THE EFFECT OF DECOMPOSING ORGANIC MATTER ON NATURAL PHOSPHATES.

By Dr. N. T. Lupton.

During the past few years especial attention has been called to the fertilizing value of natural or raw phosphates, when applied alone in the form of floats and when mixed with organic matter, such as cotton seed and cotton seed meal.

If floats can be shown to produce as good results as acidulated phosphates, which is claimed by some, the cost of commercial fertilizers ought to be greatly reduced and the extensive deposits of soft, aluminous phosphates found in Florida and elsewhere find a ready sale. While the results of experiments are somewhat conflicting, there appear to be conditions under which floats, or ground raw phosphates, do produce as good, if not better results, than acid phosphates. The presence of decomposing organic matter is generally regarded as one of these conditions, but chemists are not agreed as to the precise nature of its action.

Liebig, in his letters on "Modern Agriculture," published in 1859, advances the theory that organic matter undergoing decay accumulates carbonic acid in the soil, and when rain falls it dissolves the carbonic acid and thereby acquires the power of taking up phosphate of lime. This carbonic acid water does not withdraw from the soil the phosphate of lime contained in it, but wherever it meets with the granules of apatite or phosphorite, it dissolves a certain portion. Under these circumstances, a solution of phosphate of lime must consequently be formed, which spreads in all directions around each granule. Wherever this solution comes in contact with soil not already saturated with phosphate of lime, the soil will take up and retain a certain portion of this salt. The portion of soil now saturated with phosphate will oppose no further obstacle to the wider diffusion of the solution.

Voelcker (Bied. Centr. 1880—866, 867) as quoted in the Journal of the English Chemical Society, Vol. 24, Second Series, page 640, draws the following conclusions:

1. Phosphates are not readily taken up by plants in a soluble form, but must be returned to an insoluble condition before they yield their useful properties.

2. The efficacy of insoluble calcium phosphate corresponds with the minuteness of division in which it is found in a fertilizer.

3. The finer the particles in a phosphatic material, the more energetic its action as a manure.

Fleischer and Kissling (Bied. Centr. 1883—155, 161) on the application of insoluble phosphates to soils, found that the action of moorland soils when mixed with insoluble phosphates is to render a portion of the phosphate soluble in water, amounting to 5.5 per cent., in one case, of the total phosphoric acid; a portion at the same time was reduced to the di-calcium salt, and in one compost heap as much as 17 per cent. of the total acid was brought into this form.

The general outcome of their experiments is that it is more advantageous to apply insoluble phosphate than superphosphate on humous soils, as they are capable of bringing insoluble phosphate into a soluble condition. This applies, however, only to peaty soils, as the presence of lime hinders this action.

In Volume 30 of the Journal of the Chemical Society, page 774, is an abstract of an article from the Journal of the Royal Agricultural Society, 1884, by Dyer, which states that the first experiments made in 1882 in a stiff clay soil containing no calcium carbonate, ground and unground coprolites were used. The comparison was made with swedes both with and without manure; in each case, the better result was from the undissolved phosphate. On the same plots, the following year, oats were grown without further addition of manure, and the produce was again, on an average, better where the undissolved phosphate had been employed. The following year 225 bushels of lime per acre were plowed in before sowing. The same quantities of manure were applied as before. The season was dry and the crop small, but in this case the produce was better where the dissolved phosphate

had been used. The ground coprolite contained more than twice as much phosphoric acid as the superphosphate.

Coming nearer home, we find that experiments made at the Alabama Agricultural Station are of similar import.

In Bulletin No. 22, new series, January, 1891, we find the following statement: "In several experiments previously conducted to ascertain the comparative agricultural value of the phosphate rock ground to impalpable powder, known as floats, with that of acidulated phosphate, the results have indicated that used in conjunction with cotton seed meal, floats are more profitable than the acid phosphate, taking into consideration the fact that floats contain nearly twice the percentage of phosphoric acid.

The soil used in these experiments was sandy drift that had been lying out many years. No commercial fertilizer had been previously applied to it."

To test more thoroughly the comparative productiveness of ground raw phosphate and acid phosphate under different conditions and to determine whether decomposing organic matter converts insoluble into soluble phosphate, two sets of experiments were carried out, one on the farm and the other in the chemical laboratory, the results of which will now be given.

The materials used were carefully analyzed by Dr. Anderson, assistant chemist, with the following results:

The acid phosphate used, gave

Water soluble phosphoric acid (P_2O_5)	....	9.10 per cent.
Citrate soluble " "	....	2.94 "
Acid soluble " "	....	2.32 "
Total phosphoric acid (P_2O_5)	....	14.36 "

The Florida phosphate reduced to a fine powder, similar to floats, gave

Moisture	4.18
Insoluble matter	32.39
Total phosphoric acid (*acid soluble*)	16.54
Iron and aluminium oxides	8.89

None of the lime phosphate was soluble in water and only 0.32

was soluble in ammonium citrate. The analysis shows an inferior grade of raw phosphate. The material purchased as "South Carolina floats" contained 2.26 per cent. of available phosphoric acid in the form of citrate soluble acid and a total phosphoric acid of 28.73 per cent. The available phosphoric acid in each of the materials used in the experiments may be stated as follows:

