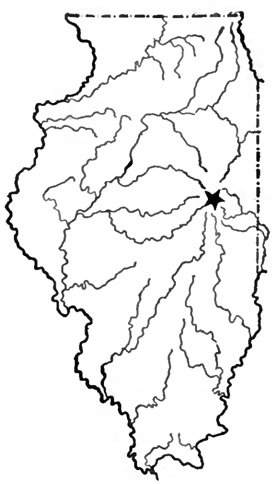
UNIVERSITY OF ILLINOIS

# Agricultural Experiment Station.

BULLETIN NO. 93.

# SOIL TREATMENT FOR PEATY SWAMP LANDS, INCLUDING REFERENCE TO SAND AND "ALKALI" SOILS.

By CYRIL G. HOPKINS.



URBANA, ILLINOIS, JANUARY, 1904.

## Summary of Bulletin No. 93.

1. There are many thousand acres of peaty swamp land in northern Illinois, much of which produces almost no crops because the soil is deficient in the element potassium, although it is rich in all other elements of plant food. Page 275.

2. On the University of Illinois soil experiment field near Tampico (Whiteside County), on peaty swamp soil, the addition of potassium produced yields of 36 to 60 bushels of corn in 1902, and 45 to 66 bushels in 1903, while, with no potassium applied, no ear corn was produced. Page 277.

3. On the University of Illinois soil experiment field near Momence (Kankakee County), on peaty swamp soil, potassium produced 20 to 32 bushels of corn in 1902, and 67 to 73 bushels in 1903, while without potassium the average yield was only 5 bushels. Page 282.

4. Some kinds of peaty swamp soil will improve with the right kind of cultivation, and finally become very productive soils, which will not require the continued use of potassium, while other kinds will probably always require potassium to be applied. Page 292.

5. Some kinds of peaty swamp soils after years of cultivation are found to resemble sand ridge soil, which is most deficient in the element nitrogen, which can be obtained from the air at very slight cost by means of suitable leguminous crops. Page 294.

6. Nitrogen applied to the University of Illinois soil experiment field, near Green Valley (Tazewell County), on sand ridge soil, has increased the yield of corn from about 30 bushels to more than 60 bushels per acre. Page 295.

7. This bulletin tells how and where to purchase potassium, how to use it, and how to save it so that most of it can be used again and again for several crops. Page 297.

8. Certain kinds of farm manure produce fairly good results on some peaty swamp soils, but commonly it is better farm practice to use the manure on other kinds of soil and buy potassium for the peaty swamp soils. Page 298.

9. There is no more profit in starving plants than there is in starving animals. While heavy applications of potassium must sometimes be made at first, with proper management only light applications will be required after a few years. Page 299.

10. Farmers who have tried potassium in 1903 on peaty swamp lands report an increase of more than 30 bushels of corn, this increase being due to potassium. Page 300.

11. The so-called "alkali" soils of Illinois, which are also being investigated, are not the same as peaty swamp soils. Page 301.

12. The Experiment Station cannot undertake to analyze miscellaneous samples of soil for private parties. Methods of soil investigation must be systematic and exact. Page 302.

13. Upon request to the Illinois Experiment Station, Urbana, Ill., this bulletin will be sent to any one interested in Illinois agriculture.

# SOIL TREATMENT FOR PEATY SWAMP LANDS, INCLUDING REFERENCE TO SAND AND "ALKALI" SOILS.

By Cyril G. Hopkins, Chief in Agronomy and Chemistry.

There are immense areas of peaty swamp lands in the northern and north-central part of Illinois. As a rule these soils do not grow good crops. When first broken, they sometimes yield one or two fair crops of corn, but generally the third crop is very poor, and afterward little or no corn is produced. Oats do somewhat better, but usually the yield of grain is very unsatisfactory, even when a fair amount of straw is grown. These soils are usually very black and very rich in organic matter, and they are frequently drained at great expense with the expectation that they will be very productive and almost inexhaustible, but not infrequently they yield disappointment and financial loss.

While it will not be possible to locate and investigate all of the different tracts of peaty soil until we extend the detail soil survey over the entire state, nevertheless we have already obtained considerable information regarding these lands in connection with our general survey of Illinois soils, and this bulletin is published because we know that this information can be used by many Illinois farmers and land-owners with advantage and profit in increasing the productive capacity of such soils.

These peaty swamp soils are present in large areas in Lee County, in southern Whiteside County, in Rock Island County, in the northeastern part of Henry County, and in the northwestern part of Bureau County. In Kankakee and Iroquois Counties, in northern Mason County, and southwestern Tazewell County, large tracts of peaty soil are found; and smaller tracts are found in the counties of Winnebago, Boone, McHenry, Lake, Dekalb, and Kane, and there is more or less of this soil in several other northern counties, such as Kendall, Will, LaSalle Grundy, Livingston, etc. Some peaty soil has been found in northern Ford County, and one small tract in western McLean County. This soil is also known to extend into northern Indiana* and southern Wisconsin,* and it is reported as present in Iowa to considerable extent.

Commonly the peaty soil occupies the lower lying areas, but sometimes it is found in table-lands. It is always on land which was at one time poorly drained.

The peaty soil varies from almost pure brown peat, containing 80

*The experiment stations of Indiana and Wisconsin have published some results of investigations relating to similar soils, and in several cases a deficiency of potassium has been strongly indicated. (See page 290.)

percent or more of combustible material, to black muck, containing much less organic matter. In some places these soils extend continuously over tracts of considerable size (sometimes over several square miles), to the exclusion of other types of soil; but more commonly the peaty soils occupy irregularly shaped areas scattered about in bodies of land of different kinds. Sandy land is frequently found adjoining or surrounding the tracts of peaty soil, and sand is the most common subsoil found under peaty swamp soils, although a clay subsoil is found in many places, and sometimes the peaty soil is underlain, at a depth of only a few feet, with limestone rock. Occasionally the peaty soil adjoins ordinary Illinois prairie land.

Peat itself consists largely of partially decayed sphagnum moss, which grew in the water which once covered these areas. In growing, the moss obtains carbon, from the carbon dioxid in the air, and hydrogen and oxygen, from water, being similar to other plants in this respect. The water in which the sphagnum moss grows is more or less stagnant. It is usually surface-drainage or seepage water, and contains sufficient nitrogen, phosphorus, potassium, and other essential elements of plant food to meet the needs of the growing moss. Both nitrogen and phosphorus enter into fairly stable organic combinations with the carbon, hydrogen, and oxygen, and when the moss changes to peat, and even when the peat partially decays, these two elements, nitrogen and phosphorus (especially the nitrogen), are largely retained in the organic matter. The potassium, however, reverts more largely to the soluble form and it is finally lost to a greater or less extent in the drainage waters flowing from the peat bogs.

A considerable number of the peaty swamp soils from different places in the state have been analyzed by the Experiment Station, and they are found to be very rich in nitrogen, well supplied with phosphorus, but very deficient in potassium, as compared with the ordinary fertile soils of the state. It has long been known that such soils are frequently deficient in mineral elements.

Some preliminary field tests made by the Experiment Station, and by farmers who were induced through correspondence with the Experiment Station to make some trials, gave results strongly indicating the need of applying available potassium to some of these soils. Pot culture experiments gave similar indications, and the field experiments which are reported* in this bulletin certainly furnish very conclusive proof of the power of potassium to increase the productive capacity of some of these soils.

In this connection the author desires to mention his appreciation of the assistance of Mr. J. E. Readhimer in superintending these field

*Some reference to these investigations has already been made in Circulars 64, 68, and 72. (See also previous foot-note.)

experiments, and also the value and importance of the care which has been given to these different soil experiment fields by the progressive and interested farmers upon whose farms the fields were located, as indicated in the following pages.

## TAMPICO SOIL EXPERIMENT FIELD.

This is one of the regular University of Illinois soil experiment fields. It is located in the S. E. 40 of the S. W. ¼ of Sec. 6, Twp. 19 N., R. 7 E. of the 4th P. M., on the farm of Mr. J. H. Milligan, about five miles northeast of Tampico, Whiteside County, Illinois. The soil consists of black peaty material, rich in organic matter to a depth of sixteen inches. Between 16 and 30 inches the material is lighter in color and quite sandy, with little organic matter. The subsoil below 30 inches is almost pure coarse sand. This soil is fairly representative of considerable amounts of land in southern Whiteside and adjoining counties, which is non-productive, or of very low productive capacity, especially for corn.

This field consists of ten tenth-acre plots, numbered from 101 to 110. The individual plots are each two rods wide and eight rods long, each plot being surrounded by a cropped and cultivated border one-fourth rod wide, which makes one-half rod division strips between adjacent plots. The treatment applied to these different plots is what we call our "complete fertility test." It includes trials with applications of the elements, nitrogen, phosphorus, and potassium, singly, in all possible double combinations, and all three together, all in connection with lime; also a double test as to the effect of applying lime, first with lime alone, and finally with the three elements added. The plan will be easily understood by reference to the tabular statements. (L means lime, N means nitrogen, P means phosphorus, and K means potassium, from the Latin name *kalium*, this symbol (K) being used for potassium by all nations.)

Nitrogen is applied in the form of dried blood, a material containing 12 to 14 percent of nitrogen. About 800 pounds of dried blood per acre are used each year. This would furnish about 100 pounds of nitrogen or as much as is contained in 100 bushels of corn. Of course the nitrogen is purchased and applied in readily available commercial form in order to ascertain as quickly as possible if the soil is in need of nitrogen. If this were found to be the case it would simply indicate that in farm practice more nitrogen should be obtained from the air by means of leguminous crops, as we are doing in our rotation experiments (see Bulletin No. 88, "Soil Treatment for Wheat in Rotations"), and not that commercial nitrogen should be bought and applied to the soil (100 pounds of commercial nitrogen cost about $15, while that quantity of nitrogen can be obtained from the air with clover and other legumes for about $1).

