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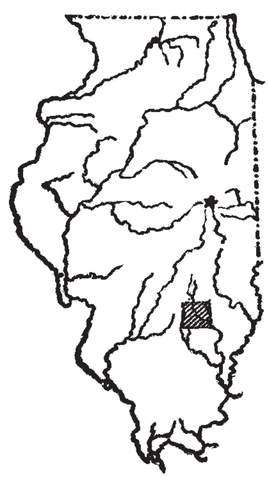
Agricultural Experiment Station

SOIL REPORT NO. 1

CLAY COUNTY SOILS

BY CYRIL G. HOPKINS, J. G. MOSIER,
J. H. PETTIT, AND J. E. READHIMER



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INTRODUCTION

The Illinois County Soil Reports, beginning with Report No. 1, "Clay County Soils," constitute a series of publications separate and distinct from the bulletins and circulars of the Experiment Station. At least three of these county reports will be sent to the Station's entire mailing list. These three are the reports of Clay County, representing the common soils of southern Illinois; Moultrie County, representing the common corn belt soils; and Hardin County, representing the unglaciated Ozark Hills region. As a rule the other soil reports will be sent only to the residents of the respective counties, and to others upon request. This plan requires that each county report shall be as complete as practicable, and consequently this general discussion of soil principles, which appears as an introduction in the Clay County Report, may be found with any necessary modifications as an appendix to every other county report.

A study of the soil map and the tabular statements concerning crop requirements, the plant food content of the different soil types, and the actual results secured from definite field trials with different methods or systems of soil improvement, and a careful study of the discussion of general principles and of the descriptions of individual soil types will furnish the most necessary and useful information for the practical improvement and permanent preservation of the productive power of every kind of soil on every farm in the county.

More complete information concerning the most extensive and important soil types in the great soil areas in all parts of Illinois is contained in Bulletin No. 123, "The Fertility in Illinois Soils," which contains a colored general survey soil map of the entire state.

Other publications of general interest are:

Bulletin No. 76, "Alfalfa on Illinois Soils."
Bulletin No. 94, "Nitrogen Bacteria and Legumes."
Bulletin No. 99, "Soil Treatment for the Lower Illinois Glaciation."
Bulletin No. 115, "Soil Improvement for the Worn Hill Lands of Illinois."
Bulletin No. 125, "Thirty Years of Crop Rotation on the Common Prairie Lands of Illinois."
Circular No. 110, "Ground Limestone for Acid Soils."
Circular No. 127, "Shall we use Natural Rock Phosphate or Manufactured Acid Phosphate for the Permanent Improvement of Illinois Soils?"
Circular No. 129, "The Use of Commercial Fertilizers."
Circular No. 149, "Some Results of Scientific Soil Treatment" and "Methods and Results of Ten Years' Soil Investigation in Illinois."

NOTE.—Information as to where to obtain limestone, phosphate, bone meal, and potassium salts, methods of application, etc., will also be found in Circular 110.

SOIL SURVEY METHODS

The detail soil survey of a county consists essentially of indicating on a map the location and extent of the different soil types; and, since the value of the survey depends upon its accuracy, every reasonable means is employed to make it trustworthy. To accomplish this object three things are essential: first, careful, well-trained men to do the work; second, an accurate base map upon which to show the results of their work; and, third, the means necessary to enable the men to place the soil type boundaries, streams, etc., accurately upon the map.

The men selected for the work must be able to keep their location exactly and to recognize the different soil types, with their principal varieties and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one soil expert will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and, if the work is correctly done, the soil type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are made on a scale of one inch to the mile. The official data of the original or subsequent land survey are used as a basis in the construction of these maps, while the most trustworthy county map available is used in locating temporarily the streams, roads, and railroads. Since the best of these published maps have some inaccuracies, the location of every road, stream, and railroad must be verified by the soil surveyors, and corrected if wrongly located. In order to make these verifications and corrections, each survey party is provided with an odometer for measuring distances, and a plane table for determining the directions of roads, railroads, etc.

Each surveyor is provided with a base map of the proper scale, which is carried with him in the field, and the soil type boundaries, additional streams, and necessary corrections are placed with proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils being carried in the field for this purpose.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle, while distances in the field off the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

SOIL CHARACTERISTICS

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, but sometimes one type will grade into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil type boundaries is unavoidable.

Several factors must be taken into account in establishing soil types. These are (1) the geological origin of the soil, whether residual, glacial, loessial, alluvial, colluvial, or cumulose; (2) the topography, or lay of the land; (3) the structure, or the depth and character of the surface, subsurface, and subsoil; (4) the physical or mechanical composition of the different strata composing the soil, as the percentages of gravel, sand, silt, clay, and organic matter which they contain; (5) the texture, or porosity, granulation, friability, plasticity, etc.; (6) the color of the strata; (7) the natural drainage; (8) agricultural value, based upon its natural productiveness; (9) native vegetation; (10) the ultimate chemical composition and reaction.

The common soil constituents are indicated in the following outline:

CONSTITUENTS OF SOILS

Soil Constituents	Organic Matter	Comprising undecomposed and partially decayed vegetable material	
	Inorganic Matter	Clay	.001 mm.* and less
		Silt	.001 mm. to .03 mm.
		Sand	.03 mm. to 1. mm.
		Gravel	1. mm. to 32 mm.
		Stones	32. mm. and over.

*25 millimeters equal 1 inch.
Further discussion of these constituents is given in Circular 82.

GROUPS OF SOIL TYPES

The following gives the different general groups of soils:

Peats—Consisting of 35 percent or more of organic matter, sometimes mixed with more or less sand or silt.

Peaty loams—15 to 35 percent of organic matter mixed with much sand and silt and a little clay.

Mucks—15 to 35 percent of partly decomposed organic matter mixed with much clay and some silt.

Clays—Soils with more than 25 percent of clay, usually mixed with much silt.

Clay loams—Soils with from 15 to 25 percent of clay, usually mixed with much silt and some sand.

Silt loams—Soils with more than 50 percent of silt and less than 15 percent of clay, mixed with some sand.

Loams—Soils with from 30 to 50 percent of sand mixed with much silt and a little clay.

Sandy loams—Soils with from 50 to 75 percent of sand.

Fine sandy loams—Soils with from 50 to 75 percent of fine sand mixed with much silt and little clay.

Sands—Soils with more than 75 percent of sand.

Gravelly loams—Soils with 25 to 50 percent gravel with much sand and some silt.

Gravels—Soils with more than 50 percent of gravel.

Stony loams—Soils containing a considerable number of stones over one inch in diameter.

Rock outcrop—Usually ledges of rock having no agricultural value.

More or less organic matter is found in nearly all of the above classes.

SUPPLY AND LIBERATION OF PLANT FOOD

The productive capacity of land in humid sections depends almost wholly upon the power of the soil to feed the crop; and this, in turn, depends both upon the stock of plant food contained in the soil and upon the rate at which this is liberated, or rendered soluble and available for use in plant growth. Protection from weeds, insects, and fungous diseases tho exceedingly important is not a positive, but a negative factor in crop production.

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter, which may be added to the soil by direct application of ground limestone and farm manure. Organic matter may also be supplied by green manure crops and crop residues, such as clover, cowpeas, straw, and cornstalks. The rate of decay of organic matter depends largely upon its age and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which represents, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old inactive organic matter. The recent history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in grass root sods of old pastures.

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even though plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

As the organic matter decays, certain decomposition products are formed, including much carbonic acid, some nitric acid, and various organic acids, and these have power to act upon the soil and dissolve the essential mineral plant foods, thus furnishing nitrates, phosphates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

As already explained, fresh organic matter decomposes much more rapidly than the old humus, which represents the organic residues most resistant to decay and which consequently have accumulated in the soil during the past centuries. The decay of this old humus can be hastened both by tillage, which maintains a porous condition and thus permits the oxygen of the air to enter the soil more freely and to effect the more rapid decomposition or oxidation of the organic matter, and also by incorporating with the old resistant residues some fresh organic matter, such as farm manure, clover roots, etc., which decay rapidly and which thus furnish or liberate organic matter and inorganic food for bacteria, which, under such favorable conditions appear to have power to attack and decompose the old humus. It is probably for this reason that peat, a very inactive and inefficient fertilizer when used by itself, becomes much more effective when incorporated with fresh farm manure, so that when used together, two tons of the mixture may be worth as much as two tons of manure, but if applied separately, the peat has little value. Bacterial action is also promoted by the presence of limestone.

It should be kept in mind that crops are not made out of nothing. They are composed of ten different elements of plant food, every one of which is absolutely essential for the growth and formation of every agricultural plant. Of these ten elements of plant food, only two (carbon and oxygen) are secured from the air by all plants, only one (hydrogen) from water, and seven from the soil. Nitrogen, one of these seven elements secured from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) secure six elements from the soil (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

Plants are made of these plant-food elements in just the same sense that a building is made of wood and iron, brick, stone, and mortar. Without materials, nothing material can be made. The normal temperature, sunshine, rainfall, and length of season in southern Illinois are sufficient to produce 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay; and, where the land is properly drained and properly tilled, such crops would frequently be secured *if the plant foods were present in sufficient amount and liberated at a sufficiently rapid rate to meet the absolute needs of the crops.*

CROP REQUIREMENTS

The accompanying table shows the requirements of such crops for the five most important plant food elements which the soil must furnish. (Iron and sulfur are supplied normally in sufficient abundance compared with the amounts needed by plants, so that they are not known ever to limit the yield of crops):

TABLE 1.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen, pounds	Phosphorus, pounds	Potassium, pounds	Magnesium, pounds	Calcium, pounds
Kind	Amount					
Wheat, grain	50 bu.	71	12	13	4	1
Wheat straw	2½ tons	25	4	45	4	10
Corn, grain	100 bu.	100	17	19	7	1
Corn stover	3 tons	48	6	52	10	21
Corn cobs	½ ton	2	..	2	..	..
Oats, grain	100 bu.	66	11	16	4	2
Oat straw	2½ tons	31	5	52	7	15
Clover seed	4 bu.	7	2	3	1	1
Clover hay	4 tons	160	20	120	31	117
Total in grain and seed		244*	42	51	16	4
Total in four crops		510*	77	322	68	168

To be sure, these are large yields, but shall we try to make possible the production of yields only half or a quarter as large as these, or shall we set as our ideal this higher mark, and then approach it as nearly as possible with profit? Among the four crops, corn is the largest, with a total yield of more than six tons per acre; and yet the 100-bushel crop of corn is often produced on rich pieces of land in good seasons. In very practical and profitable systems of farming, the Illinois Experiment Station has produced, as an average of the six years, 1905 to 1910, a yield of 87 bushels of corn per acre in grain farming (with limestone and phosphorus applied, and with crop residues and legume crops turned under), and 90 bushels per acre in live-stock farming (with limestone, phosphorus, and manure).

