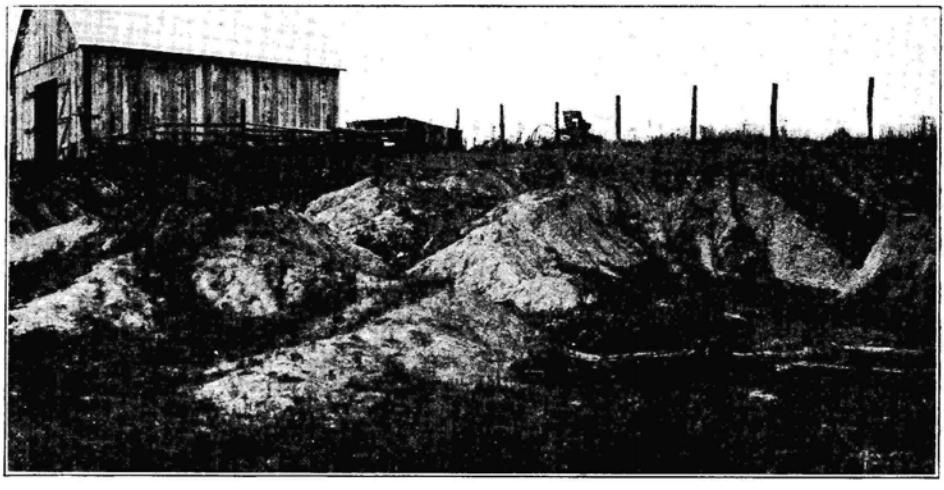

FIG. 9.—PROPER SOIL TREATMENT AND CROPPING WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 10.

reducing erosion on this gently sloping land. Long shallow draws may often be kept in permanent sod to great advantage. Broad base terraces may be effectively used where the slope is a little too steep for effective control to be secured with a good cropping system only. It is surprising however how effective a good cropping system is in decreasing washing. Experimental results indicate that on relatively gentle slopes of about 4 percent the surface seven inches of soil may be washed off in about twenty-five years where a poor cropping system is used, and that the use of a good cropping system alone will extend the time for the removal of the same amount of soil to some 350 years.

The method or combination of methods suitable for the control of erosion on any given area depends on many factors; that is to say, no generally applicable,

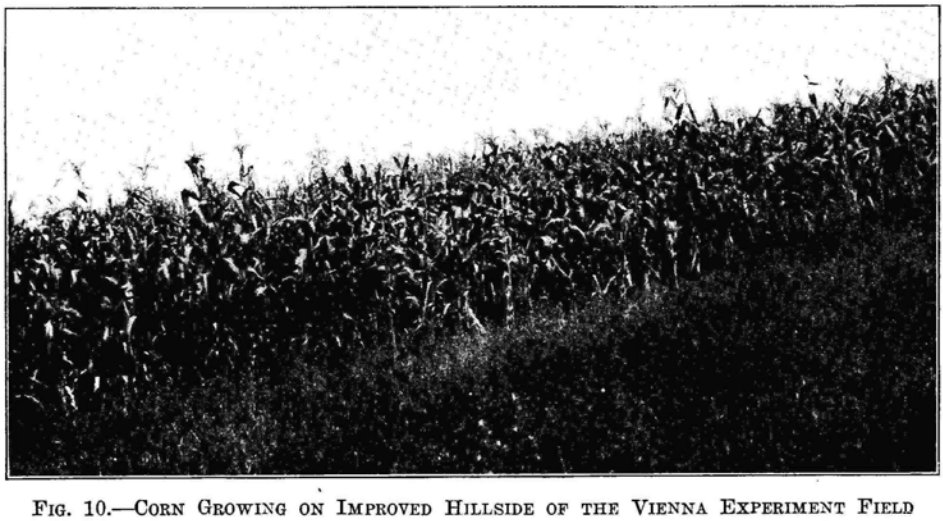

FIG. 10.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 9.

detailed directions for controlling erosion can be given because such important factors as steepness of slope, length of slope, and permeability of the soil must be taken into consideration.

A detailed discussion of methods of controlling erosion will be found in Bulletin 207, "Washing of Soils and Methods of Prevention," and Circular 290, "Saving Soil by Use of Mangum Terraces," published by this Station.

APPLYING LIMESTONE TO CORRECT ACIDITY

The maintenance of a favorable soil reaction has been mentioned as one of the essentials in a rational system of soil management, and in contemplating a soil-improvement program one of the first steps for consideration is the application of limestone.

In considering the use of limestone it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, a plant-food element for which certain crops have a high requirement. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial bacteria. It plays an essential role in the chemical transformation of nitrogen. It helps to check the growth of certain fungous diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Most important of all its properties is its power to neutralize soil acidity, thus making possible thru the growing of legumes the reclamation of millions of unproductive acres as well as the improvement of land of moderate or even high productive capacity.

Soils vary tremendously with respect to acidity, and the question arises as to how the farmer is to know whether his land needs limestone. Much information on this subject, as it pertains to Illinois land, is to be found in connection with the soil survey. Some soil types are uniformly acid, and therefore in their description attention is called to the necessity of applying limestone; other types being alkaline thruout, do not need lime, and in the discussion this fact is recorded. There are, however, extensive soil types in which the lime requirement is not uniform. It may vary from field to field on the same farm. It may even change on a given field with the passing of time, especially under heavy cropping. Obviously in such cases a definite recommendation in regard to liming cannot be given, and under these circumstances the farmer is advised to resort to a test which he himself can learn to make.

