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

BULLETIN NO. 287 JANUARY, 1922

DIVISION OF CHEMISTRY

AVAILABILITY OF SOME NITROGENOUS AND PHOSPHATIC MATERIALS

B. YOUNGBLOOD, DIRECTOR.
COLLEGE STATION, BRAZOS COUNTY, TEXAS.

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BULLETIN NO. 287. JANUARY, 1922.

AVAILABILITY OF SOME NITROGENOUS AND PHOSPHATIC MATERIALS.

BY

G. S. FRAPS.

In connection with the use of fertilizers, it is important to know the readiness with which the different fertilizer materials give up their plant food to plants. A material which contains a high percentage of plant food, but gives it up only slowly, has, of course, only a low value to plants.

In connection with the study of soil chemistry, it is also important to know the readiness with which minerals contained in the soil give up their phosphoric acid and potash to plants.

Tests of various materials containing plant food to ascertain their availability have been made at this Station, some of which are reported in this bulletin. Some of these tests relate to the use of the materials as fertilizer, while others relate to their possible value to plants when occurring as soil minerals. These tests have been made from time to time during past years, and while not as complete as might be desired, it seems advisable to publish them.

AVAILABILITY OF NITROGEN OF CHARRED WHEAT

A quantity of wheat was damaged in an elevator fire, part of it being merely damaged by water, and part of it being charred by the heat. The Experiment Station was immediately called upon for information concerning the feeding value and the fertilizing value of this material. For this reason, it seemed desirable to make some pot experiments to ascertain the availability of the nitrogen in the wheat which was charred.

The experiments were carried out in the usual manner. The charred wheat was ground, and a quantity used containing 0.1 gram of nitrogen to 5000 grams of soil. Acid phosphate and potassium sulphate were added as usual. Two pots received no addition, while two pots received 0.1 gram nitrogen in cottonseed meal and other pots received nitrate of soda, for the purpose of comparison.

Table 1. Percentage of nitrogen removed from cottonseed meal compared with that from charred wheat and nitrate of soda.

	Cottonseed meal	Charred wheat	Nitrate of soda
9312 Corn	13.0	0	19.5
9330 Corn	24.4	4.9	59.4
9332 Corn	22.6	0	43.2
1956 Corn	18.1	0.8	.....
Average	19.5	1.4	40.7
Relative rank	100	7	208

The percentage of the added nitrogen recovered is given in Table 1. The amount of nitrogen recovered by one crop of corn from nitrate of soda was 40.7 per cent., from cottonseed 19.5 per cent., and from charred wheat 1.4 per cent. This is the average of four tests on four different soils. According to this experiment, the nitrogen in charred wheat has little fertilizing value. Details of the experiment are given in Table 2.