1. Cotton seed meal, available acid (P_2O_5) 3.19 per cent.
2. Cotton seed, " " 1.03 "
3. Florida raw phosphate, " " 0.32 "
4. South Carolina floats, " " 2.26 "
5. Acid phosphate, " " 12.04 "

Two qualities of land were selected at the station for the field experiments, one a strong red soil, the other a poor sandy soil. The results obtained were as follows; on the poor soil the fertilizers were sown broadcast:

		Lbs. Seed Cotton per acre.
No. 1	400 lbs. pulverized Florida phosphate.	290.5
" 2	800 " " "	219.8
" 3	400 " acid phosphate	196.7
" 4	800 " "	144.2
" 5	No fertilizer	106.4
" 6	400 lbs. Florida phosphate with 400 lbs. cotton seed meal	249.2
" 7	800 lbs. Florida phosphate with 800 lbs. cotton seed meal	322.7
" 8	400 lbs. acid phosphate with 400 lbs. cotton seed meal	252.0
" 9	800 lbs. acid phosphate with 800 lbs. cotton seed meal	320.6
" 10	No fertilizer	233.8

Each plot was one-seventh of an acre and the usual precautions were taken to remove disturbing elements and have the conditions of cultivation and growth as uniform as possible. The details of

the work were under the immediate supervision of Mr. Clayton, assistant agriculturist. On the strong red soil, the fertilizers were applied in the drill with results as follows:

		Lbs. Seed Cotton per acre.
No. 1	200 lbs. Florida phosphate with 200 lbs. cotton seed meal	1016.6
" 2	400 lbs. Florida phosphate with 400 lbs. cotton seed meal	1105.6
" 3	200 lbs. acid phosphate with 200 lbs. cotton seed meal	844.8
" 4	400 lbs. acid phosphate with 400 lbs. cotton seed meal	1108.8
" 5	No fertilizer	863.2
" 6	200 lbs. Florida phosphate with 400 lbs. cotton seed	919.2
" 7	400 lbs. Florida phosphate with 800 lbs. cotton seed	1182.4
" 8	200 lbs. acid phosphate with 400 lbs. cotton seed	1178.4
" 9	400 lbs. acid phosphate with 800 lbs. cotton seed	1387.2
" 10	No fertilizer	931.2
" 11	400 lbs. Florida phosphate	892.8
" 12	400 " acid phosphate	975.2
" 13	400 " cotton seed meal	1271.2
" 14	800 " cotton seed	1294.4

The land was not uniform in natural productiveness but improved in quality from the first to the last plot. While the results are not perfectly uniform the pulverized raw phosphate evidently produced as good if not better results than the acid phosphate, whether used alone or mixed with cotton seed and cotton seed meal.

Anticipating these results, experiments were carried on in the

laboratory during the summer to determine whether they are due to the fact that decomposing organic matter converts insoluble or acid soluble lime phosphate into the available or citrate soluble condition. For this purpose, half-gallon, wide-mouthed glass jars were used and the following mixtures placed in each :

No. 1....2 lbs. Florida phosphate with ½ lb. cotton seed meal.
" 2....1 " " " " "
" 3....2 " South Carolina floats " "
" 4....1 " " " " "
" 5....2 " Florida phosphate with ½ lb. cotton seed.
" 6....1 " " " " "
" 7....2 " South Carolina floats " "
" 8....1 " " " " "

The contents of each jar were rubbed up in a porcelain mortar moistened with water, and mixed as thoroughly as possible. The mixtures were stirred frequently, in fact nearly every day. Fermentation began within a day or two and continued during the whole period of the experiments. Samples for analysis, that is, for the determination of available phosphoric acid, were taken from the jars and analyzed with results as follows:

Date of taking Sample.	*Per cent. of available* P_2O_5 *found.*							
	1	2	3	4	5	6	7	8
July 2..	0.99	1.69	2.68	3.04	0.58	0.54	2.77	——
" 9..	1.25	1.62	2.89	2.64	0.72	0.95	2.33	2.27
" 16..	1.25	1.61	2.89	2.82	0.72	0.80	2.29	2.26
" 23..	1.16	1.80	3.37	3.22	0.84	0.49	2.37	2.39
" 30..	1.12	1.60	3.02	3.38	0.72	0.53	1.81	2.70
Aug. 6..	1.41	1.79	2.87	3.15	0.82	1.08	2.49	2.57
" 20..	1.41	1.57	2.73	3.26	0.81	1.00	2.15	2.53
Sept. 3..	1.50	2.16	2.75	3.27	1.16	1.10	1.96	2.51
" 17..	1.41	1.75	2.56	2.91	1.07	0.89	2.04	2.32
Oct. 1..	——	2.28	2.97	3.14	0.99	1.26	2.57	2.51

The above results seem to show that the fermentation of the

cotton seed and cotton seed meal had very little, if any, effect on the Florida ground phosphate or the South Carolina floats in converting the insoluble into soluble phosphate. The slight variation in the results, though favoring to some extent the conclusion that there is a slight increase in the available phosphoric acid, may be accounted for on the ground of personal error or the want of uniformity in the mixing of the materials, since it is difficult if not impossible to secure perfect uniformity in a mixture of ground phosphate and cotton seed.

AUBURN, Alabama, December, 1892.