UNIVERSITY OF ILLINOIS

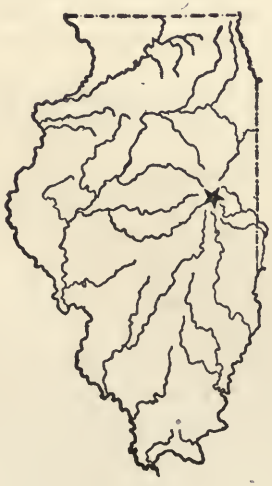
Agricultural Experiment Station

BULLETIN No. 115

SOIL IMPROVEMENT FOR THE WORN HILL LANDS OF ILLINOIS

(With special reference to Southern Illinois)

By CYRIL G. HOPKINS and J. E. READHIMER



URBANA, ILLINOIS, APRIL, 1907

Summary of Bulletin No. 115

1. Large areas of worn hill land, chiefly in southern and western Illinois, are becoming poor and unproductive. Page 431.

2. These soils are most deficient in the element nitrogen and in humus, and, if they would grow well, marked improvement could be made by clover, alfalfa, cowpeas, or other legumes, provided the crop or the manure made from it is plowed under. Page 432.

3. Most of these hill lands are so acid, or sour, that legume crops, especially clover and alfalfa, cannot be grown successfully; but they grow well where the acidity has been destroyed by an application of ground limestone. Page 433.

4. Where a three-year rotation of corn, wheat and clover (or cowpeas) has been grown in Johnson County the past three years, the average annual value of the grain crop has been $7.75 an acre on untreated land, $9.54 an acre where legumes have been plowed under, and $14.71 an acre where limestone has been applied and legumes plowed under. Page 436.

5. Ground limestone can now be secured very cheaply from the Illinois State Penitentiary at Menard, Illinois, and also from several other points in Illinois and adjoining states. Page 442.

SOIL IMPROVEMENT FOR THE WORN HILL LANDS OF ILLINOIS

(With special reference to Southern Illinois)

By CYRIL G. HOPKINS, Chief in Agronomy and Chemistry, and J. E. READHIMER, Superintendent of Soil Experiment Fields

There are large areas of worn hill land in Illinois that were once rich and productive but are now becoming poor and unproductive. By proper methods these lands can be profitably improved at small expense.

These sloping hill lands are especially extensive in the seven southernmost counties of Illinois; also in counties bordering the Mississippi, Wabash, and Illinois Rivers and to some extent along other smaller streams.

In most respects these hill lands are all very much alike and certain methods of soil improvement apply to all of them, especially for the so-called "clay hills," the soil of which, however, is not clay in the true sense, but rather a silt soil consisting largely of silt, a grade of soil particles intermediate between clay and sand, with only a small admixture of true plastic clay.

As to the composition of these worn hill lands, with respect to the essential and valuable elements of plant food, large numbers of analyses have shown that they are exceedingly rich in potassium, moderately well supplied with phosphorus, but exceedingly deficient in nitrogen. They are also very deficient in organic matter, or humus, and in southern Illinois, especially, these soils are acid or sour and consequently deficient in lime.

For the improvement of these soils they should be treated with some form of lime (as ground limestone), and then legume crops should be grown frequently in rotations to be plowed under as green manures or fed to live stock and returned to the soil in farm manure. The limestone will help especially the clover crop and this use of clover, cowpeas, soybeans, alfalfa, and other legume crops which have power to secure nitrogen from the air (a power not possessed by other crops) will add nitrogen to the soil and also restore the humus, or organic matter, which will help to prevent

surface washing; and, as it rots, or decays, in contact with the soil, this fermenting organic matter will tend to dissolve and liberate from the soil the phosphorus and potassium needed for the growth of crops.

These lands should be kept in meadow and pasture at least half of the time, and if they are too rolling they should be plowed up only once in eight or ten years to give an opportunity to repeat the limestone application and work it well into the soil. After one crop of corn and one or two small grain crops, they should be seeded down again for meadow and pasture, using a mixture of red clover, alsike clover (which lives longer than red clover), timothy, and a little red top.

The following record of investigations, including pot cultures and field experiments, will show the actual results already obtained in the improvement of these soils.