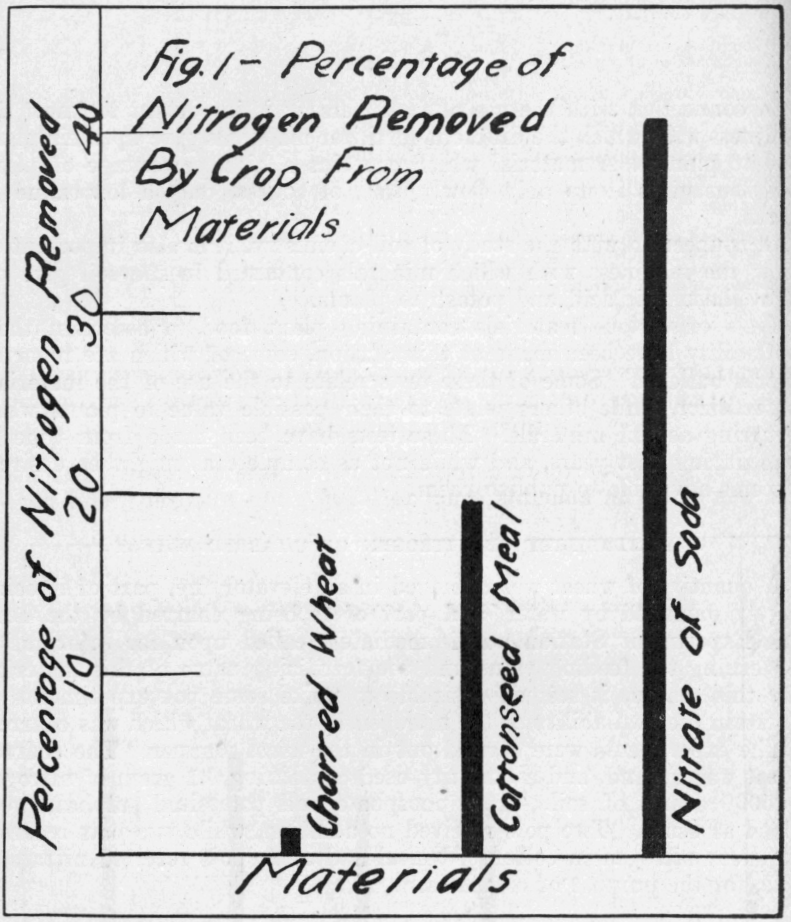

Figure 1. Percentage o f nitrogen removed by crops from charred wheat, cottonseed mea . . trate of soda.

Table 2. Details of experiments with charred wheat

	Additions	K. D.	K. D.	Cottonseed meal		Charred wheat		Nitrate of soda
				K. D.	K. D.	K. D.	K. D.	
9312	Weight of corn in grams....	7.5	8.4	10.6	12.2	7.0	7.8	.....
	Percentage of nitrogen in crop.....	.50	.49	.48	.44	.52	.42	.....
	Grams nitrogen in crop....	0.0375	0.0412	0.0509	0.0537	0.0364	0.0327	.....
	Average.....	.0393	.....	.0523	.....	.0345	.....	.....
9330	Weight of corn in grams....	7.5	8.4	14.5	16.5	7.2	9.1	24.5
	Percentage of nitrogen in crops.....	.61	.49	.44	.43	.61	.58	.42
	Grams nitrogen in crops....	0.0458	0.0412	0.0638	0.0720	0.0439	0.0528	.1029
	Average.....	.0435	.....	.0679	.....	.0484	.....	.....
9332	Weight of corn in grams....	8.3	10.2	14.8	14.5	7.6	6.8	23.3
	Percentage of nitrogen in crops.....	.53	.42	.47	.43	.53	.44	.42
	Grams nitrogen in crops....	0.0440	0.0428	0.0696	0.0624	0.0403	0.0299	.0979
	Average.....	.0434	.....	.0660	.....	.0351	.....	.....
1956	Weight of corn in grams....	20.2	20.2	25.7	24.0	23.9	18.1	.....
	Percentage of nitrogen in crops.....	0.45	0.43	0.44	0.42	0.41	0.45	.....
	Grams nitrogen in crops....	.0909	.0869	.1131	.1008	.0980	.0815	.....
	Average.....	.0889	.....	.1070	.....	.0897	.....	.....

AVAILABILITY OF NITROGEN OF COTTONSEED MEAL, COTTONSEED MEAL AND CARBONATE OF LIME, CYANAMID, MUCK TANKAGE, AND HORN AND HOOF MEAL

These experiments were conducted on seven different soils. The material was added in amounts equal to 0.106 gram nitrogen; acid phos-