The phosphorus is applied in steamed bone meal. This material contains about 12½ percent of the element phosphorus, and is one of the best forms of phosphorus to purchase when needed in general farming. About 200 pounds of steamed bone meal per acre are applied each year. This furnishes about 25 pounds of phosphorus, or more than is contained in a 100-bushel crop of corn, the grain containing about 17 pounds and the stalks 6 pounds of that element. Owing to the fact that the steamed bone meal is not completely available the first season, the first annual application is usually 400 instead of 200 pounds (phosphorus in steamed bone meal usually costs from 10 to 12 cents a pound, the steamed bone meal itself being $25 to $30 a ton).

Potassium is applied in the form of potassium chlorid (containing about 42 percent of potassium), or potassium sulfate (containing about 40 percent of that element). About 200 pounds of the salt are applied the first year, and 100 or 200 pounds per acre each year afterward. One hundred bushels of corn contain about 19 pounds of potassium, and the corresponding three tons of stalks contain about 52 pounds of that element. If the stalks or the ashes from the stalks are left on the land, well distributed, the annual loss in potassium is only about 20 pounds for a very large crop of corn, and 100 pounds of potassium chlorid will furnish 42 pounds of the element potassium. If both grain and stover are removed about 200 pounds must be added each year.

The results obtained from the Tampico soil experiment field in 1902 (the first year) are shown in Table 1. It should be stated that although lime was applied to certain plots in this field in the beginning of the experiment, in accordance with our regular plan of "complete fertility tests," it has produced no effect whatever, and the subsequent analysis of soil samples taken at the time the field was located also shows that the soil is not in need of lime. (Lime is not added as an element of plant food, but only to correct any possible acidity of the soil, and thus to insure good physical conditions where the elements of plant food are added.)

TABLE 1.—CROP YIELDS IN SOIL EXPERIMENTS; TAMPICO FIELD, 1902.

| Soil plot No. | Soil treatment applied to peaty swamp soil. | Yields per acre. | |
|---|---|---|---|
| | | Corn, bushels. | Stover, pounds. |
| 101 | None | 0 | 1,000 |
| 102 | Lime | 0 | 800 |
| 103 | Lime, nitrogen | 0 | 1,200 |
| 104 | Lime, phosphorus | 0 | 2,000 |
| 105 | Lime, **potassium** | **36.3** | 3,600 |
| 106 | Lime, nitrogen, phosphorus | 0 | 1,400 |
| 107 | Lime, nitrogen, **potassium** | **40.0** | 3,500 |
| 108 | Lime, phosphorus, **potassium** | **37.5** | 3,100 |
| 109 | Lime, nitrogen, phosphorus, **potassium** | **60.0** | 4,400 |
| 110 | Nitrogen, phosphorus, **potassium** | **52.5** | 4,750 |

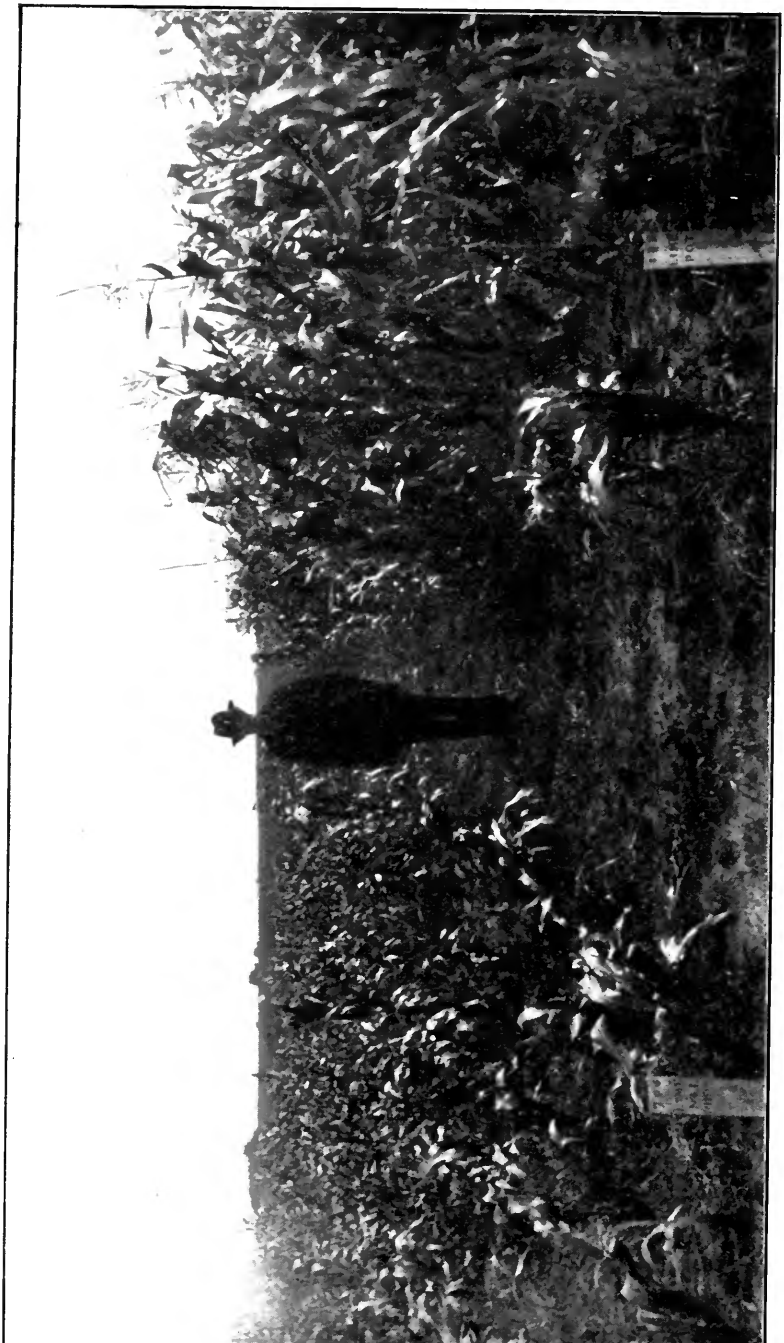


PLATE 1.—CORN ON PEATY SWAMP LAND, TAMPICO FIELD, 1902. NITROGEN AND PHOSPHORUS ON LEFT; POTASSIUM ON RIGHT.

It will be observed that every plot to which potassium was applied produced a fair crop of corn, varying from 36 to 60 bushels, while no ear corn was produced on any plot not treated with potassium. Even the yield of stover, or barren stalks, was small on plots not receiving potassium. There was considerable variation in the yield of corn from the plots treated with potassium. This was probably caused more by the excessive rainfall and consequent injury to some plots from too much water than from the effect of other applications beside potassium. Like much of these swamp lands, this field was not sufficiently well drained to protect it in excessively wet seasons. Plot 109 is slightly higher than most of the other plots, and this is believed to account largely for the higher yield on that plot.

Plate 1 shows the corn growing on Plot 106 with nitrogen and phosphorus, on the left, and on Plot 105 with potassium, on the right.

Table 2 shows the results obtained from this same field in 1903 (the second year).

TABLE 2.—CROP YIELDS IN SOIL EXPERIMENTS; TAMPICO FIELD, 1903.

| Soil plot No. | Soil treatment applied to peaty swamp soil. | Yields per acre. | | | |
|---|---|---|---|---|---|
| | | Corn, bushels. | | | Stover, pounds average. |
| | | N. ½ plot. | S. ½ plot. | Average. | |
| 101 | None | 0 | 0 | 0 | 570 |
| 102 | Lime | 0 | 0 | 0 | 590 |
| 103 | Lime, nitrogen | 0 | 0 | 0 | 480 |
| 104 | Lime, phosphorus | 0 | 0 | 0 | 740 |
| 105 | Lime, **potassium** | 42.3 | 48.5 | **45.4** | 4,150 |
| 106 | Lime, nitrogen, phosphorus | 0 | 0 | 0 | 600 |
| 107 | Lime, nitrogen, **potassium** | 57.6 | 59.7 | **58.7** | 4,170 |
| 108 | Lime, phosphorus, **potassium** | 47.1 | 46.6 | **46.9** | 3,860 |
| 109 | Lime, nitrogen, phosphorus, **potassium** | 66.3 | 65.4 | **65.9** | 4,380 |
| 110 | Nitrogen, phosphorus, **potassium** | 53.2 | 64.0 | **58.6** | 3,960 |

The five plots receiving potassium produced from 45 to 65 bushels of corn per acre, while no ear corn was produced on any of the five plots to which no potassium was applied. Owing to the very wet season of 1903, the yields from most of the plots receiving potassium are lower than they would otherwise have been, Plot 109 being the highest, as in 1902, and largely for the reason previously given. It is evident that the excessive amount of water in the soil retarded the nitrification of the organic nitrogen naturally contained in the soil in very large amounts; while the nitrogen supplied in the form of dried blood, being in the surface soil and very easily nitrified, did effect some increase in the yield wherever both potassium and nitrogen were added. This effect was