Any citizen of the state may obtain from the county farm adviser or from the Experiment Station instructions for making a systematic limestone map of his fields, showing not only the areas that need liming but also approximately the amount of limestone to apply. Such a test made on soils where the lime requirement is decidedly variable is saving many hundreds of dollars in expenditures for limestone where limestone is not needed, as well as preventing the waste of clover seed on soils too acid to grow clover. For a description of this test see Circular 346 of this Station, "Test Your Soil for Acidity."

A good indication as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover. This crop does not thrive on acid soils and its thrifty growth therefore indicates that the soil is not acid, at least in a harmful degree. Some legumes, for example red clover, will grow fairly well on soil of moderate acidity provided conditions are otherwise favorable. Too much reliance therefore should not be placed on the behavior of

FIG. 11.—SWEET CLOVER AS AN INDICATOR OF THE NEED FOR LIMESTONE
Left, no limestone; right, limestone. Sweet clover is one of the most sensitive crops to soil acidity. This crop will not grow on acid soils until limestone has been applied.

legumes as an indicator of the need of liming, for it frequently happens that fair stands are mistaken for good stands and even good yields can often be greatly increased by the use of limestone. Therefore it is well to be definitely informed regarding the condition of the soil with respect to acidity, using, where necessary, a reliable test such as that mentioned above.

MAINTAINING A WELL-PLANNED CROP ROTATION

In any program of permanent soil improvement one should adopt at the outset a good system of crop rotation, including a liberal use of legumes. It is impossible to prescribe the best rotation for every individual case because what will prove to be the most advantageous system to follow depends upon a number of different factors. Of primary importance among these factors is the location of the farm with respect to soil, to climate, and to market. The particular rotation to be followed will be determined further by the type of farming—whether grain, livestock, orcharding, or other kind of enterprise. Finally, not the least important to be considered are the personal interests and inclinations of the farmer himself.

Following are a few suggested rotations, applicable mainly to the corn belt, which are intended to serve merely as patterns or outlines, to be modified according to special circumstances. In these suggested rotation programs the more common crops are mentioned merely as types, for which other crops of similar nature may be substituted as desired. In the following lists, for example, oats may be replaced by barley or spring wheat, and likewise winter rye might take the place of winter wheat. Or it may be advisable in some cases to divide the acreage of small grain and raise different kinds; for example, plant a part of the land to oats and a part to barley. The word "clover" in the following lists of rotations is used in a general sense to designate red, alsike, or sweet clover, or even a clover-grass mixture to serve either as pasture or meadow. In the event

of clover failure soybeans may be substituted. The value of sweet clover, especially as a green manure, for building up depleted soils is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized. In the following lists the word "clover" in parentheses signifies that clover is seeded in the grain crop.

Numberless different cropping systems might be enumerated, ranging thru various long-term and short-term rotations, but it will suffice for the present purpose to mention only a few systems as suggestive of types of rotations.

Six-Year Rotations

Among the longer type of rotations the following six-year systems are suggested as being good practical rotations adaptable under many circumstances. Two such programs are presented, one in which corn predominates and the other in which wheat is the major crop. Following are the crop sequences:

System A	*System B*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)
Clover	Clover

In grain farming most of the crop residues are returned to the soil and the clover may be left on the land or returned after threshing out the seed. In livestock farming the clover may be mixed with alfalfa or with timothy, the crop being used for pasture or for meadow as desired. Soybeans, a crop that is rapidly coming into favor, can be introduced into System A by replacing either the first or the second corn crop or the last clover crop. In System B perhaps the best place for soybeans would be following the second wheat crop, altho it is possible to grow them in place of the oats.

An objection sometimes arises to wheat following clover on account of the wheat lodging. This lodging is not so likely to happen when the clover is cut as hay and removed from the land.

Five-Year Rotations

A five-year rotation system offers one of the most convenient cropping plans that can be devised for general farming. It is flexible, it provides diversification, and it can be made to give large place to legumes. Here again two different basal systems are presented, one designed primarily for corn as the major crop and the other for wheat:

System C	*System D*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)

It is of interest to observe that if soybeans were to replace second-year corn in System C or oats in System D, and the clover catch crop were allowed to grow a while in the spring before corn planting, then a legume crop would appear on every acre every year.

Four-Year Rotations

The four-year rotation represents a rather common cropping system. Among the several possibilities the following are suggested as practical programs for a four-year rotation:

System E	*System F*
Corn	Corn
Corn	Oats (clover)
Oats (clover)	Wheat (clover)
Clover	Clover

System E which calls for half the land to be in corn, requires a productive soil. However, half the land is under legumes and this is also true of System F. Soybeans might take the place of one of the corn crops in System E. In System F they might take the place of the oats provided the bean crop is removed early in order to make way for the fall seeding of the wheat.