On the Edgewood Experiment Field, less than five miles from the north line of Clay County, and on the common prairie land of southern Illinois, yields have been obtained as high as 91 bushels per acre of corn, 74 bushels of oats, and 2.91 tons of air-dry clover hay, in the first cutting, and probably more than 1 ton in the second crop, which, however, was plowed under without weighing.

*These amounts include the nitrogen contained in the clover seed or hay, which, however, may be secured from the air.

THE FERTILITY IN CLAY COUNTY SOILS

ORIGIN OF SOIL MATERIAL

Clay County was covered by the Illinoisan ice sheet, which generally leveled down hills and filled valleys, and left that part of the state as a broad level expanse broken only by a few morainal or preglacial ridges, remnants of which now form our ridge soils. The ice sheet in its movement southward carried large amounts of earthy material of various sizes, including boulders, gravel, sand, silt and clay, which were deposited when the ice melted, forming what is known as till, boulder clay, or glacial drift, which may be recognized readily by its composite character.

After the ice sheet melted, the surface of the glacial drift was slowly and gradually changed into a soil which varied somewhat as soils do now.

At the close of the Iowan glaciation, which followed the Illinoisan, the entire state was covered with a wind-blown dust, known as loess, which was deposited somewhat uniformly over this region to a depth of from 4 to 10 feet, burying the old soil completely. A new soil was formed from this fine material by the subsequent weathering and the accumulation of organic matter, which has been modified to form the present soils. The old buried soil, known as the Sangamon soil, is sometimes exposed along streams or roadsides, occasionally as a dark heavy stratum two or three feet thick, while in other places it is represented only by a weathered surface of the glacial drift.

TABLE 2.—SOIL TYPES OF CLAY COUNTY

Soil type No.	Names	Area in acres	Percent of total
	(a) Upland Prairie Soils (Page 22)		
330	Gray silt loam on tight clay	110,720	37.000
328	Brown-gray silt loam on tight clay	960	.330
329	Drab silt loam	14,400	4.800
326.1	Brown silt loam on clay	824	.270
331	Deep gray silt loam	1,760	.590
	(b) Upland Timber Soils (Page 26)		
332	Light gray silt loam on tight clay	51,200	17.130
332.1	White silt loam on tight clay	224	.073
334	Yellow-gray silt loam	21,240	7.090
335	Yellow silt loam	41,760	14.000
	(c) Ridge Soils (Page 29)		
235	Yellow silt loam	2,560	.854
233	Gray-red silt loam on tight clay	9,180	3.000
	(d) Swamp and Bottom land Soils (Page 30)		
1331	Deep gray silt loam	31,680	10.580
1361	Mixed sandy loam	12,800	4.270
1315	Drab clay	25	.008
1301	Deep peat	15	.005
	Totals	299,348	100.000

The data in Table 3 represent the total amounts of plant food found in 2 million* pounds of the surface soil, which corresponds to an acre of soil about 6⅔ inches deep, including at least as much soil as is ordinarily turned with the plow, and representing that part of the soil with which we incorporate the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement. This is the soil stratum upon which we must depend in large

*The amounts are for only 1 million pounds of the peat soil because its specific gravity is only one-half that of normal soils.

part to furnish the necessary plant food for the production of the crops grown.

In Table 3 is recorded the invoice of the plowed soil, showing the total amounts of these five elements of plant food contained in each of the different types of soil in Clay County. (For more details see Bulletin 123.)

TABLE 3.—FERTILITY IN THE SOILS OF CLAY COUNTY, ILLINOIS
Average pounds per acre in 2 million pounds of surface soil (about 6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Limestone required
	Upland Prairie Soils								
330	Gray silt loam on tight clay	26970	2790	750	24830	4690	3420		1130
328	Brown-gray silt loam on tight clay...	30600	3020	1020	25760	5780	4020		160
329	Drab silt loam	23640	2560	630	25110	4560	6270		1520
326.1	Brown silt loam on clay	30740	3320	700	24700	5520	7720		1500
331	Deep gray silt loam....	20800	2180	600	24220	3000	4900		1640
	Upland Timber Soils								
332	Light-gray silt loam on tight clay...	17810	1580	760	27860	4310	4620		480
322.1	White silt loam on tight clay	16980	1120	400	29380	4940	4060		840
334	Yellow-gray silt loam....	19600	1650	550	30200	5490	6920		40
335	Yellow silt loam	16990	1540	510	31430	3800	3000		2250
	Ridge Soils								
235	Yellow silt loam........	41970	3890	820	29500	8140	6040		140
233	Gray-red silt loam on tight clay...	27380	2720	760	27300	5200	4320		1040
	Swamp and Bottom-land Soils								
1331	Deep gray silt loam....	31470	2910	1350	34740	7700	7580		100
1361	Mixed sandy loam........	26950	2700	750	31410	6350	7950		80
1315	Drab clay.....	43960	4180	1040	35300	10920	8160		40
1301	Deep peat* ...	297660	16790	930	6190	7240	107900	224680	

The importance of maintaining a rich surface soil cannot be too strongly emphasized. It is well illustrated by data from the Rothamsted Experiment Station, the oldest in the world. Thus on Broadbalk field, where wheat has been grown since 1844, the average yields for the ten years, 1892 to 1901 were 12.3 bushels per acre on plot 3 (unfertilized) and 31.8 bushels on plot 7 (well fertilized), but the amounts of both nitrogen and phosphorus in the subsoil (9 to 27 inches) were distinctly greater in plot 3 than in plot 7, thus showing that the higher yields from plot 7 were due to the fact that the plowed soil had been enriched. In 1893, plot 7 contained per acre in the surface soil (0 to 9 inches) about 600 pounds more nitrogen and 900 pounds more phosphorus than plot 3. Even a rich subsoil has little value if it lies beneath a worn-out surface.

*Amounts reported are from 1 million pounds of peat soil.

By easy computation it will be found that not one of the prairie soils of Clay County contains enough total nitrogen in the plowed soil for the production of maximum crops for ten rotations; while the upland timber soils contain as an average only about half as much nitrogen as the prairie land.

Practically the same condition obtains with respect to phosphorus, only two of the eleven upland soils containing as much of that element as would be required for ten crop rotations if such crop yields were secured as suggested in Table 1; and in case of the cereals it will be seen that about three-fourths of the phosphorus taken from the soil is deposited in the grain, while only one-fourth remains in the straw or stalks. If only the grain and seed were sold from the farm the total supply of phosphorus in the plowed soil is no more than would need to leave the farm during the full time of one life (70 years).

On the other hand, the potassium is sufficient for 2000 years, if only the grain is sold, or for 300 years if the total crops are removed; and the corresponding figures are about 1200 and 300 years for magnesium, and about 3000 and 100 years for calcium.

Thus when measured by the actual crop requirements for plant food magnesium and calcium are more limited than potassium. But with these elements we must also consider the loss by leaching. As an average of 90 analyses* of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905.

It is of interest to note that thirty crops of clover of 4 tons each would require 3510 pounds of calcium, while the most common prairie land (gray silt loam on tight clay) contains only 3420 pounds of total calcium in the plowed soil of an acre.

These general statements relating to the total quantities of plant food in the plowed soil certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people. We must also consider, however, the question of the rate at which these plant food elements may be liberated and thus made available for plant growth.

METHODS OF LIBERATING PLANT FOOD

Limestone and decaying organic matter are the principal materials the farmer can utilize most profitably to bring about the liberation of plant food.

The limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also of the nitrifying bacteria which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen.

*Reported by Doctor Bartow and associates, of the Illinois State Water Survey.

At the same time the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms.

Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil and burn out the organic matter; but it should never be forgotten that tillage is wholly destructive, that it adds nothing whatever to the soil, but always leaves the soil poorer. Tillage should be practiced so far as is necessary to prepare a suitable seed-bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable in seasons of normal rainfall; and it is much better actually to enrich the soil by proper applications or additions, including limestone and organic matter (both of which have power to improve the physical condition as well as to liberate plant food) than merely to hasten soil depletion by means of excessive cultivation.

PERMANENT SOIL IMPROVEMENT

The best and most profitable methods for the permanent improvement of the common soils of Clay County are as follows:

(1) Apply at least two tons (and better five tons) per acre of ground limestone, preferably at times magnesian limestone ($CaCO_3$ $MgCO_3$) which contains both calcium and magnesium, and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). Afterward continue to apply about two tons per acre of ground limestone every four to six years.