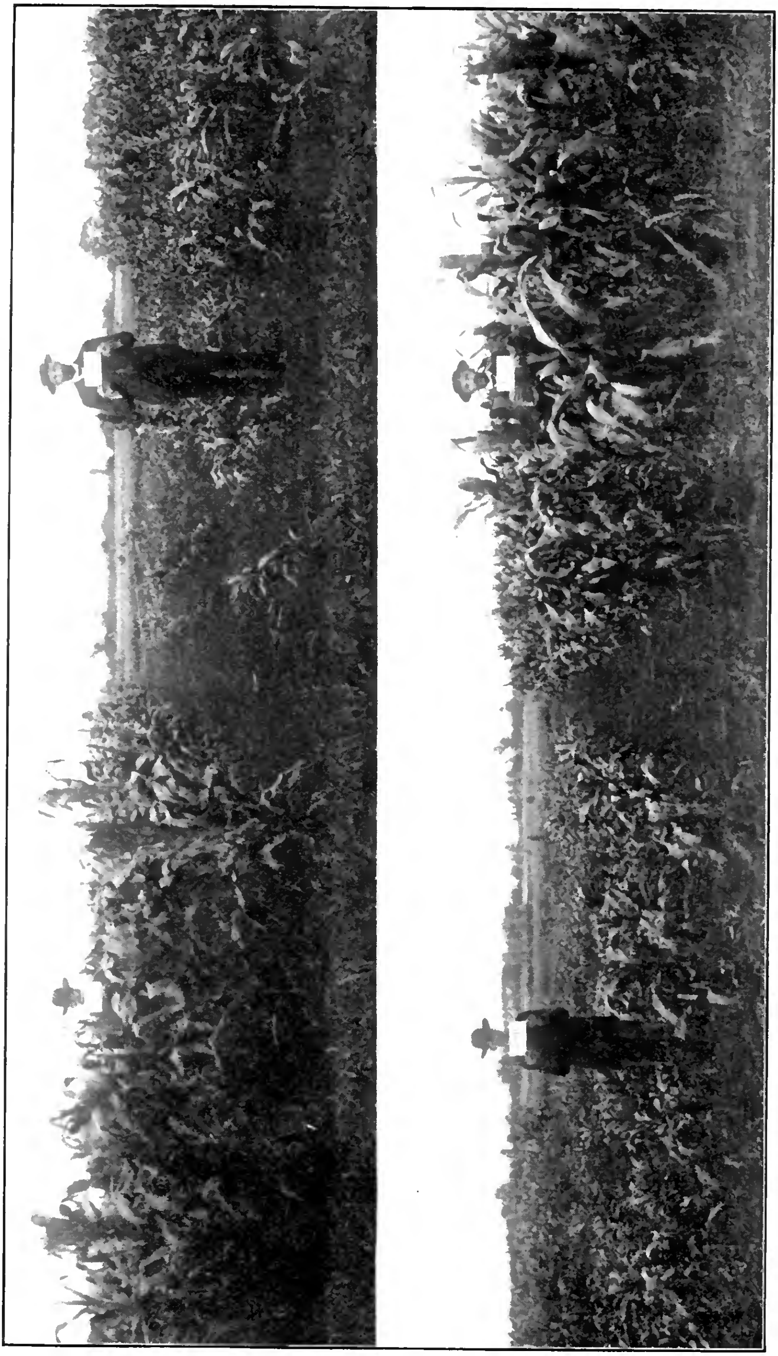


Plate 2.—Corn on Peaty Swamp Land, Tampico Field, 1903. Upper View: Potassium on Left, with Nitrogen and Phosphorus on Right. Lower View: Nitrogen and Phosphorus on Left, with Nitrogen and Potassium on Right.

plainly apparent during the growing season, the stronger growth and darker color of the plants treated with nitrogen in connection with potassium being distinctly discernible. Of course this result does not indicate that commercial nitrogen could be used with profit on this soil, but rather that the field needs better drainage in such wet seasons. (This is being arranged for.) This soil is naturally several times richer in nitrogen than the most fertile soils in the corn-belt. It is also well supplied with phosphorus. With more perfect drainage and a plentiful supply of potassium, this soil is undoubtedly capable of producing even more than 65 bushels of corn to the acre. (See results obtained from the Momence field.)

Plate 2 shows the 1903 crop growing on the Tampico field. The upper view shows Plot 5 (**potassium**) on the left, and Plot 6 (nitrogen and phosphorus) on the right. The lower view shows Plot 6 (nitrogen and phosphorus) on the left, and Plot 7 (nitrogen and **potassium**) on the right. (As stated above, this soil naturally contains abundance of lime, a small amount of which was added to these plots in the beginning of the experiment before the soil had been analyzed, not as plant food, but only to insure good physical condition. The lime was not needed, however, and it has produced no effect.)

## MOMENCE SOIL EXPERIMENT FIELD.

This is also one of the regular University of Illinois soil experiment fields. It is located in the N. E. 40 of S. E. ¼ of Sec. 6, Twp. 30 N., R. 11 W. of 2nd P. M., on the farm of Mr. C. C. Porter, about three miles south of Momence, Kankakee County, Illinois, on peaty swamp soil which is underlain with impure limestone at a depth of two to three feet, with about 12 inches of yellow sandy subsoil between the black soil and the underlying rock.

A considerable part of the north half of plots 101 and 102 and a smaller part of the other plots extend over somewhat different land where the soil contains sufficient available potassium to produce a medium crop of corn in a good season.* The south halves of the plots are on soil which is fairly representative of the most non-productive phase of this peaty swamp soil. There are very large areas of swamp soil in Kankakee and adjoining counties of very low productive capacity, much of which will probably respond to the same treatment as this field. (There are some probable exceptions, however, which will be noted below.)

The Momence field is laid out in the same manner and receives the same kinds of treatment as the Tampico field. Table 3 shows the results which were obtained in 1902.

*In locating our soil experiment fields, we endeavor to select as uniform land as possible, but if there is any apparent difference in the field we always try to put the check plot with no treatment on the best soil in order that the effect of the treatment shall not be exaggerated.

TABLE 3.—CROP YIELDS IN SOIL EXPERIMENTS; MOMENCE FIELD, 1902.

| Soil plot No. | Soil treatment applied to peaty swamp soil. | Yields per acre. | |
|---|---|---|---|
| | | Corn, bushels. | Stover, pounds. |
| 101 | None | 6.9 | 940 |
| 102 | Lime | 5.5 | 820 |
| 103 | Lime, nitrogen | 0 | 560 |
| 104 | Lime, phosphorus | 1.3 | 500 |
| 105 | Lime, **potassium** | **23.7** | 2,720 |
| 106 | Lime, nitrogen, phosphorus | 0 | 500 |
| 107 | Lime, nitrogen, **potassium** | **19.7** | 2,420 |
| 108 | Lime, phosphorus, **potassium** | **32.0** | 2,940 |
| 109 | Lime, nitrogen, phosphorus, **potassium** | **25.2** | 2,480 |
| 110 | Nitrogen, phosphorus, **potassium** | **24.1** | 2,460 |

The crop was injured very considerably during the wet season of 1902, because of inadequate drainage, a condition which was corrected before the 1903 crop was grown on this field. Nevertheless the effect of potassium on the 1902 corn crop is very marked. Aside from the ends of the plots which occupied somewhat higher ground, capable of producing a medium crop, the five plots receiving no potassium produced practically no ear corn, while the five plots treated with potassium yielded 20 bushels or more of corn per acre. Marked increase in the yield of stover also follows the application of potassium.

Although the season of 1903 was also one of abundant rainfall, the Momence field had been provided with sufficient drainage to prevent serious injury from water as will be seen from the results which are given in Table 4.

TABLE 4.—CROP YIELDS IN SOIL EXPERIMENTS; MOMENCE FIELD, 1903.

| Soil plot No. | Soil treatment applied to peaty swamp soil. | Yields per acre. | | | |
|---|---|---|---|---|---|
| | | Corn, bushels. | | | Stover, pounds average. |
| | | N. ½ plot. | S. ½ plot. | Average. | |
| 101 | None | 29.7 | 0 | 14.9 | 1,080 |
| 102 | Lime | 14.2 | 0 | 7.1 | 820 |
| 103 | Lime, nitrogen | 7.2 | 0 | 3.6 | 750 |
| 104 | Lime, phosphorus | 9.2 | 0 | 4.6 | 1,040 |
| 105 | Lime, **potassium** | 72.0 | 72.5 | **72.6** | 3,770 |
| 106 | Lime, nitrogen, phosphorus | 7.7 | 0 | 3.9 | 730 |
| 107 | Lime, nitrogen, **potassium** | 79.2 | 63.0 | **71.1** | 3,160 |
| 108 | Lime, phosphorus, **potassium** | 78.2 | 68.0 | **73.1** | 3,380 |
| 109 | Lime, nitrogen, phosphorus, **potassium** | 71.5 | 62.0 | **66.7** | 3,010 |
| 110 | Nitrogen, phosphorus, **potassium** | 77.7 | 63.0 | **70.4** | 3,230 |

These results are certainly exceedingly marked as to the effect of potassium in this soil. On the south halves of the plots, on the most non-productive soil, no ear corn was produced on any of the five plots receiving no potassium, while the five plots treated with potassium produced from 62 to 72 bushels of good sound corn per acre. On the north halves the potassium increased the yield from less than ten bushels to more than 70 bushels per acre. (The north ends of plots 101 and 102 are not fairly comparable with the remaining plots, as will be plainly seen from the yields produced. This will be understood from the previously given explanation.)

It is very evident that potassium is the only element of plant food needed to change this almost barren soil to one of the most productive soils in the corn belt.

Plates 3, 4, and 5 show the crops growing on the Momence field in 1903. Plates 3 and 4 show Plots 1, 2, 3, 4, and 5, in the order given.

The upper view in Plate 3 shows Plot 1, to which no treatment was applied. On the right, looking over Plots 2, 3, and 4, we see Plot 5, to which potassium was applied.

The lower view in Plate 3 shows Plot 2, to which lime only was applied. On the right we see the good corn in Plot 5, beyond plots 3 and 4.

The upper view in Plate 4 shows Plot 3, to which nitrogen was applied, on the right of which is Plot 4, with Plot 5 beyond.

The lower view of Plate 4 shows Plot 4 (phosphorus) on the left, and Plot 5 (**potassium**) on the right, where the corn yielded 72 bushels to the acre.

The upper view of Plate 5 shows Plot 5 (**potassium**) on the left, Plot 6 (nitrogen and phosphorus) in the middle, and Plot 7 (nitrogen and **potassium**) on the right. Potassium on Plot 5 made 72 bushels, and on Plot 7 potassium with nitrogen made 71 bushels of good sound corn (80 pounds per bushel), while Plot 6 between those two made less than 4 bushels of nubbins.

