IS ROCK PHOSPHATE[1] A GOOD FERTILIZER FOR NORTH DAKOTA?

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With the short supply of superphosphate and other types of phosphate fertilizers containing readily available sources of phosphoric acid, many inquiries have been received regarding the merits of rock phosphate and colloidal phosphate. Some elaborate claims have been made to promote the sale of rock phosphate in the various forms in which it has been marketed. The many types of rock phosphate include the land pebble, hard rock, soft rock, and waste pond or colloidal phosphate of Florida; the brown rock, blue rock, and whiterock of Tennessee; and western rock phosphates of Montana, Idaho, Wyoming, and Utah. All the above types are naturally occurring forms of rock phosphate.

This report is prepared to furnish the reader with information on rock phosphate and to review the results that have been obtained experimentally with Tennessee rock phosphate in North Dakota.

The yearbook of Agriculture for 1938, Soils and Men, contains considerable information on fertilizer materials. The following statements on rock phosphate are quoted: "Rock phosphate occurs in great deposits throughout the world, those of greatest importance in the United States being located in Florida and Tennessee in the East, and in Idaho, Montana, Utah, and Wyoming in the West."

"While a certain quantity of finely ground rock phosphate is used for direct application to the soil, it is slight in comparison with the enormous quantity of rock converted into superphosphate by acid or other chemical treatment. There are, no doubt, certain soil conditions and farm practices that enable finely ground phosphate rock to give a good account of itself, but taken by and large, most soils and crops require a more available source of phosphoric acid, such as superphosphate, ammonium phosphate, or other phosphatic material, the phosphoric acid of which is either water or citrate soluble."

"'Colloidal Phosphate' is a trade name applied to a finely divided, comparatively low-grade rock phosphate or phosphatic clay. It is also designated 'waste pond phosphate' for the reason that in the hydraulic operation involved in mining rock phosphate in Florida, a considerable quantity of fine phosphatic material, virtually colloidal from a mechanical standpoint, is washed into ponds and settles out. When removed following drainage and evaporation of the water, it contains a relatively high proportion of clay, so that the colloidal phosphate usually contains only from

[1]See also North Dakota Agricultural Experiment Station Bulletin 198, "Studies on the use of raw rock phosphate", by H. L. Walster, 1926.
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eighteen to twenty-three percent of phosphoric acid. On account of the presence of so much foreign material, principally clay, colloidal phosphate is considered to be unsatisfactory for treatment with sulfuric acid. The claim is made for this material and others of a similar nature that not only is the phosphoric acid more quickly available than that of mechanically ground rock phosphate, but also that the content of minor elements in colloidal phosphate makes it superior to its close relative, rock phosphate. These claims, while highly interesting, have failed of substantiation in a number of States, particularly so when a comparison of such material with superphosphate is taken into consideration."

"As a general rule the effectiveness of any rock phosphate material is dependent upon its degree of fineness, the quantity applied to the soil, and the reaction of the soil. It has been shown that the best response ensues when the soil possesses relatively strong acid reaction".

The above statements, together with the fact that most of the soils in North Dakota are not acid but neutral to alkaline in reaction, should make one question the advisability of using rock phosphate in any of its marketable forms. The one confusing fact that is not clear to the farmer or to many of the fertilizer dealers is why one fertilizer material containing a high analysis of phosphoric acid isn't just as good as another. Most analyses of rock phosphate or colloidal phosphate indicate twenty to thirty-five percent **total phosphoric acid** content but rock phosphate does not contain any significant quantity of **available phosphoric acid.**

Available phosphoric acid is that part of the total content of phosphoric acid in a fertilizer that is **soluble either in water or in a neutral solution of ammonium citrate.** The available phosphoric acid, that is the sum of the water soluble phosphoric acid and the citrate soluble phosphoric acid, may be only a small part or it may be a very large part of the total phosphoric acid in any fertilizer.

The following, Table 1, condensed from U. S. D. A. Technical Bulletin 364, gives the average content of total phosphoric acid of the domestic rock phosphates.

Table 1.—Phosphoric Acid in Rock Phosphates

Field	Rock Type	No. of Samples	Average per cent Total Phosphoric Acid (P_2O_5)
Florida	Land Pebble	28	32.78
	Hard Rock	10	34.73
	Soft Rock	4	30.43
	Waste Pond (Colloidal)	10	21.74
Tennessee	Brown Rock	18	32.61
	Blue Rock	8	30.83
	White Rock	2	33.00
Idaho	Western Rock	10	32.36
Montana	Western Rock	14	33.12
Wyoming	Western Rock	5	29.03

The phosphoric acid in rock phosphate is present in the rock in a relatively insoluble form (tricalcium phosphate) which is not readily available to plants. By treating ground rock phosphate with sulphuric acid, the rock is converted into new chemical compounds (monocalcium phosphate and calcium sulphate) which are relatively soluble. The treatment of phosphate rock with acid therefore converts the relatively insoluble forms of tricalcium phosphate of rock phosphate into an available form—monocalcium phosphate. The analysis of superphosphate is not expressed in terms of total phosphoric acid but as the **available** or easily soluble percentage of phosphoric acid it contains. When buying phosphate fertilizers, one should look at the analysis on the bag label to see whether he is buying **total phosphoric acid** or **available phosphoric acid.**

Experiments With Rock Phosphate in North Dakota

I. An experiment was started in 1914 to determine what yield advantage could be obtained by supplementing manure with rock phosphate. A five-year rotation of corn, barley, wheat, sweet clover, and flax was followed. Every crop in the rotation was grown in duplicate plots each year. On one of the duplicate plots, rotted manure was applied at the rate of 10 tons per acre once every fifth year, to the other plot the same quantity of rotted manure was applied and supplemented with one ton of rock phosphate per acre once every fifth year. All plots were given the above treatment the first or second year of the experiment. After the initial application, the rock phosphate mixed with the manure, was applied in the fall on the flax plots in the rotation sequence before plowing for corn. The results of the experiment continued until 1937, are given in Table 2.

Table 2.—Comparing the yields of corn, barley, wheat, sweet clover and flax in a 5-year rotation (F.S. 13) when fertilized with rotted manure or rotted manure plus rock phosphate.
Average Yield—1915-1937

Treatment	Corn Bu. Per Acre 18 Yrs.[1]	Barley Bu. Per Acre 22 Yrs.[2]	Wheat Bu. Per Acre 23 Yrs.	S. Clover Lbs. Hay Per Acre 21 Yrs.[3]	Flax Bu. Per A 22 Yrs.[4]
Rotted Manure	25.1	38.4	20.2	5108	9.1
Rotted Manure and Rock Phosphate	23.6	38.6	20.7	4763	8.8

[1]Drowned out 1915. Only fodder yields available in 1917, 1918, 1919, and 1920.
[2]Damage by hail in 1918. No yield taken.
[3]Stands in 1931, 1933 and 1937, not satisfactory, replowed and planted to soy beans. 1934 yields omitted, too weedy.
[4]Stand in 1916 poor, weedy—discarded.

The results from Table 2 indicate that the addition of one ton of rock phosphate every five years to manure has not increased the yield of any of the crops in the rotation over the manure treated plots. No evidence of any benefit of the rock phosphate is apparent even though the plots with added rock phosphate have received five tons of rock phosphate per acre during the course of the experiment.

II. Another experiment was started in 1912 to compare superphosphate with rock phosphate as a supplement to manure and crop residues (straw). A four-year rotation of corn, wheat, sweet clover, and oats was followed where fresh manure was applied in the rotation, and a four-year rotation of potatoes, wheat, sweet clover, and barley was followed where crop residues were returned to the soil. All treatments were applied once every four years preceding the corn and the potatoes in the rotations. Superphosphate was applied at the rate of sixty pounds of phosphoric acid (P_2O_5) per acre (400 pounds of sixteen percent or 140 pounds of forty-three percent superphosphate). Rock phosphate was applied on an equal money value basis to the cost of the superphosphate. The rate of application varied from 330 pounds per acre to 650 pounds per acre depending on the year. Fresh manure and crop residue applications were in proportion to the total grain crops removed. Each crop in the rotation was grown once every four years. Yield results are given in Table 3.

Table 3.—Comparing yields of corn, potatoes, wheat, oats and barley on plots where superphosphate alone, superphosphate and manure and rock phosphate and manure have been applied.

Average yield in bushels per acre 1912-1945

Treatment	Corn 8 Yrs.[1] 1912, 1916, 1920 1924, 1928, 1932 1936, 1940, 1944	**Percent Increase Over Check**	Wheat 9 Yrs. 1913, 1917, 1921 1925, 1929, 1933 1937, 1941, 1945	Percent Increase Over Check	Oats 8 Yrs. 1915, 1919, 1923 1927, 1931, 1935 1939, 1943	**Percent Increase Over Check**
None—check	27.8	....	24.7	....	59.1	..
Superphosphate alone	30.4	**9**	28.1	14	61.1	**3**
Manure and Superphosphate	31.8	**14**	30.7	24	60.5	**2**
Manure and Rock Phosphate	31.8	**14**	29.1	18	61.5	**4**

Treatment	Potatoes 7 Yrs.[2] 1912, 1916, 1920 1924, 1928, 1932 1936, 1940	**Percent Increase Over Check**	Wheat 9 Yrs. 1913, 1917, 1921 1925, 1929, 1933 1937, 1941, 1945	Percent Increase Over Check	Barley 8 Yrs. 1915, 1919, 1923 1927, 1931, 1935 1939, 1943	**Percent Increase Over Check**
None—check	110.7	....	24.5	....	31.5	..
Crop residues and Superphosphate	128.0	**16**	29.2	19	34.2	**9**
Crop residues and Rock Phosphate	124.3	**12**	26.9	10	33.6	**7**

[1]Fodder yield only in 1920, not included in the average.
[2]1916 yield not obtained.

In Table 3 yields from plots receiving rock phosphate and fresh manure were not greatly different from those receiving manure and superphosphate except for wheat where the yields on the superphosphate plots were better than the wheat yields on the rock phosphate plots. Although this experiment did not have plots where manure alone was applied, an adjacent experiment showed a 9 percent increase in corn yield, a 15 percent increase in wheat yield and a 2 percent increase in oats yield for the manure treated plots over the no treatment plots during the same crop years as given in Table 3. This would indicate that manure is contributing a large share of the yield increase on all plots.

Summary

1. Rock phosphate applied at the rate of one ton per acre every five years as a supplement to ten tons of rotted manure has not shown any significant yield increase over the manured plots on any crop in a five-year rotation of wheat, barley, corn, flax, and sweet clover during the period 1915 to 1937.

2. Rock phosphate applied with fresh manure and crop residues at a rate equal to superphosphate in money value has not produced yield returns to warrant its use in place of superphosphate in two four-year rotations during the period 1912 to 1945.

3. Rock phosphate is not considered a good source of phosphoric acid for crops grown under North Dakota soil conditions. Fertilizers carrying the "available" forms of phosphoric acid are more likely to produce increased yields than fertilizer materials containing the phosphoric acid in relatively "unavailable" forms.