Three-Year Rotations

One of the most common rotations practiced in the corn belt is the three-year crop succession of corn, oats, and clover (System G). From the standpoint of soil maintenance this is a good rotation. Legumes appear on the land two years out of three. It is also advantageous from the standpoint of labor economy, for plowing is required only once in three years. Its main disadvantage perhaps lies in the restricted crop diversification.

System G	*System H*
Corn	Wheat (clover)
Oats (clover)	Corn
Clover	Soybeans

An opportunity to introduce wheat into a three-year cropping plan is offered in System H. It is of interest to note that by seeding a catch crop of sweet clover in the wheat, to be plowed under the following spring just before corn planting, the land is under legumes some portion of the season every year. It will be necessary to harvest the soybeans early either by using an early variety or by cutting for hay in order to prepare the land for winter wheat. In some regions it may be desirable to substitute cowpeas for the soybeans.

Two-Year Rotation

The well-known practice of alternating corn and oats has long been pointed out as an example of a bad rotation under which thousands of corn-belt farms are headed toward ruination. However, with the advent of sweet clover, that great soil restorer, a corn-oats rotation becomes a practical possibility.

System I

Corn
Oats (sweet clover)

In this system sweet clover is sown in the oats, pastured in the fall and the following spring if desired, and then plowed down in preparation for corn. From the standpoint of soil upkeep, this cropping plan, which may fit well in certain situations, is offered as an interesting possibility, altho from the general

farm-management point of view it may lack some of the advantages of the longer rotations described above.

Altho oats are mentioned as the spring grain crop, as a matter of fact by dividing the land devoted to small grain and introducing barley, these two crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

Alfalfa and Pasture in Rotation

Alfalfa is a highly desirable crop to grow, especially in livestock farming. Its possible use as a biennial legume in the rotation has already been pointed out. It is often desirable, however, to include alfalfa as a perennial stand in the cropping system. This can be done by providing one extra field. The alfalfa occupies a field during a complete rotation period of the other crops plus one year extra. The alfalfa is then shifted to another field while the other crops rotate, and so on around the entire field system.

It may be observed that this same plan for alfalfa in rotation will provide for continuous pasture of any kind, either of perennial grass or of grass and clover mixture.

SUPPLYING RIGHT KINDS AND AMOUNTS OF ORGANIC MATTER

Organic matter acts beneficially chiefly in two ways: it helps to maintain favorable physical conditions in the soil; and it supplies food material for the microscopic organisms which inhabit the soil and which in turn, thru their life processes, effect many of the necessary chemical transformations that render plant food available for the growing crops.

The main sources of supply for organic matter are stable manure, crop residues, and green manures.

A recent study of the results from the soil experiment fields located in many different parts of Illinois reveals the fact that the system of treatment that has most frequently returned the greatest profit is manure with limestone. Of the eight systems compared, this proved to be the winning treatment on more than 60 percent of the fields. This indicates the very great value of stable manure and suggests the importance of its careful conservation and use on every farm where this material is available. On most farms, however, there is not sufficient animal manure produced to cover the land, and thus it becomes necessary to resort to some other supply of organic matter. The alternative here lies in the so-called "crop-residues" system, in which unused materials such as stalks, straw, and chaff are returned to the land and plowed under along with leguminous green-manure crops.

In connection with the application of organic matter, an important distinction between kinds of organic matter with respect to chemical make-up has come to be recognized within the last few years. It is commonly observed that an excessive application of straw or similar material is likely to produce a depression in crop growth which may result in lowering the yield. In addition to the unfavorable physical effect of plowing down a mass of decay-resistant material, particularly if dry weather ensues, a detrimental chemical effect may also follow.

The large quantity of cellulose contained in straw stimulates the activities of a certain set of microscopic organisms. These may become so active as actually to compete with the growing plants for nitrate and so under certain circumstances to cause nitrogen hunger. Good judgment must therefore be exercised in applying strawy material. Heavy applications should ordinarily be avoided unless they can be plowed under with a good growth of legumes or else applied at such a time as not to interfere with a crop having a large nitrate requirement.

MINERAL PLANT-FOOD REQUIREMENTS AND SUPPLY

Ten chemical elements have long been accepted as being essential for the growth of the higher plants. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium, and iron. To this list certain other elements have been added from time to time as being either necessary in the physiological processes or else present merely on account of absorption from the soil solution.

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured indirectly from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient.

Table 10 shows the average content of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

TABLE 10.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.....	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.....	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.....	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs.....	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.....	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw.....	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.....	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.....	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay.....	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.....	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil. In presenting these figures it is not intended to imply that plants are restricted in their feeding to the surface stratum, nor that the total quantities of the various plant-food elements give a reliable indication of the immediate fertilizer requirements of a soil except in extreme cases. Such extreme cases, however, are relatively rare and there are the great middle classes in which chemical composition varies so little as to furnish no clue whatever to the probable effect of a particular fertilizer treatment. Much depends upon the ability of the crops grown to utilize plant-food material, and much depends upon the solubility of the plant-food substances themselves. When an element becomes so reduced, either in total quantity or in available form, as to become a limiting factor of production, then we must look for some outside source of supply. Table 11 shows the approximate quantities of some of the more important plant-food elements contained in materials most commonly used as fertilizers.