The lower view in Plate 5 shows the effect of potassium on buckwheat on the Momence field, potassium having been applied on the right, and nothing applied on the left.

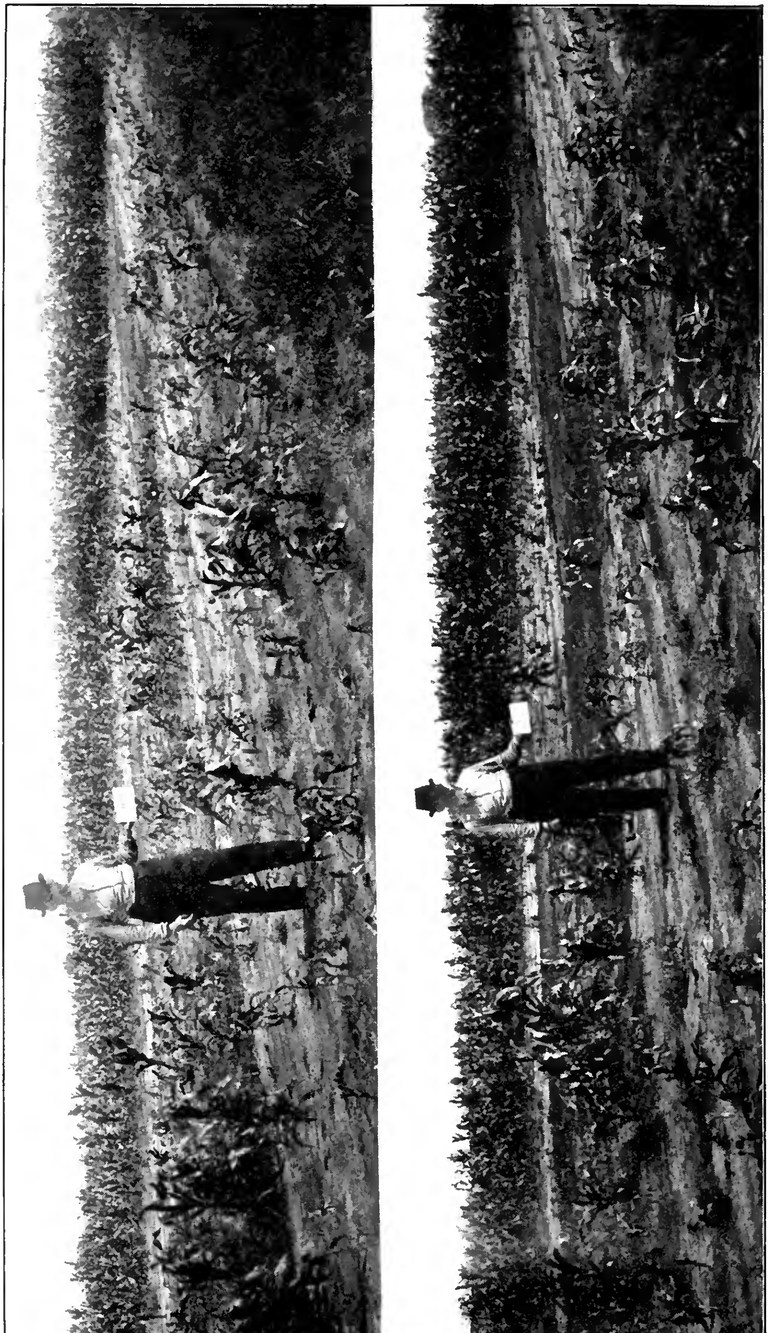


PLATE 3.—CORN ON PEATY SWAMP LAND, MOMENCE FIELD, 1903. UPPER VIEW: NO TREATMENT. LOWER VIEW: LIME TREATMENT.

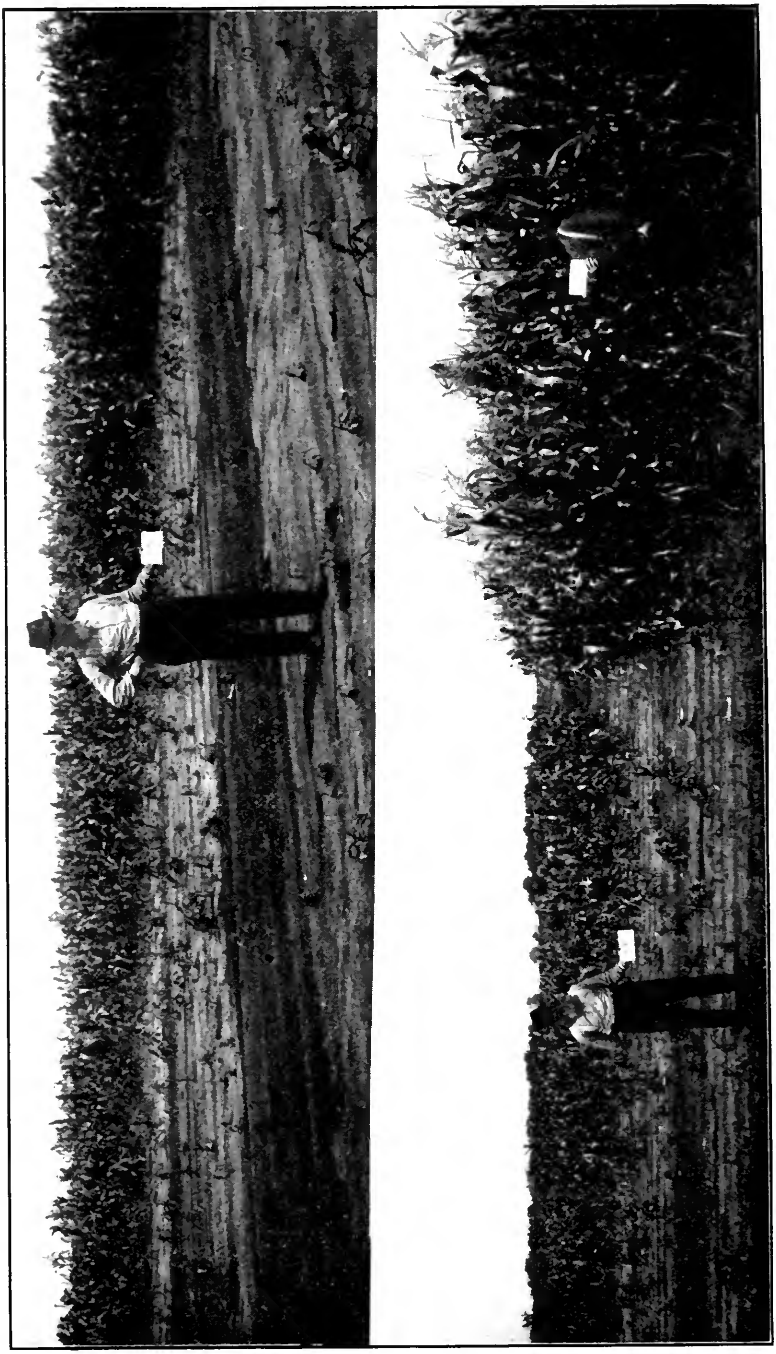


PLATE 4.—CORN ON PEATY SWAMP LAND, MOMENCE FIELD, 1903. UPPER VIEW: NITROGEN. LOWER VIEW: PHOSPHORUS ON LEFT, POTASSIUM ON RIGHT.

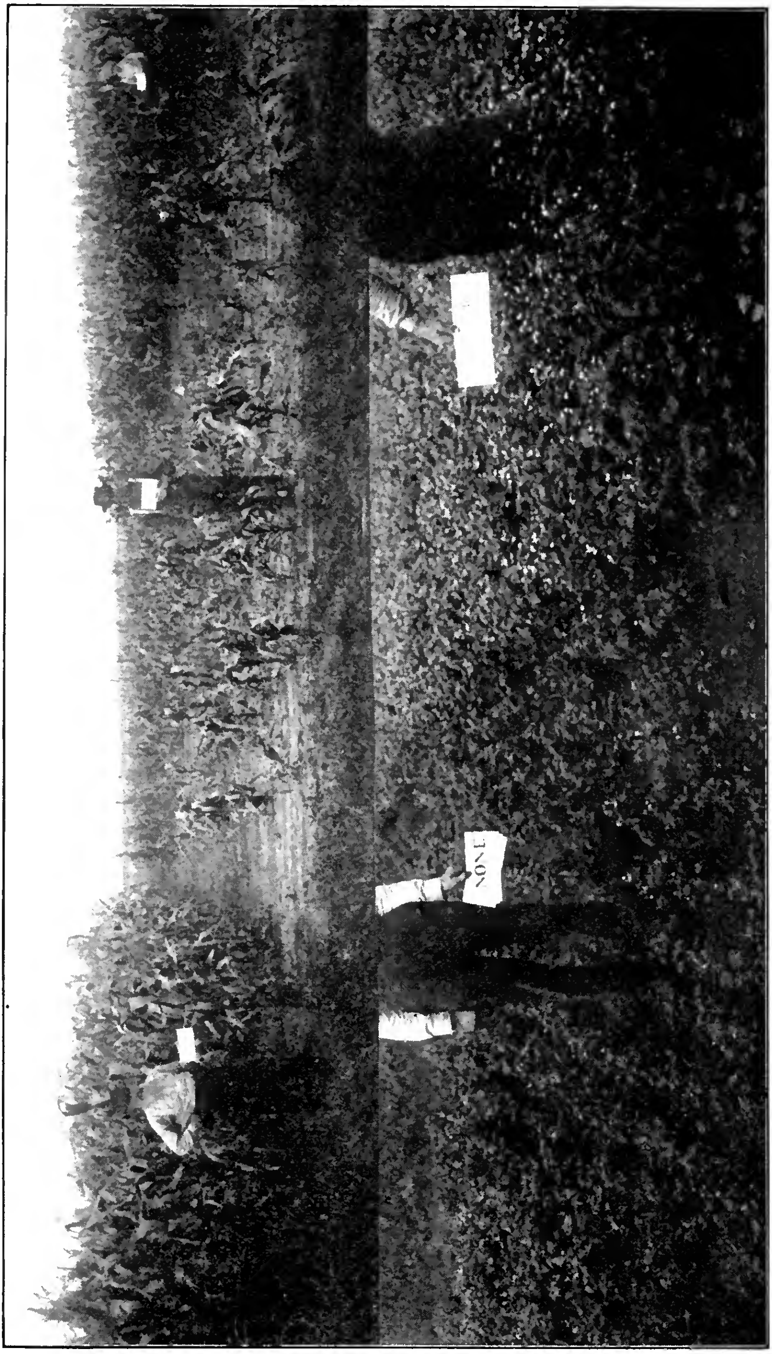


PLATE 5.—CORN AND BUCKWHEAT ON PEATY SWAMP LAND, MOMENCE FIELD, 1903. EFFECT OF POTASSIUM. "SEE HIS FEET!"
(APOLOGIES TO MESSRS. PORTER AND SONS.)

## MANITO SOIL EXPERIMENT FIELD.

This is a co-operative soil experiment field, located on peaty swamp soil about one mile northeast of Manito, in Mason County, Illinois, almost on the line between Mason and Tazewell counties. It is on the farm of Mr. James S. Pollard, which is operated by Mr. Joseph Brenner. The soil is a black peaty material, consisting largely of organic matter. It is quite uniform to a depth of several feet. At a depth of six or eight feet (in places twelve to fifteen feet), the peaty material is underlain with sand. The Manito experiment field contains ten one-acre plots. The treatment indicated in Table 5 was applied for the 1902 crop only, no subsequent applications having been made, although crops of corn for the two years, 1902 and 1903, have been harvested, the yields of corn obtained being also given in the table.

TABLE 5.—CROP YIELDS IN SOIL EXPERIMENTS; MANITO FIELD, 1902 AND 1903.

| Soil plot No. | Soil treatment applied to peaty swamp soil. (Amounts per acre.) | Corn, bushels per acre | |
|---|---|---|---|
| | | 1902. | 1903. |
| 1 | None | 10.9 | 8.1 |
| 2 | None | 10.4 | 10.3 |
| 3 | 600 lb. **Kainit** (10% potassium) | **30.4** | **32.3** |
| 4 | 600 lb. **Kainit** and 350 lb. bone meal | **30.3** | **33.3** |
| 5 | 200 lb. **potassium chlorid** (42% K) | **31.2** | **33.7** |
| 6 | 700 lb. common salt | 11.1 | 11.6 |
| 7 | 700 lb. common salt | 13.3 | 13.2 |
| 8 | 600 lb. **Kainit** (10% K) | **36.8** | **37.3** |
| 9 | 300 lb. **Kainit** (10% K) | **26.4** | **25.5** |
| 10 | None | No report | 14.7 |

A large open ditch provides fairly good drainage for the swamp in which the Manito field is located, but the excessive rainfall of 1902 certainly injured the yield to a considerable extent. The fact that no further application of potassium was made for the second crop probably accounts for the comparatively low yield of 1903. The effect of potassium on this field has been to increase the yield of corn from about 10 bushels to more than 30 bushels per acre. Phosphorus (in bone meal) applied in addition to potassium (Plot 4), produced no increase over potassium alone. The results are practically the same whether the potassium is applied in the form of potassium chlorid, containing 42 percent of potassium, or as kainit, a crude mineral containing only 10 percent of potassium. Although the application of 600 pounds of kainit is not quite equivalent to 200 pounds of potassium chlorid, the kainit has given nearly as good results during the two years' trials. The cost of 600 pounds of kainit is about the same as 200 pounds of potassium chlorid. Of course it is somewhat more expensive to handle the heavier amounts of kainit, and the fact that 200 pounds of potassium chlorid contain 84 pounds of potassium, while the 600 pounds of kainit contain only 60 pounds of potassium, is evidence that the effect of the potassium chlorid will be more lasting. Where the application of potassium was reduced from 60 pounds (in 600 pounds of kainit) to 30 pounds (in 300 pounds of kainit) the yield of corn was reduced from 36 to 26 bushels in 1902, and from 37 to 25 bushels in 1903. (See Plots 8 and 9.) It seems altogether probable that heavier applications of potassium (say 200 pounds of potassium chlorid each year) will increase the yield of corn on this soil to 60 or 70 bushels, or possibly more, as has been the result on the Momence field. This is to be tried on the Manito field.

It should be borne in mind that the stalks for a hundred-bushel crop of corn require 52 pounds of potassium (beside that required for the root growth), while the 100 bushels of grain will require 19 pounds. Of course the stalks must be grown before the ears can be produced; and, while there is a strong natural tendency in corn, as in all plants, to reproduce seed, yet it has been shown by actual trial that in such soil as that on the Tampico field, for example, which, without treatment, is incapable of producing ear corn, small applications of potassium are practically useless, as they only effect a larger growth of stalks, but do not furnish sufficient potassium to enable those stalks to produce ears. This fact was well illustrated on Mr. Milligan's land adjoining the Tampico field in 1903. Because of the marked results produced by potassium on that field in 1902, Mr. Milligan used some potassium on his own corn for 1903. The amount of potassium chlorid which he purchased was not sufficient to make a heavy application (say 200 pounds per acre) to all of the land where he wished to apply it. He reduced the application to 50 pounds of potassium chlorid per acre on some of his land. As a result he obtained a largely increased growth of stalks, but still produced practically no ear corn. On such land, 200 pounds of potassium chlorid is worth very much more when applied to one acre than when scattered over four acres.

The results obtained on Plots 6 and 7 of the Manito field prove conclusively that common salt (sodium chlorid) has no power to take the place of potassium chlorid (or other potassium salts) in the improvement of these peaty swamp soils. Plots 1, 2, 6, 7, and 10, may all be considered as check plots. From the yields obtained from these plots during the two years, it will be seen that there is some natural variation in the land, the yield increasing somewhat as we pass from Plot 1 to Plot 10. Plots 3 and 8 also illustrate this fact.

Owing to the more favorable season of 1903 (less injury from water) larger yields were produced in 1903 than in 1902 on the plots treated with potassium, although no additional potassium was applied for the 1903 crop. The one exception to this rule is plot 9, which received only

30 pounds of potassium per acre, of which too little remained for the 1903 crop to produce as good a yield as in 1902, even though the water conditions were more favorable in 1903.

## RESULTS OF INVESTIGATIONS IN INDIANA AND WISCONSIN.

As previously stated the Indiana and Wisconsin experiment stations have reported some investigations of non-productive soils, including some peaty swamp soils.

Bulletin No. 57 of the Indiana Agricultural Experiment Station on "The Improvement of Unproductive Black Soils," by Professor H. A. Huston, published in 1895, contains the following general conclusions:

"The use of straw or kainit has proved very profitable as a means of *temporary* improvement of such lands.

"The *permanent* improvement of such lands must be effected by efficient drainage."

In the summary of Bulletin No. 95 of the Indiana Station, which was published in 1903, and which is essentially a reprint of Bulletin No. 57, Professor Huston inserts the following additional conclusion:

"On black lands containing considerable sand but not having a high water level, kainit and other potash salts have proved very profitable fertilizers for corn."

Bulletin No. 80 of the Wisconsin Agricultural Experiment Station on "The Character and Treatment of Swamp or Humus Soil," by Professor F. H. King and J. A. Jeffrey, published in 1900, contains the following conclusions:

"So far as the elements of plant food are concerned [these soils] contain a higher percent than most of the best upland soils.

"But when reclaimed they are often found relatively unproductive, especially after two or three years.

"Coarse farmyard manure, in almost all cases, greatly improves even the best of these lands, enabling them to give large yields.

"Potassium carbonate, sulfate, and nitrate, and wood ashes have been found to greatly improve these soils for corn. Kainit improves the yield, but to a less degree.

"Coarse litter, like straw, plowed in, is often very helpful.

"When undrained and kept in the native wild grass and cut continuously, these lands in some known cases greatly decrease in productiveness, so much so as to hardly pay for cutting."

It is evident that in the investigations above summarized no very clear distinction is made between the very peaty swamp soils which are exceedingly deficient in the element potassium as compared with normal fertile soils, and the non-productive "alkali" or "bogus" soils, which are usually rich in all elements of plant food, including potassium. These different classes of non-productive soils are discussed in the following pages.

## PLANT FOOD IN DIFFERENT SOILS.*

It is true that plants are composed very largely of the elements carbon, hydrogen, and oxygen, that carbon is obtained from the inexhaustible supply of carbon dioxid in the air, and hydrogen and oxygen are the elements of which water is formed. It is also true that plants must be supplied with the elements calcium, magnesium, sulfur, and iron, but these four elements are required by plants in relatively small amounts, and practically all soils are abundantly supplied with them. The other three elements of plant food, nitrogen, phosphorus, and potassium, are required by plants in very considerable amounts, and they are present in most soils in limited quantities.

Nitrogen is a constituent of organic matter, consequently, if a soil is rich in organic matter (humus or vegetable matter), it is also rich in nitrogen; and if a soil is poor in organic matter, it is also poor in nitrogen. If more nitrogen is needed it can best be obtained by growing leguminous crops, provided with the proper nitrogen-gathering bacteria, which have power to obtain nitrogen from the air.

Phosphorus is also associated with organic matter to some extent, so that a soil *very* rich in organic matter (as peaty soils) is not only exceedingly rich in nitrogen, but it is usually well supplied with phosphorus. In the light-colored timber soils, and in worn prairie soils, especially those of southern Illinois, phosphorus is more or less deficient in the soil. It can be supplied very profitably in steamed bone meal, and probably in ground rock phosphate, also; but, as a rule, it should be used only in connection with leguminous crops or farm manure.