(2) Adopt a good rotation of crops, including a liberal use of legumes, and increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks) or by using for feed and bedding practically all of the crops raised and returning the manure to the land with the least possible loss. No one can say in advance what will prove to be the best rotation of crops, because of variation in prices and seasons, but the following are suggested to serve as models or outlines:

First year, corn (with some winter legume, such as red clover, alsike, sweet clover, or alfalfa, or a mixture, seeded on one-half of the field at the last cultivation).
Second year, oats or barley on one-half and cowpeas or soybeans where the winter catch crop is plowed down.
Third year, wheat or rye (with clover or clover and grass).
Fourth year, (1) clover, or (2) clover and timothy, or (3) clover and red top.
Fifth year, (1) wheat and clover, or (2) timothy and clover, or (3) red top.
Sixth year, (1) clover, or (2) clover and timothy, or (3) red top.

In grain farming, with wheat grown the third and fifth years, most of the coarse products should be returned to the soil, and the clover may be clipped and left on the land (only the clover seed being sold the fourth and sixth years); or in live-stock farming, the clover may be reseeded each spring, if necessary to maintain the stand, and the field used three years for timothy and clover pasture and meadow as desired. If red top is seeded the clover will usually make seed or both hay and seed the fourth year, and red-top seed may be sold the fifth and sixth years. To avoid clover sickness it may sometimes be necessary to substitute red clover or alsike for the other in about every third rotation, and to discontinue their use in the catch-crop mixture. If the corn crop is not too rank, cowpeas or soybeans may also be used as a catch-crop and, if necessary to avoid disease, these may well alternate in successive rotations.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of red top requires 21 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops.

Soils of moderate productive power will furnish as much nitrogen to clover (and more to cowpeas) than will be left in the roots and stubble. For grain crops, as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

(3) On all of the lands not subject to overflow (or susceptible to serious erosion by surface washing or gullying) apply the element phosphorus in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre (at least one-half ton should be used), and subsequently about one-half ton per acre every four to six years should be applied, at least until the phosphorus content of the plowed soil reaches 2000 pounds per acre, which will require a total application of five or six tons per acre of raw phosphate containing 12½ percent of the element phosphorus. Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that phosphorus delivered in southern Illinois costs about 3 cents a pound in raw phosphate (direct from the mine in carload lots), more than 10 cents a pound in steamed bone meal, and more than 12 cents a pound in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with limestone or raw phosphate.

Phosphorus once applied to the soil remains in it until removed in crops, unless carried away mechanically by soil erosion. (The loss by leaching is only about 1½ pounds per acre per annum, so that more than 150 years would be required to leach away the phosphorus applied in one ton of raw phosphate).

The phosphate and limestone may be applied at any time during the rotation, but a good method is to apply the limestone after plowing and work it into the surface soil in preparing the seed bed for wheat, oats, rye, or barley, where clover is to be seeded, while phosphate is best plowed under with farm manure, clover, or other green manures, which serve to liberate the phosphorus.

(4) Until the supply of decaying organic matter has been made adequate, some temporary benefit may be derived from the use of a

soluble salt or mixture of salts, such as kainit, which contains both potassium and magnesium in soluble form and also some common salt (sodium chlorid). About 600 pounds per acre of kainit applied and turned under with the raw phosphate will help to dissolve the phosphorus as well as to furnish available potassium and magnesium, and for a few years such use of kainit will no doubt be profitable on lands deficient in organic matter, but the evidence thus far secured indicates that its use is not absolutely necessary and that it will not be profitable after adequate provision is made for decaying organic matter, since this will necessitate returning to the soil either all produce except the grain (in grain farming) or the manure produced in live-stock farming. (Where hay or straw are sold, manure should be bought.)

TABLE 4.—FERTILITY IN THE SOILS OF CLAY COUNTY, ILLINOIS
Average pounds per acre in 4 million of subsurface soil (about 6⅔ to 20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Limestone required
	Upland Prairie Soils								
330	Gray silt loam on tight clay	28860	3420	1250	53910	13040	7620		6630
328	Brown-gray silt loam on tight clay...	18480	2320	1080	54280	11640	5080		6160
329	Drab silt loam	35780	2420	1160	50160	8840	11520		3760
326.1	Brown silt loam on clay	54800	5120	1360	48440	11520	13920		4920
331	Deep gray silt loam	34680	3800	1320	49360	7320	7880		5760
	Upland Timber Soils								
332	Light-gray silt loam on tight clay...	9240	1620	1360	57180	13880	6920		13640
332.1	White silt loam on tight clay...	11600	1120	920	60200	10280	8120		8200
334	Yellow-gray silt loam	13760	1520	860	64420	14100	7880		1680
335	Yellow-silt loam.......	15890	1830	790	64480	12720	6840		14270
	Ridge Soils								
235	Yellow silt loam........	48680	5000	1340	61040	23180	9300		12940
233	Gray-red silt loam on tight clay...	29000	3480	1240	60680	14880	7760		7880
	Swamp and Bottom-land Soils								
1331	Deep gray silt loam ..	25380	2760	2184	70480	15960	12880		1720
1361	Mixed sandy loam........	31980	3060	1180	63220	10940	13220		200
1315	Drab clay....	38480	3800	1360	71320	22440	16040		40
1301	Deep peat*...	595320	33580	1860	12380	14480	215800	449360	

THE SUBSURFACE AND SUBSOIL

In Tables 4 and 5 are recorded the amounts of plant food in the subsurface and subsoils, but it should be remembered that these supplies are of little value unless the top soil is kept rich. Probably the most important in-

*Amounts reported are from 2 million pounds of deep peat.

formation contained in Tables 4 and 5 is that all of the upland soils are even more strongly acid in the subsurface and subsoil than in the surface, thus emphasizing the importance of having plenty of limestone in the surface soil to neutralize the acid moisture which rises from the lower strata by capillary action during periods of partial drouth, which are also critical periods in the life of such plants as clover.

TABLE 5.—FERTILITY IN THE SOILS OF CLAY COUNTY, ILLINOIS
Average pounds per acre in 6 million pounds of subsoil (about 20 to 40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Limestone required
	Upland Prairie Soils								
330	Gray silt loam on tight clay	20600	2980	2000	88620	33690	19830		20540
328	Brown-gray silt loam on tight clay...	12060	2340	2040	87420	33540	18720		4860
329	Drab silt loam	34020	2910	1470	77160	19020	17280		16440
326.1	Brown silt loam on clay	53700	5640	1260	69660	24480	26760		13200
331	Deep gray silt loam........	24300	3540	1320	78720	17220	11040		17100
	Upland Timber Soils								
332	Light gray silt loam on tight clay...	12680	1910	1830	88110	31420	13680		47060
332.1	White silt loam on tight clay...	11640	1620	1500	91800	15540	10920		25320
334	Yellow-gray silt loam....	13230	1950	1560	96270	29310	10770		20490
335	Yellow silt loam........	15200	1720	1160	92480	20760	11880		12280
	Ridge Soils								
235	Yellow silt loam........	26880	3450	1350	95790	31410	20100		10410
233	Gray-red silt loam on tight clay...	25020	3360	1800	87720	29280	16620		27360
	Swamp and Bottom-land Soils								
1331	Deep gray silt loam....	19260	2470	2940	106300	24240	16620		6590
1361	Mixed sandy loam........	20130	2100	1350	94350	16890	14760		4350
1315	Drab clay.....	33600	3660	2040	107040	35880	25680		60
1301	Deep peat* ...	892980	50370	2790	18570	21720	323700	674040	

On soils which are subject to surface washing, including especially the yellow silt loam of the upland timber area, and to some extent the yellow-gray silt loam, and the ridge soils (and even the gray silt loam prairie on rolling areas), the supply of minerals in the subsurface and subsoil tend to provide for a low-grade system of permanent agriculture if some use is made of legume plants, as in long rotations with much pasture, because both the minerals and nitrogen are thus provided in some amount almost permanently; but where such lands are farmed under such a system not more than two or three grain crops should be grown during a period of 10 or 12 years, the land being kept in pasture most of the time; and a liberal use of limestone, as top dressings if necessary, and occasional reseeding with clovers will benefit both the pasture and indirectly the grain crops.

*Amounts reported are from 3 million pounds of deep peat

TABLE 6.—CROP YIELDS PER ACRE ON DUBOIS EXPERIMENT FIELD

On Prairie Land; Gray Silt Loam on Tight Clay

Soil treatment applied	1902 Corn bu.	1903 Oats bu.	1904 Wheat bu.	1905 Clover tons	1906 Corn bu.	1907 Oats bu.	1908 Wheat bu.	1909 Soybeans bu.
Land not Tile-drained								
None	6	9	6	1.3	30	19	1	3.5
Lime	7	16	7	1.6	35	28	8	6.7
Lime, phosphorus	13	26	25	2.4	39	44	18	8.5
Lime, phosphorus, and potassium	12	30	28	2.9	49	50	21	9.5
Land Tile-drained								
None	1	17	3	1.3	33	13	4	3.3
Lime	3	17	12	1.7	34	24	11	6.2
Lime, phosphorus	7	28	28	2.3	30	32	19	7.2
Lime, phosphorus, and potassium	14	26	32	3.0	55	44	23	10.3
Average of Two Series								
None	4	13	5	1.3	31	16	3	3.4
Lime	5	17	9	1.7	34	26	10	6.5
Lime, phosphorus	10	27	27	2.4	34	38	19	7.9
Lime, phosphorus, and potassium	13	28	30	2.9	52	47	22	9.9
Gain for lime and phosphorus	6	14	22	1.1	3	22	16	4.5
Value of increase	$2.10	$4.20	$15.40	$6.60	$ 1.05	$6.60	$11.20	$4.50
Value of crops from untreated land	$1.40	$3.40	$ 3.50	$7.80	$10.85	$4.80	$ 2.10	$3.40

RESULTS OF FIELD EXPERIMENTS AT DU BOIS

Before considering in detail the individual soil types, it seems advisable to study some of the results already obtained where definite systems of soil improvement have been given an actual trial in different parts of southern Illinois.