TABLE 11.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Superphosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 10. [2]Young second-year growth ready to plow under as green manure. [3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

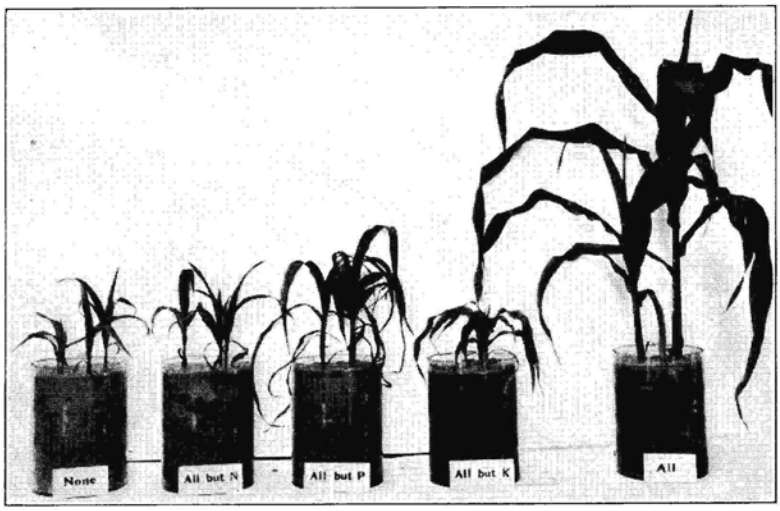

FIG. 12.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost, when purchased on the open market, is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as the clovers are able, with the aid of certain bacteria, to draw upon this supply of air nitrogen, utilizing it in their food requirements. In so doing, these leguminous plants if returned to the land add to the soil a part of the nitrogen which has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow. By taking advantage of this fact and introducing periodically into the rotation system a crop of legumes, the farmer may draw upon this cheapest source of nitrogen for soil improvement. In general farming, therefore, that is, in the production of such crops as corn, oats, wheat, and hay, legumes should furnish the main stock of nitrogen, this stock to be supplemented, of course, by all available manure and by other farm waste materials containing nitrogen.

In addition to these home sources of nitrogen supply, there are various commercial products containing nitrogen offered on the market. These materials

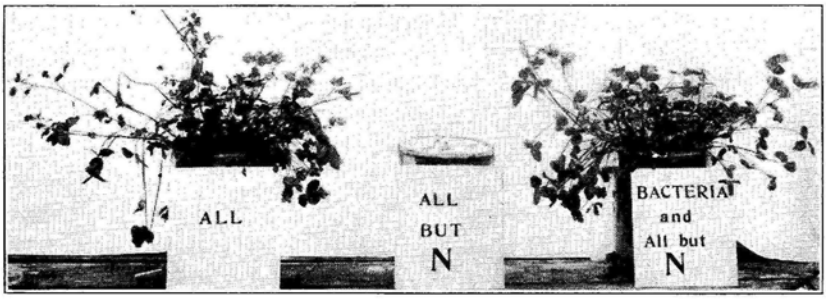

FIG. 13.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

formerly consisted largely of sodium nitrate, a mineral imported from South America; ammonium sulfate, produced in the manufacture of coal gas and coke; and certain waste and by-product materials mainly of organic composition. Within very recent time, however, tremendous developments in the synthetic production of nitrogen compounds from air nitrogen have taken place. Among these new fertilizer materials may be mentioned cyanamid, calcium nitrate, sodium nitrate, ammonium nitrate, and urea.

These developments in the artificial fixation of nitrogen will doubtless have a far-reaching effect in reducing the cost of commercial nitrogenous fertilizers. What the limits may be in this direction one dare not predict. Whether these manufactured nitrogen compounds will become so cheap some day as actually to compete with legume nitrogen is problematical, especially when the other advantages offered by legumes are considered. However, the day has not yet arrived when we can afford to dispense with legumes as a green manuring crop in the production of grain and hay.

Accepting, then, this principle that legumes and farm wastes must constitute the main source of nitrogen supply, the question arises—can these home-grown materials be supplemented to advantage by the use of commercial carriers of nitrogen?

The impossibility of making blanket recommendations has already been pointed out. The question finally resolves itself into a matter of expense and profit for each individual case. Sodium nitrate is purchased on the market at present at about $65 a ton. If a farmer applies 100 pounds an acre, he provides about two-fifths of an ounce to a hill of corn. A ton would cover 20 acres and the cost would be about $3.25 an acre. Under present prices an increase of about four to five bushels of corn or wheat would be required in order to cover the cost before any profit could be realized.

Under what circumstances might such increases in yield be reasonably expected? It is possible that in many cases where manure or legumes have not been used, such an application of nitrogen would return a profit, but such usage should be regarded as a temporary expedient rather than a permanent practice

in soil management. Under adverse weather conditions, when soil nitrates are formed too slowly or are washed away by excessive rain, an application of nitrogen fertilizer may prove highly beneficial to wheat and corn.

