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# PHOSPHATES FOR KENTUCKY SOILS

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## PHOSPHATES FOR KENTUCKY SOILS

**By R. E. STEPHENSON**

After the application of lime, the fertilizer most needed on Kentucky soils outside the Bluegrass section is some form of phosphate. The common sources of phosphorus are acid phosphate, basic slag, bone meal and ground rock phosphate.

The question naturally arises, which form is the most desirable to use. Since rock phosphate is by far the cheapest source of phosphorus its effectiveness has been tested in comparison with acid phosphate which is the most commonly used of any phosphate fertilizer.

Acid phosphate is made by treating a given weight of rock phosphate with an equal weight of sulfuric acid to change the phosphate of the rock into a more soluble form of higher availability to crops. A ton of raw ground phosphate rock of the grade generally used therefore contains twice as much phosphorus (12 to 14 per cent of the element) as a ton of standard acid phosphate. The phosphorus of the rock will gradually become available, the only question being whether it will act rapidly enough to give profitable returns.

The following tables give the increases of the different crops in the rotation (corn-soybeans-wheat-clover) on six Kentucky soil experiment fields, representing six different types of soil. Acid phosphate was used at the rate of 800 lbs., rock phosphate 1600 lbs., and limestone 2 tons per acre per rotation. In computing the returns, corn was valued at $1.00 per bushel, wheat at $1.50 per bushel, and hay from soybeans and clover $1.00 per hundred. The acid phosphate was valued at $25.00 per ton, or $10,00 per acre for the 800 lbs.; the rock phosphate at $12.50 per ton, or $10.00 per acre for the 1600 lbs., and the limestone at $2.50 per ton, or $5.00 per acre for the two tons per rotation.

The total value of the crop increases is given, with the net returns and per cent profit for each of the phosphates used alone and with limestone. It must be remembered that net returns and per cent profit are based upon the above prices of crops and fertilizers, and will vary, of course, with varying prices. No charge is made for the labor of their application, but neither is any value given the corn stover and wheat straw produced. The one should about offset the other. The comparisons are made on 40 corn crops, 34 soybean crops, 27 wheat crops, and 24 clover crops that have been produced during the 3 to 8 years in which the fields have been under experiment.

The soils of the central Bluegrass region are too rich in phosphorus for phosphate treatments to show results; consequently data from the Lexington soil experiment field are not presented. Only crop increases are given in the summary tables, but the yields of the check plots are given in the last table to which the increases may be added to obtain total yields.

When net returns are considered (value of increase less cost of fertilizers) the rock phosphate has given $3.01 per acre per year compared with $1.91 for acid phosphate, averaging all fields and all years. On the same basis lime and rock phosphate have given $8.08 compared with $11.12 for lime and acid phosphate per acre per year. Neither acid phosphate nor rock phosphate alone gave sufficient increase to pay its cost on the Lone Oak field, and acid phosphate failed to pay for its cost on the Mayfield field. Leaving these two fields out, the showing is much better for the other fields, as may be observed from the table below. Wherever lime was used with the phosphates there was a profitable return, tho on the Fariston field the returns were greater from rock phosphate when lime was not used.

The following tables giving yields on the various soil experiment fields are included for the benefit of those who wish to study more in detail the results which may apply to their own soil areas.

**Acid Phosphate and Rock Phosphate on Unlimed Soil.**

Crop Increases per Acre
Averages from All Fields.

| | Kind of Phos. | Corn, Bus. | Soybean Hay, Lbs. | Wheat, Bus. | Clover Hay, Lbs. | Gross Value of Increase | Net Return | Per Cent Profit |
|---|---|---|---|---|---|---|---|---|
| Greenville | RP* | 7.4 | 748 | 4.1 | 1673 | $37.76 | $27.76 | 277.6 |
| | AP | 6.5 | 646 | 3.0 | 458 | 22.04 | 12.04 | 120.4 |
| Lone Oak | RP | -0.5 | -22 | 1.0 | 294 | 3.72 | -6.28 | -62.8 |
| | AP | -0.5 | -64 | -1.2 | 238 | -0.56 | -10.56 | -105.6 |
| Mayfield | RP | 2.3 | 287 | 1.1 | 542 | 12.24 | 2.24 | 22.4 |
| | AP | 3.0 | 16 | 2.3 | 175 | 8.36 | -1.64 | -16.4 |
| Russellville | RP | 4.6 | 502 | 4.1 | 1249 | 28.26 | 18.26 | 182.6 |
| | AP | 5.9 | 504 | 3.5 | 840 | 24.59 | 14.59 | 145.9 |
| Berea | RP | 4.8 | 571 | 2.3 | 203 | 15.99 | 5.99 | 59.9 |
| | AP | 5.5 | 720 | 2.2 | 157 | 17.57 | 7.57 | 75.7 |
| Fariston | RP | 17.7 | 797 | 3.0 | 402 | 34.19 | 24.19 | 241.9 |
| | AP | 15.7 | 592 | 4.3 | 578 | 33.85 | 23.85 | 238.5 |
| Average | RP | 6.05 | 480.5 | 2.6 | 727 | 22.03 | 12.03 | 120.3 |
| | AP | 6.01 | 402. | 2.35 | 408 | 17.64 | 7.64 | 76.4 |

*AP=Acid Phosphate.
RP=Rock Phosphate.
Minus sign (—) means decreased yield or loss.

**Acid Phosphate and Rock Phosphate on Limed Soil.**

Crop Increases per Acre

Averages from all Fields

| | Kind of Phos. | Corn, Bus. | Soybean Hay, Lbs. | Wheat, Bus. | Clover Hay, Lbs. | Gross Value of Increase | Net Returns | Per Cent Profit |
|---|---|---|---|---|---|---|---|---|
| Greenville | RP* | 14.2 | 1516 | 5.2 | 1474 | $51.90 | $36.90 | 246.0 |
| | AP | 16.7 | 1928 | 7.7 | 1979 | 67.32 | 52.32 | 348.8 |
| Lone Oak | RP | 7.4 | 734 | 5.4 | 1481 | 37.65 | 22.65 | 151.0 |
| | AP | 4.3 | 657 | 6.5 | 1825 | 38.87 | 23.87 | 159.1 |
| Mayfield | RP | 11.8 | 1094 | 9.0 | 2652 | 62.76 | 47.76 | 318.4 |
| | AP | 12.0 | 789 | 7.5 | 2836 | 59.50 | 44.50 | 296.7 |
| Russellville | RP | 6.0 | 635 | 4.8 | 1963 | 39.18 | 24.18 | 161.2 |
| | AP | 8.8 | 742 | 7.5 | 2072 | 48.19 | 33.19 | 221.3 |
| Berea | RP | 14.6 | 1474 | 5.8 | 1930 | 57.34 | 42.34 | 282.3 |
| | AP | 12.8 | 1568 | 8.6 | 2163 | 63.01 | 48.01 | 320.7 |
| Fariston | RP | 13.4 | 1029 | 2.8 | 724 | 35.13 | 20.13 | 133.5 |
| | AP | 28.7 | 1954 | 7.7 | 1982 | 79.61 | 64.61 | 430.7 |
| Average | RP | 11.2 | 1080 | 5.5 | 1704 | 47.30 | 32.30 | 215.3 |
| | AP | 13.9 | 1273 | 7.6 | 2143 | 59.46 | 44.46 | 296.4 |

* AP=Acid Phosphate.
RP=Rock Phosphate.
Minus sign (—) means decreased yield or loss.

**Yields on Check Plots of All Fields.**

| | Corn, Bus. | Soybean Hay, Lbs. | Wheat, Bus. | Clover Hay, Lbs. | Gross Value |
|---|---|---|---|---|---|
| Greenville | 30.5 | 1840 | 7.4 | 679 | $66.79 |
| Lone Oak | 34.8 | 2574 | 10.3 | 1772 | 93.71 |
| Mayfield | 25.8 | 2269 | 7.9 | 368 | 64.02 |
| Russellville | 34.5 | 2064 | 12.0 | 1707 | 90.21 |
| Berea | 26.4 | 2584 | 5.2 | 116 | 61.20 |
| Fariston | 13.3 | 1174 | 3.3 | 137 | 31.36 |
| Average | 27.55 | 2084 | 7.7 | 797 | $67.88 |

From the tables above it may be observed that when rock phosphate and acid phosphate are compared on unlimed soil, the rock phosphate is ahead in every case, except on the Berea field, when the total value of the increase is considered. It is worthy of note that neither acid phosphate nor rock phosphate shows any considerable effect on unlimed soil on the Lone Oak field.

When limestone is used with the phosphate treatments, the results are reversed. When total values are considered, rock phosphate and limestone stands ahead only on the Mayfield field. There are some variations for the individual crops which may be easily noted from the tables, but these are not especially significant.

Lime and fertilizers have been applied in the amounts already noted once each four years on the corn ground, but their effect is not completely exhausted in that time. When crop residues (straw, stalks, etc.) or manure are returned, quite an appreciable portion of the phosphorus used in the growing crops gets back to the soil.

Calculation of the phosphorus required for average yields produced shows that about two-thirds of the phosphorus applied in acid phosphate is used each rotation by the crops grown. This gives in round numbers 20 pounds of phosphorus in excess of the requirement. If the application were halved there would still be enough phosphorus to supply three-fourths of the total requirements, and more than enough to supply the actual crop increase. If then three-fourths of the phosphorus used by the crops produced is turned back to the soil (in the form of manure and residues) phosphorus is being supplied at rates approximately 1 1/3 times as fast as used, a reserve is being stored up in the soil, and the soil should get better each rotation.

In the case of rock phosphate, four times as much phosphorus is actually applied to the soil, in 1600 lbs. of raw rock, as in 800 lbs. of acid phosphate; an excess of approximately 185 pounds of phosphorus is applied each rotation, or more than six times the actual crop demands. If the application were halved there would still be more than three times the rotation demands. Add to this the phosphorus turned back to the soil in manure (approximately three-fourths of the amount used by the crops) and it is easy to see that the soil is rapidly building up in phosphorus content. Applications at this smaller rate should double the phosphorus content of the soil in 10 to 15 years. When only residues instead of manure are returned, phosphorus does not accumulate in the soil as rapidly because from half to three-fourths of the phosphorus used by crops is removed in the grain.

The large amount of phosphorus obtained in the rock phosphate is the strong argument for its use. Everyone is well aware of the fertility of the soils of the central Bluegrass section. That the chief reason for their superior fertility lies in their high phosphorus content is likewise fully understood. But the phosphorus in these soils is mostly in exactly the same chemical combination as that in the ground raw rock used in the field tests above. Rock phosphate therefore is quite effective where it is a natural constituent of the soil and there is no reason why it should not be effective where rightly used as a source of phosphorus on poor soils.

## WHERE THE RESULTS ARE APPLICABLE

The results obtained on the Berea field will apply to the knob regions of Bath, Bullitt, Estill, Fleming, Garrard, Jefferson, Lewis, Madison, Marion, Nelson, Oldham and Powell counties.

Those of the Russellville field will apply to the limestone region of southwestern Kentucky, which includes parts of Adair, Allen, Barren, Breckenridge, Bullitt, Caldwell, Casey, Christian, Clinton, Crittenden, Cumberland, Edmonson, Grayson, Green, Hardin, Hart, Larue, Livingston, Logan, Lyon, Meade, Metcalfe, Monroe, Pulaski, Rockcastle, Russell, Simpson, Taylor, Todd, Trigg, Warren and Wayne counties.

Those of the Mayfield and Lone Oak fields will apply to the soils of Ballard, Calloway, Carlisle, Fulton, Graves, Hickman, Marshall and McCracken counties.

The results from the Greenville field will apply to the Western Coal Field which includes parts of Butler, Caldwell, Christian, Daviess, Edmonson, Grayson, Hancock, Henderson, Todd and Union counties and all of Hopkins, McLean, Muhlenberg, Ohio and Webster counties.

Those from the Fariston field will apply to the western part of the Eastern Coal Field and the worn lands of the eastern half of the Eastern Coal Field in the counties of Bell, Breathitt, Boyd, Carter, Clay, Elliott, Floyd, Greenup, Harlan, Jackson, Johnson, Knott, Knox, Laurel, Lawrence, Lee, Leslie, Letcher, McCreary, Magoffin, Martin, Menifee, Morgan, Owsley, Perry, Pike, Pulaski, Rockcastle, Rowan, Wayne, Whitley and Wolfe.

## DIRECTIONS FOR THE USE OF PHOSPHATES

### Acid Phosphate

In farm practis probably the most economical way to use acid phosphate is to drill 300 to 400 pounds per acre when wheat or other small grain is sown. This will be sufficient for the wheat and for the clover or grass crop which usually follows wheat. If this practis is followed regularly with each rotation and manure is used on the land on which tobacco or corn is grown following the clover and grass, it will not be necessary to use additional phosphate, provided the manure has been carefully saved, and as much as six to eight tons per acre has been used.

If it is desired to use acid phosphate in connection with manure for corn, tobacco, or other crops, it may be applied when the manure is being spread. When loading the spreader, place a layer of manure and sprinkle over it uniformly some acid phosphate. Two layers of manure and phosphate should give an even spread of the phosphate on the land. The amount of phosphate for each load of manure is determined by dividing the application of phosphate desired per acre by the number of loads of manure used per acre.

For inter-tilled crops, such as corn, tobacco and beans planted in rows, it is best to apply the acid phosphate broadcast, or drill it with the fertilizer attachment of a grain drill. Without doubt, it is more effective applied this way than in the row, for the feeding roots have a better opportunity to come in contact with the phosphate thruout the growing season. Broadcast applications should be made on the broken ground so that it may be thoroly distributed in the soil in the preparation of the seed bed. Where an application of as much as 600 pounds or more per acre is used, to last for a period of three or four years or more, the phosphate may be applied broadcast on the unbroken ground and disked in before breaking.

Only with very small amounts of acid phosphate, say 100 pounds per acre or less, would we recommend drilling in the row. But we do not believe it advisable to use such small applications.

Experiments on some of the Kentucky experiment fields indicate that it makes very little difference in yields whether large amounts of acid phosphate are applied at once for a rotation, or the same amount is divided into annual applications for the same period of time. Very little phosphate is lost by leaching.

When acid phosphate is to be used on land where lime is used, the lime should either be applied first and worked into the soil, or the lime and acid phosphate may be applied together, provided they are worked into the soil before it rains.

These directions will apply to the use of bone meal and basic slag.

Where lime is badly needed and is difficult to obtain because of long haul or other reasons, it is suggested that 250 pounds of acid phosphate be mixed with 500 to 750 pounds of finely ground limestone, and that as large an application of the mixture as can be run thru the fertilizer attachment of the grain drill be applied when wheat or other small grain is sown. The materials should be applied *as soon as mixed,* preferably the day they are mixed. Experimental results indicate that this treatment will greatly aid in getting a crop of clover following the grain.

### Rock Phosphate

Rock phosphate should not be used in small annual applications. One thousand to 1500 pounds per acre, sufficient for three to five years, should be applied broadcast on the unbroken ground and should be disked in before breaking. It may be applied with a lime spreader, thru the fertilizer attachment of a grain drill, or when manure is being spread, in the manner already indicated for acid phosphate.

A good way to use rock phosphate is to apply it in the stalls as the manure accumulates, using 2 or 3 pounds per day for an animal weighing 1000 pounds. A pint of rock phosphate weighs about $1\frac{1}{4}$ pounds. It is doubtful if mixing with manure adds materially to the availability of the phosphate over what it would be were the phosphate and manure applied separately, but it is a saving of time to apply them together.

Contrary to much that has been written on the subject, it has been found on the Kentucky experiment fields that rock phosphate gives good results on thin land the first year before animal manure or green manure crops have been used. Of course, much larger yields will be obtained by the use of manures than without them.

When the price of acid phosphate is twice as much per ton as rock phosphate, or more, farmers may well consider the use of rock phosphate, altho it is more bulky and troublesome to handle. The excess of phosphorus that is stored in the soil by its use is an important consideration.