In Table 6 are recorded some exceedingly valuable, trustworthy, interesting and instructive data. These results were secured by eight years of actual trial on the most common type of soil in Clay County, which is also a very common type in Washington County, where the DuBois Experiment Field is located.

Anyone of common sense can understand this table if he is willing to study it.

Has tile-drainage been beneficial? There are 32 comparisons which bear upon the answer to this question,—8 with no soil treatment, 8 with lime applied, 8 with lime and phosphorus, and 8 comparisons where lime, phosphorus, and potassium were used; and the average of these results certainly does not justify investing in tile drainage for this land.

Does the application of lime and phosphorus produce benefit? The answer to this is found in the fact that the value of the eight crops on the untreated land amounted to only $37.75, whereas the value of the increase produced by lime and phosphorus was $51.65. In other words, the treatment produced more than the land did, raising the crop values from $37.75 to $89.40, counting corn at 35 cents a bushel, oats at 30 cents, wheat at 70 cents, hay at $6.00 a ton, and soybeans at $1.00 a bushel, prices which are somewhat below the 10-year average. It should be stated, too, that marked improvement was made in quality (especially in wheat and clover), which is not given credit in these values.

The materials used per acre in these experiments were 5 tons of burned lime (applied only at the beginning), 1600 pounds of steamed bone meal (800 pounds for each four-year rotation), and 800 pounds of potassium sulfate (400 pounds for each rotation); but other investigations (reported in Circulars 110 and 127) have shown that ground natural limestone and fine-ground natural rock phosphate are more economical and profitable forms of lime and phosphorus; and the effect produced by potassium sulfate can also be secured at much less expense either by means of decaying organic matter (from crop residues, green manure crops, or farm manure) or by the use of less expensive soluble salts, such as kainit, as shown below. If we allow $10 for ground limestone (which would pay for the full equivalent of the lime applied) and $20 for the bone meal (its actual cost), we find that the increase produced has paid for these materials and left a net profit of $2.70 per acre per annum, or 70 percent above the cost.

Furthermore about one-half of the lime applied and at least two-thirds of the phosphorus applied still remain in the soil for the benefit of future crops.

The potassium applied during the eight years cost $20 and produced increases valued at $19.55, leaving a loss of 6 cents per acre per annum, and furthermore the potassium removed is equal to the total amount applied.

On five other plots in the DuBois field commercial nitrogen was used alone or with other elements during the first three years, but at large financial loss, and with no apparent residual effect. Since 1907, a system has been adopted for those plots which will supply both the nitrogen and organic matter by means of legume catch crops and crop residues, but another rotation will be required to get this system underway so as to produce any marked effect upon crop yields.

Owing to the severe drouth in the summer of 1908, the clover failed on the DuBois field, and consequently soybeans were substituted.

RESULTS OF FIELD EXPERIMENTS AT FAIRFIELD

The accompanying photographic reproductions show more plainly than words or figures the effect and the importance of applying limestone and phosphorus to the common upland soil of southern Illinois. These photographs were taken in 1910, and show four parts of a field which was all seeded alike to clover in 1909. This 40-acre experiment field is about one mile north of Fairfield, in Wayne County, which adjoins Clay County on the south.

The Fairfield Experiment Field is divided into four tracts of land, and a four-year rotation is practiced, consisting of corn, cowpeas (or soybeans), wheat, and clover. If the clover fails, cowpeas or soybeans may be substituted for that season; and if the winter wheat fails, oats or barley may be substituted in the spring. One half of the field, or 20 acres, is tile-drained, while the other half has only the ordinary surface drainage, as commonly

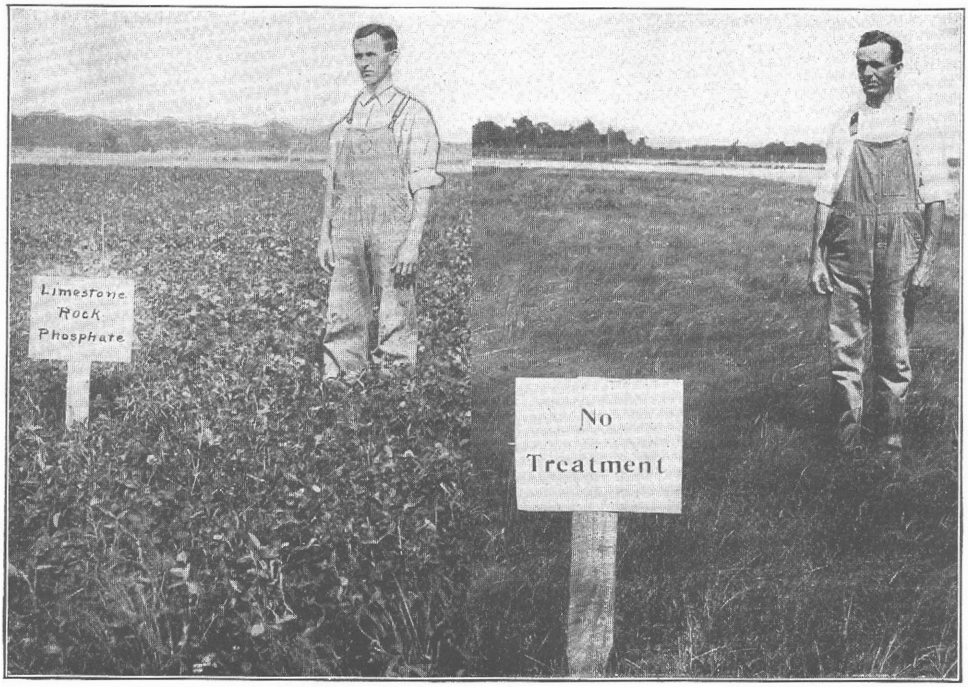

PLATE 1.—CLOVER ON FAIRFIELD EXPERIMENT FIELD, 1910. (THE FIRST CROP, SHOWN IN PHOTOGRAPHS, WAS CLIPPED AND LEFT ON THE LAND; THE SECOND CROP PRODUCED NO CLOVER SEED ON THE UNTREATED LAND, BUT $1\frac{1}{3}$ BUSHELS WERE HARVESTED WHERE THE LIMESTONE AND PHOSPHATE WERE APPLIED).

provided by plowing in rather narrow lands and keeping the middle furrows open.

Grain farming is practiced on half of the tiled land and also on half of the land not tiled; while live-stock farming is practiced on the other half of each part. A part of each of these divisions is treated with 2 tons of limestone and 1 ton of fine-ground raw rock phosphate, per acre, every four years, while another part is not so treated.

In the system of grain farming the plan is to return to the land all produce except the grain or seed, while in live-stock farming all produce (or its equivilent) is to be used for feed and bedding and the manure returned to the land in proportion to the crop yields produced during the previous rotation. It should be stated, however, that during the first rotation the manure was applied in the same amount (8 tons per acre) both where limestone and phosphate were used and where they were not used; but in the second rotation, as when manure is applied to the 1910 clover ground for the 1911 corn crop, the application of manure will be in direct proportion to the crop yields produced during the preceding four years. Thus, if the land treated with limestone and phosphate has produced as an average, one-half larger crops of corn, cowpeas, oats, and clover during 1907, 1908, 1909, and 1910, then one-half more manure will be applied to that land for the 1911 corn crop, than to the land which receives manure alone. Likewise the clover and other crop residues returned in the grain system during the second and subsequent rotations will be in proportion to the yield produced on the respective parts of the field.

PLATE 2.—CLOVER ON FAIRFIELD EXPERIMENT FIELD, 1910. (THE FIRST CROP, SHOWN IN PHOTOGRAPH, MADE $\frac{3}{5}$ TON OF FOUL GRASS WITH BUT LITTLE CLOVER WHERE MANURE ALONE WAS USED, AND $2\frac{2}{3}$ TONS OF CLEAN CLOVER HAY WHERE THE SAME AMOUNT OF MANURE WAS USED WITH LIMESTONE AND PHOSPHATE).

The best plan is to apply the phosphate and plow it under with manure or other organic matter; and to apply the limestone immediately after the ground is plowed for wheat in order that it may be mixed with the surface soil in the preparation of the seed-bed where clover is to be seeded the following winter or spring. However, the time and method of application are very secondary matters; the important thing is to get the limestone and phosphate on the land and well mixed with the plowed soil, altho it is better to mix one with the soil before applying the other, because when applied in intimate contact the limestone tends temporarily to lessen the availability of the phosphorus, probably by immediately neutralizing the nitric, carbonic, and organic acids produced in the decay of organic matter.

At $1.25 a ton for limestone, and $7.50 a ton for rock phosphate, the cost of those materials amounts to $10 an acre every four years; but after three or four rotations the phosphate application will be reduced to about one-half ton, which will reduce the annual expense to about $1.50 per acre, an expense which would be practically covered by an increase of 4 bushels of corn, 1½ bushels of cowpeas or soybeans, 2 bushels of wheat, 5 bushels of oats, or ¼ ton of hay.

In Table 7 are recorded the crop yields obtained since the work was begun on the land on which the 1910 clover fields are shown in the photographs. On this field clover was sown without a nurse crop late in the season of 1905, and the 1906 hay crop was mostly red top, the land having been used as a red top meadow previously.