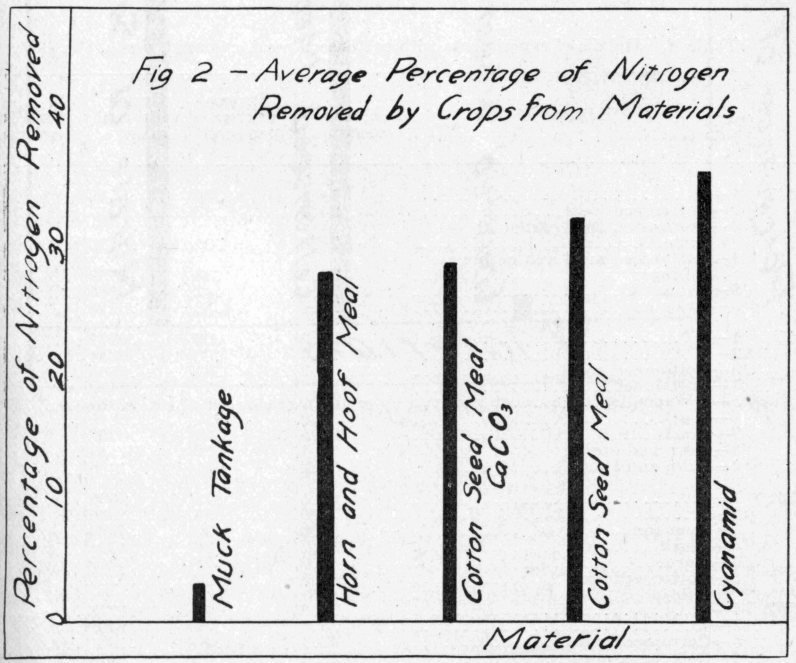

Figure 2. Availability of nitrogen.

phate and sulphate of potash were added. Sorghum was grown as the experimental crop. A second crop was also grown on some of the soils, but the amount of the additional nitrogen taken up by this second crop was in most cases very small, so that the results with this crop are not given. The amount of soil used was 5000 grams. A summary of the experiments is given in Table 3 and details in Table 4.

Table 3. Percentage of nitrogen removed by sorghum.

	Cottonseed meal	Cottonseed meal and carbonate of lime	Cyanamid	Muck tankage 2388	Horn and hoof meal 2387
4647	28.3	23.1	43.7	.....	.....
4650	22.0	.....	19.4	3.6	30.8
4597	13.2	35.1	49.2	0	20.0
3341	75.7	.....	26.8	6.4	38.8
4602	32.5	27.5	38.4	.....	.....
4603	11.3	.....	27.8	0	2.8
4644	42.3	.....	.....	5.11	46.8
Average	32.2	28.6	35.9	3.0	27.8
Relative rank	100	89	111	9	86

The effect of the addition of carbonate of lime to cottonseed meal was tested on account of the great benefit which is known to occur when this addition is made to cottonseed meal to be nitrified. The addition was made only on three soils. With two of these soils, there was a decrease in the percentage of nitrogen taken up, and with one there was an increase.

Table 4. Details of experiments with cottonseed meal, cyanmid, muck, etc.

	Addition	Grams sorghum	Nitrogen in crop, per cent	Grams nitrogen in crop	Gain in grams
4647	1—0	14.3	.36	.0515	.....
	2—Cottonseed meal	24.7	.33	.0815	.0300
	3—Cottonseed meal carbonate of lime	20.0	.36	.0720	.....
	4—Cottonseed meal and carbonate of lime	24.2	.33	.0799	.0245
	5—Cyanamid	23.0	.42	.0966	.....
	6—Cyanamid	27.6	.36	.0994	.0465
4650	1—0	25.2	.29	.0731	.....
	2—0	27.7	.30	.0831	.....
	3—Cottonseed meal	29.2	.31	.0905	.....
	4—Cottonseed	38.7	.29	.1122	.0233
	5—Cyanamid	32.9	.30	.0987	.0206
	6—Muck	28.0	.30	.0840	.....
	7—Muck	27.5	.29	.0798	.0038
	8—Horn and hoof	38.1	.30	.1143	.....
	9—Horn and hoof	34.2	.31	.1060	.0326
3341	1—0	63.5	.73	.4636	.....
	2—0	58.9	.95	.5596	.0960
	3—Cyanamid	52.9	.93	.4920	.0284
	4—Muck	54.7	.86	.4704	.0068
	5—Horn	64.7	.78	.5047	.0411
	6—Cottonseed meal	34.8	1.52	.5290	.0644
4597	1—0	29.6	.43	.1273	.....
	2—0	35.8	.41	.1468	.....
	3—Cottonseed meal	42.1	.40	.1684	.....
	4—Cottonseed meal	32.1	.41	.1316	.0140
	5—Cottonseed meal and lime	34.5	.40	.1380	.....

Table 4. Details of experiments with cottonseed meal, cyanmid, muck, etc.