A peculiar hazard accompanies the application of nitrogen that does not obtain in applying phosphate or potash. Nitrates are readily washed away, and if circumstances are such that the first crop fails to utilize the nitrogen, little or no residual effect on the following crops can be expected. For this reason special caution should be used against applying excessive amounts of nitrogen. Usually it is well to divide the application of a quickly soluble nitrogen fertilizer such as sodium nitrate, using a portion at planting time and distributing the remainder at a later date. Nitrogenous fertilizers are often made up of a mixture of materials whose nitrogen becomes soluble with varying degrees of rapidity, thus automatically distributing the action of the nitrogen over a period of time.

Phosphorus Problem

Different soil types display great variation in phosphorus content and, on the other hand, soils of like total-phosphorus content exhibit great variation in response to phosphate fertilization. The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of farm manure and phosphatic fertilizers and perhaps the use of rotations in which deep-rooting leguminous crops are frequently grown. Results obtained from the soil experiment fields of Illinois show that some soils respond highly to phosphate fertilization, while others give a very low response or none. Reports from county farm advisers and farmers in general are in agreement with these experimental results.

As stated above, the total quantity of phosphorus present in a soil is not a reliable indicator of the probable response to phosphate fertilization. Apparently it is a matter of solubility or the chemical form in which the phosphorus exists rather than total quantity.

A simple field test has recently been devised at the Illinois Experiment Station which will distinguish soils having a high amount of available phosphorus from those having a low amount. Information concerning this test is furnished in Bulletin 337, "A Field Test for Available Phosphorus in Soils."

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate and superphosphate. Other valuable carriers of phosphorus are bone meal and basic slag.

Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer. Considerable experimentation in the finer grinding is under way in the hope of increasing the plant-food value of the product and thus make possible a reduction in the amount that it is necessary to apply.

Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further

processing, different concentrations are produced. The most common grades of superphosphate now on the market contain 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Likewise the 12 to 15 percent of phosphorus in rock phosphate corresponds to 29.5 to 34.3 percent of phosphoric acid. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food, altho this fact has little agricultural significance for Illinois, where the soils generally are sufficiently stocked with sulfur. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than is the phosphorus in raw rock phosphate, altho there is often good response in the crops immediately following the application of rock phosphate.

Obviously the carrier of phosphorus that will give the most profitable returns, considered from all standpoints, is the one to use. The question of which is the most profitable, however, remains unsettled, altho it has been the subject of much discussion and investigation. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

On several of the Illinois soil experiment fields rock phosphate and superphosphate are being compared in systems of management looking toward permanent soil improvement, and are applied in amounts corresponding approximately to equivalent money expenditures. So far as these comparisons show, there appears to be little consistency in the results. In some years and on some crops superphosphate has furnished the greater profit; in other years and on other crops the reverse is true. In some cases neither material has paid for its cost, indicating that phosphorus is not a limiting factor in production on all soils. On the whole, therefore, if possible residual effects are disregarded, there appears to be no indisputable evidence for general discrimination between the two forms of phosphate.

Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium altho it exists mainly in a very slowly soluble form and probably only a very small percentage of the total potassium exists in a form available to plants at any one time.

Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils usually respond to potash fertilization. The Illinois Experiment Station has demonstrated in field experiments located on peat land that the difference between success and failure in raising crops on such land depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certin soil types that are rather high in organic matter, including peat and dark-colored sandy, silt, and clay loams. The unproductiveness of these soils is probably due largely to the unavailable condition of the soil potassium as well as to an unbalanced condition of the plant nutrients resulting from an excess of nitrate nitrogen. The addition of potash has a beneficial influence upon both of these unfavorable conditions.

Potash fertilizer may be procured in the form of one of the potassium salts, such as the chlorid, sulfate, or carbonate, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content.

Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned above, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

Use of Mixed Commercial Fertilizers

A mixed commercial fertilizer is a combination of substances containing either two or three of the plant-food elements nitrogen, phosphorus, and potassium. If the material contains all three of these elements, it is said to be a "complete" mixed fertilizer; if only two of the three are present, it is said to be an "incomplete" mixed fertilizer.

A complete mixed fertilizer has the general formula $N–P_2O_5–K_2O$ (nitrogen, phosphorus pentoxid, potassium oxid), the proportions of the elements varying according to the way in which the material is compounded. By substituting figures for the letters in this formula the percentage composition of the fertilizer is indicated. Thus a fertilizer of the formula 5-15-5 contains 5 percent nitrogen, 15 percent phosphorus pentoxid (usually designated as phosphoric acid), and 5 per cent potassium oxid (usually called potash). Translated into pounds, this means that a ton of the fertilizer contains 100 pounds of nitrogen, 300 pounds of phosphoric acid, and 100 pounds of potash. For the benefit of those who are accustomed to think in terms of the simple plant-food elements rather than these combinations, it may be explained that the above amounts correspond to 100 pounds of the element nitrogen (N), 131 pounds of the element phosphorus

(P), and 83 pounds of the element potassium (K). Changing the formula to read 0-15-5 indicates that no nitrogen is contained in it; 5-15-0 means that no potassium is present; and 5-0-5 indicates that phosphorus is absent.

In compounding these fertilizers, several ingredients carrying a single kind of plant-food element may be used. For example, a portion of the total nitrogen may be furnished by sodium nitrate, while another portion may be carried in dried blood or in ammonium sulfate. In addition to these plant-food materials, fillers and conditioners are often used in such amounts as to make the finished product contain the desired percentage of plant food.