THE VIENNA EXPERIMENT FIELD

The Vienna soil experiment field is located on worn hill land about one mile southeast of Vienna, Johnson County, on the farm of Mr. J. M. Price. The soil on which the field is located is representative of the red silt loam hill land of the unglaciated area, comprising the greater portion of the seven southernmost counties of the state: Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac. This type also extends north into Jackson, Williamson, Saline, Gallatin, and other counties. The soil is yellowish red in color and is commonly spoken of as the red clay hill soil of southern Illinois. It is most deficient in the element nitrogen. It is somewhat poor in phosphorus, but the total supply of potassium is very great. It is, as a rule, too acid to grow clover successfully. It is also very poor in humus, or decaying organic matter, so much so that not even potassium is rendered available as rapidly as needed by the growing crops. The land on which the field is located has been cropped for about seventy-five years. It is somewhat rolling and has surface-washed to some extent in places. It had never had any soil treatment so far as can be determined. It was badly run down when the Agricultural Experiment Station came into possession of it in 1902.

PLAN OF EXPERIMENTS

The field is divided into three series of five fifth-acre plots. A three-year rotation of corn, cowpeas, and wheat was followed for

four years, then changed to corn, wheat, and clover. In 1902, oats were grown in the place of wheat.

The soil treatment has been as follows:

Plot 1 of each series, no treatment except as the cowpea stubble or the second growth of clover has been plowed under in the regular course of the rotation.

Plot 2, legume catch crops plowed under.

Plot 3, legumes plowed under and lime applied.

Plot 4, legume, lime, and phosphorus.

Plot 5, legume, lime, phosphorus, and potassium.

The legume treatment consists of plowing under legume catch crops grown after the wheat and in the corn after the last cultivation. The first three crops of cowpeas in the regular rotation were also plowed under, one crop on each of the series on all of the plots except the untreated check plot, No. 1. Since that time the regular cowpea crops have been harvested and removed from all of the plots.

The primary object in applying lime is to correct soil acidity. In the spring of 1902 one ton per acre of slacked lime was applied; but, a method having been worked out by which we were able to determine by chemical analysis how much lime is equivalent to the soil acidity to any depth, it was found that the soil on this field was acid in the surface, more acid in the subsurface, and still more acid in the subsoil, and in order to provide ample lime to correct this acidity an additional application of eight tons per acre of ground limestone was made in the fall of 1902. While the lime does not descend into the subsoil in appreciable amounts, some acidity from the subsoil may be brought to the surface in capillary moisture. Further investigations are in progress relating to the liming of soils, but from all information now available it is believed that two to four tons per acre of ground limestone as an initial application will give very satisfactory results. Heavier applications may possibly give more profit per acre, but less profit per ton of limestone used.

Phosphorus has been applied at the rate of 25 pounds, and potassium at the rate of 40 pounds, per acre per annum, the present regular practice being to apply once in three years 600 pounds of steamed bone meal, containing 12½ percent phosphorus, and 300 pounds of potassium sulfate, containing 40 percent of potassium.

Four crops of wheat, one of oats, five of corn and five of cowpeas have been grown on the field since the work was begun in 1902. The yields of wheat and oats are given in Table 1.

TABLE 1.—CROP YIELDS FROM VIENNA SOIL EXPERIMENT FIELD

Soil plot Nos.	Red silt loam hill land of the unglaciated area.	Bushels per acre.					
		1902 Oats, series 200.	1903 Wheat, series 300.	1904 Wheat, series 200.	1905 Wheat, series 100.	1906 Wheat, series 200.	Total from last 3 crops.
	Treatment applied.	Total yield.	Total yield.	Total yield.	Total yield.	Total yield.	Wheat, bu.
1	None.....	19.1	.4	6.7	1.3	3.8	11.8
2	Legume	18.8	.6	7.1	10.8	5.4	23.3
3	Legume, lime.	19.8	.7	10.0	18.2	17.9	46.1
4	Legume, lime, phosphorus.	20.0	8.0	14.8	25.6	11.3	51.7
5	Legume, lime, phosphorus, potassium ..	31.7	11.0	17.5	30.0	15.0	58.7

In 1903 the wheat crop was almost a failure in this section of the state. The first three plots produced less than a bushel per acre. Plot 4 produced 8 bushels, while plot 5 produced 11 bushels, indicating that the decaying organic matter was so deficient that the phosphorus and potassium naturally present in the soil were not made available.

In 1905, the yield was increased from 1.3 bushels on the untreated plot to 18.2 bushels on the legume-lime plot, a gain of 16.9 bushels per acre, due to the plowing under of cowpeas, which had grown much better where lime was applied. The addition of phosphorus and potassium gave a further increase.