	Addition	Grams sorghum	Nitrogen in crop, per cent	Grams nitrogen in crop	Gain in grams
4597	6—Cottonseed meal and lime	52.5	.42	.2205	.0372
	7—Cyanamid	35.3	.47	.1659	.....
	8—Cyanamid	47.2	.45	.2124	.0522
	9—Muck tankage	26.3	.43	.1105	.....
	10—Muck tankage	31.8	.42	.1336	0
	11—Horn and hoof	39.5	.40	.1580	.....
	12—Horn and hoof	36.0	.44	.1584	.0212
4602	1—Cottonseed meal	18.3	.37	.0677	.....
	2—Cottonseed meal	23.2	.34	.0789	.0345
	3—Cottonseed meal and lime	19.0	.34	.0646	.....
	4—Cottonseed meal and lime	17.4	.41	.0713	.0291
	5—Cyanamid	21.8	.40	.0872	.....
	6—Cyanamid	17.1	.42	.0718	.0407
	7—0	9.7	.40	.0388	.....
4603	1—0	30.9	.36	.1112	.....
	2—Cottonseed meal	40.4	.33	.1332	.0120
	3—Cyanamid	40.2	.35	.1407	.0295
	4—Muck	28.6	.34	.0972	0
	5—Horn and hoof	38.1	.30	.1143	.0030
4644	1—0	5.3	.73	.0387	.....
	2—0	6.3	.63	.0497	.....
	3—Cottonseed meal	5.5	.65	.0358	.....
	4—Cottonseed meal	6.1	.64	.0390	.0024
	5—Muck	7.3	.60	.0438	.....
	6—Muck	7.0	.58	.0406	.0077
	7—Horn and hoof	6.3	.59	.0372	.0027

Cyanamid on some of the soils is much less available than cottonseed meal, and on other soils is decidedly more so. On an average, its nitrogen is about 10 per cent. more available than the nitrogen of cottonseed meal.

Muck tankage, so called, is a vegetable material. The availability of the nitrogen in this material is very low. Its nitrogen has about 10 per cent. of the value of that in cottonseed meal.

Horn and hoof meal is often considered to have only a low availability. The availability found in these experiments varies, but on an average it is about 16 per cent. less than that of cottonseed meal. Previous experiments have shown this material to be about as available as cottonseed meal. (See Fraps, "Principles of Agricultural Chemistry," page 300.)

AVAILABILITY OF MINERAL PHOSPHATES

In Bulletin 178 of this Station, the effect of additions of carbonate of lime, starch, sawdust, and corn cobs upon the phosphoric acid of the soil was discussed and it was shown that the addition of carbonate of lime increased slightly the size of the crop and the amount of phosphoric acid withdrawn.

The experiment here reported was run on one soil with several mineral phosphates, and additions of various substances. Corn was grown as the experimental crop, upon 5000 grams of soil, with mineral phosphate equal to 0.2 gram phosphoric acid and with 25 grams of carbonate of lime or other addition. Ammonium nitrate and sulphate of potash were also added.

The relative availability of the phosphates with and without the addi-

tions is shown in Table 5. Duplicate pots were used, and the results given are the average.

Table 5. Percentage of phosphoric acid received from phosphate alone and with the additions named

	Alone	Serpentine	Carbonate of lime	Siderite	Starch	Sawdust	Limonite
Rock phosphate	0	0	0	.....	.....	.....	0.2
Acid phosphate	19.8	18.4	17.2	16.3	4.1	17.3	20.4
Vivianite	6.5	.....	5.6	16.0	2.8	7.0	4.0
Triplite	4.5	.....	13.5	.....	.....	1.8	.....
Wavellite	1.6	.....	1.0	.....	.....	1.0	.....
Dufrenite	1.5	.....	2.5	.....	.....	4 8	.....

With this particular soil, the phosphoric acid of rock phosphate was not taken up at all. The phosphoric acid of vivianite had about one-third the availability of that of acid phosphate, and triplite about one-fourth. Wavellite and dufrenite had about one-tenth of the availability of acid phosphate.

Starch decreased the amount of phosphoric acid taken up, probably on account of the fermentation it caused in the soil. Carbonate of lime decreased slightly the amount of phosphoric acid removed from acid phosphate, vivianite, and wavellite, and increased slightly that taken up from dufrenite. Carbonate of lime exerted a very high effect upon triplite, increasing the phosphoric acid taken up decidedly. Siderite decreased the availability of phosphoric acid in rock phosphate, and increased decidedly the availability of that in vivianite. Starch decreased the phosphoric acid removed very decidedly, from acid phosphate and from vivianite. Sawdust decreased the phosphoric acid removed from acid phosphate, triplite, and wavellite, and increased that taken up from vivianite and from dufrenite. Limonite slightly increased the phosphoric acid taken up from the acid phosphate, and decreased that taken up from vivianite.

The results of this single experiment on these materials cannot give more than indications.

AVAILABILITY OF PHOSPHORUS COMPOUNDS IN COTTONSEED MEAL

Previous work by J. B. Rather (Texas Bulletin 146) has shown that the phosphorus compounds of cottonseed meal are largely organic in nature and not inorganic as has been supposed. (S. C. Bulletin 8.) The principal compound was shown to be a salt of phytic acid. (Texas Bulletin 156.) Cottonseed meal has an extensive application as a commercial fertilizer in the South, especially in Texas. While the amount of phosphoric acid introduced into a fertilizer by cottonseed meal is small, the availability of the phosphorus compounds of cottonseed meal is of theoretical importance. It is all the more so because the methods of determining available phosphoric acid in mineral fertilizers are not necessarily applicable to organic fertilizers.

According to Berthlot (E. S. Record 19,528) phytin is readily assimilated by such lower plants as yeasts, fungi, algae, and bacteria. Aso and Yoshida (J. College of Imp. Univ., Tokyo, I, 153-161) compared

the manurial values of phytin, lecithin, and nuclein with sodium, aluminum, iron, and tricalcium phosphate. Phytin was found to be nearly equal in manurial value to iron phosphate.

Method of Conducting the Experiments.—Three soils were selected which were very poor in both total and active phosphoric acid. Washed gravel was added in sufficient amounts to an 8-inch Modified Wagner pot to make the total weight 2 kilograms. Five kilograms of soil were then added. The soil had previously been pulverized in a wooden box with a wooden mallet until it would pass a 3-mm. sieve, gravel being removed. All pots received 2.5 grams of calcium carbonate at the beginning of the experiment and 1 gram each of potassium sulphate and ammonium nitrate before planting each crop. The seeds were weighed out with the aid of a balance so that each pot received the same amount of seed within 0.1 gram. Water was added to one-half the saturation capacity of the soils and brought up to this point three times weekly throughout the growth of the crops. Water was added between these periods as seemed necessary. The crops were grown in glass-roofed houses with canvas walls and ceiling.

To two pots of each soil, no addition of fertilizer was made except that already mentioned, which was added to all pots. Forty milligrams of available phosphoric acid in the form of acid phosphate were added to two pots of each soil. Forty milligrams of phosphoric acid in the form of crude phytin from cottonseed meal were added to two pots. To two pots of each soil were added 40 milligrams of phosphoric acid in the form of a water extract from cottonseed meal.

The aqueous extract was made as follows: One hundred grams of cottonseed meal was digested for three hours with 500 c.c. water at room temperature with frequent shaking. The solution was filtered and washed to a volume of 500 c.c. Twenty-five cubic centimeters of this extract contained 32.85 mg. phosphoric acid (P_2O_5).

The crude phytin was prepared by digesting a portion of the above cottonseed meal with water, filtering and precipitating with alcohol. The precipitate was filtered, air-dried, and powdered. It contained 20.20 per cent. phosphoric acid. There was no further addition of phosphoric fertilizer during the experiment. During the seasons of 1913 and 1914, corn was grown, followed by sorghum. The period of growth was in every case two months from the date of planting. After harvesting, the crops were air-dried in an oven at a low temperature, weighed, ground, and the phosphoric acid determined in each.

Results of the Experiment.—The amount of phosphoric acid in each crop from the phosphoric acid pots, less the amount in the crop from the blank pots, was taken to be the amount of fertilizer recovered. This is expressed in percentage of phosphoric acid added. The results are shown in Tables 6 and 7.

Table 6. Phosphoric acid recovered in crops, percentage.

	Form of phosphoric acid	Corn 1913	Sorghum 1913	Corn 1914	Sorghum 1914	Total four crops
5938	Acid phosphate	35.0	22.0	1.0	3.3	61.3
	Crude phytin	19.0	13.8	0.0	1.2	34.0
	Aqueous extract	13.5	2.5	0.0	0.6	16.6
6268	Acid phosphate	23.8	8.5	4.5	2.0	38.8
	Crude phytin	14.5	15.5	3.1	3.0	36.1
	Aqueous extract	2.5	7.0	0.0	3.5	18.0
5969	Acid phosphate	23.3	25.0	25.6	13.0	86.9
	Crude phytin	11.8	51.3	13.5	13.0	88.6
	Aqueous extract	5.5	16.5	2.0	13.5	37.5
	Average acid phosphate					62.3
	Average crude phytin					52.9
	Average aqueous extract					24.0

On one soil, the phosphorus in crude phytin has only half the availability of that of acid phosphate, but with the other two soils, the availability is practically the same, when measured by four crops. When measured by the first crop, the phosphorus in crude phytin is about half as available as that in acid phosphate. The availability increases with the second crop.

The phosphoric acid in the aqueous extract of cottonseed meal has a much lower availability than that in crude phytin.

The work on phytin described above was carried out by Mr. J. B. Rather.

Table 7. Details of experiments with phytin.

	Form of phosphoric acid	Corn			Sorghum			Corn			Sorghum		
		Weight crop grams	Per cent P_2O_5 in crop	Mg P_2O_5 in crop	Weight crop grams	Per cent P_2O_5 in crop	Mg P_2O_5 in crop	Weight crop grams	Per cent P_2O_5 in crop	Mg P_2O_5 in crop	Weight crop grams	Per cent P_2O_5 in crop	Mg P_2O_5 in crop
5938	None	12.6	.213	26.8	17.2	.153	26.3	8.8	.215	17.6	6.2	.17	10.5
	None	12.9	.215	27.7	17.3	.155	26.8	7.9	.205	16.2	6.2	.16	9.9
	Acid phosphate	21.2	.205	43.5	22.2	.157	34.9	10.1	.175	17.7	7.5	.15	11.3
	Acid phosphate	19.3	.203	39.1	22.0	.163	35.9	10.5	.158	16.8	8.4	.14	11.8
	Crude phytin	15.7	.193	30.3	19.0	.159	30.2	11.5	.155	17.8	8.3	.14	11.6
	Crude phytin	20.9	.189	39.5	23.2	.150	34.8	7.7	.200	15.4	6.5	.15	9.8
	Aqueous extract	13.1	.213	27.9	17.8	.155	27.6	8.2	.187	15.3	6.7	.15	10.1
	Aqueous extract	17.4	.213	37.0	20.7	.133	27.5	8.8	.190	16.7	7.7	.14	10.8
6268	None	9.2	.178	16.4	13.0	.120	15.6	7.9	.195	15.4	11.6	.13	15.1
	Acid phosphate	16.2	.170	27.5	17.8	.110	19.6	9.5	.170	16.2	11.0	.14	15.4
	Acid phosphate	14.5	.173	75.0	16.0	.115	18.4	11.0	.165	18.2	11.7	.14	16.4
	Crude phytin	14.5	.169	24.5	19.7	.105	20.7	11.2	.150	16.8	12.0	.13	15.6
	Crude phytin	12.7	.157	19.9	19.9	.115	22.9	10.8	.157	16.5	13.0	.13	16.9
	Aqueous extract	10.5	.157	16.5	15.3	.120	18.4	8.6	.140	12.0	11.5	.14	16.1
5969	None	7.7	.199	15.3	10.3	.170	17.5	6.5	.147	9.6	8.2	.15	12.3
	None	8.1	.183	14.8	12.2	.147	17.9	6.8	.205	13.9	8.0	.15	12.0
	Acid phosphate	15.6	.168	26.2	18.2	.153	27.8	9.9	.187	18.5	9.6	.17	16.3
	Acid phosphate	12.1	.186	22.5	18.8	.147	27.6	14.5	.180	26.1	11.5	.16	18.4
	Crude phytin	11.2	.183	20.5	23.2	.165	38.3	8.9	.200	17.8	10.5	.17	17.9
	Crude phytin	10.9	.174	19.0	20.6	.185	38.1	9.5	.175	16.6	10.5	.16	16.8
	Aqueous extract	9.7	.179	17.4	14.0	.193	27.0	7.4	.158	11.6	7.0	.25	17.5
	Aqueous extract	9.8	.174	17.1	14.6	.148	21.6	8.0	.170	13.6	8.0	.22	17.6

AVAILABILITY OF PHOSPHORIC ACID OF COTTONSEED MEAL

In this test, 40 mg. phosphoric acid was added in the form of available phosphoric acid in acid phosphate or as total phosphoric acid in cottonseed meal, to 5000 grams soil, together with 1 gram each potassium sulphate and nitrate of soda. Pots to which no phosphoric acid was added were also used.

The percentage of phosphoric acid removed is shown in Table 8. Details are given in Table 9. The percentage of phosphoric acid removed from the cottonseed meal is always higher for the first crop than for the acid phosphate. If we compare with the preceding work, we find that phosphoric acid of cottonseed meal is more available than phytin used alone. Possibly the decomposition of the organic matter of the cottonseed meal aids in the decomposition of the phytin.

Table 8. Percentage of phosphoric acid removed from acid phosphate and cottonseed meal.

		Acid phosphate	Cottonseed meal
9284	Corn	9.5	16.5
9286	Corn	15.0	18.5
9286	Sorghum, second crop	21.0	5.0
9271	Corn	7.9	11.7
9271	Sorghum, second crop	19.5	1.5
	Average	24.3	17.4
	Relative value	100	72

Table 9. Details of experiments on phosphoric acid of cottonseed meal.

	Addition	Grams crop	Per cent phosphoric acid in crop	Grams phosphoric acid in crop
9284	1—0	6.5	.12	0.0078
	2—0	5.7	.19	0.0108
	3—Acid phosphate	7.2	.20	0.0144
	4—Acid phosphate	5.6	.21	0.0118
	5—Cottonseed meal	12.5	.16	0.0200
	6—Cottonseed meal	8.5	.14	0.0119
9286	1—0	7.8	.18	0.0140
	2—0	8.3	.13	0.0108
	3—Acid phosphate	9.2	.21	0.0193
	4—Acid phosphate	8.4	.21	0.0176
	5—Cottonseed meal	10.9	.14	0.0153
	6—Cottonseed meal	13.4	.18	0.0241
9286	1—0 Second crop	2.4	.18	0.0043
	2—0	1.7	.24	0.0041
	4—Acid phosphate	7.4	.17	0.0126
	5—Cottonseed meal	3.7	.17	0.0063
9271	1—0 Second crop	8.6	.21	0.0181
	2—0	8.4	.24	0.0202
	3—Acid phosphate	9.9	.27	0.0267
	4—Acid phosphate	9.1	.30	0.0273
	5—Cottonseed meal	14.6	.24	0.0350
	6—Cottonseed meal	13.1	.22	0.0288
9271	1—0	12.0	.16	0.0192
	2—0	9.4	.13	0.0122
	3—Acid phosphate	19.2	.14	0.0269
	4—Acid phosphate	15.2	.13	0.0198
	5—Cottonseed meal	12.9	.11	0.0142
	6—Cottonseed meal	12.5	.15	0.0188

AVAILABILITY OF THE PHOSPHORIC ACID OF BASIC SLAG

Basic slag phosphate is a by-product obtained in the manufacture of steel from iron containing phosphorus. The phosphoric acid is combined with lime, and is more available than phosphoric acid in rock phosphate, but less available than the phosphoric acid in acid phosphate.

Some years ago, a committee was appointed by the Association of Official Agricultural Chemists for the purpose of studying methods for determining the availability of the phosphoric acid of Thomas phosphate, and the experiments here reported were made on samples furnished by this committee, and in co-operation with them. The final report of this committee was made by Mr. Haskins at the meeting in October, 1921. The amount of soil used was 5000 grams, and the amount of phosphatic materials corresponded to approximately 35 milligrams. The quantity taken was based upon the total phosphoric acid in the basic slag and the phosphate rock, and on the available phosphoric acid in the acid phosphate.

Table 10. Average rank based on phosphoric acid recovered, compared with acid phosphate as 100.

Soil		Slag A	Slag B	Slag C	Slag D	Acid phosphate	Acid phosphate double quantity	Rock phosphate
6881	Rank, 3 crops.....	53	56	79	43	100	91	32
6684	Rank, 3 crops.....	16	104	56	38	100	118	109
7236	Rank, 3 crops.....	.....	107	62	40	100	113	22
7230	Rank, 3 crops.....	78	79	37	34	100	85	62
6885	Rank, 3 crops.....	94	142	48	.....	100	.....	.....
9283	Rank, 2 crops.....	89	77	86	70	100	.....	84
	Average.....	66	94	61	45	100	102	62
9288	Rank, 2 crops (not included in average).....	260	173	73	67	100	.....	27

Table 10 gives the relative rank of the phosphoric acid in these materials, compared with the available phosphoric acid in acid phosphate as 100. The phosphoric acid in the crop without phosphate was deducted. This is based on the relative amounts of phosphoric acid taken by three crops with five of the soils, and two crops with six. If the first crops only were considered, the rank of the basic slag would be lower. That is to say, the phosphoric acid of the acid phosphate is taken up most quickly by the first crop.

There is a considerable variation in the availability of the phosphoric acid of the basic slag in the different soils. It does not hold the same relative rank in all the soils. The average availability compared with acid phosphate varies from 45 to 94, the average of all being about 65 per cent.

The availability of the phosphoric acid of rock phosphate combined with acid phosphate is higher than that given in Bulletin 212 of this Station, but this difference may be due to the continuation of the experiment after the available phosphoric acid in the acid phosphate was practically exhausted by the first one or two crops. This would result

in an apparent availability much lower for the acid phosphate and much higher for the rock phosphate than should really be the case. The same thing would work in favor of the other less available materials, including the basic slag.

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SUMMARY AND CONCLUSIONS

1. The nitrogen of charred wheat has little fertilizing value.

2. While carbonate of lime increases nitrification of cottonseed meal when added to soils with cottonseed meal, in two cases there was a decrease in the amount of nitrogen taken up by plants, and in one case there was a slight increase.

3. Cyanamid on some of the soils is much less available than cottonseed meal, and on other soils is decidedly more so. As an average on tests on six soils, the nitrogen of cyanamid is about 10 per cent. more available than the nitrogen of cottonseed meal.

4. The availability of nitrogen of muck tankage is about 10 per cent. of that of cottonseed meal.

5. The nitrogen of horn and hoof meal has an availability about 84 per cent. of that of cottonseed meal, in the experiments here reported.

6. In a test on one soil, the phosphoric acid of rock phosphate was not taken up at all. The phosphoric acid of vivianite had about one-third the availability of that of acid phosphate, and triplite about one-fourth. Wavellite and dufrenite had about one-tenth the availability of the phosphoric acid of acid phosphate.

7. Starch decreased the amount of phosphoric acid taken up, probably on account of the fermentation. Carbonate of lime decreased slightly the amount of phosphoric acid removed from acid phosphate, vivianite and wavellite, and increased slightly that taken up from dufrenite. Carbonate of lime increased the phosphoric acid taken up from triplite decidedly.

8. Siderite decreased the availability of phosphoric acid in rock phosphate, and increased decidedly that of vivianite.

9. When measured by four crops, the phosphorus in phytin is taken up about the same as that of acid phosphate. When measured by the first crop the phosphorus in crude phytin is about half as available as that in acid phosphate.

10. The phosphorus in the aqueous extract of cottonseed meal has a much lower availability than that in crude phytin.

11. Phosphoric acid is taken up from cottonseed meal to a greater extent than from acid phosphate.

12. There is a considerable variation in the availability of the phosphoric acid of basic slag in different soils. The average availability compared with acid phosphate varies from 45 to 94 per cent., the average of all being about 65 per cent. This is based on experiments on six soils and on three crops. If the first crops only were considered, the rank of the basic slag would be lower, since the phosphoric acid of the acid phosphate is taken up more quickly by the first crop.