TABLE 7.—CROP YIELDS PER ACRE ON FAIRFIELD EXPERIMENT FIELD

On Prairie Land: Gray silt Loam on Tight Clay

Soil treatment applied	1906 Clover (?) tons	1907 Corn bu.	1908 Cowpeas bu.	1909 Oats bu.	1910 Clover (?) crops
Land not Tile-drained					
Limestone and phosphorus	.50	45.4	9.0	35.7	1.50 bu.
None	.20	34.2	5.3	29.9	.00 bu.
Manure	.39	42.1	7.4	34.2	1.06 ton.
Manure, limestone, phosphorus	.48	52.4	9.4	40.9	3.50 tons.
Land Tile-drained					
Limestone and phosphorus	.12	39.0	7.7	33.0	.89 bu.
None	.10	32.1	4.7	25.8	.00 bu.
Manure	.25	35.3	5.4	30.8	.76 ton.
Manure, limestone, phosphorus	.44	49.5	11.5	37.3	3.62 tons.
Average of both Tiled and Untiled Land					
Limestone and phosphorus	.31	42.2	8.4	34.4	1.20 bu.
None	.15	33.2	5.0	27.9	.00 bu.
Manure	.32	38.7	6.4	32.5	.91 ton.
Manure, limestone, phosphorus	.46	51.0	10.5	39.1	3.56 tons.
Average gain for limestone and phosphorus	.15	10.6	3.8	6.5	1.20 bu. 2.65 tons.
Value of increase	$ .90	$3.71	$3.80	$1.95	$ 7.20 $15.90

Note.—Where no manure is applied the first cutting of clover is left on the land, the second cutting saved for seed, and the threshed clover straw returned to the land. The photographs show the 1910 fields in both the grain system and the live-stock system (first crop).

The 4-inch tile were laid in the fall and winter of 1905-1906. They were placed only four rods apart, half of the strings about 20 to 24 inches deep and the other half about 36 to 40 inches deep, and they were covered with about 4 inches of cinders before the ditches were filled. They have a satisfactory grade and a good outlet is provided. The tiled land is somewhat more nearly level than the untiled land, altho the entire field is what would be called level prairie land.

While it is very possible that, with the continued use of clover (the "best subsoiler") in the rotation, the tile drainage may ultimately prove to be a profitable investment, it is plain to see that the first requisites for the improvement of this soil are limestone, phosphorus, and organic matter.

As an average of both systems of farming on both tiled and untiled land, the increases produced by limestone and phosphorus during the first rotation have paid $10.36* an acre, or more than they cost delivered at the average railroad station in southern Illinois; and the increase in the two

*Possibly this should be increased or decreased slightly because, as hereinafter reported, on one-half of the land under experiment potassium salts are applied; and, while they produce practically no effect on the manured land, the effect is very appreciable on the unmanured land; and altho the potassium salts are applied to one-half of the check plots the same as to one-half of the land receiving limestone and phosphorus, so that the $10.36 is the actual increase produced by the limestone and phosphorus above the return from land otherwise treated the same, nevertheless there is a possibility that on part of the land represented in this summary the effect of the potassium salts was different where used with limestone and phosphorus than where used alone. No potassium salts had been applied to the land where the photographs were taken or to the land from which the reported 1910 yields of clover hay or seed were secured.

cuttings of clover hay in the first year of the second rotation has a value of $15.90, or more than enough to pay for the second application of both limestone and phosphate, thus leaving as net profit any increases that may be produced during the next three years; and these increases will be augmented because of the larger amount of organic manures to be returned to the better yielding land. In the grain system the limestone and phosphate produced 1.20 bushels of clover seed, valued at $7.20.

Wheat was seeded on this land in the fall of 1908, but it was winter-killed so completely that oats were seeded in the spring as a substitute. In 1908, wheat on another series of plots produced 4.1 bushels on untreated land, 13.7 bushels where limestone and phosphate had been used, 6.0 bushels where manure had been applied for corn two years before, and 18.6 bushels per acre where manure, limestone, and rock phosphate had been applied, thus showing an average increase from limestone and phosphorus of 11.1 bushels. In 1910, on still other series of plots the average increase from limestone and phosphorus was 17 1 bushels of wheat, 19 bushels of corn, and 7.7 bushels of soybeans.

ADVANTAGE OF CROP ROTATION AND PERMANENT SYSTEMS

It should be noted that the clover is not likely to be well infected with the clover bacteria during the first rotation; but even a partial stand of clover the first time will probably provide a thousand times as many bacteria for the next clover crop as one could afford to apply in artificial inoculation, for a single root tubercle may contain a million bacteria developed from one during the season's growth.

This is only one of several advantages of the second rotation over the first four years. Thus the mere practice of crop rotation is an advantage, especially in helping to rid the land of insects and foul grass and weeds. The deep-rooting clover crop is an advantage to subsequent crops because of that characteristic. The larger applications of organic manures are a great advantage; and in systems of permanent soil improvement, such as are here advised and illustrated, more limestone and more phosphorus are provided than are needed for the meager or moderate crops produced during the first rotation, and consequently the crops in the second rotation have the advantage of such accumulated residues (well incorporated with the plowed soil) in addition to the regular applications made during the second rotation. Thus, with the crop yields shown in Table 7, it is safe to say that one-fourth of the limestone and more than four-fifths of the phosphorus applied remain in the soil at the end of the first four years.

This means that these systems tend positively toward the making of rich land from poor land—toward the making of $200 land out of $50 land. The ultimate analyses recorded in Tables 3, 4 and 5 give the absolute invoice of these southern Illinois soils. They show that they are positively deficient only in limestone, phosphorus, and nitrogenous organic matter; and the accumulated information from careful and long-continued investigations in different parts of the United States positively establish the fact that in general farming these essentials can be supplied with greatest economy and profit by the use of ground natural limestone, very finely ground natural rock phosphate, and legume crops to be plowed under directly or in farm manure. No other applications are absolutely necessary, but, as already explained, and as shown in Table 6, the addition of some soluble salt in the beginning of a system of improvement on these soils produces some temporary benefit, and if some inexpensive salt such as kainit is used it may produce sufficient increase to more than pay the added cost.

THE POTASSIUM PROBLEM

As reported in Illinois Bulletin 123, where wheat has been grown every year for more than half a century at Rothamsted, England, exactly the same increase was produced (5.6 bushels per acre), as an average of the first 24 years, whether potassium, magnesium, or sodium was applied, the rate being 200 pounds of potassium sulfate and molecular equivalents of magnesium sulfate and sodium sulfate. As an average of 58 years (1852 to 1909) the yield of wheat has been 12.8 bushels on untreated land, 23.3 bushels where 86 pounds of nitrogen and 29 pounds of phosphorus per acre per annum were applied; and, as further additions, 85 pounds of potassium raised the yield to 31.4 bushels; 52 pounds of magnesium raised it to 29.4 bushels; and 50 pounds of sodium raised it to 29.6 bushels. Where potassium was applied the average wheat crop removed 40 pounds of that element in the grain and straw, or three times as much as would be removed in the grain only for such crops as are suggested in Table 1. The Rothamsted soil contained abundance of limestone, but no organic matter was provided except the little in the stubble and roots of the wheat plants.

On another field at Rothamsted the average yield of barley for 58 years (1852 to 1909) has been 14.5 bushels on untreated land, 38.8 bushels where 43 pounds of nitrogen and 29 pounds of phosphorus have been applied per acre per annum; while the further addition of 85 pounds of potassium, 19 pounds of magnesium, and 14 pounds of sodium (all in sulfates) raised the average yield to 41.7 bushels, but, where only 70 pounds of sodium were applied in addition to the nitrogen and phosphorus, the average has been 43.4 bushels. Thus, as an average of 58 years, the use of sodium produced 1.8 bushels less wheat and 1.7 bushels more barley than the use of potassium, with both grain and straw removed and no organic manures returned.

While about half of the potassium, nitrogen, and organic matter, and about one-fourth of the phosphorus, contained in manure, will be lost by three or four months' exposure in the ordinary pile in the barn yard, there is practically no loss if plenty of absorbent bedding is used on cement floors, and if the manure is hauled to the field and spread within a day or two after it is produced. Again, while the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus in average live-stock farming, they retain less than one-tenth of the potassium, from the food consumed; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is wholly negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The removal of one inch of soil per century by surface washing (which is likely to occur wherever there is satisfactory surface drainage) would permanently maintain the potassium in grain farming by renewal from the subsoil, provided one-third of the potassium is removed by cropping before the soil is carried away. Thus, aside from the peat soil, there is no soil in Clay County which contains less than 3,600 pounds of potassium per acre-inch. One-third of this is 1200 pounds, while 100 years of grain farming would carry away from the farm only 1275 pounds of potassium in the grain and seed of such crops as are mentioned in Table 1.

From all of these facts it will be seen that the potassium problem is not one of supply but of liberation; and the Rothamsted records show that other soluble salts have practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted with no return of organic residues, probably the soluble salt functions in both ways.

As an average of 84 separate tests conducted in 1907, 1908, and 1909, on the Fairfield Experiment Field, an application of 200 pounds of potassium sulfate, containing 85 pounds of potassium costing $5.10, increased the yield of corn by 7.9 bushels per acre; while 600 pounds of kainit, containing only 60 pounds of potassium and costing $4.00, gave an increase of 10.6 bushels. Thus, at 40 cents a bushel for corn, the kainit has paid for itself; but these results, like those at Rothamsted and DuBois, were secured where no adequate provision had been made for decaying organic matter.

Additional experiments at Fairfield include an equally complete test with potassium sulfate and kainit on land to which 8 tons per acre of farm manure had been applied. As an average of 84 tests with each material, the 200 pounds of potassium sulfate increased the yield of corn by .8 bushel while the 600 pounds of kainit gave an increase of 1.1 bushels. Thus, where organic manure was supplied, practically no effect was produced by the addition of either potassium sulfate or kainit; in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for; and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate as determined by chemical analysis; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

If we remember that, as an average, live stock destroy two-thirds of the organic matter of the food consumed, it is easy to determine from Table 1 that more organic matter will be supplied in a proper grain system than in a strictly live-stock system; and the evidence thus far secured from older experiments at the University and at other places in the state indicates that if the corn stalks, straw, clover, etc. are incorporated with the soil as soon as practicable after they are produced (which can usually be done in the late fall or early spring), there is little or no difficulty in securing sufficient decomposition in our humid climate to avoid serious interference with the capillary movement of the soil moisture, a common danger from plowing under too much coarse manure of any kind in the late spring of a dry year.

If, however, the entire produce of the land is sold from the farm, as in hay farming, or when both grain and straw are sold, of course the draft on potassium will then be so great that in time it must be renewed by some sort of application. As a rule, such farmers ought to secure manure from town, since they furnish the bulk of the material out of which the manure is produced.

INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIES

Gray Silt Loam on Tight Clay (330)

This is the predominating type of soil in the lower Illinoisan glaciation and greatly exceeds any other type in Clay County, the area being 100,720 acres, or 37 percent of the area of the county. Its topography is nearly level or gently undulating, tho in places somewhat rolling.

The type variations* are due primarily to three things: (1) the organic matter content; (2) the topography and consequent surface drainage; and (3) the depth, thickness, and density of the tight clay layer. Adjoining the somewhat rolling areas or in the vicinity of ridges, this type has received some wash that has buried the tight clay to such depths that it is less objectionable, and generally made it a better soil than the average. This is particularly noticeable in parts of Townships 3 and 4, Range 5.

In some of the low areas that grade toward drab silt loam (329), or brown silt loam on clay (326.1) the organic matter content is higher in the subsurface and subsoil, giving a better phase of the type. This fact is noticeable in certain areas in Townships 4 and 5, Range 7, and to a less extent in small areas in Township 3, Range 6.

The surface stratum, 0 to 6⅔ inches, consists of a friable, silt loam, varying from light to dark gray in color and containing sufficient clay to make it slightly plastic when wet. A few small gravels of quartz and concretions of hydrated iron oxid are sometimes found in it. The organic matter content varies somewhat from an average of 2.4 percent as determined from the total organic carbon. The surface soil is fairly pervious to water but the low organic matter content and lack of granulation render it in poor tilth, causing it to "run together" very readily from heavy rains or by freezing and thawing when wet.

The subsurface soil, averaging about 13 inches in thickness, varies from a gray silt loam to a very light gray or even white silt. The upper part of this stratum is sometimes about the same in color as the surface soil, but much oftener the plowline marks the beginning of a much lighter colored soil, which becomes still lighter with depth, passing into a distinct "gray layer," varying in thickness from 2 to 10 inches. This "gray layer" is deficient in organic matter, close-grained, very compact when dry, and quite slowly pervious to water. When saturated, it is soft, and posts may be driven very readily thru it. A few small quartz gravels and some concretions of hydrated iron oxid may be present in this stratum.

The subsoil averages about 20 inches from the surface but varies from only a few inches on the "scalds" to 2 feet or more on the best phase of the type. It is usually made up of two distinct layers, the upper tight clay, or so-called "hardpan," and a lower, friable, porous, silty layer. The former

*This type also contains many small unproductive areas known as "scalds" or "scald spots" readily recognized in a plowed field by their light color. Occasionally one of these spots may cover several acres but ordinarily these areas are only a few square rods. On these spots the ordinary surface soil, and, in many cases, the subsurface soil, is almost absent, thus bringing the subsoil to or very near the surface which constitutes the "scald". These spots are very irregular in their occurrence, some fields being entirely free from them, while in others there may be several or many. Bracted plantain (sometimes less properly called buckhorn) of stunted growth is a common plant upon these "scalds".

varies from 2 or 3 to more than 12 inches in thickness and is usually a tight, silty clay, reddish or yellowish in color, very sticky and gummy when wet and very hard when dry.

As a rule, the drainage of this type is rather poor, due to one or both of two causes, (1) the lay of the land, and (2) the tight clay subsoil. It is still a question whether it can be tile-drained profitably; but experiments now in progress will ultimately answer the question. Usually the surplus water can be disposed of fairly well by giving proper attention to surface drainage, by means of ditches and furrows.

For the economical and permanent improvement of this soil, adopt a good rotation of crops, including about one-third legume crops, plow under everything except the grain and seed (in grain farming) or make and use as much manure as possible (in live-stock farming), and apply about 1000 pounds of limestone and 200 pounds of raw phosphate, per acre, for each year in the rotation, as explained above. (Heavier initial application should be made if possible.)

Brown-Gray Silt Loam on Tight Clay (328)

This type occupies only small areas, totaling 960 acres in this county, but forms the prevailing type in the transitional area between the middle and lower Illinoisan glaciation. However, small isolated areas are found in the heart of the lower Illinoisan glaciation. With few exceptions the topography is flat or only slightly undulating.

This type contains "scalds," where the subsoil comes to the surface or injuriously near it. These are very irregular in their occurrence, some fields being devoid of them, while in others they are numerous.

The surface soil, 0 to 6⅔ inches, is a dark gray to brown silt loam, varying in color with its gradation toward other types. It contains about 2.8 percent of organic matter and has a small amount of clay and some fine sand, but medium and coarse silt predominates. It is porous, friable and easy to work.

The subsurface stratum varies much as to thickness and color. The average thickness is 10 to 12 inches altho it may be entirely absent in some places and in others 18 inches or more in thickness. It consists of a grayish brown silt loam, the color becoming lighter with depth. There is usually a distinct gray or grayish brown layer just above the subsoil, which varies in thickness from 2 to 10 inches. Where the type grades into the gray silt loam on tight clay (330) this layer may become quite well developed and partake somewhat of the impervious character of the corresponding layer in that type.

The subsoil is found at variable depths from only a very few inches on the "scalds" to 2 feet or more on the better phase of this type. It consists of two distinct layers, the upper, a plastic, gummy, yellow, drab, or dark olive-colored clay, very tight and nearly impervious to water. This stratum is from 3 to 18 inches thick and below it is a clayey silt, friable and pervious, of a yellow color or yellow with drab mottlings.

The upper layer of the subsoil is too impervious to allow good underdrainage, so that special surface drainage is commonly provided. The discussion of tile drainage for the gray silt loam on tight clay (330) applies as well to this type.

In general the same system of improvement should be adopted as for the gray silt loam on tight clay, altho the brown-gray silt loam contains somewhat more nitrogen and phosphorus in the surface soil and less acidity in the subsoil. However, the difference in the plowed soil of an acre amounts to only about 20 loads of manure and 1 ton of phosphate, and the nitrogen is in the less active form of old humus.

Drab Silt Loam (329)

Some of the low and more poorly surface-drained areas of the prairie land have received deposits of finer material washed in from the slightly higher surrounding land, and a greater accumulation of organic matter has taken place, more particularly in the subsurface and subsoil, owing to the more luxuriant growth of vegetation and the better conditions for preventing complete decay. This has given rise to a type of soil, the drab silt loam (329) which is darker in color, better in texture, and somewhat more productive than the surrounding gray silt loam on tight clay (330), the ordinary prairie of this glaciation. The drab silt loam (329) needs under-drainage to bring it to its best condition of tilth and productiveness; and the physical composition, texture, and structure indicate that tile drainage will greatly benefit this soil, but actual field experiments are necessary to determine how satisfactorily tile will work. With the limited appropriation hitherto provided for the investigation of Illinois soils, it has not been possible for the University to establish an experiment field upon this soil type which is of very considerable importance, not only because of the 14,400 acres of this type in Clay County, but also because of its presence in most other counties in the lower Illinoisan glaciation.

The surface stratum of the drab silt loam (329) is a dark drab to brown silt loam, the former color predominating. The physical composition and texture of this soil indicate that it will work up well when thoroly drained.

The subsurface varies from a dark gray to a drab silt loam, frequently with blotches of yellow iron oxid. The amount of clay varies considerably, the stratum being very silty in some areas while in others it has sufficient clay to make it plastic, but in either case is pervious to water.

The subsoil varies in color from drab to yellowish gray with sometimes irregular blotches of all mixed together, while in physical composition it varies from a friable silt to a clay. The subsoil is rather heavy yet it is sufficiently pervious so that tile drains will very probably work well, and there are very few areas of this type that would not be greatly benefited by efficient under-drainage.

The variations of this type are due to gradations toward other types. Where it is grading toward the gray silt loam on tight clay (330) or the light gray silt loam on tight clay (332), the soil becomes lighter in color and the subsurface more silty, while the subsoil becomes lighter and less pervious to water. If the type is grading toward brown silt loam it becomes darker and slightly heavier. When drained and properly treated it promises to become one of the best types in southern Illinois, because of the absence of the gray layer and tight clay stratum in the subsurface and subsoil.

From the standpoint of fertility and methods of improvement the drab silt loam does not differ essentially from the more common gray silt loam prairie land; but with equal provisions for drainage and plant food the drab silt loam will be a more productive soil, especially in very wet or very dry seasons, because of its more pervious character and consequent greater power to handle moisture, not only by permitting the downward flow when saturated and the upward capillary rise from the lower subsoil in time of drouth, but also because of its greater capacity for absorbing and retaining moisture; and of course it also furnishes a greater feeding range for plant roots than the less porous types.

Brown Silt Loam on Clay (326.1)

The areas of this type occur in about the same location as those of the drab silt loam (329), but have received more wash from adjoining higher land. It contains more organic matter in the subsurface and subsoil than any other upland type in the county. It is a good soil physically but, like the drab silt loam, needs under-drainage. The total area in the county is only 824 acres.

The surface soil is a dark brown to black silt (or clayey silt) loam, rather plastic when wet, but somewhat granular under proper conditions for granulation.

The subsurface stratum differs from the surface in having a slightly lighter color and containing more clay, there being sufficient to render it quite plastic.

The subsoil is a brownish or dark drab silty clay somewhat impervious but probably susceptible of satisfactory drainage. While tile will probably not draw as far in this type or in the drab silt loam (329) as in some corn belt types, yet by putting the lines of tile from four to eight rods apart this land could all be well drained, so far as can be judged from physical characteristics.

The nitrogen content of the subsurface and subsoil is naturally higher because it is one of the constituents of the organic matter, but such organic nitrogen, particularly in those strata, becomes available too slowly to be a factor of great significance; and, like the other types already described, the essential requirements for the improvement of this soil are limestone, phosphorus, and nitrogenous organic matter.

Deep Gray Silt Loam (331)

This type occurs in low, poorly drained areas that have received a considerable amount of material washed from the surrounding higher lands, but the material deposited contains less clay than that received by the previously described types of similar topography.

The surface soil is a gray to dark gray silt loam, under which to a depth of 40 inches is a gray silt loam or gray silt that differs from the surface chiefly in having a lighter color. Locally a stratum of clayey silt may be developed at about 36 inches in depth. This soil will certainly underdrain, and when drained will become very productive with proper treatment.

As will be seen from Tables 3, 4, and 5, this type averages about as high in acidity and rather lower in plant food than any of the other prairie types. The greater porosity and deeper feeding range for plants are distinct advantages; but the same systems of improvement should be followed.

(b) TIMBER UPLANDS

Light Gray Silt Loam on Tight Clay (332)

This type occurs in old timbered regions where the land is so nearly level that there is no chance for rapid surface drainage. The type was originally the same as the gray silt loam on tight clay (330) but has a lower organic matter content because of the long-continued growth of timber. The upland soils that were timbered for centuries have less organic matter and are consequently much lighter in color than the adjoining prairie because of the fact that forest trees add very little organic matter to the soil whereas the process of decomposition is going on more or less rapidly in all soils. The leaves and twigs of the trees fall upon the surface of the ground and decay completely; whereas the prairie grasses form a mass of roots in the soil which, when they die, are prevented from complete decay by the absence of sufficient oxygen. In this way prairie grasses and other plants cause a gradual accumulation of organic matter. If prairie land becomes forested the organic matter is slowly diminished to a low point. The average amount of organic matter in the upland timber soils of the state is 2 percent while the prairie soils have 5.3 percent, the corn belt soils being included in both cases. Some of the level timber soils are so depleted in this constituent that they do not have over 1 percent in the surface stratum.

This type has two distinct phases, one a slightly better surface-drained but lighter colored, and less productive, and the other the more swampy areas (where water oaks commonly grew), a darker surface and more porous soil, so that better drainage is probably possible. The amount of this latter phase is small as compared with the former and is frequently confined to narrow strips too small to map.

"Scalds" are found upon this type but are not so common as upon the gray silt loam on tight clay (330) or brown gray silt loam on tight clay (328).

The surface soil of the most common level timber land (332) of this glaciation is a light gray to almost white silt loam containing about 1½ percent of organic matter. It is somewhat porous and incoherent but contains sufficient clay to bake when puddled and dried. When the moisture content is at its optimum it works very well, but because of the low organic matter content it is "run together" badly by rains or by freezing and thawing when wet. This layer as well as the subsurface and subsoil contains large numbers of iron oxid concretions of various sizes up to one-fourth inch in diameter. Small pebbles of quartz are sometimes found, possibly having been brought to the surface from the underlying glacial till by burrowing animals during past centuries.

The subsurface varies from a light gray silt loam to a white silt, compact but friable, from 2 to 20 inches in thickness. Water passes thru it slowly.

The subsoil consists of a compact yellowish gray clayey silt or silty clay, only slowly pervious to water, but usually not quite so tight as the corresponding layer of the gray silt loam on tight clay (330). In places the type has a somewhat more friable subsoil and is not so impervious as the above, and where the tight clay occurs at the greater depths from the surface it is less objectionable.

The invoice of plant food shows great need of nitrogen and phosphorus, and, with these and a liberal use of limestone and organic matter, the soil can be made highly productive with proper surface drainage.

White Silt Loam on Tight Clay (332.1)

This type is found on the level upland and is or has been covered by a growth of stunted trees principally the so-called post oak. The term post-oak flat or post-oak soil is commonly applied to this type altho these terms are often applied locally to the poorer phase of light gray silt loam on tight clay (332). The surface drainage is very poor and the subsoil is almost impervious. The total mapped area in the county, is only 224 acres, but there are many small areas of this type that cannot be shown on the map, and much of the light-gray silt loam on tight clay (332) grades toward this related type (332.1).

Where the type has been cultivated, the surface soil is a white silt, while in the timbered areas there may be an inch or two of dark gray silt loam underlain by the characteristic white silt. The organic matter content is even lower than in the preceding type. Because of this and the high silt content, the soil "runs together" badly. Iron oxid concretions are always present.

The subsurface layer is a white silt with many iron oxid concretions. The thickness varies from 4 to 16 inches, passing abruptly into the subsoil which is a light yellow, iron-stained silty clay, very tough and plastic when wet and hard when dry. Both subsurface and subsoil are almost impervious and when these layers are dry water moves down into them with extreme slowness.

In nitrogen and phosphorus this is one of the poorest soils found in the state, the total in the surface soil 6⅔ inches deep being about equal to the needs of three rotations in nitrogen and of five rotations in phosphorus, with such crops as are suggested in Table 1; and with no provision to make plant food available the crops produced on this type are often not worth raising. With liberal use of limestone, phosphorus, and organic matter this soil can be markedly and profitably improved where the surface drainage is adequate; but, like all soils with tight clay subsoils, it will not be a good soil for very wet or very dry seasons.

Yellow-Gray Silt Loam (334)

This type lies between the yellow silt loam (335), on the one hand, and the gray silt loam on tight clay (330) or light gray silt loam on tight clay (332), on the other, and it is somewhat intermediate in character. For general agricultural purposes it is one of the best types of soil in the county, provided it exists in large areas; whereas small areas are sometimes almost valueless because of scald spots.

The common topography is undulating but varies from nearly level to almost broken land. The slopes are rather long and gentle, but in places very short abrupt slopes of yellow silt loam occur which are too small in area to show separately on the map. The surface drainage is generally good, in fact so good that there is considerable washing going on where the methods of culture are not the best for preventing it. While this type was generally timbered, it sometimes extends out into the prairie along natural drainage channels and as these particular areas represent recent erosion of the prairie, it shows "scalds" or tight clay outcrops, the presence of which renders these narrow areas very inferior to the type generally, and in some places almost worthless. These numerous "scald" areas are rarely over two or three acres in extent and more frequently only a fraction of an acre, often occurring as narrow strips along the stream or draw.

The total area of yellow-gray silt loam is 21,240 acres, or 7.09 percent of the total area of the county.

Since the type is a transitional form between other types, the surface soil varies a great deal. The predominating phase is a yellowish or grayish yellow silt loam, but the type varies from that to a gray silt loam as it grades toward the gray and the light gray silt loam on tight clay (330 or 332), or to yellow silt loam as it passes into the eroded type (335).

In physical composition, it contains some fine sand and locally, in small areas, quite appreciable amounts, but the prominent constituent is silt of various grades. The soil is deficient in organic matter, there being only 1½ to 2 percent present. The surface soil is porous and friable but "runs together" badly because of its shortage in organic matter.

The subsurface, like the surface, varies from a yellowish gray to yellow silt loam sufficiently porous to permit percolation, and the physical composition is such as to allow ready capillary movement. The thickness of the subsurface stratum varies from a few inches to about 16 inches.

The subsoil is a yellow or mottled grayish silt or clayey silt, somewhat compact but pervious. The depth to the subsoil is quite variable owing to the amount of washing that has taken place. In places the surface and subsurface have been entirely removed, but this is unusual, and the depth to the subsoil varies commonly from 10 to 20 inches.

With good farming and a liberal use of limestone, phosphorus, and legumes, this soil can be profitably improved until it will produce larger crops than the present average of the $200 corn belt land, which, of course, will just as certainly lose its high productive power if the common agricultural practice of the corn belt is continued, with no adequate return to the soil for the large amounts of plant food removed in crops.

Yellow Silt Loam (335)

This type includes the broken, very rolling, and hilly land along the streams and sometimes on the steep slopes of ridges. It is of such a steeply sloping character that much of it should never have been put under cultivation. When properly treated it makes excellent pasture land, and much of it should be kept forested. When cultivated the utmost care should be taken to prevent washing as this is the most serious danger to this type of soil. Already many fields have been ruined by gullying. In Clay County it covers an area of 41,760 acres, or 14 percent of the total.

The surface soil is a friable yellow silt loam varying somewhat with topography, the less broken being grayish yellow while the steep slopes are reddish yellow, or brownish yellow where a little more organic matter remains. As a rule, the soil has enough fine sand for fairly good texture, but it is very deficient in organic matter and this condition contributes toward its excessive washing. "Clay points", or places where the top soil has been removed by washing, are quite common and they are very unproductive.

The subsurface varies but is from 6 to 14 inches thick where little or no washing has taken place. It consists usually of a friable yellow slightly loamy silt mottled with gray or with reddish blotches of iron oxid.

The subsoil is usually a somewhat friable and quite pervious yellow clayey silt. Where much washing has occurred the glacial drift frequently forms the subsoil.

Where soil improvement is attempted, large use should be made of limestone and legumes. Limestone may be applied as a top-dressing even on permanent pastures, and some clover can usually be introduced into the pasture herbage by mixing the clover seed with much limestone and some dry soil containing clover bacteria, and sowing with a sharp disk drill with fertilizer attachment, thus placing the inoculated clover seed in the soil itself and in contact with the limestone. As a rule it is not advisable to apply phosphorus to this soil except where ample provision is made for increasing the organic matter and nitrogen and for preventing loss by erosion; and the phosphorus should not be used as a top-dressing, but thoroly mixed with the plowed soil before seeding down to grass and clover.