In 1906, legume-lime treatment increased the yield from 3.8 bushels on the check plot to 17.9 bushels, an increase of 14.1 bushels. The addition of phosphorus and potassium produced no increase, and the yields were irregular, for some reason not yet understood.

By computing from the total wheat yields for the last three years we have the following results:

Untreated land produced	11.8	bushels
Legume treatment increased the yield.....	11.5	"
Legume-lime treatment increased the yield.....	34.3	"
Land with legume-lime treatment produced.....	46.1	"
Phosphorus treatment increased the yield.....	5.6	"
Potassium treatment increased the yield.....	7.0	"

It will be seen that the use of legume green manure crops has doubled the yield of wheat and that four times as much wheat has been grown where legume-lime treatment has been used as on the

untreated land. It should be kept in mind, however, that the important direct effect of the lime (ground limestone) is to increase the growth of the green manure crops.

The yields of corn for the five years are given in Table 2.

TABLE 2.—CORN YIELDS FROM VIENNA SOIL EXPERIMENT FIELD

Soil plot Nos.	Red silt loam hill land of the unglaciated area.	Corn, bushels per acre.					
		1902 Series 100.	1903 Series 100.	1904 Series 300.	1905 Series 200.	1906 Series 300.	Total from last 3 crops.
	Treatment applied.	Total yield.	Total yield.	Total yield.	Total yield.	Total yield.	Corn, bu.
1	None.....	15.5	9.3	30.5	37.5	41.2	109.2
2	Legume.....	13.3	5.0	35.5	42.9	40.6	117.0
3	Legume, lime.	14.9	8.3	49.1	61.9	48.9	159.9
4	Legume, lime, phosphorus .	12.5	7.4	49.4	57.2	40.9	147.5
5	Legume, lime, phosphorus, potassium ..	19.9	11.6	44.7	56.5	40.9	142.1

We see from Table 2 that the yields of corn were small in 1902 and 1903. This was partly due to the dry weather, and partly due to the lack of available plant food, there having been no previous legume treatment for the 1902 corn crop and but a light catch crop of cowpeas grown in 1902 for the 1903 corn crop. The yields were much larger in 1904, 1905, and 1906 because there had been more nitrogen and decaying organic matter added to the soil through the turning under of cowpeas which usually made a good growth where lime had been applied, and the seasons were better.

By adding the results for the last three years we have the following significant figures:

The untreated land produced..... 109.2 bushels
Legume treatment alone increased the yield only. 7.8 "
Legume-lime treatment increased the yield..... 50.7 "

Neither phosphorus nor potassium increased the yield of corn beyond that produced by legume-lime treatment. In some cases the yields are even lower where these elements were applied. This is doubtless due to natural differences in these plots, Nos. 4 and 5 being more subject to surface washing than Nos. 1, 2, and 3. (It is the regular plan to put the untreated check plots on the best land and the best treated plots on the poorest land, if any natural differences exist in the field.)

While some gains have been made on wheat and corn by legume treatment without lime, the most marked and by far the most profitable gains have been made where lime (ground limestone) has been used in connection with the legume green manures. At 70 cents a bushel for wheat and 35 cents a bushel for corn, the value of the increase produced by lime as an average of the years 1904, 1905, and 1906, has been $5.32 an acre for wheat and $5.01 for corn. These amounts would pay 5 percent interest on more than $100, which is five to ten times as much as would be needed to make a heavy initial application of ground limestone.

Pot Culture Experiments on Unglaciated Hill Land

Some very instructive results have been obtained from a series of pot culture experiments which have been in progress since 1902 in the pot culture greenhouse, and in which this red silt loam of the unglaciated hill land has been used. The soil was collected by Mr. W. O. Farrin in the fall of 1901 and represents the old worn hill soil of Pulaski County. It is much poorer in nitrogen and humus than the average of the type, although large areas are to be found as badly worn as the field from which this soil was collected. This field has been under cultivation for about seventy-five years and was still being cropped when the soil was collected. During the earlier period of its cultivation the soil frequently produced 25 bushels of wheat an acre, but during the later years about 5 bushels has been the average crop in normal seasons.

The first year's work with these pot cultures was performed by Mr. Farrin as a thesis for graduation from the University of Illinois, College of Agriculture, in 1902.

Table 3 gives the results of five years' experiments with pot cultures on this type of soil.

From a study of Table 3 it is seen that practically no gain has been made except where nitrogen was supplied, either directly in commercial form or indirectly by means of legume treatment. It should be borne in mind that no legume treatment preceded the 1902 wheat crop. The catch crop of cowpeas which was planted after the 1902 wheat crop and turned under later in the fall produced a marked effect upon the 1903 wheat crop. This effect became more marked in 1904 and 1905 when every pot receiving legume treatment outyielded the pot receiving lime-nitrogen treatment. Previous to 1905, the addition of phosphorus to nitrogen or legume treatment always increased the yield, and the addition of potassium still further increased the yield after the first year.

The effect of both phosphorus and potassium has been less where decaying organic matter has been provided in the legume treatment than where the nitrogen has been supplied in commercial form carrying but little organic matter. Since 1905 there has been practically no effect from either the phosphorus or potassium when added to legume treatment. When added to commercial nitrogen, however, they both gave a substantial gain in yield. This condition is doubtless brought about by the liberation of both phosphorus and potassium from the soil by the decay of the organic matter of the legume.

The last line in the table gives the yields from a pot of virgin soil collected from a piece of unbroken virgin sod land adjoining the cultivated field from which the soil in all the other pots was taken. It is seen that the yields from this pot are gradually decreasing, doubtless due to the exhaustion of the nitrogen contained in the soil.

TABLE 3.—WHEAT YIELDS FROM PULASKI COUNTY SOIL
(Pot culture experiments)

Red silt loam hill land of the unglaciated area. Soil treatment applied.	1902 Wheat, grams.	1903 Wheat, grams.	1904 Wheat, grams.	1905 Wheat, grams.	1906 Wheat, grams.	Total for last 4 years. Wheat, grams.
None	3	5	4	4	4	17
Legume, lime	4	10	17	26	19	72
Legume, lime, phosphorus	3	14	19	20	18	71
Legume, lime, phosphorus, potassium	3	16	20	21	19	76
Lime, nitrogen	26	17	14	15	9	55
Lime, phosphorus	3	6	4	6	4	20
Lime, potassium	3	3	3	5	5	16
Lime, nitrogen, phosphorus	34	26	20	18	18	82
Lime, nitrogen, potassium	33	14	21	21	16	72
Lime, phosphorus, potassium	2	3	3	5	3	14
Lime, nitrogen, phosphorus, potassium	34	31	34	21	20	106
Virgin soil (no treatment)	24	17	15	17	13	62

The results from the pot cultures bear out very conclusively the results obtained from the field tests; namely, that marked improvement can be made on this soil by turning under legume crops where lime has been applied.

Another series of pot culture experiments, with soil from the worn hill lands of Henry County, in northwestern Illinois, carried on at the university by Mr. I. D. Allison, under the direction of the Agricultural Experiment Station, furnishes additional information concerning the great need of nitrogen for these hill lands.

The plan of these experiments, the soil treatment applied, and the results obtained are all shown in Table 4.

TABLE 4.—OAT YIELDS FROM HENRY COUNTY SOIL
(Pot culture experiments)

Gray silt loam hill land Upper Illinois Glaciation. Soil treatment applied.	Oat yields, grams per pot.
None	5
Lime	4
Lime, nitrogen	45
Lime, phosphorus	6
Lime, potassium	5
Lime, nitrogen, phosphorus	38
Lime, nitrogen, potassium	46
Lime, phosphorus, potassium	5
Lime, nitrogen, phosphorus, potassium	38
Nitrogen, phosphorus, potassium	31
None	5

It will be seen that the yield of oats was increased from about 5 to 40 by the addition of nitrogen. In other words, where nitrogen was applied the yield of oats was about eight times as large as where no nitrogen was applied to the soil.

No definite effect can be seen from the use of phosphorus or potassium. The application of lime alone without nitrogen produced no benefit, but it is noteworthy, perhaps, that the lowest yield obtained with nitrogen added was where lime was omitted, thus indicating that lime and nitrogen together are best for this soil. This means, of course, that if the soil is sour, lime should be applied, and then legume crops should be grown to get nitrogen from the air, these crops to be plowed under either directly or in farm manure.

CROP ROTATIONS

The methods employed by which the most profitable results given in Tables 1 and 2 have been obtained consist of crop rotation, in which a legume has been grown every third year in the regular rotation and also legume catch crops, as cowpeas, planted after the wheat and in the corn to supply the humus and nitrogen so badly needed; also the addition of sufficient lime to correct the acidity of the soil in order to encourage the development and activity of the nitrogen-fixing and nitrifying bacteria. The rotation practiced on this soil experiment field has been a three-course system of corn, wheat, and legume, with catch crops of legumes after the wheat and in the corn at the time of the last cultivation. A longer rotation of six years is even better adapted to the worn hill lands of southern Illinois. The following is suggested:

First year, corn
Second year, cowpeas or soybeans
Third year, wheat
Fourth year, clover and timothy meadow
Fifth year, pasture
Sixth year, pasture

A legume catch crop should be planted in the corn at the last cultivation. For this purpose cowpeas serve very well, but some results already obtained in other experiments indicate that ordinary sweet clover (melilotus alba) will be of very much greater value. This may be allowed to stand over winter and make a large growth before being plowed under in the late spring and before planting the regular cowpea crop.

If sweet clover is to be seeded the land should be inoculated by scattering a few hundred pounds to the acre of infected soil collected from old alfalfa land or from a patch of sweet clover which is well provided with root tubercles.

In practicing a six-year rotation the farm should be divided into six nearly equal fields so that every crop may be grown every year. Thus, on a 120-acre farm there would be 20 acres of corn, 20 acres of cowpeas or soybeans, 20 acres of wheat, 20 acres of clover, and two 20-acre pastures, and every year there should be 20 acres of second-year pasture ground to be plowed for corn, and 20 acres of cowpea or soybean ground to be seeded to wheat. If any crop fails some other similar crop should be substituted which will not seriously interfere with the rotation. Thus, if wheat winter-kills, oats may be seeded in the spring and the clover seeded with the oats.

The Use of the Crops

The wheat should be sold and also the clover seed if not needed for home use. Some cowpea or soybean seed and some corn may also be sold, but all forage, hay, corn stover, and wheat or oat straw, and most of the corn should be fed on the farm, plenty of bedding being used and all manure carefully returned to the land, preferably as soon as possible after being made. It may be spread on the meadow or pasture land which is to be plowed for corn. If desirable, the cowpea or soybean crop may largely be "hogged" off, thus getting the benefit of the seed, while the vines and the manure dropped by the hogs are left on the land to enrich it for the wheat crop. If there is permanent pasture on the farm, this rotation may be reduced to the first four years.

The Use of Limestone

The old worn hill soils of the unglaciated area are markedly acid and farmers find it difficult to grow clover successfully on them. At least two tons to the acre of ground limestone should be applied as an initial application. Afterward one ton to the acre every four to six years will probably be sufficient to keep the soil sweet.

There is no danger of applying too much ground limestone. The Agricultural Experiment Station of Illinois has applied as high as 10 tons per acre with only good results; and the Rothamsted (England) Experiment Station reports applications of chalk equivalent to 100 tons per acre of ground limestone, and the soil remains very productive. It is well known that natural limestone soils are both productive and durable.

From two to four tons per acre of ground limestone should be sufficient to give profitable returns, although four to eight tons per acre might give better and more profitable returns per acre, but probably less profit per ton than the lighter application. Any other form of lime may be used in place of limestone if it can be obtained more cheaply, provided an ample supply of organic matter is maintained in the soil.

The limestone may be applied at any time when it can be hauled and spread. It will not give the best results till it becomes well mixed with the plowed soil.

It has been proved that alfalfa will not grow successfully on the worn hill lands of southern Illinois without lime, but that it grows luxuriantly where the land has first been well limed.

THE USE OF PHOSPHORUS

While phosphorus has produced some marked results on the wheat crop, it has not as yet increased the yield of corn, and has not been used with profit in the rotation.

It is very probable that after the land has been much improved with the use of lime and the turning under of legume crops and manures and other organic matter, then we may be able to use phosphorus with profit to increase still further the crop yields; but further investigation is needed to determine this.

It should be remembered that even where we try to prevent surface-washing by very deep plowing, by use of winter cover crops, and by keeping the land in pasture much of the time, there is still some loss of surface soil from rolling land. This brings new supplies of phosphorus within reach of the feeding roots of plants; so that a system of permanent agriculture (of low grade at least) is possible on these soils without the return of phosphorus.

THE USE OF POTASSIUM

As was stated in the beginning, the total supply of potassium in these soils is very great. Still the application of potassium has always produced an effect on the wheat crop. This is possibly due to the stimulating or corrosive effect of the potassium salt in liberating other plant food elements, as nitrogen and phosphorus, rather than the direct effect of the element as plant food. It will be noted that as the supply of organic matter is increased in the soil the effect of potassium is less and less marked. Where the supply of potassium in the first seven inches of the soil is sufficient to produce two thousand forty-bushel crops of wheat, it would seem unnecessary to apply it to the land. We believe that when more decaying organic matter has been worked into the soil all of the potassium that is necessary for the growth of maximum crops will be made available. We, therefore, do not recommend the use of potassium on these soils.

PERMANENT SYSTEMS

We should allow 50 cents an acre a year for ground limestone, after the heavy initial application has been made (the cost of which should be added to the value of the land), one ton costing about $1.00 to $2.00 delivered in carload lots at most railroad stations in southern or western Illinois. It is assumed that the seed for legume catch crops will be raised on the farm, and in some cases, as with

cowpeas or soybeans, the pasturing of such crops may pay for seed and seeding.

As a rule, the greatest difficulty to be overcome in the introduction of a more intensive system of agriculture, by which larger crops and greater profits are to be made, is for the farmer to persuade himself to hold fast to a good rotation of crops and to continue to make good use of all obtainable farm manure, by which means alone can he hope to maintain sufficient nitrogen and humus in the soil.

Neither ground limestone, nor steamed bone meal, nor raw natural rock phosphate will ever injure the land, but the benefit to be derived from the use of those materials alone is temporary in continuous grain growing, and no profitable and permanent system of agriculture can be adopted for Illinois which does not include a rotation of crops with a liberal use of legumes, and it is exceedingly good practice to make and use as much farm manure as possible.

APPLICATION OF LIMESTONE

It makes no great difference as to when or how we apply such materials as ground limestone, rock phosphate, or steamed bone meal, except that they must be well mixed with the soil before the best results can be secured, consequently there is likely to be less benefit the first year than in later years.

Probably one cannot do better than to apply limestone on newly plowed land in August or September, to be mixed with the soil by disking, harrowing, etc., in preparing the ground for wheat where clover is to be seeded the next spring.

Steamed bone meal is commonly drilled in with the wheat, but, if rock phosphate is used, it should be plowed under with manure or clover or other decaying organic matter.

For much further information concerning the methods of applying limestone, including directions for making a limestone spreader, comparative value of burned lime, slacked lime, and ground limestone, see Illinois Circular 110, "Ground Limestone for Acid Soils."

This will be sent free of charge upon application to Director E. Davenport, Agricultural Experiment Station, Urbana, Illinois; and if requested the applicant's name will be placed upon the permanent mailing list for subsequent publications.

Notes.—Ground limestone now can be obtained at 75 cents a ton from the Southern Illinois Penitentiary, Menard, Ill., and at different prices from Casper Stolle Quarry & Contracting Co., St. Louis, Mo., (quarry at Stolle, Ill.); Southwestern Contracting & Engineering Co., East St. Louis, Ill.; Crystal Carbonate Lime Company, Ellsberry, Mo.; Carthage Superior Limestone Co., Carthage, Mo.; Mitchell Lime Company, Mitchell, Ind. Some of these companies furnish fine ground limestone and some furnish limestone screenings, which include both very fine dust and some coarser particles, even as large as wheat grains. In carload lots the price on board cars at the plant varies from 50 cents to $1.00 a ton, according to the fineness. The freight charges will vary from 50 cents or less to $1.50 or more, depending upon the distance. At most points in Illinois the cost delivered in bulk in box cars should be between $1.00 and $2.00 a ton. The quickest action will be secured by using the finest material and mixing it most thoroughly with the soil, but sometimes one can get one and one-half tons of material containing one ton of fine dust and half a ton of coarser particles, varying in size from less than pin heads to wheat grains, at no greater expense than would be required for one ton of fine ground stone containing no coarser particles.

Finely ground raw rock phosphate (12½ percent phosphorus) can be obtained from Robin Jones, Nashville, Tenn., or from the N. Y. & St. L. Mining & Mfg. Co., St. Louis, Mo., delivered in carload lots for about $8.00 a ton in southern Illinois, the cost being $1.00 to $2.00 higher for central and northern Illinois points.

A good grade of steamed bone meal (about 12½ percent phosphorus) can be obtained delivered in Illinois for about $25.00 a ton, from the local agents of Morris & Co., Swift & Co., or the Packers Fertilizer Association, Chicago, Ill., or from Michigan Carbon Works, Detroit, Mich.