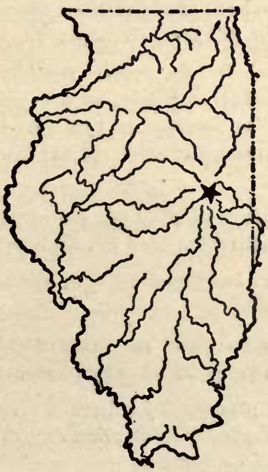
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 193

SUMMARY OF ILLINOIS SOIL INVESTIGATIONS

By CYRIL G. HOPKINS, J. G. MOSIER, and F. C. BAUER



URBANA, ILLINOIS, DECEMBER, 1916

SUMMARY OF BULLETIN NO. 193

1. The Illinois Agricultural Experiment Station has been conducting extensive investigations upon the improvement of Illinois soils for the past fifteen years by means of a systematic soil survey, chemical analysis, and culture experiments. Pages 451–462

2. Field investigations have been conducted upon fifty experiment fields located upon representative types of soil in various parts of the state. Thirty-nine of these fields are in operation at the present time. Pages 454–459

3. Illinois soils exist in fourteen great soil areas, as shown on the colored map. Pages 463–464

4. In the counties covered by the first ten soil reports, 62 individual soil types have been discovered. These types are extremely diverse and for convenience are grouped into six classes; namely, prairie, timber, terrace, ridge, swamp and bottom-land, and residual soils. Pages 464–465

5. The fertility invoices of the individual soil types show a great variation in the content of the essential plant-food elements. Illinois soils may be deficient in one or more of five plant-food elements; namely, nitrogen, phosphorus, potassium, calcium, and magnesium,—and they may be either acid or alkaline. Thus the problem of maintaining the fertility of the soil is sometimes complicated, tho usually limited essentially to the application of limestone and phosphorus and the turning under of nitrogenous organic matter. Pages 465–467

6. As a rule, the results of the field experiments harmonize with the information given by the chemical composition of the soil. They have shown: (1) that the maintenance of organic matter and nitrogen is the greatest practical problem of the Illinois farmer; (2) that phosphorus is the one element of plant food that is most universally deficient; and (3) that limestone must be supplied in abundance to many soils before they can be permanently improved. Pages 467–483

7. On the ordinary corn-belt soil, proper treatment has produced a total value for one rotation (1911-1914) of $98.58, as contrasted with $65.00 where no treatment was given. One dollar invested in rock phosphate has paid returns as follows: first rotation, $1.18; second rotation, $1.62; third rotation, $2.70. Pages 473–475

8. Southern Illinois prairie land has been improved by proper soil treatment so that the total increase over untreated land has been 207 percent. Page 477

9. On peat soil, potassium has increased corn yields by more than 30 bushels per acre. Page 482

10. On sand soils, during six years the value of the crops per acre has been increased $73.37 by nitrogen and only 22 cents by phosphorus in addition. Page 482

11. Every farmer should practice a high-grade system of permanent agriculture. This is made possible by good crop rotation and the application of materials economically supplementing soil deficiencies. Page 483

Available publications relating to Illinois soil investigations. Page 484

SUMMARY OF ILLINOIS SOIL INVESTIGATIONS

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The wealth of Illinois is in her soil, and her strength lies in its intelligent development.—DRAPER.

The purpose of this bulletin is to summarize the results of the soil investigations which have been carried on by the Illinois Agricultural Experiment Station, in order that the farmers and landowners may know of the progress being made, and thus hasten the adoption of systems of farming that will increase and permanently maintain the productive capacity of Illinois soils, instead of decreasing their fertility, as is done under the most common practices.

NATURE AND EXTENT OF INVESTIGATIONS

The Illinois Agricultural Experiment Station began to investigate the soils of the thirty-six million acres of land within the borders of the state in 1901, with an appropriation from the General Assembly of $10,000 per annum for two years. In other words, this huge task was begun with an annual appropriation of one cent for each thirty-six acres. The growth of the work has since been so rapid and its value so evident that there is now an appropriation of one cent annually for about every four acres.

The purpose of these investigations has been five-fold, for the intelligent use of Illinois soils requires definite knowledge in regard to: (1) the plant-food requirements of the crops to be produced; (2) the total stock of plant food contained in the soil; (3) the availability of the plant-food elements by practical methods of farming; (4) the most practical economical methods of supplementing or increasing the plant food in the soil; and (5) the systems of farming that will most profitably and permanently maintain the productive capacity of the soil. Such knowledge has been rendered possible by means of systematic soil survey, chemical analysis, and culture experiments.

SOIL SURVEY

The soil survey has furnished much valuable information: first, by establishing by a general survey the existence of extensive soil types in the great soil areas into which the state is naturally divided; and second, by determining by detailed county survey the soil types upon every farm in the state. This detail survey when completed and mapped will give every farmer and landowner definite information concerning the soils upon his own farm, even down to ten-acre units or less.

A map showing accurately the location and extent of the different soil types, with their principal variations and limits, is essentially the objective of the soil survey. During the fifteen years the work has been in progress, a general survey of the state has been made and more than sixty counties have been completely, or almost completely, surveyed in detail, in such order that every unsurveyed county borders two or more surveyed counties. At the present rate of progress the detail survey of the state should be completed in six or seven years.

Chemical Analysis

Chemical analysis of the soil has furnished an accurate invoice of the total amounts of the different essential elements of fertility contained in the soil to a depth to which plant roots normally extend. For obvious reasons this soil depth is divided into three strata: the surface, the subsurface, and the subsoil. The surface soil extends to the depth of good plowing (0 to 6⅔ inches) and is that part with which the farm manure, limestone, phosphate, or other fertilizer is incorporated, and that part which must be depended upon largely to furnish the necessary plant food for the production of crops. The subsurface soil lies between the depths of 6⅔ and 20 inches, and may be stirred by subsoiling. The subsoil extends from 20 to 40 inches.

After a county has been surveyed, representative samples of every soil type established by the survey are secured from each of the three strata. Great care is used in every case to avoid the taking of samples that would not in every way be true to the soil type. Old stack yards and feed lots and fields that have been heavily manured or fertilized are avoided, and all other abnormalities are guarded against. When a suitable area has been selected, many soil samples are drawn at different places some rods apart. The samples of each stratum are thoroly mixed and about ten pounds of the mixed soil is then bagged and given an official number. An exact record is also kept of the location from which the samples have been taken. Extensive types are sampled many times in the county; less extensive types are sampled as they occur.

The soil samples thus secured are sent to the Station laboratories, where they are prepared for analysis by thoro air-drying and pulverizing. The pulverizing consists, first, in reducing the entire sample to such condition that it will pass thru a millimeter sieve (25 holes to the linear inch), a record being kept of the amount of pebbles, rock, and other material that will not pass thru; and for certain determinations it consists further in reducing about 100 grams of this soil to such fineness that it will all pass thru a sieve having 10,000 holes to the square inch. In all, nine different determinations are then made, as follows: for dry matter, for total organic carbon, total nitrogen, total phosphorus, total potassium, total calcium, total magnesium, total inorganic carbon for the presence of limestone, and for soil acidity, these being the most important plant-food elements and soil characteristics which are more or less under the control of the farmer. After the soil is analyzed, the reserve is stored away in vaults for any possible future use, such, for example, as determining the degree of solubility in various solvents, in case conditions should ever justify such work.

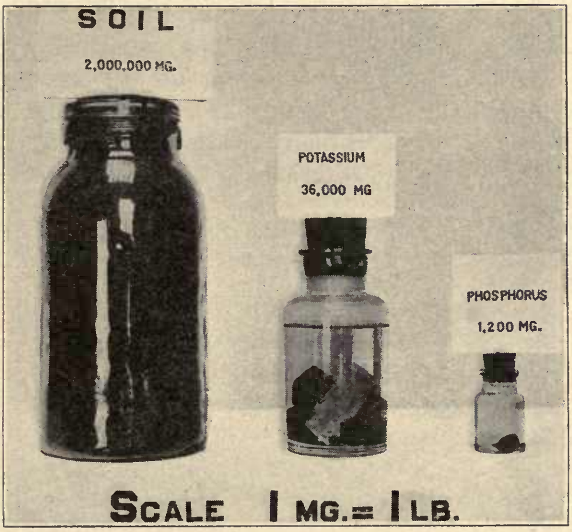


FIG. 1.—PROPORTIONATE AMOUNTS OF POTASSIUM AND PHOSPHORUS IN THE SURFACE SOIL OF AN ACRE OF TYPICAL CORN-BELT SOIL

All results of the chemical analyses are reported on the acre basis, assuming the weight of the surface soil to be 2 million pounds; the subsurface, 4 million pounds; and the subsoil, 6 million pounds. In the case of sand soils, however, 2½ million, 5 million, and 7½ million pounds, respectively, are used as the bases, and for peat soils, 1 million, 2 million, and 3 million pounds, on account of the difference in the specific gravities of these types. The results are so reported because they are easily understood and readily compared in practical application, and they are also scientifically exact.

Since the beginning of the work about 7,000 samples of soil have been collected from various parts of the state, and of this number approximately 4,600 have been analyzed. At the present rate of collecting and analyzing the samples (about five counties a year), twelve to thirteen years will be required to complete the work for the entire state.

EXPERIMENT FIELDS

Culture experiments have been conducted by the University upon experiment fields established in all sections of the state upon important and representative soil types. The fields are so operated as to give the farmer positive information upon practical, economical, and permanent systems of soil management. Such experiments have been conducted on fifty fields in various parts of the state, thirty-nine of which are in operation at the present time.

The first fields were established in the summer and fall of 1901 upon rented tracts of land. More or less difficulty prevailed at that time in securing suitable tracts because in many cases the farmers had little interest or confidence in the work; but this indifference gradually changed to real interest, and at the end of six years the University was operating twenty fields.

By 1908 the value of such fields for purposes of investigation and demonstration of soil improvement methods began to impress many people. Suitable tracts of land for such experiments were then offered and donated permanently to the University by local communities and individuals, and from thenceforth the University has established no field except upon permanently deeded land. In recent years many more such tracts have been offered than could be accepted.

In establishing a permanent field, it is the policy of the University to choose a location where the results will, in every respect, be of the greatest value to the community. The land above all must be uniform in order that practical and trustworthy information may be secured. It must represent an extensive soil type so that the results secured from different systems of farming will be widely applicable to the conditions of the community. It should be upon a main thorofare and within easy walking distance from railroad stations so that it will be easily accessible to visitors.

As new and permanent fields have been established, a number of the older temporarily rented fields in the same general locality have been given up, sometimes because the lease expired and could not be renewed. Fields that have been discontinued were located near the following places: Myrtle, Ogle county; Tampico, Whiteside county; Green Valley, Tazewell county; Lincoln, Logan county; Manito (old field), Mason county; Sibley, Ford county; Auburn, Sangamon county; Manito (new field), Tazewell county; Mascoutah, St. Clair county; Vienna (fertility field), Johnson county; and Momence, Kankakee county.

At the present time twelve rented fields are still being operated, six of them temporarily and six with perpetual leases. Some of the former will undoubtedly have to be discontinued sooner or later on account of the impossibility of securing permanent possession of the land. These temporary fields are located near the following places: Antioch, Lake county; DeKalb, DeKalb county; Fairfield, Wayne county; Galesburg, Knox county; McNabb, Putnam county; and Rockford, Winnebago county. The six fields which may be permanently retained by the University are located near Odin, Marion county; Cutler, Perry county; Bloomington, McLean county; DuBois, Washington county; Union Grove, Whiteside county; and Virginia, Cass county.