A distinction between what are considered "high-grade" and "low-grade" fertilizers is now being made upon the arbitrary basis of a total of 16 so-called "units of plant food." Thus a 2-8-2 fertilizer carrying 12 units of plant-food would classify as a low-analysis grade. The advantage of using the higher grade products is becoming more and more generally recognized by both consumers and producers of fertilizers. In the latest developments still more concentrated forms of fertilizers are being produced containing as much as 60 units of plant food. If the economy of production and the agricultural value justify the general use of materials of such high concentration, there should be a great saving in the cost of transportation and handling thru the use of fertilizers of this type.

The question arises repeatedly regarding the employment of mixed commercial fertilizers, and particularly their employment in connection with a basic program of soil improvement built around the use of legumes and limestone where necessary.

An important principle to be borne in mind in the use of any fertilizer is represented in the so-called "law of the minimum," that is, that no benefit can result from the application of a given plant-food element unless the need for that element is a limiting factor in plant growth. If, for example, there is already in the soil enough available phosphorus to produce a 40-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only 40 bushels or less, all the phosphorus one might apply would be absolutely ineffective in increasing the yield beyond this 40-bushel limit.

The most serious objection to the indiscriminate use of mixed commercial fertilizers lies in the fact that frequently only one, or perhaps two, of the plant-food elements carried by the fertilizer are actually needed, in which case a useless expense is incurred for the unnecessary element or elements.

This question of the use of commercial fertilizers is exceedingly complicated because so much depends upon numberless conditions of soil and season. We may be able to analyze in part the conditions of the soil, but we are powerless in predicting the conditions of the oncoming season. A given fertilizer may pay a handsome profit this season but on the same field next year may be absolutely without effect, or even detrimental to the crop. That is why it is impossible to make any general statement or to give a blanket recommendation concerning the use of such fertilizers.

The matter finally resolves itself into two questions: cost of material and benefit derived. Fortunately the cost of material can be definitely determined.

In order to get an idea of the expense of applying mixed commercial fertilizers, perhaps we cannot do better than to figure the cost per acre based upon the published recommendations and price quotations of a fertilizer company. The following estimates are based upon the recommendations of such a company as given for the dark-colored silt or clay loam soils of Illinois on land having had manure and clover, and the prices are those quoted for the spring of 1929.

Thus, for the corn crop, 150 pounds per acre of a 5-15-5 fertilizer is recommended to be applied in drills or hill-dropped. The price of this fertilizer is quoted at $53.15 a ton, which would make the cost $3.99 per acre. According to an official report, the farm value of corn for December, 1928, in Illinois was 70 cents a bushel. At this rate an increase of 5.7 bushels of corn per acre would be required to cover the cost of the fertilizer, taking no account of the extra expense in applying it.

For spring grains the recommendation is to use a 0-21-9 fertilizer at the rate of 250 pounds an acre if drilled or 400 pounds if broadcast. The price is $45.10 a ton, thus making the cost per acre $5.64 drilled or $9.02 broadcast. If the spring grain were oats, valued at 38 cents a bushel, the increase in yield to cover the cost of fertilizer would have to be nearly 15 bushels an acre in the case the fertilizer were drilled; if it were broadcast nearly 24 bushels would be required to pay the cost before any profit would be realized. If instead of oats the spring grain were wheat valued at $1.02 a bushel, the increase in yield necessary to pay for the fertilizer would be 5½ bushels if the fertilizer were drilled and nearly 9 bushels if broadcast. In like manner the recommended application for potatoes is found to cost $13.13 an acre if the fertilizer is drilled and $26.25 if broadcast. The application recommended for pastures and meadows would cost $13.13 an acre.

The above examples afford some idea of the cost of using mixed commercial fertilizers for the production of our common field crops in so far as the prices quoted remain representative. Unfortunately it is impossible to furnish information with the same certainty concerning the profit that is likely to be derived from these fertilizers, for that will depend upon several varying factors, mainly the amount of increase in yield and the price received for it.

What kind of fertilizers will be profitable and under what particular conditions they will pay must be determined mainly on the basis of actual experience. In this connection it should be borne in mind that in all experimental trials great care must be exercised in drawing conclusions. The soil of a farm or even of a field is seldom perfectly uniform throuout, and differences in yield really due to differences in soil may easily be mistaken for effects of the fertilizer treatment. Therefore small differences in yield should be critically considered before being accepted as significant. It is particularly risky to base conclusions upon the results of a single year, because of peculiar seasonal effects. Never are two seasons exactly alike, and the results of this year may not apply next year. If outstanding effects from fertilizers occur the first year they are tried, such results may be taken as indicative and accepted as a tentative guide for further work,

but final conclusions should be withheld until these results are well confirmed in subsequent trials.

To what extent mixed commercial fertilizers can be profitably employed in connection with a basic program of soil improvement is a problem of great consequence. No doubt there are many instances in which such fertilizers may be used with profit, but it is just as certain that in many other instances their use would result in financial loss. Before investing in mixed fertilizers, farmers should carefully consider the cost, which, as explained above, is an item that can be definitely determined. With the investigations now under way, the Experiment Station hopes soon to be in possession of much more definite information than now exists regarding the use, under present-day conditions, of these mixed commercial fertilizers.

Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
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34 Marion, 1926
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LEGEND

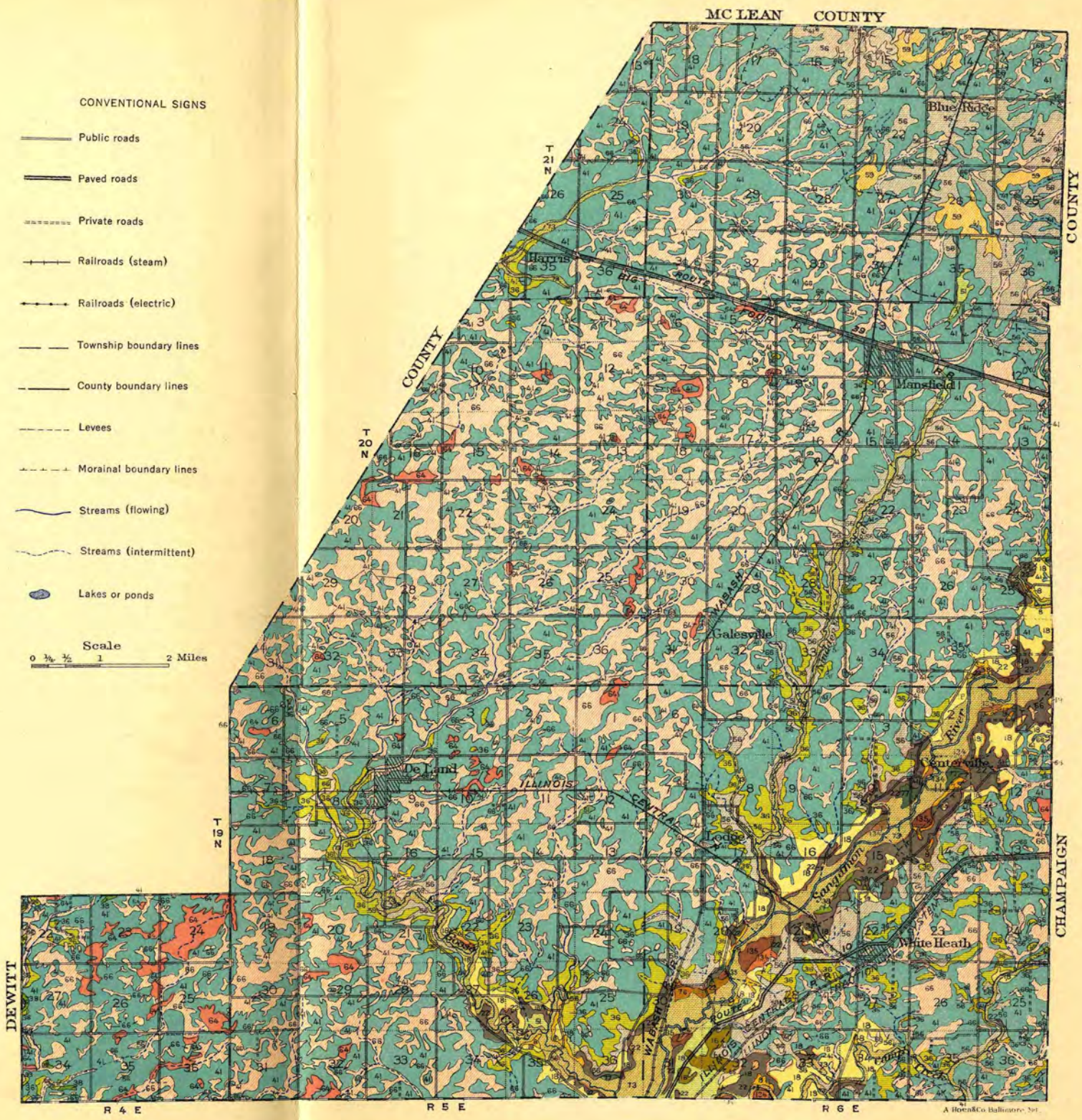
36	Light Brown Silt Loam
38	Light Brown Sandy Loam
41	Brown Silt Loam
56	Brown Silt Loam On Drift
22	Reddish Brown Silt Loam On Drift
59	Brown Silt Loam On Calcareous Drift
66	Black Clay Loam On Drab Clay
64	Black Clay Loam On Calcareous Drift
18	Brownish Yellow-Gray Silt Loam
17	Brownish Yellow-Gray Silt Loam On Compact Medium Plastic Clay
16	Brownish Yellow-Gray Silt Loam On Tight Clay
8	Eroded Gravelly Loam
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel
135	Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel
51	Deep Dark Brown Silt Loam
107	Deep Black Clay Loam
77	Deep Brown Silt Loam
75	Black Mixed Loam
73	Brown Mixed Loam

CONVENTIONAL SIGNS

- Public roads
- Paved roads
- Private roads
- Railroads (steam)
- Railroads (electric)
- Township boundary lines
- County boundary lines
- Levees
- Morainal boundary lines
- Streams (flowing)
- Streams (intermittent)
- Lakes or ponds