(c) RIDGE SOILS

Yellow Silt Loam (235)

The morainal and preglacial ridges of the lower Illinoisan glaciation have given a slight variation to the usual level topography of this region. These have been covered with from 8 to 15 feet of loess and this, together with the excellent drainage, has resulted in the formation of a soil very different from the surrounding prairie but somewhat resembling in texture the better phase of the yellow silt loam timber land (335), already described. The total area of the type is 2560 acres. The ridges upon which this type occurs vary from 20 feet to 100 feet or more in height.

The surface soil is a yellow or yellowish-brown silt loam with considerable very fine sand. The color varies with the amount of erosion that has gone on. Where little washing has occurred the color may be a yellowish brown, while with more washing it will become yellow. The soil is loose, porous, readily pervious to water and its physical composition is such as to give it great water-retaining power and strong capillarity so that it will resist drouth well. The organic matter content is about 3½ percent.

The subsurface layer, 6⅔ to 20 inches, varies from a yellowish brown silt loam to a yellow silt or slightly clayey silt. It becomes more compact with depth but still retains its perviousness and capillary power.

The upper part of the subsoil is somewhat compact and slightly clayey but passes into a friable silt containing some fine sand. It is yellow or reddish-yellow in color. Below 24 inches it may be slightly gray or marked with gray blotches, and when grading toward yellow-gray silt loam (334) may become decidedly gray. This soil, considered from a physical standpoint, is about as good as could be desired. Its organic matter content should be maintained and even increased in order to prevent destructive washing. It is a well-aerated, well-drained soil and will withstand drouth well, and in those respects it is decidedly the best upland type in the county.

It also contains a fair amount of plant food, exceeding in its nitrogen content all other upland types and even the extensive bottom lands. Nevertheless it is plain to see that nitrogen and phosphorus are the limiting elements in this as well as in most other soils of the county; and with the well developed acidity of the subsurface and subsoil, the essential requirements for its improvement are the same; namely, a liberal use of limestone, phosphorus, and legume crops in a good rotation, the legumes and at least the coarse product of the other crops being returned to the soil either directly or in manure. By these means this soil can readily be made to produce crop yields equal to those of the best soils in the state. It is especially well adapted for alfalfa when well treated with limestone and manured and inoculated to give the alfalfa a good start.

Gray-red Silt Loam on Tight Clay (233)

This type of soil occurs on the low ridges, which are in part at least of preglacial origin, varying from 5 to 75 feet above the surrounding upland. As a rule, it is one of the poorest upland types in the state, but the areas in this county are usually a better phase of the type. It comprises 9180 acres, or 3 percent of the area of the county. The surface drainage is usually good, and in some places the type may suffer from erosion; but it is extremely doubtful whether tile-drainage will profitably benefit this soil, at best not until other methods of improvement have been put into practice.

The surface soil is a friable gray silt loam very similar to that of the gray silt loam on tight clay (330), and the subsurface layer resembles the corresponding one in the above type both in texture and thickness but contains more of the higher oxid of iron, giving it a reddish color.

The subsoil varies in depth from 7 to 20 inches from the surface and consists of a layer of plastic, gummy, impervious red clay varying from 4 to 12 inches thick and underlain by a less plastic and more silty stratum. When dry the red clay becomes so hard that it is next to impossible to bore into it with an auger. Where this layer becomes the surface soil, which it does on some small eroded areas, the soil is practically worthless.

In plant food content this soil is almost a perfect duplicate of the gray silt loam on tight clay, not only in the surface, but likewise in the subsurface and subsoil; but with its tighter texture and more rolling topography, more erosion and less leaching have occurred, and consequently it has retained more acidity and somewhat more of the abundant mineral elements. Methods for improvement are, of course, the same as for the more extensive gray silt loam on tight clay.

(d) BOTTOM LANDS

Deep Gray Silt Loam (1331)

This type occurs along most of the streams of the lower Illinoisan glaciation. The material from which it is formed comes from the gray, yellow-gray, and yellow silt loams of the upland, and has a gray or yellowish gray color. It overflows during floods and in most places still receives frequent or occasional deposits of new material. If we disregard the difficulties from overflow and of drainage, this is the most valuable important soil type in the county.

There is in the county a total area of 31,680 acres of this type. It lies so low that the drainage is generally poor and there is often much difficulty in getting sufficient outlet for under-drainage or sometimes even for adequate surface drainage. Where a satisfactory outlet can be secured tile drainage greatly benefits this soil.

The surface soil is a gray silt loam varying from a light drab to drab in color and from a loam to a clayey silt loam in physical composition. The subsurface and subsoil are about the same as the surface except lighter in color and commonly a little more clayey with depth. In the smaller stream bottoms the recent deposits are frequently yellow and consequently there may be a stratum of yellow on the gray varying from a few inches to a foot or more in thickness.

In phosphorus content this soil slightly exceeds the most common prairie soil of the corn belt, and the porous subsoil affords such a deep feeding range that the application of that element is not likely to give profitable returns, except where overflow is not common and where the soil has been long cropped.

The soil is moderately acid and rather poor in nitrogen, altho this percentage deficiency is counterbalanced to a large extent by its great depth and porosity.

While the overflow and drainage problems are of first importance, where these are under sufficient control to permit of soil improvement the use of limestone and the addition of nitrogenous organic matter, as by plowing under clover or manure, will make this soil still more productive; and, if protected so as to prevent the usual overflow deposits, the addition of phosphorus will ultimately be necessary, and is likely to be very profitable for the highest improvement of the soil. To illustrate it may be pointed out that on the University farm at Urbana, land which has yielded 65 bushels of corn per acre as a six-year average, in a rotation of corn, oats, and clover, where limestone and organic manures have been provided, has with the addition of phosphorus made an average of 87 bushels during the same years. Thus there may be room for phosphorus "at the top", even where very satisfactory yields may be secured without its application and where other factors are of first importance.

Mixed Sandy Loam (1361)

This type occurs chiefly in the bottom lands of the smaller streams and principally in the northwest part of the county, where its greater prevalence is probably due to the presence in that section of a deposit of sandstone which frequently outcrops along the streams. The breaking down of this sandstone, together with the small amount washed in from the upland, furnishes sufficient sand to form the type. Practically all of it is subject to overflow. It varies greatly in physical composition which in places is changed more or less with each flood.

The surface soil is a brown, yellowish brown, or yellowish gray sandy loam. It is very pervious to water but usually has enough of the finer soil constituents to make it sufficiently retentive of moisture to grow good crops. All grades of sand are present but the coarse and medium predominate. In small areas it varies in physical composition from loam to sand. The organic matter content also varies, but averages about 2½ percent.

The subsurface is a sandy loam, lighter in color than the surface, often becoming more sandy with depth and usually passing into a coarse yellow or yellowish gray sand subsoil.

The content of sand and the depth to the sand subsoil varies with the topography, the higher places being more sandy, while the low areas are more silty and more variable in the subsoil. The soil is very productive except on very sandy spots, which are sometimes present but not large enough to map.

Because of their open character sand soils are aerated to much greater depths than soils in which silt or clay predominate and because of this a much larger amount of plant food is made available even though the sand soil may be no richer in the important elements. Thus with the same content of nitrogen and phosphorus as the gray silt loam prairie, the sand soil will produce twice as large crops, because the aeration and feeding range is at least twice as great. The acidity of the sand soil is slight. Where it is subject to frequent overflow it is doubtful if any applications will prove profitable, but where overflow is not common both limestome and manure may well be used in preparing the soil for alfalfa for which it is well adapted if the drainage is good.

Drab Clay (1315)

The total area of this type in the county comprises 25 acres situated in the bottom land near the Little Wabash River in an area adjoining the deep peat (1301). It is a common type in old bayous along the Mississippi, Kaskaskia, and Wabash Rivers, occurring in the low, poorly drained areas, chiefly former stream channels, now partly filled with the finest sediment. The surface soil is a dark drab, granular, plastic clay. The subsurface and subsoil are lighter in color than the surface but also consists of plastic clay. The type is difficult to work, especially if not well drained, the common condition.

It is a neutral soil and fairly well supplied with plant food. The one area found in the county is only a few inches above the usual level of the ground water. It has never been cropped and probably never will be unless it is included in some future extensive drainage district in which the general level of the Little Wabash River should be lowered so as to provide an outlet for such low-lying bottom lands.

Deep Peat (1301)

This type is found in a single small area of only 15 acres where springs abound (Section 3, Township 3, Range 8), and the type represents the accumulation of vegetation formed by the growth of grasses, sedges, mosses and other plants. The surface of the peat is only a few inches above the water level, and as an outlet for adequate drainage could be provided only at great expense (or in connection with an extensive drainage system), the utilization of this area for anything but pasture is quite impracticable at present. The samples show considerable carbonate present, principally as fragments of shells.

This soil contains about 50 percent of organic matter and more than 20 percent of limestone. If it could be obtained in dry condition so as to reduce the expense of hauling, it could be used with some profit as a fertilizer on the acid upland soils in the neighborhood, which, as a rule, are also markedly deficient in nitrogen and organic matter. The addition of a small application of manure or some clover turned under would hasten the decomposition of the peaty material and thus greatly increase its value when used as a fertilizer. (It should be noted that the specific gravity of peat soil is only about one-half that of normal soil; and consequently an acre of peat soil 6⅔ inches deep weighs, in the dry condition, 1 million pounds, while ordinary soils weigh 2 million pounds for the same stratum.)

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