In addition to the six permanently leased fields, the University has secured possession of twenty-seven fields so long as they are used for agricultural experimentation or demonstration. The permanent fields now owned by the University or controlled without rental expense are located as follows:

(1) Aledo experiment field, Mercer county, about one-half mile west of the railway station at Aledo. The land was purchased and donated by the business men and landowners of Aledo and vicinity, in part thru the efforts of William and Vashti College.

(2) Carlinville experiment field, Macoupin county, part of an eighty-acre tract on which Blackburn College is located. The permanent possession and use of this land was a direct donation from Blackburn College.

(3) Carthage experiment field, Hancock county, within the corporate limits of Carthage, about five blocks south of the courthouse. The land was purchased and donated by the business men and landowners of Carthage and vicinity, partially on account of their interest in Carthage College.

(4) Clayton experiment field, Adams county, adjoining the town of Clayton. The field is about five blocks south of the railway station, and reached by a concrete walk. The land was donated by the citizens of Clayton and vicinity.

(5) Dixon experiment field, Lee county, on the north side of the interurban railroad about two miles west of Dixon. The land was purchased and donated by the citizens of Dixon and vicinity.

(6) Enfield experiment field, White county, three-quarters of a mile northeast of the town of Enfield. The land was purchased and donated by about six hundred citizens of White county.

(7) Ewing experiment field, Franklin county, about one-half mile northeast of the village of Ewing. The land was purchased and donated by Ewing College with the assistance of friends of that institution.

FIG. 2.—A STAR INDICATES THE LOCATION OF AN EXPERIMENT FIELD

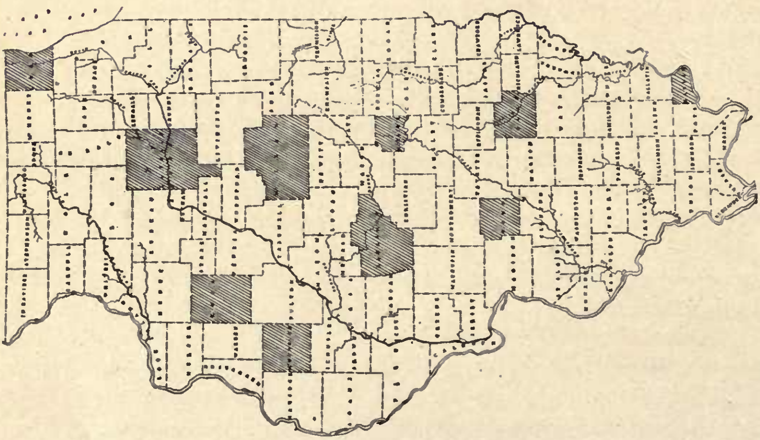


FIG. 3.—SHADED COUNTIES INDICATE FIRST TEN COUNTIES FOR WHICH SOIL REPORTS HAVE BEEN PUBLISHED

(8) Hartsburg experiment field, Logan county, about one-half mile east of the village of Hartsburg. This land was donated by the Scully estate.

(9) Joliet experiment field, Will county, three miles northwest of Joliet, on the Joliet-Plainfield wagon road and the Aurora-Joliet interurban line. The land was purchased and donated by Will county.

(10) Kewanee experiment field, Henry county, about midway between Kewanee and Galva on the Galva and Kewanee electric line. The car stops at Midland about one-half mile south of the field. The land was purchased and donated by the citizens of Kewanee, Galva, and vicinity.

(11) LaMoille experiment field, Bureau county, about one mile south of the corporate limits of LaMoille. The land was donated by Mrs. Anna Norris Kendall, and was a part of the farm on which her own residence, "Elizabeth Cottage," is located.

(12) Lebanon experiment field, St. Clair county, about five blocks south of the main street of Lebanon. The land was purchased and donated by McKendree College, the purchase price being contributed for the purpose by Governor Charles S. Deneen, an alumnus and trustee of McKendree and at the time an ex-officio trustee of the University of Illinois.

(13) Minonk experiment field, Woodford county, one mile west of Minonk. This land was donated by Mr. and Mrs. Bela M. Stoddard, of Minonk.

(14) Mount Morris experiment field, Ogle county, immediately adjoining the residence district on the south side of Mount Morris. The land was purchased and donated by Mount Morris College and citizens of Mount Morris and vicinity.

(15) Newton experiment field, Jasper county, about one and one-half miles northwest of Newton. The land was purchased and donated by Jasper county and the citizens of Newton and vicinity.

(16) Oblong experiment field, Crawford county, five blocks south of the station at Oblong. The land was purchased and donated by the citizens of Oblong and vicinity.

(17) Oquawka experiment field, Henderson county, about one mile northeast of the C. B. & Q. station at Oquawka. The field was donated by Mr. Alex Moir and others.

(18) Pana experiment field, Christian county, just north and east of Pana, one mile from the Big Four and Illinois Central passenger station. This field was donated by the late Captain Kitchell, of Pana.

(19) Raleigh experiment field, Saline county, one-half mile south of Raleigh, on land purchased and donated by citizens of Raleigh, Galatia, and vicinity.

(20) Sidell experiment field, Vermilion county, one mile directly east of Sidell. The land was purchased and donated by the citizens of Sidell and vicinity.

(21) Sparta experiment field, Randolph county, immediately north of the city of Sparta. The land was purchased and donated by the citizens of Sparta and vicinity.

(22) Spring Valley experiment field, Bureau county, about one-half mile from the business part of Spring Valley. The land was donated by the vocational township high school of Spring Valley.

(23) Toledo experiment field, Cumberland county, about one-half mile south of the courthouse at Toledo. The land was purchased and donated by the county.

(24) Urbana experiment field, Champaign county, on the University farm. Part of this field has been under continuous experiment for thirty-seven years. So far as is known, it is the oldest experiment field in the United States on which the originally planned experiments are still in progress. It is unquestionably the most valuable land within the borders of the state, considering the annual lesson it now presents to the agricultural world.

(25) Brookport-Unionville experiment field, Massac county, adjoining the village of Unionville, five miles east of Brookport, on land purchased and donated by citizens of Massac county and southern Pope county. This experiment field is located on the most southern table land of the state, within five miles of the mouth of the Tennessee river, which flows northward from Alabama and is said to modify appreciably the temperature of the Ohio river below Paducah and Brookport.

(26) Vienna experiment field, Johnson county, about one mile south of Vienna.[1] This field is rolling hill land and is devoted to a special study of surface washing and methods for its prevention. On part of the field destructive erosion is permitted to continue, as an object lesson. The land cost $20 an acre.

(27) West Salem experiment field, Edwards county, three-quarters of a mile southwest of the station at West Salem. The land was purchased and donated by the citizens of West Salem and vicinity.

Thirty-six of the thirty-nine fields listed here are operated primarily to give Illinois farmers the most complete information possible upon systems of farming that will permanently maintain or increase the productive capacity of their soils. Of the three remaining, the fields near DeKalb in DeKalb county, and near Fairfield in Wayne county are given over mainly to crop investigations, and the Vienna field, as has been stated, is devoted to the study of methods of preventing soil washing and erosion. The distribution of these experiments fields is shown by Fig. 2.

[1]This tract is in addition to the leased land mentioned in the list of discontinued fields, page 454.

PLAN AND METHODS OF FIELD INVESTIGATIONS

Each experiment field contains on the average about twenty acres of land, divided into series which correspond to the different fields upon a farm. Each series is further divided into smaller areas, usually ten fifth-acre plots, and these are treated in such a manner that positive information can be secured in regard to the needs of the soil. Untreated plots are retained as checks in order to determine the effect of every kind of soil treatment applied.

Crops are grown upon these fields in a definite rotation. On some fields two or more rotations are being tried. There are usually a sufficient number of series so that the crops of the main rotation are represented every year. The crops grown are those common to the locality and include wheat, corn, oats, barley, red clover, alsike, sweet clover, alfalfa, cowpeas, soybeans, vetch, timothy, and potatoes.

Altho there may be a number of ways of meeting the needs of the soil with respect to better production, the Illinois Agricultural Experiment Station makes use largely of natural methods and natural materials. Instead of applying expensive complete fertilizers, which may produce a more or less rapid response, wide use is made of such natural materials as farm manure, legume crops, crop residues, ground limestone (both ordinary and dolomitic, each of which is found in abundance in Illinois), steamed bone meal (a farm product), and ground natural raw rock phosphate. Abundant information points to the fact that in the long run and under normal conditions the use of these materials in well planned systems of farming usually proves to be the most practical and economical method of soil improvement. In some comparative experiments and on some abnormal soils, purchased nitrogen, manufactured acid phosphate, potassium salts, and other commercial fertilizers are used.

In order that the reader may better understand the operation of a typical experiment field, the arrangement and methods used on the field located at Urbana are here described. The accompanying diagram of the field shows the manner in which the series and individual plots are arranged. The treatment given each plot and the method of numbering is indicated thereon. Each plot covers exactly one-tenth of an acre.

A combination rotation is practiced which is well suited to the farming conditions of this region of the state. Corn, oats, clover, and wheat, in the order named, rotate once completely over four fields while a fifth field is in alfalfa. After the four crops have been rotated over the four fields for five years, the alfalfa is changed to one of the other fields, and the old alfalfa field is then used in the four-year rotation. This is repeated until the alfalfa again occupies the same field. The whole rotation will cover a period of twenty-five years.

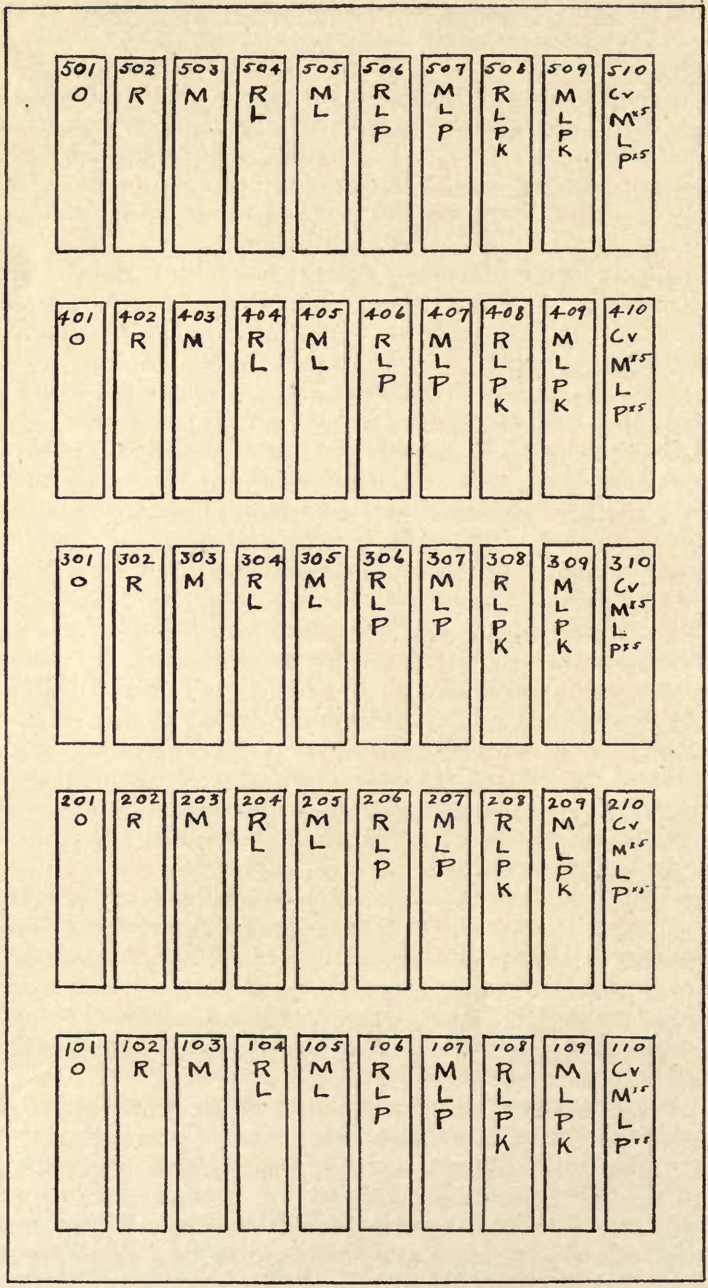


FIG. 4.—DIAGRAM OF URBANA EXPERIMENT FIELD

0=No treatment; M=Manure; L=Limestone; P=Phosphorus; R=Residues (corn stalks, straw of wheat and oats, and all legumes except seed); K=Potassium; Cv=Cover crop

As may be noted from the diagram, two different systems of farming are practiced; namely, a live-stock system and a grain system. In the live-stock system, the feed grains and all the hay and forage (corn stalks and straw) are used for feed and bedding. The resulting manure is returned to the land and constitutes the important source of nitrogen and organic matter for soil improvement. In the grain system, the nitrogen and organic matter are maintained by plowing under all crop residues after the seed is removed (corn stalks, the straw from wheat, oats, soybeans, clover, etc., and some cover crops). Under this system, the grain, the alfalfa, and the clover or other legume seed are marketed. Alfalfa is regarded as a money crop, since sufficient residues are provided in the regular four-year rotation to supply the needs of the non-legumes for nitrogen.