Scale

0 ⅛ ½ 1 2 Miles



SOIL SURVEY MAP OF PIATT COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

LEGEND

- 36 Light Brown Silt Loam
- 38 Light Brown Sandy Loam
- 41 Brown Silt Loam
- 56 Brown Silt Loam On Drift
- 22 Reddish Brown Silt Loam On Drift
- 59 Brown Silt Loam On Calcareous Drift
- 66 Black Clay Loam On Drab Clay
- 64 Black Clay Loam On Calcareous Drift
- 18 Brownish Yellow-Gray Silt Loam
- 17 Brownish Yellow-Gray Silt Loam On Compact Medium Plastic Clay
- 16 Brownish Yellow-Gray Silt Loam On Tight Clay
- 8 Eroded Gravelly Loam
- 134 Brownish Yellow-Gray Silt Loam Over Sand Or Gravel
- 135 Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel
- 51 Deep Dark Brown Silt Loam
- 107 Deep Black Clay Loam
- 77 Deep Brown Silt Loam
- 76 Black Mixed Loam
- 73 Brown Mixed Loam

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- Public roads
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- Morainal boundary lines
- Streams (flowing)
- Streams (intermittent)
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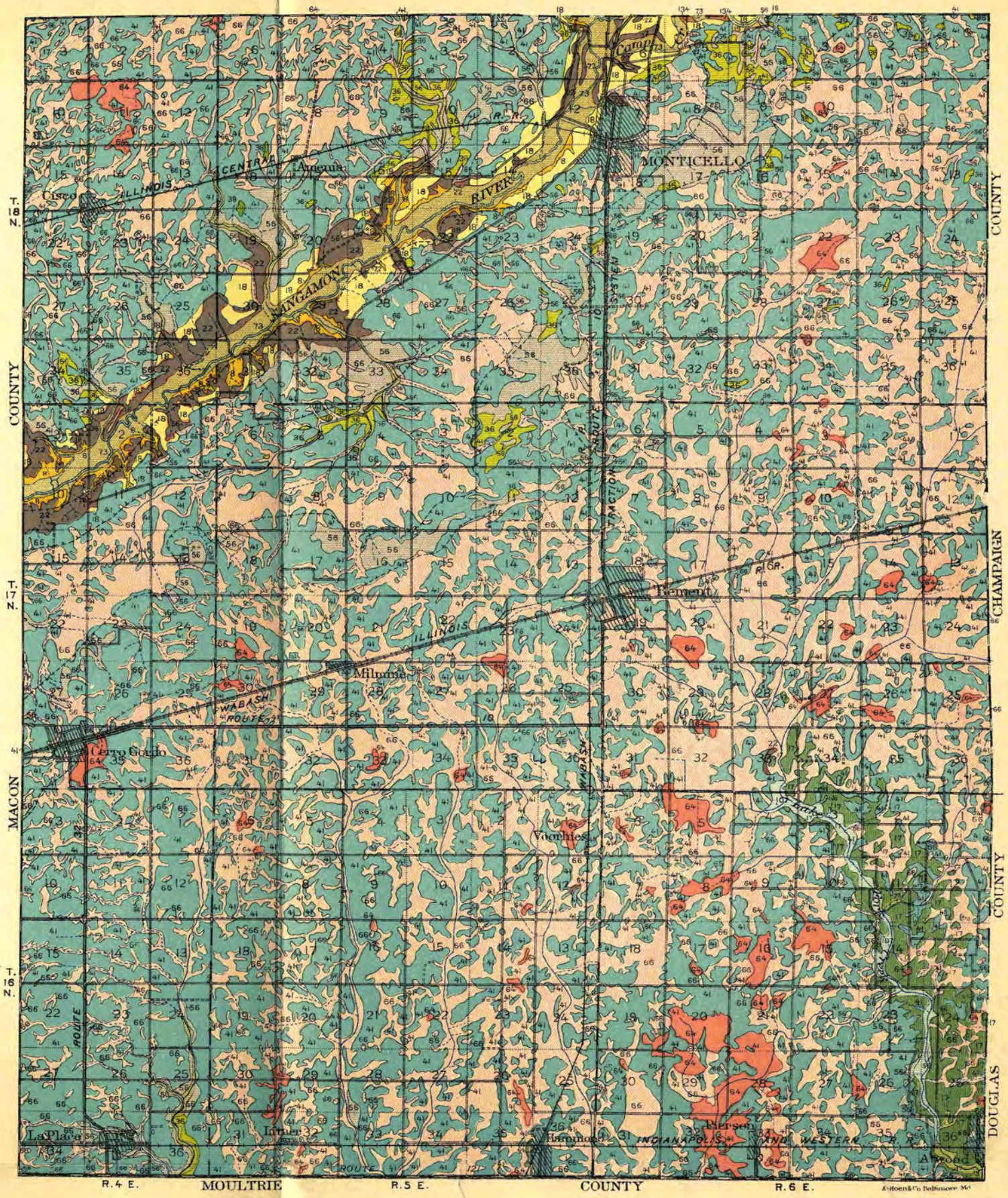
Scale
0 ¼ ½ 1 2 Miles



SOIL SURVEY MAP OF PIATT COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION