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AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
W. B. BIZZELL, President

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DIVISION OF CHEMISTRY

THE EFFECT OF ROCK PHOSPHATE UPON THE CORN POSSIBILITY OF THE PHOSPHORIC ACID OF THE SOIL

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CONTENTS.

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BULLETIN No. 289. FEBRUARY, 1922.

THE EFFECT OF ROCK PHOSPHATE UPON THE CORN POSSIBILITY OF PHOSPHORIC ACID OF THE SOIL.

BY

G. S. FRAPS.

In connection with soil-fertility studies, it is important to know the relation between the effect of the phosphoric acid of the rock phosphate on crops and the phosphoric acid that can be withdrawn from the soil by crops. The phosphoric acid of rock phosphate is readily soluble in N/5 nitric acid, as is shown in Bulletin 126. There is a relation between the phosphoric acid withdrawn from the soil, and the active phosphoric acid contained in the soil, as shown in Bulletins 126 and 267. Bulletin 212 contains a study of the availability of rock phosphate, when added in small amounts; and it is shown that the average availability of rock phosphate applied at the rate of about 40 parts per million of soil, to several crops, in 21 experiments is 9.1 ± 1.1, compared with 43.9 ± 2.3 for acid phosphate in the same experiments. Bulletin 212 goes on to discuss this matter as follows:

"Whether the relative value above given applies to field conditions, and to larger applications of rock phosphate, requires further study. It does not follow, for example, that the application of 5 pounds of phosphoric acid in rock phosphate will produce the same effect as 1 pound of phosphoric acid in acid phosphate, for the reason that rock phosphate is only slightly soluble in the soil moisture, and five times the application may only increase slightly the amount of phosphoric acid presented to the roots. There may be a point at which increased applications of rock phosphate may have no effect upon the size of the crop, as it is possible that the phosphoric acid of rock phosphate may not enter the plants rapidly enough to produce the corresponding growth. That is to say, the rock phosphate is only slightly soluble and may not increase the concentration of the soil moisture sufficiently to produce rapid growth, and further additions of rock phosphate might not increase the concentration of the phosphoric acid in the soil moisture beyond a certain point."

The object of this bulletin is to study the point mentioned above.

METHOD OF WORK.

The soils used in the experiments were selected by the determination of active phosphoric acid as probably deficient in phosphoric acid. To 5000 grams of soil, were added one gram of ammonium nitrate, 1 gram of potassium sulphate, and then either nothing else, or the proper phosphate. For dicalcium phosphate, 1 gram was used. For rock phosphate, 5 grams were used for pots marked R, 10 grams for pots marked 2R, 20 grams for pots marked 4R, and 25 grams for pots marked 5R. Corresponding amounts of Florida soft phosphate were used for pots marked F. The phosphoric acid contained in the materials used is given in Table 1. Corn was planted first, harvested

after about sixty days, and sorghum planted as a second crop. The crops were dried thoroughly, weighed, and the phosphoric acid determined in them. The phosphoric acid was not estimated in some of the crops grown with the use of dicalcium phosphate as these were grown for checks.

Table 1. Analysis of Minerals.

		Percentage of P_2O_5
837	Phosphate rock	30.40
4479	Rock phosphate	30.75
8260	Dicalcium phosphate	37.45
14990	Phosphate rock	30.14
16341	Florida soft phosphate	22.93

COMPARISON OF WEIGHT OF CROPS.

In an experiment of this kind, it is important that there should be a wide spread between the pots which receive no phosphoric acid, and those which receive the phosphoric acid. That is to say, the soil should be deficient in phosphoric acid, as shown by the small crop when nitrogen and potash are added without phosphoric acid, and on the other hand, the soil should be capable of producing a good crop when the missing phosphoric acid is applied together with nitrogen and potash. If the soil is not deficient in phosphoric acid, the effect of the addition of phosphate may be hardly visible. If the soil is not capable of producing a good crop when the highly available phosphoric acid is present, the added phosphoric acid does not have an opportunity to show what can be done.

The weight of the crops in grams grown in a number of these pots is shown in Table 10. The weights given in parenthesis with soils 2839 and 5967 have been interpolated for the purpose of securing the averages.

All of the soils used for the crops in Table 2 did not comply with the requirements set forth above. Soils 2839 and 5967, while deficient, did not produce as good a yield with corn as they should when the complete fertilizer was added. Soil 12740 with sorghum, and a few of the other soils, did not produce as well with the complete fertilizer as we should desire.

On an average, the soils with the rock phosphate added produced about 75 per cent. of the soils with the dicalcium phosphate added, and the soils with no phosphate produced about 40 per cent. as much as the soil with complete fertilizer. The addition of rock phosphate at a rate of 1 ton to the acre did not produce as large yield as the addition of dicalcium phosphate at the rate of 400 pounds to the acre.

PHOSPHORIC ACID REMOVED.

Table 11 shows the phosphoric acid removed in parts per million of soil on all the pots used in this discussion. The conclusions in this bulletin are based upon the phosphoric acid removed from the soil, and not upon the weights of the crops.

EFFECT OF ONE TON ADDITIONS OF ROCK PHOSPHATE.

Table 2 shows the average results secured with 50 crops, on about 25 soils. The average phosphoric acid removed per million of soil per crop is 5.53 when no phosphate was added, and 9.43 when the quantity of rock phosphate added was equal to about 300 parts phosphoric acid per million of soil or about a ton to the acre. This also is expressed

Table 2. Effects of rock phosphate on phosphoric acid of soil.

	No phosphate added	Rock phosphate 300 parts P_2O_5 per million of soil
Average per million phosphoric acid removed	5.53	9.43
Corn possibility of phosphoric acid removed	17.61	30.18
Gain in corn possibility due to one ton rock phosphate per acre, bushels	.....	13.57
Equivalent phosphoric acid content of soil (Bull. 267, Table 2)	20.30	40.60
Percentage of added phosphoric acid removed per crop	.....	1.30
Number of crops averaged	50	50

in terms of the corn possibility of the phosphoric acid removed in bushels per acre, on the assumption that 40 bushels of corn require 25 pounds of phosphoric acid. One ton rock phosphate to the acre caused an increase in the corn possibility of phosphoric acid of 13.5 bushels. The addition of 300 parts per million of phosphoric acid in the form of rock phosphate does not necessarily mean that the active phosphoric acid of the soil is increased to that extent. While it was shown in Bulletin 126 of this Station that apatite, phosphorite, and vivianite were practically completely dissolved when presented at the rate of .2 gram phosphoric acid to 1000 cc. of N/5 nitric acid, yet it was also shown in this Bulletin that soluble phosphoric acid presented

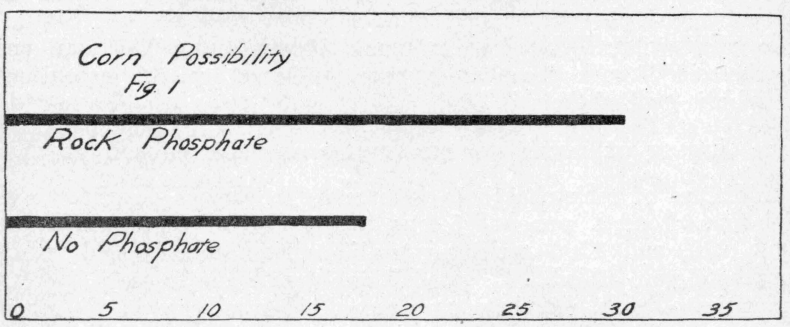

Fig 1. Phosphoric acid removed by crops from soil without phosphate and with phosphate expressed in bushels corn per acre.

to the soil was not completely removed by fifth-normal nitric acid, but that considerable percentages would be retained by some soils, on account of the power of the soils to fix, or withhold, phosphoric acid. In order to test the effect of the additions of phosphates to some of the soils used in this experiment, 0.1 gram phosphate was added to 100

grams soil and digested with 1000 cc. fifth-normal nitric acid in the usual way. The results of this test are given in Table 3. It is noted that some of the soils withheld comparatively large percentages of phosphoric acid presented to them. The effect of the addition of the phosphate was to increase the active phosphoric acid of the soils in varying amounts, ranging from 87 to 288 parts per million.

Table 3. Effect of rock phosphate upon active phosphoric acid of soil in parts per million.

	Addition	In soil	Added	Total	Recovered
9354	Soft phosphate	9	230	239	141
12470	Hard phosphate	9	301	310	255
12471	Hard phosphate	7	301	308	181
12662	Hard phosphate	7	304	311	104
17440	Hard phosphate	7	301	308	281
17440	Soft phosphate	7	230	237	210
17441	Hard phosphate	8	301	309	136
17441	Soft phosphate	8	230	238	87
8838	Hard phosphate	14	301	315	288
9353	Hard phosphate	12	301	313	280
9353	Soft phosphate	12	230	242	200
12663	Hard phosphate	15	301	316	134

A comparison of the phosphoric acid recovered in parts per million after the addition of rock phosphate (see Table 4) with that recovered from soils of the equivalent active phosphoric acid content shows that the rock phosphate did not have nearly the effect upon the crop production of the soil that the active phosphoric acid added to the soil should have had, if it had the same effectiveness as the active phosphoric acid in ordinary soil. The phosphoric acid equivalent to the crop produced was 40 to 60 parts per million, while the active phosphoric acid in the soil after the addition of rock phosphate was 87 to 281 parts per million.

In Bulletin 267, Table 21, it is shown that the percentage of total soil phosphoric acid removed by four crops varies from 2 to 7 per cent. varying with the quantity of associated active phosphoric acid. The percentage of phosphoric acid removed from rock phosphate by one crop is shown in Table 4 to average 1.30 per cent. The total phosphoric acid of rock phosphate appears to be as available as the total phosphoric acid of the soil.

EFFECT OF INCREASED QUANTITIES OF ROCK PHOSPHATE.

Additions of rock phosphate were made to various pots at the rate of 1 ton, 2 tons, 4 tons, and 5 tons, to the acre, or approximately 300, 600, 1200, and 1500 parts per million of phosphoric acid in rock phosphate were added. These additions were made to see if increased quantities of rock phosphate gave any decided increase in the amount of phosphoric acid removed from the crops.

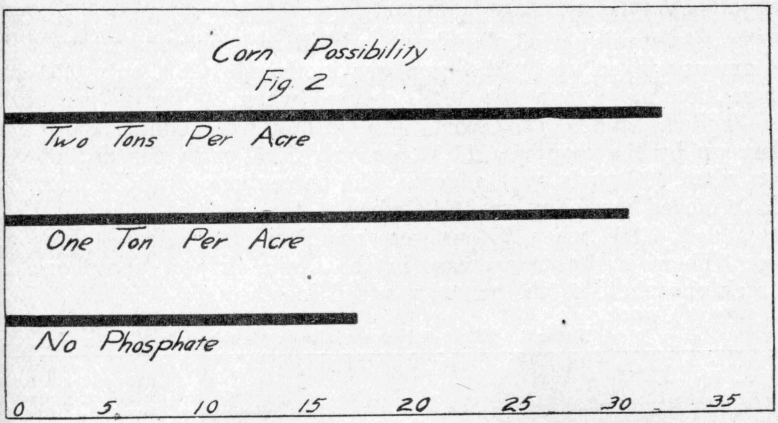

Fig 2. Effect of increasing the rock phosphate upon the corn possibility of the soils.

The average results of this work are given in Tables 4, 5, and 6. They are averaged in separate tables, in order to compare no phosphate, and 1 ton rock phosphate, with the heavier applications, for the reason that the applications were not all made on the same soils and it was necessary to average them separately. In order to avoid confusion, the averages are presented in different tables.

Table 4. Effects of increased rock phosphate on crops.

	No phosphate	One ton per acre	Two ton per acre
Phosphoric acid added, per million of soil	0	300	600
Phosphoric acid removed per crop per million of soil	5.38	9.49	10.12
Corn possibility of phosphoric acid removed, bushels per acre	17.22	30.36	32.38
Equivalent phosphoric acid content of soil per million	20.30	40.60	40.60
Percentage of added phosphoric acid removed	.....	1.4	0.8
Number of crops averaged	44	44	44

In Table 4 the rock phosphate was applied to 44 crops, at the rate of 300 to 600 parts to the million of soil. Increasing the phosphoric acid from 300 parts per million to 600 parts per million increases the phosphoric acid removed per crop on an average only .63 parts per million. The percentage of added phosphoric acid removed was decreased, being 1.4 per cent. for 300 parts per million, and 0.8 per cent. for 600 parts per million.

Table 5. Effect of four tons rock phosphate.

	No phosphate	One ton per acre	Two tons per acre	Four tons per acre
Phosphoric acid added per million of soil	0	300	600	1200
Phosphoric acid removed per crop per million of soil	5.86	10.14	10.69	11.84
Corn possibility of phosphoric acid removed, bushels per acre	18.75	32.45	34.14	37.89
Equivalent phosphoric acid content of soil per million	20.30	40.60	40.60	60.80
Percentage of added phosphoric acid removed per crop	.....	1.43	0.80	0.50
Number of crops averaged	33	33	33	33

Similar results are seen in Table 5, the average of 33 crops. When 600 parts per million of phosphoric acid in rock phosphate were added, the amount taken up by the crop was increased 10.69, only 0.54 parts per million more than the 10.15 secured when 300 parts per million were added. When 1200 parts per million were added, the amount taken up by the crop was 11.84, or only 1.15 parts per million more than when 600 parts were added. The percentage of added phosphoric acid removed per crop was 1.43 when 1 ton rock phosphate per acre was added, 0.80 when 2 tons were used, and 0.50 when 4 tons were used. There is thus a decrease in the availability of phosphoric acid of rock phosphate as the quantity added increases.

Table 6. Effect of increase of rock phosphate.

	No phosphate	Rock phosphate one ton	Rock phosphate five tons
Phosphoric acid added, per million of soil	0	300	1500
Phosphoric acid removed per crop, per million	3.22	7.49	8.82
Corn possibility of phosphoric acid removed, bushels per acre	10.30	23.97	28.22
Equivalent phosphoric acid content of soil	.....	30.40	30.40
Percentage of added phosphoric acid removed	.....	1.4	0.4
Number of crops averaged	8	8	8

Table 6 shows the effect of no phosphate, 1 ton rock phosphate, and 5 tons rock phosphate to the acre. The increase of 4 tons over the first ton only gave an increase of 1.35 parts per million of phosphoric acid per crop. The percentage of phosphoric acid removed was 1.4 for 300 parts per million phosphoric acid, and 0.4 for 1500 parts per million.

These experiments show very clearly that additions of rock phosphate exceeding 1 ton to the acre have comparatively slight effects upon the amount of phosphoric acid removed by crops. The additions follow the "law of diminishing returns", and the returns diminish very rapidly. It is also seen that the addition of 1 ton rock phosphate to the acre increases the corn possibility of the phosphoric acid removed by corn and sorghum about 13 bushels to the acre, and since only 1.4 per cent. of the phosphoric acid is on an average removed by each crop, this increase should occur for a number of years. The addition of rock phosphate to the soil may be considered as a permanent investment in soil fertility. It will pay comparatively small returns every year, but the returns are continued for a long time.

COMPARISON OF HARD ROCK PHOSPHATE AND SOFT FLORIDA PHOSPHATE.

The rock phosphate referred to in the previous discussion is Tennessee hard phosphate. It has been claimed that the phosphoric acid of Florida soft phosphate is much more available to plants than that of hard rock phosphate, and for this reason we tried it in some of the pots. The average results are given in Tables 7, and 8. In Table 7 it is seen that the phosphoric acid is slightly more efficient in soft phosphate than in hard rock phosphate. The percentage of added phosphoric acid removed is 1.52 for the hard rock phosphate, and 1.98 for the soft phosphate.

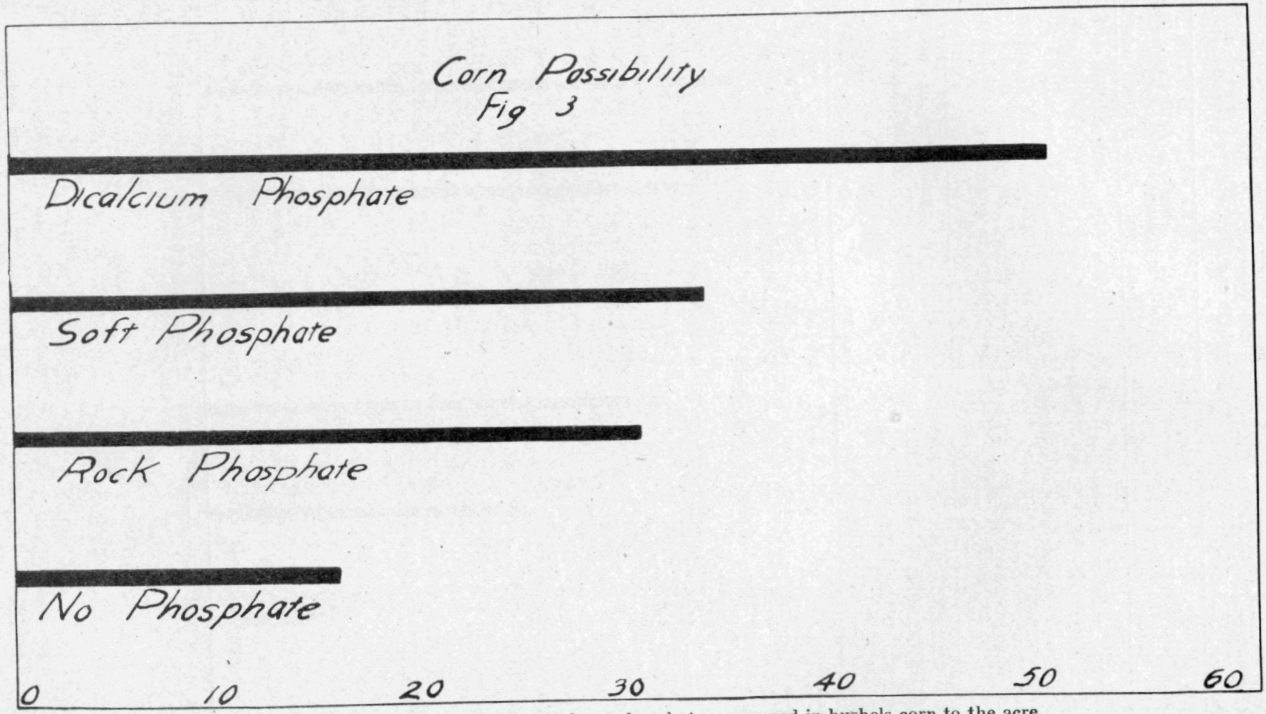

Fig. 3. Recovery of phosphoric acid from phosphate, expressed in bushels corn to the acre.

The results with dicalcium phosphate are also averaged for the purpose of comparison. The increase of the corn possibility and the amount of phosphoric acid is, as should be expected, much larger with

Table 7. Comparison of rock phosphate and Florida soft phosphate.

	No phosphate	Rock phosphate	Soft phosphate	Dicalcium phosphate
Phosphoric acid added per million of soil	0	300	229	75
Phosphoric acid removed per crop, per million of soil	5.09	9.63	10.63	15.96
Corn possibility of phosphoric acid removed, bushels per acre	16.29	30.82	34.02	51.01
Equivalent phosphoric acid of soil	20–30	40–60	40–60	300–400
Percentage of added phosphoric acid removed	.....	1.52	1.98	14.50
Number of crops averaged	12	12	12	12

the dicalcium phosphate than with the other applications, and is not approached by the high applications of other phosphates.

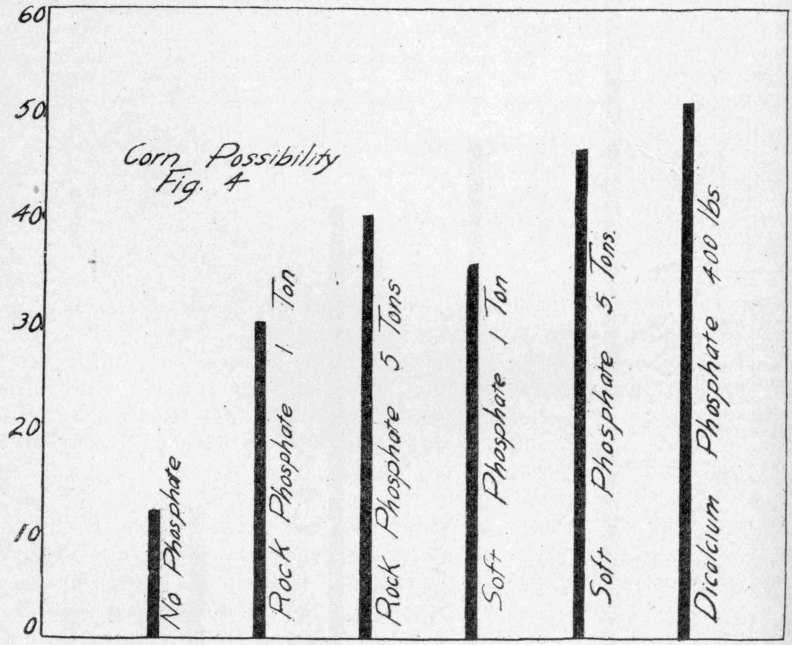

Fig. 4. Effect of increased quantities of phosphates upon the corn possibility of the soil.

Table 8. Effect of increase of Florida soft phosphate.

	No phosphate	Rock phosphate 1 ton	Rock phosphate 5 tons	Soft phosphate 1 ton	Soft phosphate 5 tons	Dicalcium phosphate 400 lbs.
Phosphoric acid added per million	0	300	1500	220	1100	75
Phosphoric acid removed per crop per million of soil	3.77	9.43	12.61	11.21	14.64	16.03
Corn possibility of phosphoric acid removed, bushels per acre	12.06	30.18	40.35	35.87	46.85	51.30
Percentage of added phosphoric acid removed	.....	1.88	0.59	3.34	0.99	16.34
Number of crops averaged	4	4	4	4	4	4

Table 8 shows the effect of increased amounts of soft phosphate compared with increased amounts of hard phosphate, but only four crops are averaged. As in Table 7, the soft phosphate is more effective than the hard phosphate.

RELATION OF THE PHOSPHORIC ACID OF ROCK PHOSPHATE TO THE ACTIVE PHOSPHORIC ACID OF THE SOIL.

Table 9 contains the averages when the soils are arranged in groups according to their content of active phosphoric acid. The first group

Table 9. Effect of rock phosphate on active phosphoric acid of soil.

	No phosphate	Rock phosphate	No phosphate	Rock phosphate	No phosphate	Rock phosphate
Original active phosphate acid of soil in parts per million	0–10	0–10	10.1–20	10.1–20	20.1–30	20.1–30
Average phosphoric acid per million removed	3.6	8.9	5.8	10.0	8.4	13.1
Corn possibility of phosphoric acid removed, in bushels per acre	11.5	28.5	18.6	32.0	26.9	41.9
Gain in corn possibility due to rock phosphate	.....	17.0	.....	13.4	.....	15.0
Equivalent phosphoric acid content of soil	.....	30–40	.....	40–60	.....	80–100
Percentage added phosphoric acid removed	.....	1.8	.....	1.4	.....	1.6
Number of crops averaged	16	16	20	20	4	4

contains soils with originally less than 10 parts per million of active phosphoric acid. The second group contains soils with active phosphoric acid 10.1 to 20 parts per million, and the third group, which only includes 4 crops of 2 soils, includes soils with 20.1 to 30 parts per million of active phosphoric acid.

The addition of rock phosphate to these soils increases the average phosphoric acid removed by the crops in each case. The increase in corn possibility is 17.0 bushels for the first group, 13.4 for the second group, and 15.0 bushels for the third group. The percentage of added phosphoric acid removed by each crop is 1.8 for the first group, 1.4 for the second group, and 1.6 for the third group. There is a slight tendency towards a decreased effect of the rock phosphate as the active phosphoric acid in the soil increases. This decrease, however, is not great.

It was pointed out in Bulletin 126 of this Station, that the phosphoric acid of rock phosphate is almost entirely soluble in fifth-normal nitric acid in the quantities in which it would ordinarily occur in

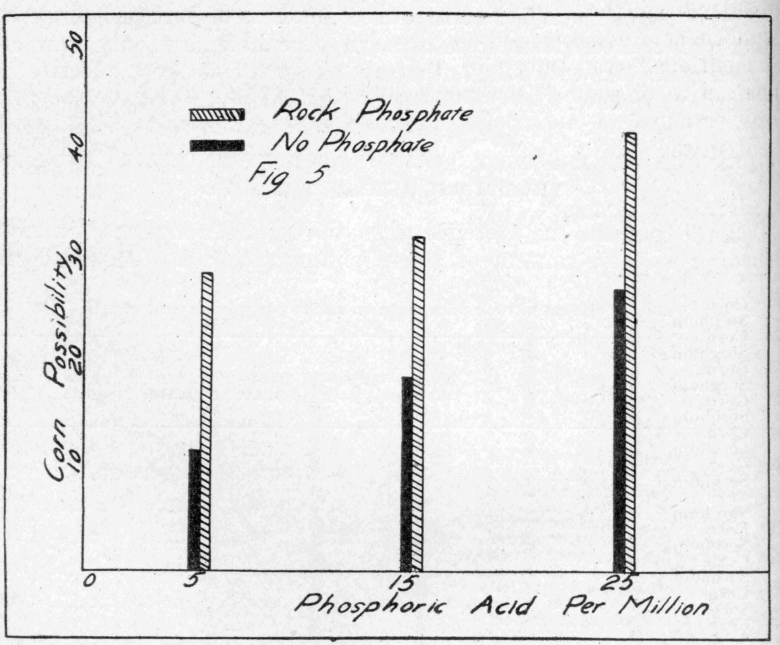

Fig. 5. Phosphoric acid removed by crops from soils of different active phosphoric acid, with and without phosphates, expressed as corn possibility.

soil. The addition of phosphoric acid in rock phosphate does not increase the yield of the crop for the amount of phosphoric acid removed by it in proportion to the active phosphoric acid added. This is brought out in all of the tables presented. For example in Table 11, the addition of rock phosphate to soils containing less than 10 parts per million phosphoric acid, increases the amount of phosphoric acid taken up by corn and sorghum so that they would be ranked with soils containing 30 to 40 parts per million in active phosphoric acid. With soils originally containing 10.1 to 20 parts per million of active phosphoric acid, the addition of rock phosphate raises them to a group containing 40-60 parts per million, and soils containing 20-30 parts per million of active phosphoric acid, are raised by the rock phosphate

to a group containing 80-100 parts active phosphoric acid per million. The effect of the addition of 300 parts per million of phosphoric acid in rock phosphate to the first group is to increase the phosphoric acid taken to about the equivalent of that which would be taken from 30 parts per million of active phosphoric acid. In the second group, the increase is about 40 parts per million equivalent of active phosphoric acid, and with the third group about 70 parts per million. The conclusion is that the phosphoric acid of rock phosphate is not as available as the active phosphoric acid in the soil. The term "available" is here used advisedly because the phosphoric acid taken up does not all come from the active phosphoric acid, but the amount of active phosphoric acid really represents the condition of solubility of the soil phosphates. The actual increase in the quantity of active phosphoric acid which would be caused by the addition of the phosphates here mentioned, was shown in Table 5.

The active phosphoric acid introduced in the soil by rock phosphate is less valuable to plants than the active phosphoric acid originally present in the soil.

Table 10. Weights of crops in grams.

		KN	KN	KNR	KNR	KND	KND
2839	Corn	1.4	3.8	3.5	6.9	10.7	13.7
	Sorghum	12.9	16.5	12.8	12.8	25.0	20.8
5967	Corn	2.0	1.8	2.2	2.2	5.2	3.0
	Sorghum	3.0	3.0	13.0	14.6	14.0	16.0
8838	Corn	22.2	20.9	36.9	40.9	48.9	43.2
	Sorghum	25.0	27.3	39.9	42.6	43.7	31.4
9353	Corn	15.3	15.7	29.0	27.2	48.3	50.4
	Sorghum	21.7	27.0	38.9	37.0	49.1	46.9
9354	Corn	5.8	8.0	11.0	13.4	39.2	39.4
	Sorghum	15.2	13.0	44.0	21.7	48.0	51.6
10602	Corn	14.4	13.2	17.2	17.7	21.4	21.3
	Sorghum	32.9	32.9	40.9	37.9	42.7	35.1
12470	Corn	19.7	8.7	27.2	31.7	44.0	41.0
	Sorghum	9.1	10.2	18.2	24.6	24.0	17.1
12471	Corn	0.9	0.3	7.0	8.7	17.5	18.1
	Sorghum	6.0	9.6	31.8	31.9	42.9	35.6
12654	Corn	7.7	11.6	11.7	11.5	29.5	35.7
	Sorghum	23.9	26.4	26.7	25.0	31.3	35.1
12662	Corn	3.9	3.0	17.3	22.8	20.2	28.0
	Sorghum	9.1	7.7	20.5	20.7	17.9	23.9
12663	Corn	13.8	13.5	14.5	15.0	25.9	25.7
	Sorghum	13.6	19.3	20.2	19.9	27.5	27.8
12664	Corn	4.3	5.0	6.7	7.0	12.7	14.0
	Sorghum	17.6	19.7	22.6	22.4	34.3	31.6
12665	Corn	16.4	19.2	43.8	42.6	50.5	49.0
	Sorghum	22.7	18.9	32.7	26.6	29.2	34.1
12666	Corn	6.7	3.5	27.5	19.2	42.0	39.7
	Sorghum	16.1	15.5	30.3	29.1	29.5	32.1
12667	Corn	14.9	13.7	39.0	36.9	35.6	41.0
	Sorghum	24.0	26.8	37.5	24.9	30.2	24.5
12672	Corn	3.2	3.3	9.2	10.5	22.2	23.5
	Sorghum	16.5	11.8	27.4	25.9	27.7	27.6
12673	Corn	20.7	19.9	26.5	30.4	44.2	34.0
	Sorghum	24.9	26.5	31.9	25.4	31.5	39.6
12680	Corn	10.9	8.5	25.5	28.0	30.7	33.5
	Sorghum	11.7	6.9	25.0	21.7	20.7	10.7
12739	Corn	9.0	6.5	8.0	8.2	14.3	20.0
	Sorghum	21.6	18.3	20.8	14.3	33.1	28.0
12740	Corn	1.5	1.2	3.0	2.2	6.5	3.2
	Sorghum	9.5	8.7	10.7	11.0	19.2	17.2
17440	Corn	14.0	14.4	38.8	32.3	49.9	53.4
	Sorghum	15.0	14.0	44.2	39.0	46.5	44.6
17441	Corn	4.0	4.2	7.4	8.1	18.4	21.9
	Sorghum	5.7	6.7	27.9	21.5	49.0	50.9
	Average	13.0	12.9	23.5	22.1	30.8	30.3

Table 11. Phosphoric acid removed in parts per million of soil.

		1 KN	2 KNR	3 KN5R	4 KNF	5 KN5F	6 KND	7 KN2R	8 KN4R
2839	Corn	1.20	1.84	.....	2.18	.....	5.54	.....	.....
	Sorghum	4.84	7.36	.....	7.48	.....	10.20	.....	.....
5967	Corn	0.82	0.94	0.82	.....	.....	1.84	.....	.....
	Sorghum	1.38	6.17	7.72	.....	.....	6.28	.....	.....
8838	Corn	10.24	5.94	.....	11.84	.....	17.20	.....	.....
	Sorghum	7.80	19.04	.....	17.15	.....	18.10	.....	.....
9353	Corn	7.28	10.42	.....	10.68	.....	24.22	.....	.....
	Sorghum	6.06	12.12	.....	12.52	.....	18.74	.....	.....
9354	Corn	2.96	5.02	2.76	8.24	.....	14.94	.....	.....
	Sorghum	5.54	11.16	8.84	12.68	.....	18.44	.....	.....
10602	Corn	5.42	8.56	.....	.....	.....	10.04	.....	.....
	Sorghum	11.52	18.14	.....	.....	.....	19.38	.....	.....
12470	Corn	9.46	12.38	.....	.....	.....	.....	.....	.....
	Sorghum	3.96	10.70	.....	.....	.....	.....	.....	.....
12471	Corn	0.84	3.48	.....	.....	.....	8.20	.....	.....
	Sorghum	3.53	13.06	.....	.....	.....	.....	.....	.....
12654	Corn	4.64	5.22	.....	.....	.....	.....	4.08	7.16
	Sorghum	9.36	10.02	.....	.....	.....	.....	12.48	9.96
12662	Corn	1.60	8.78	.....	.....	.....	.....	11.72	.....
	Sorghum	3.34	10.16	.....	.....	.....	.....	8.70	.....
12663	Corn	6.70	6.94	.....	.....	.....	.....	7.46	7.24
	Sorghum	6.58	9.64	.....	.....	.....	.....	11.30	11.96
12664	Corn	2.24	3.16	.....	.....	.....	.....	3.50	2.80
	Sorghum	6.58	8.10	.....	.....	.....	.....	11.92	10.56
12665	Corn	6.60	19.88	.....	.....	.....	.....	18.16	19.48
	Sorghum	8.40	13.84	.....	.....	.....	.....	15.20	16.82
12666	Corn	1.94	9.26	.....	.....	.....	.....	5.14	14.76
	Sorghum	6.64	12.20	.....	.....	.....	.....	10.60	11.32
12667	Corn	5.10	16.40	.....	.....	.....	.....	16.38	16.18
	Sorghum	11.36	11.86	.....	.....	.....	.....	15.30	13.54
12672	Corn	1.44	4.64	.....	.....	.....	9.12	7.70	.....
	Sorghum	5.80	12.00	.....	.....	.....	.....	15.52	.....
12673	Corn	8.94	11.84	.....	.....	.....	18.54	12.08	16.72
	Sorghum	8.20	12.42	.....	.....	.....	.....	17.06	17.54
12680	Corn	4.36	13.66	.....	.....	.....	15.72	14.96	15.72
	Sorghum	4.20	10.78	.....	.....	.....	.....	10.82	.....
12739	Corn	3.20	3.78	.....	.....	.....	8.04	2.24	.....
	Sorghum	6.72	6.18	.....	.....	.....	.....	5.86	.....
12740	Corn	0.56	1.86	.....	.....	.....	2.40	0.40	0.82
	Sorghum	3.02	3.18	.....	.....	.....	.....	3.26	6.90
17440	Corn	5.82	15.26	13.78	16.72	15.54	20.66	.....	.....
	Sorghum	5.78	15.54	17.78	16.56	21.92	18.70	.....	.....
17441	Corn	1.80	3.44	4.36	4.10	5.64	7.30	.....	.....
	Sorghum	1.68	6.46	14.50	7.44	15.46	17.44	.....	.....
17443	Corn	7.02	7.52	.....	.....	.....	.....	.....	.....
	Sorghum	10.16	10.44	.....	.....	.....	.....	.....	.....
17480	Corn	8.94	8.76	.....	.....	.....	.....	.....	.....
	Sorghum	5.40	6.70	.....	.....	.....	.....	.....	.....

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SUMMARY AND CONCLUSIONS.

Pot experiments to test the effects of rock phosphate upon the phosphoric acid removed by corn and sorghum were conducted on soils low in active phosphoric acid.

The phosphoric acid removed per crop was 5.53 parts per million with no phosphate, average of 50 crops on about 25 soils, while with one ton of rock phosphate equal to about 300 parts phosphoric acid per million of soil, the phosphoric acid removed became 9.43 parts per million. This was a total increase of 3.4 parts per million, equal to 13.5 bushels corn.

The average percentage of phosphoric acid removed from rock phosphate is 1.3, and from soil phosphates 0.5 to 1.75.

Increasing the phosphoric acid added in rock phosphate from 300 parts per million to 600 parts per million increased the phosphoric acid removed per crop on an average only .63 parts per million.

The percentage of added phosphoric acid removed was 1.4 for 300 parts per million and 0.8 for 600 parts per million on the same crop on the same soil.

The percentage of added phosphoric acid removed per crop was 1.43 when one ton rock phosphate per acre was added, 0.80 when two tons was added, and 0.50 when four tons was added.

Additions of rock phosphate exceeding one ton to the acre have comparatively slight effects upon the amount of phosphoric acid removed by crops. The additions follow the law of diminishing returns, and the returns diminish rapidly.

Soft Florida phosphate is slightly more effective than hard Tennessee phosphate. The percentage of added phosphoric acid removed is 1.52 for hard rock phosphate and 1.98 for soft rock phosphate.

The amount of phosphoric acid removed from dicalcium phosphate is much greater than from the rock phosphate, and is not approached by the large applications of phosphates.

The phosphoric acid of rock phosphate is almost entirely soluble in fifth-normal nitric acid under the conditions of the analysis of soils, but the phosphoric acid added to the soil by rock phosphate does not represent as highly available phosphoric acid as is represented by the active phosphoric acid already present in the soil.