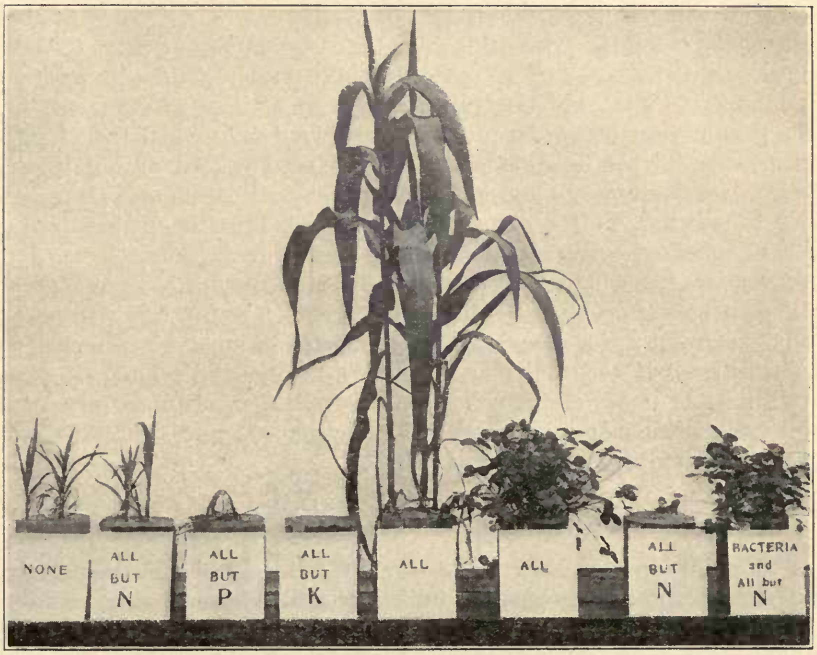


FIG. 5.—POT CULTURES SHOWING THE EFFECT OF THE PRESENCE AND ABSENCE OF PLANT FOODS

(Observe that inoculated clover without applied nitrogen grows as luxuriantly as uninoculated clover supplied with commercial nitrogen)

In both systems of farming there are check plots which do not receive any treatment. The only benefits the soil receives are those which are incidental to the rotation. Everything is removed from the land, and nothing returned; which means a gradual decrease in productive power and eventual land ruin. The purpose of these plots is to show by comparison the value of the treatment. The other plots receive additional treatments in such a way that the definite needs of the soil may be determined; whether it be manure or residues alone, or lime in addition, or lime and phosphorous in addition, that must be supplied in order to insure greater production. To two plots in the series, potassium is added in order to obtain information in regard to the possible need for that element. In both systems of farming, provision is made for the maintenance and the increase of those elements of plant food and those physical conditions necessary for the best plant growth as indicated by the soil survey, the soil analysis, and other sources of knowledge.

VALUE OF INVESTIGATIONS

The value of these investigations as the results are disseminated is to make clear the vital facts that the productive power of the soil depends upon its ability to feed the plant, and that low production is due to deficiencies of the soil and to poor methods of management. The problems of better farming will be solved only when the investigations reveal the location and extent of every kind of soil in the state; positive information as to the extent and depletion of the fertility; whether, in the case of normal soils, limestone, phosphorus, and nitrogenous organic matter, in this order or in some other order, are required; or whether, in the case of abnormal soils, some one essential element may be almost entirely lacking, such as potassium in peaty soils; in what cases some injurious substance must be removed or neutralized in a soil that may be rich in all essentials; and, in general, how the needs of the soil may be supplied in the most practical and economical manner in order that permanent and profitable systems of agriculture may be established.

SOIL PUBLICATIONS

The information secured by the soil survey, chemical analysis, and field-culture experiments is disseminated by means of circulars, bulletins, and soil reports.[1] The circulars are usually concerned with some special phase of soil improvement and are of general interest to the farmers of the state. The bulletins report the results of investigations upon Illinois soils with respect to specific problems, and most important of these is Bulletin 123, "The Fertility in Illinois Soils," which appeared immediately after the completion of the general soil survey of the state in 1907. This publication reports the stock of fertility contained in twenty-five of the most important and extensive types of soil in the state, and the results of field experiments previously conducted on the more extensive soil types to ascertain prac-

[1]See page 484 for a list of available publications.

tical methods of soil improvement. This information can be applied to more than half the soils of the state.

Soil reports are published for each county after the detail soil survey has been made and the essential information collected. Each report contains a colored map showing the location and extent of every soil type in the county, an invoice of the total stock of fertility, a record of the results of field experiments, a description in more or less detail of the essential characteristics of each soil type, the interpretation of the data presented, and an exposition of the principles of soil improvement involved. Such a publication gives the reader a complete text and reference book upon the soils of the county concerned. Previous to the preparation of this bulletin, soil reports had been published for ten counties; namely, Clay, Moultrie, Hardin, Sangamon, LaSalle, Knox, McDonough, Bond, Lake, and McLean.

The location of the first ten counties for which soil reports have been published is shown by Fig. 3, page 456. As may be seen from the order of publication of the reports and the wide distribution of the counties over the state, the selection has been made with a view to rendering the largest benefit to the great sections of the state. Thus the Clay county report gives information, not only to the farmers of Clay county, but also to that great section of the state, the wheat belt, located in what is known as the lower Illinoisan glaciation (see colored map), for Clay county is quite similar to the other counties of this region. In the same way the second report, Moultrie county, represents the southern part of the great corn belt of the state, especially so far as it lies in the early Wisconsin glaciation. The third report, Hardin county, represents the unglaciated area in the extreme southern part of the state, etc., etc.

THE SOILS OF ILLINOIS

THE LARGE SOIL AREAS

Geological investigations indicate that at one time glaciers or ice sheets covered the greater portion of Illinois. An immense amount of miscellaneous material was collected and carried along by these glaciers, and large deposits of boulder clay or glacial till were formed by the tremendous grinding of accumulated material between the ice of the glaciers and the surface of the earth over which the glaciers passed. The drift material which resulted includes clay, silt, sand, and some coarser material varying in size from pebbles to boulders. Wherever the forward movement of the glacier just kept pace with the melting of the ice, a large amount of material was deposited, forming moraines or glacial ridges—elevations of various sizes which now mark the boundaries of the glacier last covering the territory. With the final melting and disappearance of the ice, a great deal of finely reduced rock material was scattered and transported over other territory by water and wind. The wind-blown material, known as loess, is found in almost all parts of the state at depths varying from three feet or less to one hundred feet or more near the Mississippi and Illinois rivers.

During the Glacial period, glaciers advanced, receded, and advanced again, over the same or different territory. Thus, at the end of the Glacial period, large soil areas existed which now differ principally on account of age. Following an earlier glaciation known as the Kansan, which entered the state from the west, it is believed that there were three main glaciations in Illinois. The first, called the Illinoisan, probably made three advances, now marked more or less distinctly by terminal moraines, ridges, etc. The oldest of these advances is designated as the lower Illinoisan, the second as the middle Illinoisan, and the third as the upper Illinoisan. In the same way the second glaciation is now known as the pre-Iowan and the Iowan, and the third as the early Wisconsin and the late Wisconsin. The great areas covered by these glaciations, together with the unglaciated areas, the areas of deep loess, the moraines, and the early and the late bottom and swamp lands, constitute the fourteen great soil areas of Illinois, as may be seen by the accompanying map.

INDIVIDUAL SOIL TYPES

Within these great soil areas, sixty-two individual soil types have been identified by detail soil survey in the first ten counties for which reports have been published. These soils are extremely diverse and vary considerably with respect to fertility and to physical characteristics, but for convenience and ready comparison they may be grouped into six general classes as follows:

(1) Upland prairie soils, rich in organic matter. These were originally covered with wild prairie grasses whose network of roots was protected from complete decay by the imperfect aeration resulting from the covering of fine soil material and the moisture it contained. The flat prairie land is richer in organic matter because there the grasses and roots grew more luxuriantly and the higher moisture content preserved them still further from decay. The upland prairie soils vary in topography from level to rolling, and include gray silt loam on tight clay of the lower Illinoisan glaciation, which is the extensive type in the wheat belt; brown silt loam, the most common corn-belt soil, found extensively in the middle and upper Illinoisan and the early Wisconsin glaciations; and the heavy black clay loam, of a somewhat swampy nature before drainage, found in the very flat prairies in the corn-belt glaciations.

(2) Upland timber soils, including those zones along stream courses upon which forests have grown for a long period of time.

These soils are characterized by a yellow, yellowish gray, or gray color, which is due to their low organic-matter content. This lack of organic matter is the result of the long-continued growth of forest trees, for as the forest invaded the prairies two effects were produced: the shading of the trees prevented the growth of the prairie grasses, and the trees themselves added very little organic matter to the soil since the leaves and branches either decayed completely or were burned by forest fires. The timber lands are divided chiefly into two classes, the undulating and the hilly areas.

(3) Terrace soils, formed on terraces or benches, in valleys. These soils are largely the result of the deposition of material from overloaded streams during the melting of the glaciers. The streams of these partly filled valleys later cut thru the deposit and formed new bottom lands or flood plains at a lower level, leaving the old fill as a terrace. From this action, first and second bottoms have resulted.

(4) Ridge soils, including those on morainal ridges, most of which have been forested.

(5) Swamp and bottom-land soils, which include the flood plains along streams and the peaty swamp areas.

(6) Residual soils, formed by the accumulation of loose material resulting from the weathering of rocks in place. Very little of this class of soils exists in Illinois owing to the action of the glaciers in removing the residual material and covering it with glacial drift.

FERTILITY INVOICE

The fertility invoice of the more extensive soil types of the state—those occupying 5 percent or more of a county—is given in Table 1. The results reported are as a rule averages of many analyses, which like most things in nature show more or less variation, but for all practical purposes these averages are most trustworthy and sufficient.