Potassium is commonly associated with clay, that is, the true sticky, plastic clay. It is contained in all ordinary Illinois soils, as the common prairie soils, in great abundance (southern Illinois soils have only a moderate supply). Peaty soils not mixed with sticky clay are, as a rule, very deficient in potassium. Sand soils also are usually poor in potassium. Sand soils are likewise commonly deficient in the other elements of plant food, especially in nitrogen. (Absolutely pure sand contains no plant food whatever.)

With these facts in mind, it is possible for the farmer to estimate with some degree of accuracy what will be required to increase the productive capacity of the different kinds of peaty swamp soils, and whether the treatment must be continued indefinitely, year after year, or whether the soil is likely to improve, or "farm out," after a few years.

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*For more complete information regarding the different elements of plant food, the reader is referred to Circular No. 68, "Methods of Maintaining the Productive Capacity of Illinois Soils," a copy of which will be sent upon request to any one interested in Illinois agriculture.

## General Information Regarding Peaty Swamp Soils.

Peaty swamp soils may well be separated arbitrarily into five fairly distinct classes:

1. Soils in which the very peaty material extends to a depth of three or four feet at least and often to much greater depths.
2. Soils with one to three feet of peaty material resting on deep sand.
3. Soils with one to three feet of peaty material resting on rock, usually with some inches of sandy material between the two.
4. Soils with six inches to three feet of peaty material resting on a clayey subsoil.
5. Soils with only a few inches of peaty material resting on sand.

If the soil has one to three feet of very peaty material and this is underlain with a deep sand subsoil or with sand resting on rock, or if the peaty soil itself is very deep (3 or 4 feet or more), then the land is almost certainly deficient in potassium, and the chief part of the potassium required to produce crops must always be supplied, either in the form of commercial potassium salts or in farm manure, because of the simple fact that it cannot be furnished by either the soil or subsoil in sufficient quantities for continuous large crops. As the one to three feet of peaty material is exceedingly rich in organic matter, and is much richer in nitrogen, and usually somewhat better supplied with phosphorus, than the most fertile normal soils in the corn-belt, that land is not in need of either of those elements, and probably it will be unnecessary to grow clover or to apply phosphorus on such soils for many years. Indeed, it seems altogether likely that the most profitable system of farming for such soils is almost continuous corn, unless some rotation should become necessary because of corn insects. As farm manure contains about as much nitrogen as potassium, and also some phosphorus, it is better farm practice to use farm manure on sandy land, for example, which is usually somewhat deficient in both phosphorus and potassium, and very greatly in need of nitrogen and organic matter, than it is to use the manure on this peaty soil which needs only potassium. Ordinary farm manure contains about 10 pounds of potassium in a ton, and this is not very readily available, excepting in such kinds as horse manure which decompose quickly.

If one has abundance of farm manure, and does not need to use it all on lighter soils, of course, it should be applied to the peaty soils rather than not be used at all; but under the ordinary farm conditions, where the supply of farm manure is very limited, it is good practice to purchase commercial potassium for such peaty lands as need it.

As stated above, there are some peaty soils which are underlain with clay subsoils lying from 6 inches to three feet below the surface. Such subsoils almost invariably contain abundance of potassium. Some of these are the soils which will ultimately "farm out," to use a local phrase, which means that with continued farming the soil gradually improves until it finally becomes a normally fertile soil, even without any special treatment. The time required for this improvement will depend upon the condition and method of management of the soil. The desired result is usually accomplished by getting some of the clayey subsoil mixed with the more peaty top soil. Sometimes this can be done by deeper plowing; sometimes by the tramping of live stock, where the subsoil is near the surface. Some soils of this class are temporarily benefited very markedly by even light applications of potassium, either in farm manure (preferably horse manure) or in commercial form. This will furnish sufficient potassium to give the corn a start, and the corn roots will thus be enabled to grow sufficiently to reach the clayey subsoil which will then furnish abundance of potassium for a large crop. This may last for a year or two only, when it will be found necessary to supply more potassium to the top soil; or, the one or two years' cropping and cultivation may result in the compacting of the surface soil, the mixing of the clayey subsoil with the peaty top soil, or the bringing up of sufficient potassium from the subsoil into the top soil by the roots of corn and weeds and the corn-stalks (which, it will be remembered, are quite rich in potassium, and which are usually either burned or plowed under) so that no further application of potassium may be necessary. Thus, the so-called "farming out" process may be hastened very materially, and with decided profit on some soils, by applying potassium in some form, especially where the peaty top soil is too deep to admit of reaching the clayey subsoil with the plow.

In its original condition this type of peaty land (that is, a peaty top soil underlain with a clay subsoil), contains abundance of all of the elements of plant food; but the difficulty is that the nitrogen is nearly all in the top soil, while the potassium is very largely in the subsoil (both soil and subsoil commonly contain enough phosphorus), and the chief problem with these particular soils is to bring these elements together in the top soil sufficient for the needs of the growing crop, especially during its earlier growth before its roots reach the lower stratum.

Very satisfactory results have been obtained upon this particular kind of soil, in Ford County, Illinois, simply by means of very deep plowing. Mr. S. K. Marston has a farm in what is called "Vermilion Swamp," in northern Ford County. A careful examination was made of land in this swamp some two years ago. The soil produced very poor crops of corn, but the clayey subsoil was found to be within the reach of the plow, and it was then agreed with Mr. Marston that a trial of deep plowing should be made, and the result has been very successful, as will be seen from the following extracts from a letter recently received from Mr. Marston:

"ONARGA, ILL., October 31, 1903.

"DR. C. G. HOPKINS,

"DEAR SIR:

"I went to my farm yesterday to ascertain the effect of the fertilizers that I had used. My tenant says he can see no perceptible effect. But I can say that deep plowing has done the business. I saw yesterday some of the finest, soundest, heaviest corn I ever saw, and the yield sixty bushels to the acre.

"My tenant is a thorough convert to deep plowing. His plowing this year is nearly a foot deep. We have decided that the soil contains all necessary constituents. Deep plowing seems to be a great success.

"Respectfully,

"S. K. MARSTON."

There is still another kind of peaty swamp land which must be mentioned. This is land whose soil consists of only a few inches of peaty material, which is underlain by sand to a depth of several feet. We have found quite extensive areas of this type of soil, especially in the southeastern part of Kankakee County. The sandy subsoil will usually furnish somewhat more of available potassium than the peaty material will, and the sand, being near the surface, becomes mixed with the peaty material by plowing and cultivation, so that this soil may produce fair crops for a few years. But after the rather small amount of organic matter becomes reduced by cultivation, this type of soil is but little different from ordinary sand soil, which is usually very poor in nitrogen and rather low in all elements of plant food. If the sand contains some clay, which is quite frequently the case, it will be better supplied with potassium than with the other elements. As a rule it is most deficient in nitrogen.

It will be of interest and value to farmers who may have such very sandy swamp soils to know of the results which we have obtained from our "complete fertility tests" on the sand ridge soil in Tazewell County.

## GREEN VALLEY SOIL EXPERIMENT FIELD.

This is one of the regular University of Illinois soil experiment fields. It is located in the S. W. 10 of N. W. 40 of N. W. ¼ of Sec. 3, Twp. 22 N., R. 5 W. of 3rd P. M., about two miles southwest of Green Valley, Tazewell County, Illinois, on the farm of Mr. J. C. Drake. The soil is typical of the cultivated sand ridge soil, and fairly represents very large areas of sandy land, not only in Tazewell and Mason counties, but also in Whiteside and adjoining counties, Kankakee and adjoining counties, and in smaller areas in many other parts of Illinois.

The Green Valley field contains a series of ten tenth-acre plots in the "complete fertility tests," and also three series of ten plots each in the three-year rotation experiments. As the experiments have been in progress only two years, no definite conclusions can be drawn from the rotation plots, but the "complete fertility tests," which are designed to furnish information as quickly as possible (commercial nitrogen being used instead of waiting for legumes to grow as we do in the rotations), have already furnished some marked results, as will be seen by reference to Table 6. To those who are familiar with these sand ridge soils, the fact will be appreciated that it is practically impossible to find ten acres of this land with even approximately uniform soil. This experiment field is about as uniform for this land as can well be found; but in each series there are two or three plots which are markedly better land than the remainder of the series. This better soil occupies somewhat lower lying land, which has received some wash from the higher land, and is consequently richer, especially in organic matter and nitrogen, and more productive than the average sand soil. As in all of our soil experiment fields, wherever there is noticeable variation in the soil, the check plot, that is, the plot receiving no treatment, is located on the best land (as in the Momence field, for example), in order that the effects which may be produced by the different kinds of soil treatment shall never be exaggerated, even though they may sometimes be minimized.

For comparative purposes the results obtained on Plots 1 and 2 have practically no value, and they are ignored in computing the averages given in the last three lines in Table 6. It is of interest to note, however, that the yield of corn on those two plots markedly decreased from 1902 to 1903, while every plot receiving nitrogen with either phosphorus or potassium, or both, gave a higher yield in 1903.

TABLE 6.—CROP YIELDS IN SOIL EXPERIMENTS; GREEN VALLEY FIELD, 1902 AND 1903.

| Soil plot No. | Soil treatment applied to sand soil. | Yields per acre. Corn, bushels. 1902. | Corn, bushels. 1903. | Stover, pounds. 1902. | Stover, pounds. 1903. |
|---|---|---|---|---|---|
| 401 | None | 68.7 | 56.3 | 3,660 | 3,860 |
| 402 | Lime | 68.2* | 42.0* | 2,820* | 3,460* |
| 403 | Lime, **nitrogen** | **68.6** | **65.4** | 2,880 | 4,180 |
| 404 | Lime, phosphorus | 30.3 | 24.9 | 1,940 | 3,000 |
| 405 | Lime, potassium | 23.1 | 20.1 | 1,920 | 3,080 |
| 406 | Lime, **nitrogen,** phosphorus | **57.4** | **69.8** | 3,080 | 4,400 |
| 407 | Lime, **nitrogen,** potassium | **70.0** | **72.9** | 3,620 | 4,940 |
| 408 | Lime, phosphorus, potassium | 49.8 | 36.6 | 3,180 | 3,820 |
| 409 | Lime, **nitrogen,** phosphorus, potassium | **69.5** | **69.8** | 3,580 | 4,680 |
| 410 | **Nitrogen,** phosphorus, potassium | **57.2** | **66.1** | 3,520 | 4,540 |
| | L + N, gain for nitrogen | .4* | 23.4* | 60* | 720* |
| | LP + N, gain for nitrogen | 27.1 | 44.9 | 1,140 | 1,400 |
| | LK + N, gain for nitrogen | 46.9 | 52.8 | 1,700 | 1,860 |
| | LPK + N, gain for nitrogen | 19.7 | 30.2 | 400 | 860 |
| | Average gain for nitrogen | 31.2 | 42.6 | 1,080 | 1,373 |
| | Average gain for phosphorus | 5.0 | 7.0 | 473 | 233 |
| | Average gain for potassium | 11.0 | 7.4 | 827 | 620 |

*Results based on Plots 1 and 2 are omitted in the averages for reasons explained in the text.

After discarding Plots 1 and 2, we still have a triplicate test as to the effect of each of the elements, nitrogen, phosphorus, and potassium. Thus, in 1902, Plot 4 (lime and phosphorus), produced 30 bushels of corn, while Plot 6 (lime, **nitrogen,** and phosphorus), produced 57 bushels, a gain of 27 bushels for nitrogen. Plot 5 (lime and potassium) produced 23 bushels, while Plot 7 (lime, **nitrogen,** potassium), produced 70 bushels, a gain of 47 bushels for nitrogen. Plot 8 (lime phosphorus, potassium), produced 49 bushels, while Plot 9 (lime, **nitrogen,** phosphorus, potassium) produced 69 bushels, a gain of 20 bushels for nitrogen, the average of these three different tests being 31 bushels gain for nitrogen, as recorded under "average gain for nitrogen." By similar methods it is found that, in 1903, the average increase in yield produced by nitrogen was 42.6 bushels while phosphorus produced an average increase of 5 bushels in 1902 and 7 bushels in 1903, and potassium an increase of 11 bushels in 1902 and 7.4 bushels in 1903.

No one should conclude from these results that the purchase of commercial nitrogen for use on these sand soils is likely to be profitable. The annual application of nitrogen which we have made is 100 pounds per acre (about 800 pounds of dried blood), which is barely sufficient for a crop of 70 bushels (grain and stover). This amount of nitrogen costs $15.00 in the market. At 30 cents a bushel, it would require 45 bushels of corn to pay for the original cost of the nitrogen. What these experiments teach, and that very emphatically, is the very great importance of growing legumes, or using farm manure, or both, on this sand soil. Although clover does not grow well on this soil, as a rule, we now have conclusive evidence from our rotation experiments, and from numerous trials which different farmers have been induced to make, that cowpeas are well adapted to this soil, and that its productive capacity can be very greatly increased by means of cowpeas alone.

Further investigation is required to determine whether lime, phosphorus, or potassium can be applied to this soil with profit. Certainly they should not be used extensively until the possibilities of cowpeas, soy beans, vetch, or other legumes are better known. There is reason to believe that alfalfa will do well on this soil if it is once well started, as it probably can be by using farm manure and turning under cowpeas, perhaps with the addition of one or two tons per acre of ground limestone. It is strongly recommended that such trials be made with alfalfa (on a small scale at first), providing it with the best possible conditions, including a supply of the alfalfa bacteria, and, if necessary, phosphorus and potassium.

It is believed that this information regarding sand ridge soils can be applied with marked advantage to very sandy swamp soils, especially where the original peaty material was confined to a few inches of top soil which has been worn out or destroyed by cultivation.

## SOURCES AND USE OF POTASSIUM.

From the results given in the preceding pages, the fact will be appreciated that the element potassium is a commodity of value, especially for the farmer who has to deal with peaty swamp soils. The commercial value of potassium is about 6 cents a pound for the element in soluble form. There are three common forms of potassium on the market: Potassium chlorid, which contains about 42 percent of potassium; potassium sulfate, containing 40 percent of potassium; and kainit, a crude mineral, containing only 10 percent of potassium. Potassium chlorid is frequently, but very incorrectly, called "muriate of potash." Potassium chlorid contains the two elements, potassium and chlorin, as the name indicates. The word "muriate" has no meaning except that the ending, *ate*, indicates that the compound contains oxygen, which is not the case. "Potash" is a compound of potassium and oxygen, which is not contained in potassium chlorid. It is certainly better for the farmer to say potassium and potassium chlorid and be correct and intelligent about it than to say "potash" and "muriate of potash," and be confused and ignorant as to the nature of the compound.

It should be understood that the law of Illinois requires that every bag of potassium fertilizer sold in the state shall bear a printed label stating the percentage of the element potassium which the material contains, as well as the total number of pounds of material contained in the bag.

If a bag is marked "200 pounds," and the label "42 to 44 percent potassium," this means that the 200 pounds of material contains about 42 percent (or 42 pounds in 100 pounds) of the element potassium, which would make 84 pounds of potassium in the bag, or 840 pounds in a ton, which, at 6 cents a pound, would make the salt worth $50.40 a ton.

If the bag is marked "200 pounds" and the label "10 to 11 percent potassium," this means that the bag contains about 20 pounds of the element potassium, which would make 200 pounds of potassium in a ton. At 6 cents a pound for potassium, this material would be worth $12 a ton.

It is true that fertilizer dealers frequently print on the bag the equivalent percentages of "potash," "muriate of potash," "sulfate of potash," etc., the chief effect of which is to make "big figures" and confuse the purchaser, but any farmer can understand the matter of buying potassium if he will look for the percentage of potassium. This is the number of pounds of potassium contained in 100 pounds of the material. A ton would contain 20 times as much potassium, and this is worth 6 cents a pound in Chicago.

It is understood that Armour Fertilizers Works, Union Stock Yards, Chicago, A. Smith & Brother, Tampico, Whiteside County, Illinois, and Chas. H. Chridy, Havana, Mason County, Illinois, are taking out licenses to sell potassium chlorid, and possibly kainit. Armour Fertilizers Works quote a price of $50 a ton for potassium chlorid and $15 a ton for kainit, for ton lots in Chicago, or for carload lots delivered to any point in Illinois. At these prices potassium costs 6 cents a pound in potassium chlorid, and 7½ cents a pound in kainit. A ton of potassium chlorid contains 840 pounds of the element potassium, while a ton of kainit contains only 200 pounds of potassium.

When we remember that a hundred-bushel crop of corn contains 71 pounds of potassium (19 in the grain and 52 in the stover) besides that contained in the roots, it will be seen that 200 pounds of potassium chlorid (84 pounds of the element) will be barely sufficient for the first crop. If, however, only the ear corn is removed from the land, the stalks being pastured and plowed under, only about 20 pounds of potassium are actually removed from the soil each year, even with a very large crop, the larger part of the potassium being thus left for the benefit of succeeding crops. Of course the potassium in the stalks is much less readily available than that in potassium chlorid. Nevertheless, as the stalks decay, the potassium will gradually become available. If the stalks are burned, the potassium remains in the ashes, but usually these are left in windrows, and consequently not well distributed for the next crop.

Farm manure contains about 10 pounds of potassium in a ton, but most farm manure decays slowly, a fact which is evidenced by the lasting effect of manure, its value being commonly greater for the second crop than for the first after its application, while many succeeding crops may show its effect. Horse manure decays much more quickly than cattle manure, and consequently the potassium in horse manure is quite readily available. The potassium in ordinary manure and in corn stalks is probably not worth more than 1½ or 2 cents a pound, as compared with 6 cents a pound for soluble potassium. On this basis, for use on peaty swamp soils, rich in organic matter, nitrogen, and phosphorus, ordinary farm manure is worth about 20 cents a ton when potassium chlorid is worth $50 a ton. It should not be forgotten that one ton of potassium chlorid contains as much potassium as 84 tons of average fresh farm manure. Manure would be worth only 60 cents a ton for potassium if the potassium were all readily available.

It is certain that if we are raising corn on peaty swamp soil, rich in everything except potassium, and if only about one-fifth of the potassium absolutely required to make a crop is actually removed in the ear corn, it is very unscientific and very poor farm practice to be stingy with the potassium which we supply. On such soils as those on which our experiment fields are located at Tampico, Momence, and Manito, not less than 200 pounds of potassium chlorid per annum should be applied for the first one or two years. After that, if the stalks are not removed from the land, probably 100 pounds a year will be sufficient, and perhaps this can finally be reduced to 50 pounds a year, as this would furnish 21 pounds of potassium a year, which is slightly more than would be removed in one hundred bushels of corn.

It is well known that in ordinary soils potassium applied in soluble form is not lost by leaching, and it is evident from the experiments reported in this bulletin, especially those on the Manito Field, that peaty soil also has some power to fix and hold potassium from one year to another, even during seasons of abundant rainfall.

## METHODS OF APPLYING POTASSIUM SALTS TO THE LAND.

Potassium salts may be applied in the fall or spring, but preferably at least one or two weeks before the corn is planted. The material should never be applied in the hill with corn, for the reason that it may destroy the germinating power of the seed or injure the young plant, and also because the roots of the corn plant do not stay in the hill, but they grow out through the soil in all directions, absorbing moisture and plant food. Corn fertilized in the hill, if the seed or young plants are not injured, frequently makes an abnormally strong growth for a few weeks, and later in the season suffers from dry weather more than ordinary corn, whose roots have developed more normally.

Potassium or other fertilizing material should be applied broadcast or in narrow drills, as a general rule. Any salt of potassium may be applied easily and quickly by hand, sowing or scattering it from the wagon. One farmer in Whiteside County reports having applied 100 pounds to the acre over 22 acres of land in less than three-quarters of a day, a boy being provided to drive the team. Sowing potassium chlorid by hand is less difficult than sowing wheat or oats by hand, because of the necessity of securing a uniform stand of wheat or oats, while it would matter but little if there should be a few square feet now and then which received no potassium. It passes into solution before it becomes fixed in the soil, and will thus be distributed somewhat, and the subsequent preparation of the seed bed and the cultivation of the corn will tend to mix it more uniformly with the soil.

An end gate seeder is a very good implement for applying potassium salts. Probably most farmers could apply the material about as rapidly and more uniformly with an end gate seeder than by hand.

It is good practice to apply the potassium after plowing and then to mix it with the soil by disking, harrowing, etc., in the usual preparation of the seed bed. It should not be applied when the ground is frozen if there is likely to be any overflow or surface drainage before the potassium salt dissolves and soaks into the soil.

REPORTS FROM FARMERS USING POTASSIUM ON PEATY SWAMP SOILS.

Several farmers are using potassium on peaty soils near Manito, both in Mason County and in Tazewell County. Most of them use kainit, because of its low price per ton. (Potassium chlorid is really much cheaper.) About 300 pounds of kainit (30 pounds of potassium) is the usual application. This increases the yield sufficiently so that the farming is not done at a loss, but the yield rarely exceeds half a crop; and when we consider that this peaty swamp soil is one of the richest soils in the state in the element phosphorus, and by far the richest in nitrogen, there is no apparent reason why this soil should not produce 75 to 100 bushels of corn if sufficient potassium is provided. A considerable number of farmers near Tampico have made some use of potassium during the past season, and in all cases I think they have used high grade material; that is, potassium chlorid or potassium sulfate (the sulfate is slightly more expensive than the chlorid.)

As a rule, through careless oversight or thoughtlessness, farmers do not have check plots. Too frequently they do not consider that absolute knowledge has a high money value in farming as well as in other kinds of business. It is a simple matter to leave a two-rod strip of average land across the field, taking care that no potassium is applied to this strip. It is true that the yield of corn will be lower on this strip than where potassium is applied, but it will furnish a direct comparison as to the effect of the potassium, and this knowledge may be worth many times the loss in yield as a guide in subsequent years. This check strip should be left untreated for two or three years at least.

During the season of 1903 the writer visited several fields in Whiteside County where potassium chlorid (or sulfate) had been applied for corn. By comparing the corn on these fields with corn on adjoining farms or fields where no potassium had been used, very marked effects were commonly apparent.

Under date of Nov. 6, 1903, Mr. J. H. Milligan, of Tampico, writes:

"Mr. Wheelock's corn is making from 65 to 70 bushels per acre. This is about 30 to 35 bushels net for potassium.

"Mr. Cortes applied potassium (chlorid or sulfate) at the rates of 40 pounds, 60 pounds, and 100 pounds per acre. The 40 pounds gave no result, the 60 pounds better growth, the 100 pounds makes him corn yielding 50 bushels per acre. He applied in the field on good and bad spots alike. He says where he applied 100 pounds to the acre, the corn grew and yields all about alike, showing no bad spots in growth or yield. He thinks the potassium has made 50 bushels net on all bad spots."

Under date of Nov. 3, 1903, Dr. J. H. Mosher, of Prophetstown, Whiteside County, writes:

"In reply to yours, would say I used muriate of potash of Armour & Co. I paid $56 a ton. I don't know the percent of potassium. Tenant applied 100 to 125 pounds per acre broadcast. Where applied the yield is increased 30 bushels per acre—from 20 to 50. Tenant says in spots of an acre or so it doesn't show much effect. There may be some other trouble with that land."

## "ALKALI" SOILS.

It should be understood that the peaty swamp soils reported in this bulletin are not the same as the so-called "alkali" or "bogus" soils. These "alkali" spots are very numerous in central and northern Illinois. They usually occur in the midst of the very best farming lands. They vary in size from a few square rods to several acres. They are being investigated, and some information regarding them has already been obtained, and it seems appropriate that a brief preliminary report regarding these "alkali" spots should be made in this bulletin, but this report must be considered as tentative and suggestive and not conclusive. Further investigation is needed before complete or definite information regarding these soils can be obtained.

The most common kind of so-called "alkali" spot which we have found does contain alkali, and the soil is not improperly called alkali soil. The alkali, however, is not sodium carbonate, the ordinary strong alkali of the soils of arid countries, but it is magnesium carbonate, a mild alkali. The magnesium carbonate is usually associated with much larger quantities of calcium carbonate (limestone is calcium carbonate). Although magnesium is one of the essential elements of plant food, yet an excessive amount of magnesium carbonate and bicarbonate becomes poisonous to plants, especially to corn and millet.

Usually the magnesium carbonate is more concentrated in the subsoil than in the surface, and if we can provide perfect underdrainage and prevent so far as possible the magnesium carbonate and more soluble bicarbonate from rising to the surface, and also provide abundance of plant food in the surface soil so that the corn roots are not required to live in the subsoil, these alkali soils can be made to grow good corn. In some cases applications of potassium salts may prove beneficial, but as a rule the most practical method for improving these soils is to provide good, deep underdrainage and then plow under coarse organic matter, such as straw, coarse manure, green oats, weeds, etc. This material helps the drainage, tends to prevent the rise of the alkali by retarding surface evaporation, and as it decays it liberates plant food in the surface soil, and it may be that organic acids are also liberated which unite with the magnesium to form less harmful compounds.

We have already ascertained that the magnesium can be removed from the soil by leaching or drainage after being transformed into the perfectly soluble magnesium sulfate by the double decomposition of magnesium carbonate and calcium sulfate, leaving behind harmless calcium carbonate (limestone), and we hope soon to determine whether the quantity and cost of calcium sulfate (gypsum, or land plaster) and the time required for the leaching process will prove to be too great to permit this to be done economically.

If no manure or other material is at hand, it is well to sow oats on these spots, and if they grow rank and fall down plow them under. One or two heavy crops of green oats plowed under will usually put the soil in condition to grow one or more crops of corn, and with perfect drainage these soils will usually improve with heavy cropping, for they are frequently very rich in all elements of plant food. Plenty of tile, laid deep and made to *work* (if necessary by surrounding them with straw, corn cobs, brush, etc.) is all that some of these spots need to make them grow corn.

## METHODS OF SOIL INVESTIGATION.

The Experiment Station does not undertake to analyze miscellaneous samples of soil for private parties. First, because the total annual appropriation for all soil investigations is less than 12½ cents for each quarter section of Illinois land, while it costs at least $25, or 200 times 12½ cents, to analyze a single sample of soil. Second, because analyses of miscellaneous samples of soil, collected by unauthorized and untrained persons, by inaccurate and non-uniform methods, usually imperfectly representing a single field, or sometimes a mere patch of ground, would be of little value even to the owner of the piece of land, and probably of no value to the agriculture of a state.

That farmers generally understand and appreciate that the State Experiment Station cannot, and ought not, to make such analyses is evidenced by the fact that, with few exceptions, there has been no demand upon us by Illinois citizens for such private work at public expense. That it would be impossible to do such work for all Illinois citizens is also evidenced by the fact that we have received as many as eleven samples of soil from one man with the request that they should all be analyzed

The investigation of Illinois soils is being conducted, first, by a General Soil Survey, and second, by a Detail Soil Survey. In the general survey the state is divided into very large soil areas, the divisions being based largely upon the soil formation of the areas. The principal type of soil in each great area is then investigated and reported upon. This gives valuable information concerning all of the principal or most extensive types of soil in the State, although it does not give all of the exact boundary lines of these types, and it does not include any investigation of minor or less extensive types of soil, several of which may be interspersed with the principal type of the area. A preliminary report on the general survey has already been made in Circular No. 68, and a more complete report is nearly ready for publication in bulletin form.

The detail survey is being carried on as rapidly as it can be done with accuracy. In the detail survey all the soils in an area which is being surveyed are gone over very carefully by men who are trained for this work, a complete soil map being made of all the different types of soil in the area. This soil map shows the location, extent, and boundary line of each soil type. In this detail soil mapping the Illinois Experiment Station and the Bureau of Soils of the United States Department of Agriculture are working in close co-operation. Each of these types of soil is then investigated by the Experiment Station, not only by analyzing samples of the soil, but, so far as possible, by pot cultures and by field experiments similar to those described in this bulletin. All soil samples taken for analysis are collected by Experiment Station men, who are familiar with the most accurate and scientific methods of sampling soils, in order that the samples shall be taken by uniform methods which shall render them comparable, and that they shall be truly typical samples of the different strata of the kind of soil which they are to represent. If the samples do not truly represent the soil type, the analyses would, of course, be practically worthless. It will never be possible for the Experiment Station to analyze the soil from every field of every Illinois farm, but it is possible and practicable to map the soils of the state in detail, and then to analyze representative samples of every type, so that ultimately every farmer can know what type or types of soil cover his farm, what the average composition is of each type, what crops are best adapted to the different soils, and what kinds of soil treatment or management are required to maintain or increase the crop yields.

More than one-tenth of the state has now been covered by the detail soil survey, and the samples which have been collected are now being analyzed and the results will be published in bulletin form from time to time, as the work progresses. Every farmer should make the greatest possible use of the reports on the general survey until such time as the detail survey is extended over his land. Circular No. 68, already published, furnishes information which more than half the farmers in Illinois can apply to their own soils, if they will study it as other business men study their business.