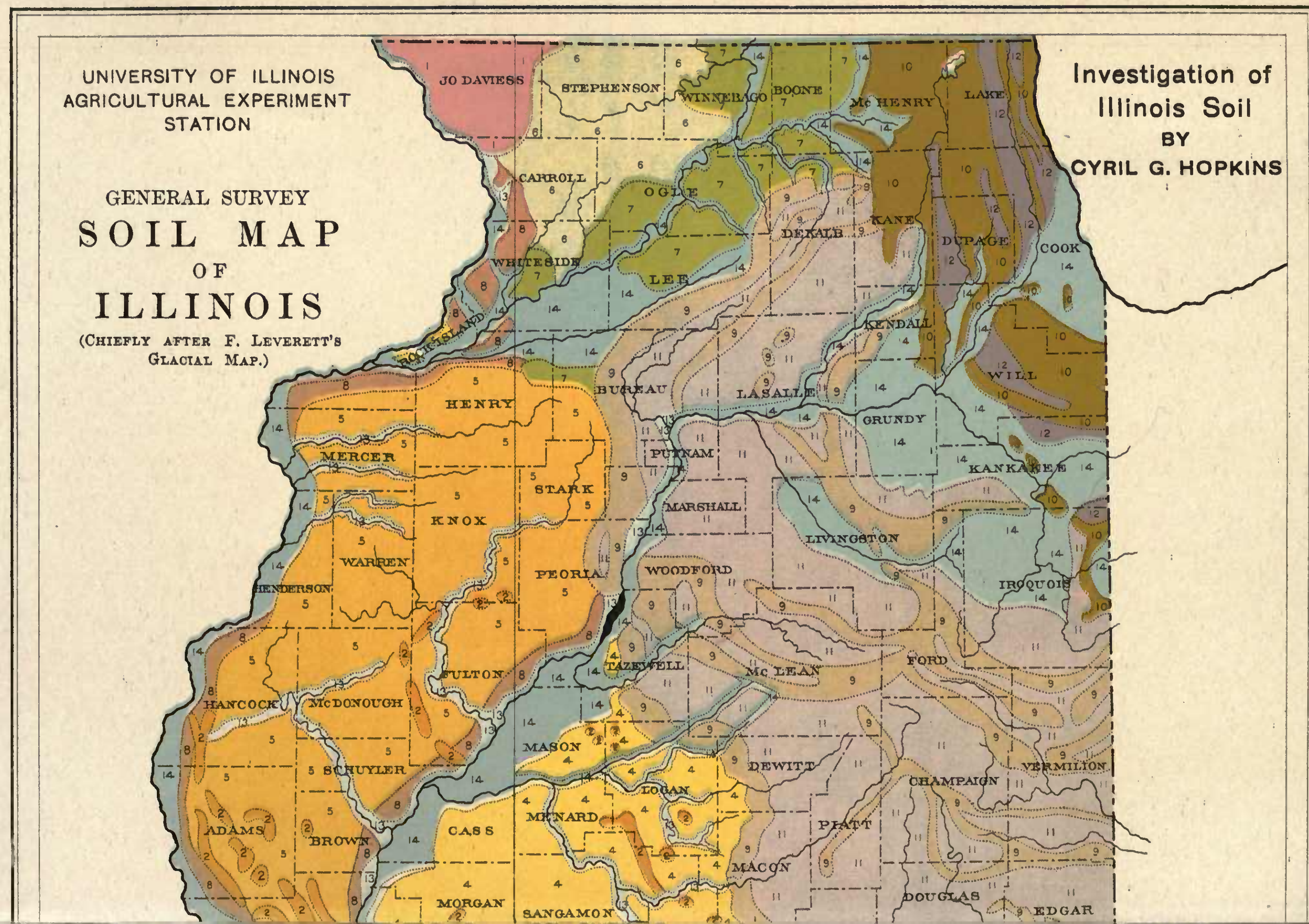
In studying this table, it will be well to keep in mind that the most productive soils of normal physical composition contain in the surface soil of an acre about 8,000 pounds of total nitrogen, 2,000 pounds of total phosphorus, and more than 30,000 pounds of total potassium. It will be noted here that some soils are extremely poor in the essential elements of fertility, while others are abundantly supplied. From the standpoint of the productive power of soils, nitrogen and phosphorus are the most extensively deficient elements of plant food. Nitrogen varies from about 900 pounds per acre in yellow silt loam to over 8,000 pounds in black clay loam and about 33,000 pounds in peat. Phosphorus varies from about 600 pounds per acre in some of the upland timber soils to 2,000 pounds in some of the upland prairie soils.

Figured on the basis of 100 bushels of corn per acre, the grain only being removed, the common corn-belt prairie land contains in

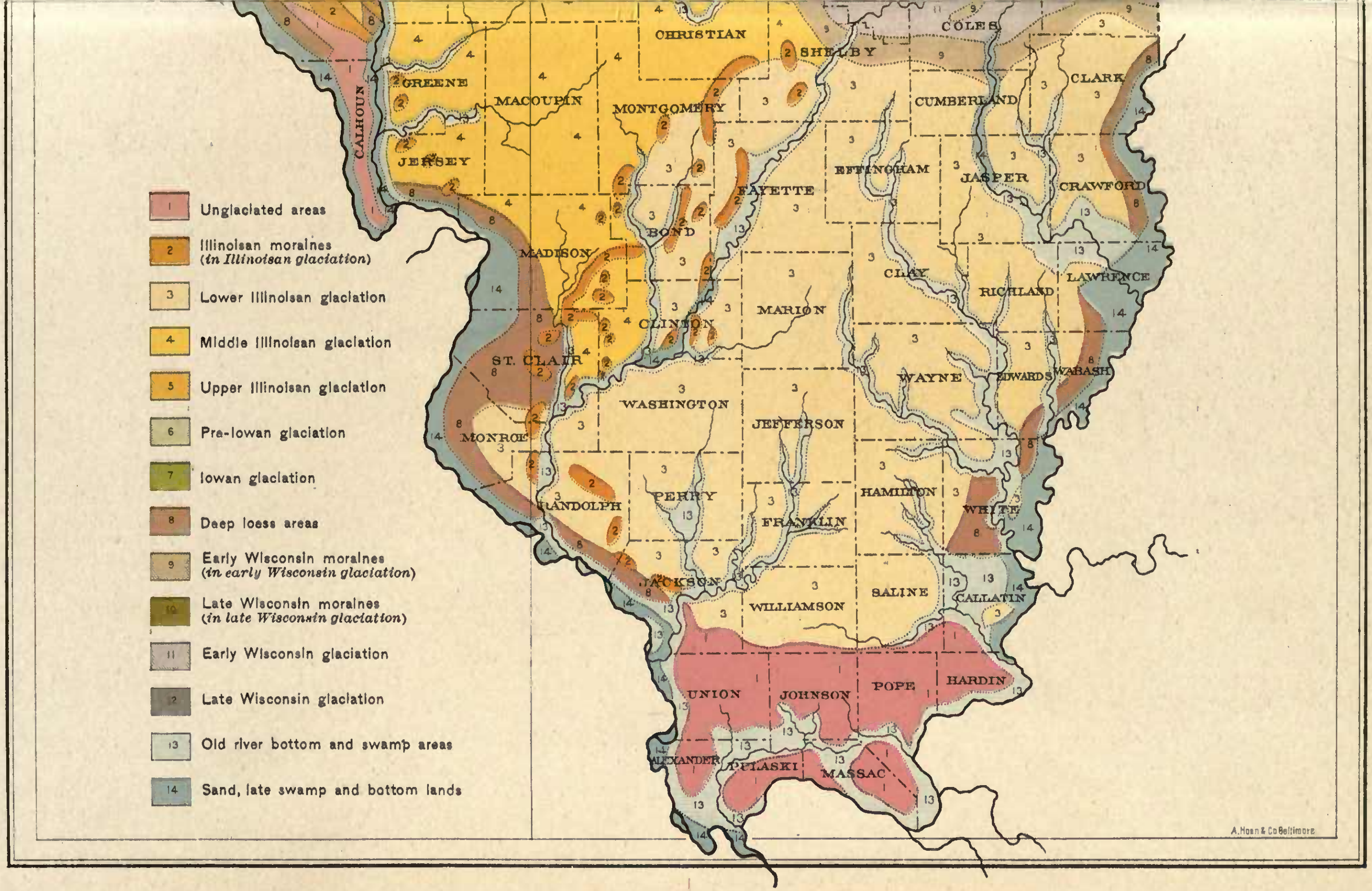
TABLE 1.—FERTILITY OF THE MORE IMPORTANT TYPES OF ILLINOIS SOILS

Average pounds per acre in 2 million pounds of surface soil (about 0—6⅔ inches)

Soil type No.	Soil type	Soil area, or glaciation	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Soil acidity present
		Upland Prairie Soils								
426	Brown silt loam	Middle Illinoisan	51 680	4 070	1 030	34 620	7 470	9 280		50
526	Brown silt loam	Upper Illinoisan	57 780	4 705	1 149	32 910	9 732	11 930		70
1126	Brown silt loam	Early Wisconsin	60 350	5 260	1 161	35 378	8 855	11 716		70
1226	Brown silt loam	Late Wisconsin	89 950	7 490	1 430	46 930	12 680	13 300		50
330	Gray silt loam on tight clay	Lower Illinoisan	26 295	2 715	760	26 120	2 700	4 310		845
420	Black clay loam	Middle Illinoisan	63 570	5 040	1 330	31 870	11 090	15 990	2 850	
1120	Black clay loam	Early Wisconsin	91 370	8 160	2 000	34 210	16 580	31 240	Often	Rarely
328	Brown-gray silt loam on tight clay	Lower Illinoisan	29 490	2 840	670	31 040	4 590	6 210		100
528	Brown-gray silt loam on tight clay	Upper Illinoisan	39 800	3 400	900	31 740	6 400	8 200		100
		Upland Timber Soils								
135	Yellow silt loam	Unglaciated	12 880	1 250	840	34 200	7 710	3 980		2 100
335	Yellow silt loam	Lower Illinoisan	19 550	1 804	603	33 727	5 122	4 020		1 595
435	Yellow silt loam	Middle Illinoisan	10 240	920	820	40 020	7 210	6 440		470
535	Yellow silt loam	Upper Illinoisan	23 440	2 235	825	36 815	6 790	7 495		60
1235	Yellow silt loam	Late Wisconsin	20 900	1 880	720	58 300	12 380	6 270		30
134	Yellow-gray silt loam	Unglaciated	15 600	1 520	870	29 150	5 510	4 390		40
334	Yellow-gray silt loam	Lower Illinoisan	23 020	2 090	510	32 850	5 680	6 120		180
434	Yellow-gray silt loam	Middle Illinoisan	26 160	2 300	1 010	35 970	5 390	7 100		30
534	Yellow-gray silt loam	Upper Illinoisan	26 485	2 530	870	35 400	6 455	8 202		75
1134	Yellow-gray silt loam	Early Wisconsin	31 504	2 592	921	36 880	6 437	7 439		109
1234	Yellow-gray silt loam	Late Wisconsin	32 220	2 720	750	46 300	9 210	7 820		40
198	Stony loam	Unglaciated	15 600	840	480	25 040	3 420	4 300		1 520
		Swamp and Bottom-Land Soils								
1326	Deep brown silt loam	Old river bottoms and swamp land	53 965	4 745	1 765	36 675	9 695	11 545		45
1331	Deep gray silt loam	Old river bottoms and swamp land	32 335	3 015	1 545	36 490	8 430	7 480		90
1361.1	Mixed fine sandy loam	Old river bottoms and swamp land	13 900	1 290	650	29 480	4 990	4 910	840	
1426	Deep brown silt loam	Sand, late swamp and bottom land	51 140	4 450	1 630	41 350	10 630	11 700	700	
1401	Deep peat	Sand, late swamp and bottom land	398 040	32 570	1 540	3 900	6 260	24 970		140



UNIVERSITY OF ILLINOIS
AGRICULTURAL EXPERIMENT
STATION
GENERAL SURVEY
SOIL MAP
OF
ILLINOIS
(CHIEFLY AFTER F. LEVERETT'S
GLACIAL MAP.)
Investigation of
Illinois Soil
BY
CYRIL G. HOPKINS
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
Mc HENRY
LAKE
CARROLL
OGLE
DEKALB
KANE
DUPAGE
COOK
WHITESIDE
LEE
ROCK ISLAND
KENDALL
WILL
BUREAU
LASALLE
GRUNDY
HENRY
MERCER
PUTNAM
KANKAKEE
STARK
MARSHALL
KNOX
LIVINGSTON
WARREN
PEORIA
WOODFORD
IROQUOIS
HENDERSON
FULTON
TAZEWELL
Mc LEAN
FORD
HANCOCK
McDONOUGH
MASON
DEWITT
SCHUYLER
VERMILION
CHAMPAIGN
LOGAN
MENARD
PIATT
ADAMS
BROWN
CASS
MACON
MORGAN
SANGAMON
DOUGLAS
EDGAR



Unglaciated areas
Illinoisan moraines (in Illinoisan glaciation)
Lower Illinoisan glaciation
Middle Illinoisan glaciation
Upper Illinoisan glaciation
Pre-Iowan glaciation
Iowan glaciation
Deep loess areas
Early Wisconsin moraines (in early Wisconsin glaciation)
Late Wisconsin moraines (in late Wisconsin glaciation)
Early Wisconsin glaciation
Late Wisconsin glaciation
Old river bottom and swamp areas
Sand, late swamp and bottom lands
CALHOUN
GREENE
JERSEY
MACOUPIN
CHRISTIAN
MONTGOMERY
SHELBY
COLES
CUMBERLAND
CLARK
EFFINGHAM
JASPER
CRAWFORD
FAYETTE
BOND
MADISON
CLINTON
MARION
CLAY
RICHLAND
LAWRENCE
ST. CLAIR
WASHINGTON
JEFFERSON
WAYNE
EDWARDS
WABASH
MONROE
RANDOLPH
PERRY
FRANKLIN
HAMILTON
WHITE
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
JOHNSON
POPE
HARDIN
ALEXANDER
PULASKI
MASSAC
A.Hoen & Co.Baltimore.

the surface about enough nitrogen for 48 crops and sufficient phosphorus for 70 crops. On the other hand, it contains enough potassium to produce 1,790 such crops; and with good methods of farming, potassium may be renewed rapidly enough from the subsoil, by unavoidable surface washing, to maintain the potassium content of the soil indefinitely. If production is to be maintained, it will be necessary, therefore, to supplement the supply of nitrogen and phosphorus in these soils. The necessity for the use of organic matter is indicated by the ratio of nitrogen to organic carbon. A narrow ratio exists where the organic-matter content is low, and a wide one where there is sufficient of this material present.

Measured by actual crop requirements, some of these soils show a deficiency in the elements calcium and magnesium. Limestone, therefore, in addition to correcting soil acidity, may have considerable value for the calcium and magnesium which it contains.

While the amount of plant food contained in the subsurface and subsoil strata is of interest, no analyses for these strata are reported here. The chief thing of importance in systems of permanent, profitable agriculture is the maintenance of a good surface soil, for even a rich subsoil is of but little value if it lies beneath a worn-out surface. For detailed discussion of the fertility in Illinois soils below the seven-inch depth, the reader is referred to the various soil reports issued by this station and to Bulletin 123.

RESULTS OF FIELD-CULTURE EXPERIMENTS

The field-culture experiments planned in connection with the information furnished by the soil survey and soil analysis have demonstrated that it is possible to practice a system of farming that is both permanent and profitable. A summary of the results secured upon a number of the most important soil types in the different soil areas, showing the effect and value of various forms of soil treatment, is presented upon the following pages. The data are arranged by soil types, which are presented according to age when occurring in more than one soil area.

Since a definite system of farming may or may not be profitable, depending upon the price received for produce, the field results are usually summarized in two sets of money values to emphasize this fact. Low prices are used to represent the value of the produce in the field, and high prices to represent the market value. The prices used are as follows: corn, 35 and 50 cents per bushel; oats, 28 and 40 cents; wheat 70 cents and $1; soybeans, 70 cents and $1 per bushel. Measured by average Illinois prices for the past ten years, the lower values are not too high for crops standing in the field ready for harvest. Unless otherwise specified, these are the values used in the following discussion.

UPLAND PRAIRIE SOILS

Black Clay Loam of Early Wisconsin Glaciation (1120)

Urbana Field.—At Urbana, on the South Farm of the University of Illinois, a series of plots devoted primarily to crop-production experiments extends across an area of black clay loam. A four-year rotation of wheat, corn, oats, and clover (or soybeans) is practiced. Where rock phosphate has been applied at the rate of 500 pounds an acre per annum in connection with crop residues in the grain system, the value of the increase per ton of phosphate has been as follows, in three successive rotations:

	Lower prices	Higher prices
First rotation	$2.13	$3.04
Second rotation	4.70	6.71
Third rotation	6.48	9.26

In the live-stock system, the phosphorus naturally supplied with the manure, supplemented by that liberated from this fertile soil, has been approximately sufficient to meet the crop requirements. The value of the increase per ton of phosphate, as an average of the twelve years, has been only $2.26 at the lower prices and $3.26 at the higher prices. These returns are less than half the cost of the phosphorus applied, and in some seasons no benefit has appeared.

Brown Silt Loam of Middle Illinoisan Glaciation (426)

Virginia Field.—At Virginia, in Cass county, the University established an experiment field in 1902 upon brown silt loam somewhat above the average in productive power. A three-year rotation was begun on three different series of plots. Corn, oats, and cowpeas were grown the first six years, after which the rotation was changed to corn, oats, and clover.

During the first seven years (1902 to 1908), phosphorus applied at the rate of 25 pounds per acre per annum in the form of steamed bone meal produced an increase of 6.8 bushels of corn, .4 bushel of oats, .04 ton of hay. During the next three years (1909 to 1911), the increases were 10.5 bushels of corn, 13.1 bushels of oats, and .69 ton of hay. These results were to be expected, for the chemical analysis of the soil shows that phosphorus is not abundant and that nitrogen is the first limiting element. Thus phosphorus could show no marked effect until nitrogen was gradually increased by the use of legume crops and farm manure.

On another series, commercial nitrogen was applied in a four-year rotation of corn, corn, oats, and wheat, thus giving an opportunity to compare this form of nitrogen to that supplied the soil by grain and live-stock farming. On plots treated alike with respect to lime and phosphorus, legumes in rotation and some crop residues plowed under increased the six-year average yield of corn by 24.2 bushels, and farm manure and legumes increased the yield by 26.6 bushels; while 100 pounds of commercial nitrogen in about 800 pounds of dried blood, costing $15 to $20 per annum, increased the yield only 19.5 bushels.

The two important lessons from the Virginia field are: first, when nitrogen is the limiting element, nothing else can take its place, and, even tho phosphorus may be deficient, its addition will not produce marked results until sufficient nitrogen is provided; second, the growing of legumes in rotation and the use of crop residues or farm manure may produce even better results than high-priced commercial nitrogen. (For further details see Soil Report No. 4, Sangamon county.)

Brown Silt Loam of Upper Illinoisan Glaciation (526)

Galesburg Field.—Upon the experiment field located near Galesburg on brown silt loam prairie soil, a six-year rotation of corn, corn, oats, clover, wheat, and clover has been practiced. There are only three independent series of plots, so that while corn is grown every year, the other crops are harvested every other year, with the exception of clover, which should be on the field every year either as a regular crop or in the stubble of oats and wheat.

The twenty plots of each series are so treated that the value of additions, consisting of phosphorus in the form of rock phosphate, potassium, and limestone, may be known in both live-stock and grain farming (see page 461). On Plot 19 of the three series, commercial nitrogen at the rate of 25 pounds an acre per annum is used in addition to the regular treatment.

Three facts are clearly brought cut by the data from this field:

First.—Commercial nitrogen at 15 cents a pound has never paid its cost. As the system of providing ''home-grown'' nitrogen has developed, the effect of commercial nitrogen has decreased, and as an average of the five years 1908-1912 it paid back only 4 percent of its annual cost.

Second.—Potassium, likewise, has never paid its cost; but during the early years, with no adequate provision for decaying organic matter, the soluble potassium salts produced marked effect, owing no doubt in part to their power to make available the raw phosphate rock applied with the potassium. With the increase of organic matter, the effect of the potassium has been greatly reduced. As an average of the six years from 1907 to 1912, potassium costing $7.50 paid back only $1.

Third.—Fine-ground rock phosphate applied at the rate of 500 pounds an acre per annum in connection with decaying organic matter has paid back the following increases in crop values per ton of phosphate applied:

	Lower prices	Higher prices
Average 1904 and 1905	$3.53	$5.04
Average 1906-1908	7.73	11.04
Average 1909-1911	8.60	12.29
Average 1912-1914	12.93	18.49

These increases have been realized by the removal from the soil of only one-third of the phosphorus applied, leaving two-thirds in the soil as positive enrichment. (See Soil Report No. 6, Knox county, for detailed data on crop yields, etc.)

Brown Silt Loam of Early Wisconsin Glaciation (1126)

Sibley Field.—The Sibley experiment field, located in Ford county upon typical brown silt loam prairie soil, was cropped previous to 1902 with corn and oats under a tenant system which had caused the active organic-matter content to be somewhat deficient. One series of plots treated in such a manner as to bring out facts concerning the needs of the soil, in which phosphorus is the limiting element, has furnished some interesting information.

In 1903 the addition of phosphorus produced an increase of 8 bushels of corn, nitrogen produced no increase, but nitrogen and phosphorus combined increased the yield by 15 bushels. After six years of additional cropping, nitrogen appeared to become the most limiting element, the increase in corn in 1907 being 9 bushels from nitrogen and only 5 bushels from phosphorus, while nitrogen and phosphorus together produced an increase of 33 bushels. Thus even tho phosphorus was a limiting element, the nitrogen becoming available an-

TABLE 2.—VALUE OF CROPS PER ACRE IN TWELVE YEARS, SIBLEY FIELD 1902 TO 1913

Plot	Soil treatment applied	Total value of 12 crops	
		Lower prices	Higher prices
101	None	$172.89	$246.98
102	Lime	186.51	266.45
103	Lime, nitrogen	177.44	253.49
104	Lime, phosphorus	217.78	311.11
105	Lime, potassium	167.32	239.03
106	Lime, nitrogen, phosphorus	246.91	352.73
107	Lime, nitrogen, potassium	198.16	283.08
108	Lime, phosphorus, potassium	204.90	292.71
109	Lime, nitrogen, phosphorus, potassium	257.91	368.45
110	Nitrogen, phosphorus, potassium	242.47	346.38

Value of Increase per Acre in Twelve Years

For nitrogen	$-9.07	$-12.96
For phosphorus	31.27	44.66
For *nitrogen* and phosphorus over phosphorus	29.13	41.62
For *phosphorus* and nitrogen over nitrogen	69.47	99.24
For *potassium*, nitrogen, and phosphorus over nitrogen and phosphorus	11.00	15.72

nually was but little in excess of the phosphorus. The untreated land apparently became less productive, whereas on land receiving both nitrogen and phosphorus the yields were appreciably increased, so that in 1907 the untreated rotated land produced only 34 bushels of corn and the land treated with lime, nitrogen, and phosphorus yielded 72 bushels per acre (more than twice as much), altho both plots produced the same yield (57.3 bushels) in 1902. The total values per acre of the twelve crops for each plot are shown in Table 2.

Here it is seen that with the lower prices phosphorus without nitrogen produced $31.27 in addition to the increase by lime, but that with nitrogen it produced $69.47 above the crop values where only lime and nitrogen have been used. The results show that in 26 cases out of 48 the addition of potassium decreased crop yields. Lime produced an average increase of $14.53, or $1.21 an acre per year; which shows that the time has come when limestone must be applied to some of the brown silt loam soils. (Detailed data in regard to crop yields will be found in Soil Report No. 10, McLean county.)

Bloomington Field.—The results of thirteen years' work on the experiment field located near Bloomington on brown silt loam prairie soil are much the same as those from the Sibley field, as may be seen from Table 3.

The treatment of this field differs from that at Sibley in that in 1905 the use of commercial nitrogen was discontinued, clover was introduced into the rotation, and crop residues were subsequently returned to the soil. With this method, phosphorus has produced even

TABLE 3.—VALUE OF CROPS PER ACRE IN THIRTEEN YEARS, BLOOMINGTON FIELD 1902 TO 1914

Plot	Soil treatment applied	Total value of 13 crops	
		Lower prices	Higher prices
101	None	$186.83	$266.90
102	Lime	186.76	266.80
103	Lime, residues	193.83	276.90
104	Lime, phosphorus	286.61	409.45
105	Lime, potassium	190.53	272.19
106	Lime, residues, phosphorus	285.03	407.19
107	Lime, residues, potassium	191.10	273.00
108	Lime, phosphorus, potassium	294.91	421.31
109	Lime, residues, phosphorus, potassium	284.47	406.39
110	Residues, phosphorus, potassium	259.10	370.15

Value of Increase per Acre in Thirteen Years

For residues	$ 7.07	$ 10.10
For phosphorus	99.85	142.65
For *residues* and phosphorus over phosphorus	–1.58	–2.26
For *phosphorus* and residues over residues	91.20	130.29
For *potassium*, residues, and phosphorus over residues and phosphorus	–.56	–.80

larger increases ($99.85) than have been produced by phosphorus and nitrogen over nitrogen on the Sibley field ($69.47). The average yearly increase due to phosphorus in connection with the use of legume

TABLE 4.—YIELDS PER ACRE, THREE-YEAR AVERAGES, URBANA FIELD

First Rotation: 1902-1904

Serial plot No.	Soil treatment	Corn *bu.*	Oats *bu.*	Hay *tons*	Value of 3 crops	
					Lower prices	Higher prices
1	None	75.4	48.8	.49	$43.48	$62.12
2	Legume cover crop	77.4	45.1	.44	42.80	61.14
3	None	75.3	50.4	.41	43.33	61.91
4	Legume cover crop, lime	78.4	47.3	.42	43.62	62.32
5	Lime	80.8	58.2	.44	47.66	68.08
6	Legume cover crop, lime, phosphorus	88.0	52.5	.50	49.00	70.00
7	Lime, phosphorus	88.8	56.6	.98	53.79	76.84
8	Legume cover crop, lime, phosphorus, potassium	90.1	48.3	.64	49.53	70.77
9	Lime, phosphorus, potassium	90.5	54.3	1.34	56.26	80.37
10	Lime, phosphorus, potassium	86.5	53.2	1.23	53.78	76.83

Second Rotation: 1905-1907

Serial plot No.	Soil treatment	Corn *bu.*	Oats *bu.*	Clover *tons*	Value of 3 crops	
					Lower prices	Higher prices
1	None	71.5	46.6	2.07	$52.56	$75.09
2	Legume cover crop	68.5	52.0	1.83	51.34	73.35
3	Manure	80.5	54.8	2.19	58.84	84.07
4	Legume cover crop, lime	72.3	58.6	1.98	55.57	79.39
5	Manure, lime	84.8	59.8	2.46	63.64	90.92
6	Legume cover crop, lime, phosphorus	90.4	70.7	2.69	70.26	100.38
7	Manure, lime, phosphorus	93.2	71.6	3.47	76.96	109.94
8	Legume cover crop, lime, phosphorus, potassium	93.8	71.7	3.06	74.32	106.18
9	Manure, lime, phosphorus, potassium	95.6	66.9	3.73	78.30	111.86
10	Manure (x), lime, phosphorus (x)	90.1	62.9	2.86	69.17	98.81

Third Rotation: 1908-1910

Serial plot No.	Soil treatment	Corn *bu.*	Oats *bu.*	Clover *tons* (*bu.*)	Value of 3 crops	
					Lower prices	Higher prices
1	None	49.4	40.8	2.30	$44.81	$64.02
2	Residues	51.5	43.4	(1.93)	43.69	62.41
3	Manure	69.3	46.2	2.53	54.90	78.43
4	Residues, lime	58.1	45.7	(2.02)	47.27	67.53
5	Manure, lime	74.9	47.5	2.94	60.09	85.85
6	Residues, lime, phosphorus	83.8	54.5	(2.64)	63.07	90.10
7	Manure, lime, phosphorus	86.6	55.4	4.17	75.01	107.16
8	Residues, lime, phosphorus, potassium	86.7	53.5	(1.99)	59.26	84.65
9	Manure, lime, phosphorus, potassium	90.9	53.6	3.90	74.12	105.89
10	Manure (x), lime, phosphorus (x)	81.3	54.3	3.79	70.19	100.27

X=extra heavy applications of manure and phosphorus; residues=corn stalks, straw of wheat and oats, and all legumes except seed.

TABLE 5.—YIELDS PER ACRE, FOUR-YEAR AVERAGES, URBANA FIELD 1911 TO 1914

Serial plot No.	Soil treat-ment	Wheat *bu.*	Corn *bu.*	Oats *bu.*	Soybeans–3 *tons (bu.)*	Clover–1 *tons (bu.)*	Alfalfa *tons*	Value of 5 crops	
								Lower prices	Higher prices
1	0......	18.3	50.8	39.8	1.60	1.70	1.70	$65.00	$92.87
2	R......	19.7	53.8	40.6	(20.1)	(.74)	1.27	64.72	92.47
3	M.....	20.3	59.3	48.8	1.60	1.43	1.13	67.44	96.35
4	RL....	22.3	55.7	42.8	(19.0)	(1.03)	1.19	67.20	96.00
5	ML....	24.9	58.6	51.6	1.66	1.94	1.67	76.19	108.84
6	RLP...	37.4	62.2	58.7	(21.0)	(2.48)	2.69	98.58	140.83
7	MLP...	36.6	63.8	60.9	1.88	2.90	2.63	98.36	140.51
8	RLPK.	36.1	58.9	59.1	(22.2)	(1.41)	2.58	94.61	135.16
9	MLPK.	35.3	59.6	65.1	2.09	2.72	2.66	98.15	140.22
10	MxLPx.	43.5	55.7	67.2	2.14	2.94	2.84	105.02	150.03

Le=legume cover crop; L=lime; P=phosphorus; M=manure; x=extra heavy applications of manure and phosphorus; R=crop residues (corn stalks, straw of wheat and oats, and all legumes except seed and alfalfa hay).

crops or nitrogen has been $7.02 an acre, which is $4.52 above the cost of phosphorus in 200 pounds of steamed bone meal, the form in which it is applied. The total phosphorus applied from 1902 to 1914, as an average of all plots where it has been used, has amounted to 325 pounds per acre and has cost $32.50. This has paid back $97.20, or 300 percent on the investment. Potassium, on the other hand, has paid back less than 7 percent of its cost in the thirteen years. (Detailed data in regard to crop yields will be found in Soil Report No. 10, McLean county.)

Urbana Field.—On the University North Farm at Urbana, on the common brown silt loam prairie soil, a rotation of corn, oats, and clover was practiced for nine years (1902 to 1910), which has been followed by a combination rotation involving corn, oats, clover, wheat, and alfalfa. The various plots upon each series are so treated as to show the value of various additions in both live-stock and grain farming. On all series, Plot 10 is treated with about five times as much manure and phosphorus as is applied on the other plots, in order to remove the limitations of inadequate fertility and thus to determine the climatic possibilities of crop yields. Tables 4 and 5 give the three-year and the four-year averages, respectively, of crop yields and the value of the crops by rotations, with both the higher and the lower prices. No detailed discussion of this interesting data will be given here (see Soil Report No. 9, Lake county, or No. 10, McLean county), but a few points of interest will be indicated for further study.

While seasonal variations are inevitable, a comparison of crop yields by rotations, with and without soil treatment, is instructive. On the untreated land distinctly higher average yields of corn appear in the first rotation than in succeeding rotations, as 75.4 bushels in the first and 49.4 bushels in the last of the three-year rotations. The difference in yields of corn between treated and untreated land becomes greater with succeeding rotations, as is seen by the difference of 13.4 bushels between Plots 1 and 7 in the first rotation, and of 37.2 bushels between the same plots in the last of the three-year rotations. Such evidence points to the fact that fertility cannot be maintained by rotation alone, but that with a good system of soil treatment maximum production may be expected indefinitely.

Attention is also called to the striking effects of soil treatment upon the wheat yields, which show 100 percent increase, as an average, during the four-year rotation. At the lower prices for produce, farm manure has been worth 84 cents per ton during the ten years it has been used on Plot 3.

As a general average, the plots receiving limestone have produced $1.22 an acre a year more than the plots not receiving limestone, and this corresponds to more than $6 a ton for all the limestone applied;

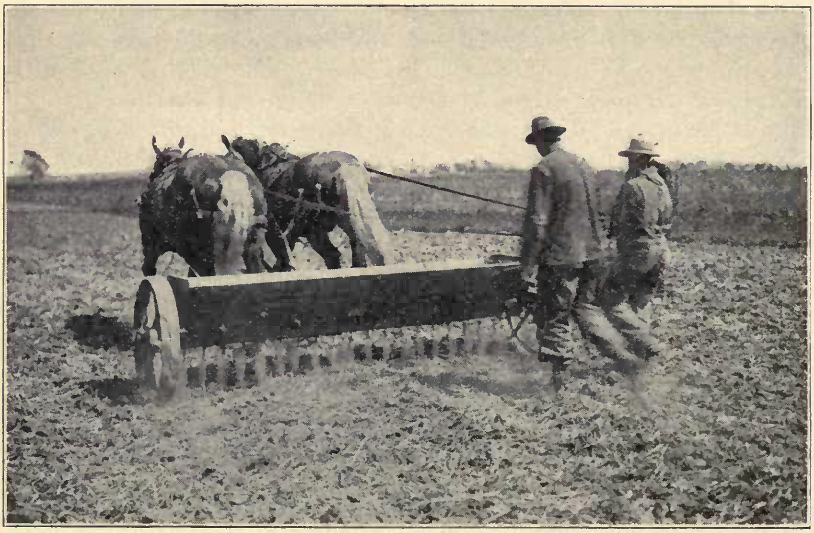


FIG. 6.—METHOD OF SCATTERING LIMESTONE AND PHOSPHORUS[1]

but the amounts of limestone applied before 1911 were so small and the results so variable that final conclusions cannot be drawn until further data are secured. However, since all comparisons of rotation periods show some increase, the need of limestone for the best results and the highest profits seems well established.

Potassium applied at an estimated cost of $2.50 an acre a year seemed to produce slight increases, on the average, during the first and second rotations, but the net result thru the 1914 yields was an

[1]For description of this machine, see page 16 of Circular 110 of this station.

average loss of $2.53 per acre per annum, including the cost of the potassium.

The annual application of 25 pounds of phosphorus in 200 pounds of steamed bone meal valued at $28 per ton, or of 75 pounds in 600 pounds of rock phosphate valued at $7 per ton, in connection with decaying organic manures, has, as an average for each dollar invested in phosphorus, paid as follows:

	Lower prices	Higher prices
First rotation, 1902–1904	$ .69	$ .99
Second rotation, 1905–1907	1.67	2.39
Third rotation, 1908–1910	2.09	2.99
Fourth rotation, 1911–1914	2.19	3.13

The excessive applications on Plot 10 have usually produced rank growth of straw and stalk, with the result that oats have often lodged badly and corn has frequently suffered from drouth and has eared poorly. Wheat, however, as an average, has yielded best on this plot. The largest yield of corn was 118 bushels per acre in 1907.

On the University South Farm at Urbana, on typical brown silt loam prairie, where one ton per acre of rock phosphate is applied every four years in connection with organic manures for a rotation of corn, oats, clover, and wheat, applications of fine-ground rock phosphate have paid as follows in the value of the increase produced:

	Per Ton of Phosphate		Per $1 Invested	
	Lower prices	Higher prices	Lower prices	Higher prices
First rotation, 1903–1906	$ 8.26	$11.80	$ 1.18	$ 1.69
Second rotation, 1907–1910	11.33	16.19	1.62	2.31
Third rotation, 1911–1914	18.89	26.98	2.70	3.85

The comparative values of the increases from rock phosphate and limestone, as an average of the four-year rotation 1911-1914, in both live-stock and grain farming, are as follows:

	Residue System		Live-stock System	
	Lower prices	Higher prices	Lower prices	Higher prices
Gain for phosphorus	$18.80	$26.86	$18.96	$27.09
Gain for limestone	2.30	3.29	2.54	3.63

Brown-Gray Silt Loam on Tight Clay of Middle Illinoisan Glaciation (428)

Mascoutah Field.—Table 6, showing the value of twelve crops from the Mascoutah experiment field located upon brown-gray silt loam on tight clay of the middle Illinoisan glaciation, are given here since there is no data for this type in either the lower or the upper Illinoisan glaciation. In order to secure information as quickly as possible, commercial plant foods in readily available form were applied in a four-year rotation of corn, corn, oats, and wheat.

TABLE 6.—VALUE OF CROPS PER ACRE IN TWELVE YEARS, MASCOUTAH FIELD
1902 TO 1913

Plot	Soil treatment applied	Total value of 12 crops	
		Lower prices	Higher prices
501	None	$90.07	$128.67
502	Lime	90.47	129.24
503	Lime, nitrogen	134.46	192.08
504	Lime, phosphorus	106.10	151.57
505	Lime, potassium	100.96	144.23
506	Lime, nitrogen, phosphorus	190.55	272.21
507	Lime, nitrogen, potassium	205.60	293.72
508	Lime, phosphorus, potassium	123.84	176.92
509	Lime, nitrogen, phosphorus, potassium	190.67	272.39
510	Nitrogen, phosphorus, potassium	177.58	253.69

Value of Increase per Acre in Twelve Years

For nitrogen	$43.99	$62.84
For phosphorus	15.63	22.33
For *nitrogen* and phosphorus over phosphorus	84.45	120.64
For *phosphorus* and nitrogen over nitrogen	56.09	80.13
For *potassium,* nitrogen, and phosphorus over nitrogen and phosphorus	.12	.18

Nitrogen is clearly the element of greatest benefit upon this soil type, as shown by the fact that in twelve years the dried blood increased the crop values, at the lower prices, from $90.47 to $134.46, a gain of $43.99. In comparison, phosphorus produced an increase valued at $15.63 and potassium an increase of only $10.49, when used singly. In considering these three elements, starting with $90.47 (Plot 2), the increases per acre in crop values were as follows:

For nitrogen over lime	$ 43.99
For phosphorus as a further addition	56.09
For potassium as a final addition	.12
For total increase	$100.20

This demonstration of doubling crop values is highly important, for it shows the possibilities of soil treatment. From the composition of the soil it is clear that both nitrogen and phosphorus must be supplied for a permanent system of farming, altho there may be some question as to which of the two is most needed. Commercial nitrogen, altho producing marked gains, never paid its cost; and while phosphorus paid nearly 200 percent on the investment in steamed bone meal when used in addition to nitrogen, the profit is more than offset by the nitrogen deficit.

On another part of Mascoutah field investigations were conducted to secure information in regard to the practicability of securing nitrogen by the less expensive practice of growing legumes in the rotation and returning to the soil the crop residues and farm manure. A comparison of these results for eight years shows that the crop values

TABLE 7.—VALUE OF CROPS PER ACRE IN FOURTEEN YEARS, DUBOIS FIELD 1902 TO 1915: NOT TILE-DRAINED

Plot	Soil treatment applied	Total value of 14 crops	
		Lower prices	Higher prices
101	None	$63.83	$91.19
102	Lime	88.28	126.11
103	Lime, residues	113.66	162.37
104	Lime, phosphorus	145.66	208.09
105	Lime, potassium	144.97	207.10
106	Lime, residues, phosphorus	165.07	235.82
107	Lime, residues, potassium	172.34	246.20
108	Lime, phosphorus, potassium	186.02	265.75
109	Lime, residues, phosphorus, potassium	196.39	280.55
110	Residues, phosphorus, potassium	140.50	200.71

Value of Increase per Acre in Fourteen Years

For lime	$24.45	$34.92
For residues	25.38	36.26
For phosphorus	57.38	81.98
For *residues* and phosphorus over phosphorus	19.41	27.73
For *phosphorus* and residues over residues	51.41	73.45
For *potassium*, residues, and phosphorus over residues and phosphorus	31.32	44.73

at the lower prices averaged $119.38 where commercial nitrogen costing $120 was used, and $119.61 and $117.20 where residues and farm manure, respectively, were used.

These data show that practically the same gross values are secured with "home-grown" nitrogen as with the purchased product, and at much less cost. (Detailed data in regard to crop yields will be found in Soil Report 8, Bond county.)

Gray Silt Loam on Tight Clay of Lower Illinoisan Glaciation (330)

DuBois Field.—Data are presented in Tables 7 and 8 showing the results of soil experiments and tile drainage upon gray silt loam on tight clay, the common prairie soil of southern Illinois.

A summary of these data shows that tile drainage has paid $6.37 per acre in fourteen years, or 45 cents per acre per year. It would require at least $1.20 per acre per year to pay 6 percent interest on the cost of the tile drainage, assumed to be $20 per acre.

A summary of the average results from the tiled and the untiled land for the fourteen years shows a crop value of $63.40 per acre from the unfertilized land, and increases for additions as follows:

For lime alone	$30.39 or	48	percent
For nitrogen and organic matter over lime	24.26 or	26	”
For phosphorus as a further addition	54.39 or	46	”
For potassium as a final addition	22.37 or	13	”
For total increase over untreated land	$131.41 or	207	percent

TABLE 8.—VALUE OF CROPS PER ACRE IN FOURTEEN YEARS, DUBOIS FIELD 1902 TO 1915: TILE-DRAINED

Plot	Soil treatment applied	Total value of 14 crops	
		Lower prices	Higher prices
111	None	$62.98	$89.97
112	Lime	99.32	141.89
113	Lime, residues	122.47	174.96
114	Lime, phosphorus	136.54	195.06
115	Lime, potassium	146.48	209.26
116	Lime, residues, phosphorus	179.84	256.89
117	Lime, residues, potassium	181.45	259.22
118	Lime, phosphorus, potassium	193.43	276.33
119	Lime, residues, phosphorus, potassium	193.26	276.08
120	Residues, phosphorus, potassium	164.70	235.29
	Value of Increase per Acre in Fourteen Years		
	For lime	$36.34	$51.92
	For residues	23.15	33.07
	For phosphorus	37.22	53.17
	For *residues* and phosphorus over phosphorus	43.30	61.83
	For *phosphorus* and residues over residues	57.37	81.93
	For *potassium,* residues, and phosphorus over residues and phosphorus	13.42	19.19

These results harmonize with those that would be expected from the chemical composition of the soil. It is likely that as the organic-matter content of the soil increases, the effect of the potassium will be diminished.

Fairfield Field.—Upon the experiment field located near Fairfield, Wayne county, on typical gray silt loam on tight clay, a four-year rotation of corn, cowpeas or soybeans, wheat, and clover is practiced upon four independent series of plots. Live-stock and grain farming, with the use of limestone and rock phosphate, are practiced upon tiled and untiled land. In Table 9 the results from the field as a whole for eight years are concisely summarized by rotations. (For more detailed information, see Soil Report No. 8, Bond county.)

Here untreated well-rotated land produced $19.69 per acre in four-years at the lower values, while the land receiving farm manure, ground limestone, and fine-ground raw rock phosphate produced $53.04 in the second rotation. If it costs $5 an acre a year to farm the untreated land, the returns lack 8 cents of paying the cost, leaving nothing for taxes and interest; moreover this land is becoming poorer each year.

From the standpoint of tile drainage the value of the increase, at the lower prices, has been $1.08 per acre for each of the eight years. It would take at least $1.50 an acre a year to pay 6 percent interest on the cost of the tile drainage at $25 per acre. During the last four years of tile drainage, the increase was $1.79 per acre per

TABLE 9.—CROP VALUES PER ACRE, FAIRFIELD FIELD
1905 TO 1912

First Rotation: Average of Four Series

Soil treatment..	None		Farm manure		Limestone Phosphate		Farm manure Limestone Phosphate	
	Lower prices	Higher prices	Lower prices	Higher prices	Lower prices	Higher prices	Lower prices	Higher prices
Value of 4 crops	$19.69	$28.14	$24.34	$34.76	$26.91	$38.44	$36.42	$52.03

Second Rotation: Average of Four Series

Soil treatment..	Crop residues		Farm manure		Crop residues Limestone Phosphate		Farm manure Limestone Phosphate	
	Lower prices	Higher prices	Lower prices	Higher prices	Lower prices	Higher prices	Lower prices	Higher prices
Value of 4 crops	$20.25	$28.92	$25.45	$36.36	$38.14	$54.49	$53.04	$75.79

year, which would pay a fair rate of interest providing the cost of the drainage did not exceed $30 per acre. Tile drainage may ultimately prove to be profitable.

UPLAND TIMBER SOILS

Yellow-Gray Silt Loam of Lower Illinoisan Glaciation (334)

Raleigh Field.—Upon the experiment field located at Raleigh, Saline county, on typical yellow-gray silt loam, a four-year rotation of wheat, corn, oats and clover (or cowpeas or soybeans) is practiced. As an average of duplicate trials each year, the crop values for the years 1911-1914 from four acres were, at the lower prices, $16.44 from untreated land, $18.22 where organic manures were applied in proportion to the amount of crops produced, and $33.58 where 6 tons per acre of limestone and organic manure were applied. Owing to the low supply of organic matter, phosphorus produced almost no benefit. However, with increasing applications of organic matter the effect of phosphorus is becoming more apparent.

Yellow-Gray Silt Loam of Late Wisconsin Glaciation (1234)

Antioch Field.—The Antioch experiment field located upon yellow-gray silt loam of the late Wisconsin glaciation was so planned that the effect of various additions might be known as quickly as possible. The elements nitrogen, phosphorus, and potassium were applied in commercial form until 1911, after which commercial nitrogen was discontinued and crop residues substituted.

Altho the soil is somewhat irregular and some abnormal seasons

TABLE 10.—VALUE OF CROPS PER ACRE IN THIRTEEN YEARS, ANTIOCH FIELD 1902 TO 1914

Plot	Soil treatment applied	Total value of 13 crops	
		Lower prices	Higher prices
101	None	$135.12	$193.03
102	Lime	119.74	171.06
103	Lime, nitrogen	124.70	178.15
104	Lime, phosphorus	202.20	288.85
105	Lime, potassium	138.88	198.40
106	Lime, nitrogen, phosphorus	179.41	256.31
107	Lime, nitrogen, potassium	133.54	190.77
108	Lime, phosphorus, potassium	201.35	287.65
109	Lime, nitrogen, phosphorus, potassium	191.22	273.18
110	Nitrogen, phosphorus, potassium	181.18	258.83

Value of Increase per Acre in Thirteen Years

For nitrogen	$ 4.96	$ 7.09
For phosphorus	82.46	117.79
For *nitrogen* and phosphorus over phosphorus	–22.79	–32.54
For *phosphorus* and nitrogen over nitrogen	54.71	78.16
For *potassium*, nitrogen, and phosphorus over nitrogen and phosphorus	11.81	16.87

have caused almost complete crop failures, the general summary strongly confirms the analytical data in showing the need of applying phosphorus, and the profit from its use, and the loss in adding potassium.

In most cases commercial nitrogen damaged the small grains by causing the crop to lodge. From the results of other fields we must conclude that better yields are to be secured by providing nitrogen by means of farm manure and legume crops grown in rotation than by the use of commercial nitrogen, which is evidently too readily available, causing too rapid growth and consequent weakness of straw. Table 10 gives the summarized results for thirteen years. (For more detailed information see Soil Report No. 9, Lake county, or No. 10, McLean county.)

Yellow Silt Loam of Unglaciated Areas (135) *of Upper Illinoisan Glaciation* (535)

Pot-Culture Experiments.—Yellow silt loam soil collected from an unglaciated area and from the upper Illinoisan glaciation was arranged in two series of ten four-gallon jars for greenhouse culture work and treated by additions in the same manner as for field-culture work.

As an average, the nitrogen applied produced a yield about eight times as large as that secured without the addition of nitrogen. To determine whether "home-grown" nitrogen would be as efficient as commercial nitrogen, other pots were arranged, and to some commercial nitrogen was applied, and in others cowpeas were grown and turned under. The increase due to commercial nitrogen was not sufficient to cover the cost of the application. After the second crop of cowpeas had been turned under, the legume manures, as an average, made rather better results than the commercial nitrogen. These results confirm the analytical data in showing the great need for nitrogen; and they further show that such nitrogen need not be purchased.

Vienna Field.—Since yellow silt loam is subject to erosion and washing, the control of these factors is exceedingly important. The experiments carried on at Vienna, Johnson county, upon an unglaciated area of this type of soil are conducted solely in the interest of these problems. The management of this field includes deep plowing, contour plowing, the use of cover crops, the increase of the organic-matter content of the soil, and the use of limestone. Some of the re-

TABLE 11.—CROP YIELDS PER ACRE FROM RECLAIMED ABANDONED HILL LAND
VIENNA FIELD

Year	Field 1	Field 2	Field 3	Field 4
1906	Corn 20.4 bu.	Cowpeas turned		
1907	Cowpeas turned	Wheat 9.6 bu.	Clover 1.00 ton	Corn 24.4 bu.
1908	Wheat 7.9 bu.	Clover .77 ton	Corn 33.5 bu.	Cowpeas turned
1909	Clover .60 ton[1]	Corn 37.8 bu.	Cowpeas turned	Wheat 8.8 bu.
1910	Corn 38.6 bu.	Cowpeas turned	Wheat 15.6 bu.	Clover 1.53 tons
1911		Wheat 17.6 bu.		Corn 32.8 bu.

Average Yields of Crops Grown

	Corn	Wheat	Clover
1906–1908	26.1 bu.	8.8 bu.	.89 ton
1909–1911	36.4 bu.	14.0 bu.	1.07 tons

[1]The yield of clover for 1909 is estimated, the weights not having been taken because of a misunderstanding.

sults obtained upon this field are recorded in Table 11. They show that such land may be reclaimed and made to produce fair crops, which tend to increase when proper care is taken to reduce washing and limestone is used in connection with a good rotation.

SWAMP AND BOTTOM-LAND SOILS

Deep Peat of Sand, Late Swamp and Bottom Lands (1401)

Manito Field.—Table 12 records the results obtained from the Manito experiment field upon deep peat soil, where experiments were begun in 1902 and discontinued in 1905. These results are in harmony with the information furnished by the analysis of peat soil as compared with the composition of ordinary normal soils. Where potassium was applied, the yield was three to four times as much as where

TABLE 12.—CORN YIELDS IN SOIL EXPERIMENTS, MANITO FIELD: 1902 TO 1905
(Bushels per acre)

Plot	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs.	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3	
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0	164.5
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

nothing was applied. Sodium chlorid (common salt, containing no potassium) produces no results and cannot therefore take the place of the potassium salts. Applications of limestone produced no effect either alone or in combination.

Sand Soil of Sand, Late Swamp and Bottom Lands (1481)

Green Valley Field.—For six years experiments were conducted at Green Valley, Tazewell county, upon sand soils that easily drifted by wind when not protected by vegetation. During that time (1902 to 1907), a four-year rotation of corn, corn, oats, and wheat was practiced upon a series of ten plots so treated as to secure information as rapidly as possible upon the needs of the soil. The summary of the six years' results are given in Table 13.

From these results it is plain that nitrogen is the element of first importance. In fact the increase in yields was practically sufficient to cover the cost of the commercial nitrogen. Potassium is evidently the second limiting element where decaying organic matter is not provided, but the limit of potassium is very far above the nitrogen limit. Phosphorus during the six years' time produced but little increase.

From the results of other experiments, it is clear that the growing of legume crops and the use of manure (and possibly limestone) on these well-drained sand soils can well take the place of commercial nitrogen. Potassium may prove profitable, at least until more organic matter is supplied.

TABLE 13.—CROP YIELDS IN SOIL EXPERIMENTS, GREEN VALLEY FIELD 1902 TO 1907

Plot	Soil treatment applied	Corn 1902	Corn 1903	Oats 1904	Wheat 1905	Corn 1906	Corn 1907	Value of 6 crops	
		Bushels per acre						Lower prices	Higher prices
401	None	68.7	56.3	49.7	18.3	32.9	35.3	$94.35	$134.78
402	Lime	68.2	42.0	35.9	19.0	17.8	29.5	78.48	112.11
403	Lime, nitrogen	68.6	65.4	44.4	23.5	62.9	58.9	127.74	182.48
404	Lime, phosphorus	30.3	24.9	20.3	16.7	10.4	13.1	44.92	64.17
405	Lime, potassium	23.1	20.1	16.9	16.5	8.4	12.8	38.82	55.46
406	Lime, nitrogen, phosphorus	57.4	69.8	51.9	26.8	70.8	64.7	125.34	178.91
407	Lime, nitrogen, potassium	70.0	72.9	54.7	36.5	74.8	73.6	142.82	204.03
408	Lime, phosphorus, potassium	49.8	39.6	36.9	13.7	18.3	27.7	67.31	96.16
409	Lime, nitrogen, phosphorus, potassium	69.5	69.8	47.8	36.2	66.4	73.6	136.47	194.97
410	Nitrogen, phosphorus, potassium	57.2	66.1	50.0	26.5	66.0	71.9	123.97	177.10
Average gain for *nitrogen*		23.5	37.8	22.3	14.3	55.0	46.9	$73.37	$104.82
Average gain for *potassium* over nitrogen		6.8	3.8	3.1	11.2	3.8	11.8	17.88	25.54
Average gain for *phosphorus* over nitrogen		−5.9	.7	.3	1.5	−.3	2.9	.22	.32

PERMANENT AGRICULTURE

The objective which all farmers should then hold before them is the establishing of practical systems of soil management by means of which the fertility of the soil will not be impoverished but will be increased, or at least maintained, thereby making agriculture permanent.

On some soils, such as yellow silt loam, where erosion by surface washing is carried on to a great extent, a low-grade system of permanent agriculture can be maintained if some use is made of legume crops in long rotations, with much pasture. This system will furnish sufficient nitrogen and organic matter and the minerals will be maintained by the renewal of the surface soil from the subsoil by erosion. It is, however, the privilege and duty of farmers upon the common soils of the state to establish a high-grade system of permanent agriculture and hand it down to posterity. Abundant information shows that this can be done: first, by making liberal use of legume crops in a good rotation; second, by applying limestone liberally to soils that are acid or bordering upon acidity; and third, by using finely ground raw rock phosphate in amounts larger than are necessary for present needs, until the soil is well supplied with the element phosphorus.

For further and more detailed information regarding the soils of the state and methods for their improvement, the reader is urged to send to the Illinois Agricultural Experiment Station for any of the soil reports, bulletins, or circulars listed on the following page.

AVAILABLE PUBLICATIONS RELATING TO ILLINOIS SOIL INVESTIGATIONS

No. BULLETINS

76 Alfalfa on Illinois Soils. 1902 (5th ed., 1913).
157 Peaty Swamp Lands; Sand and "Alkali" Soils. 1912.
177 Radium as a Fertilizer. 1915.
181 Soil Moisture and Tillage for Corn. 1915.
182 Potassium from the Soil. 1915.
190 Soil Bacteria and Phosphates. 1916.

CIRCULARS

110 Ground Limestone for Acid Soils. 1907 (3d ed. 1912).
123 The Status of Soil Fertility Investigations. 1908.
127 Shall We Use Natural Rock Phosphate or Manufactured Acid Phosphate for the Permanent Improvement of Illinois Soils? 1909 (3d ed. 1912).
130 A Phosphate Problem for Illinois Landowners. 1909.
142 European Practice and American Theory Concerning Soil Fertility. 1910.
145 The Story of a King and Queen (Corn and Clover). 1910.
150 Collecting and Testing Soil Samples. 1911 (4th ed. 1916).
155 Plant Food in Relation to Soil Fertility. 1912.
165 Shall We Use "Complete" Commercial Fertilizers in the Corn Belt? 1912 (4th ed. 1913).
167 The Illinois System of Permanent Fertility. 1913.
168 Bread from Stones. 1913.
181 How Not to Treat Illinois Soils. 1915.
185 A Limestone Tester. 1916.
186 The Illinois System of Permanent Fertility from the Standpoint of the Practical Farmer: Phosphates and Honesty. 1916.

SOIL REPORTS

No. 1 Clay County. 1911.
No. 2 Moultrie County. 1911.
No. 3 Hardin County. 1912.
No. 4 Sangamon County. 1912.
No. 5 LaSalle County. 1913.
No. 6 Knox County. 1913.
No. 7 McDonough County. 1913.
No. 8 Bond County. 1913.
No. 9 Lake County. 1915.
No. 10 McLean County. 1915.

NOTE.—Subsequent to the preparation of this bulletin, the following soil reports have been published:

No. 11 Pike County. 1915.
No. 12 Winnebago County. 1916.
No. 13 Kankakee County. 1916.
No. 14 Tazewell County. 1916.