

INFLUENCE OF GYPSUM UPON THE SOLUBILITY OF POTASH IN SOILS¹

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INTRODUCTION

The use of gypsum as a fertilizer was probably familiar to the Romans. Its beneficial effect has been noticed particularly with such field crops as clover and alfalfa, which are especially dependent upon a generous supply of potash, and its action is commonly assumed to be due to an ability to replace potassium in the soil minerals and, hence, to increase the water-soluble portion of this constituent. More recently its favorable effects upon such crops has been attributed by some investigators to its sulphur content. Some of the recently reported laboratory experiments show that applications of gypsum have a very marked effect upon the solubility of potash, while some others indicate that it either has no effect whatsoever or actually decreases the solubility of the potash.

Bradley (3)² found that gypsum added both to soils from western Oregon and to the mineral pegmatite markedly increased the content of water-soluble potash.

Dumont (5), studying the effect of gypsum upon both granitic soils and the separates from these obtained by mechanical analyses, found that when mixed with about one-third its weight of gypsum, moistened, and allowed to stand, the soil gave increasing amounts of water-soluble potash with lengthening periods of contact between soil and gypsum. In the case of the soil separates the fine sand showed an increase of 0.016 part per 1,000 of soil, while the coarser sands and the clay showed no increase even after 34 days' contact.

Morse and Curry (7, p. 49-50) found that when powdered feldspar was treated with gypsum the solubility of the potash in water was increased.

Likewise André (2) observed a greatly increased solubility of the potash of microcline when this was treated with gypsum.

On the other hand, Fraps (6), from an extended laboratory and greenhouse study of the effects of additions of gypsum upon the availability of soil potash, concludes that gypsum is often injurious. He states (p. 30):

Additions of sulphate of lime . . . have no such effect upon rendering potash available to plants as has been claimed. . . .

Most recently of all, Briggs and Breazeale (4, p. 28) found that—
gypsum solutions depressed the solubility of the potassium in orthoclase, the quantity of potash in solution decreasing progressively as the concentration of the calcium sulphate increased.

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² Reference is made by number (italic) to "Literature cited," p. 65-66.

Using virgin soils from Riverside, California, they found (*p.* 28) that the solubility of the potash was not—measurably different in distilled water and in solutions of calcium hydrate or calcium sulphate.

Also in a cultivated soil from the same locality they found that the addition of gypsum actually decreased the solubility of the potash.

Apparently in none of the previously reported experiments have the conditions of contact of the gypsum with the soil been similar to those which prevail in the field. In the experiments reported below, the soils, after having the gypsum added, were allowed to remain several months in a condition of moistness similar to that found under field conditions, which, in the case of fine-textured soils in humid regions when evaporation is low and plants are absent, appears to be somewhat below the moisture equivalent (*r.* *p.* 65).

EXPERIMENTAL WORK

In conducting these experiments the object was to determine whether gypsum, when intimately mixed with soil and kept for some months under conditions of moistness similar to those prevailing in the field, would exert any distinct effect upon the solubility of the potash. For the experiment five soils (Table I), four from different parts of southern Minnesota and one from the Minnesota Experiment Station farm at St. Paul were employed. Sample A from near Wells is a fine-textured soil that would be classified as Fargo clay loam, according to the system of the Bureau of Soils of the United States Department of Agriculture. It is representative of a large area of poorly drained soils of lacustrine origin developed on the late Wisconsin glaciation, being highly calcareous and heavily charged with organic matter. For a soil of this texture it is surprisingly low in total potash.

TABLE I.—*Composition and physical properties of Minnesota soils used in the experiment*

Soil.	Location.	Description of soils.	Reaction.	Moisture equivalent.	Organic matter. ^a	Total Potash.	Calcium carbonate. ^b
A.....	Wells.....	Clay loam of lacustrine origin. Surface foot.	Neutral.	38.9	Per cent. 8.48	Per cent. 1.55	Per cent. 4.86
B.....	Spring Valley...	Loam from Kansan till plain. Surface foot.	Acid....	23.8	3.97	1.75	.....
C.....	University Farm.	Hempstead silt loam. Surface 6 inches.	Acid....	22.0	48.3	1.78	.....
D.....	Worthington....	Silt loam from late Wisconsin till plain. Surface foot.	Neutral.	31.2	5.95	1.93	.75
E.....	Caledonia.....	Knox silt loam. Surface foot.	Acid....	23.5	2.64	2.25	.....

^a Organic matter computed from organic carbon using the formula organic carbon $\times 1.724$ = organic matter.

^b Calcium carbonate computed from carbon dioxide.

Soil B was collected from near Spring Valley and is characteristic of the soils formed on the Kansan drift sheet. It was fairly well supplied with organic matter, but strongly acid in reaction owing to heavy precipitation and age of the drift sheet.

Soil C was taken from the surface 6 inches of the Minnesota Experiment Station farm at St. Paul and is classified as Hempstead silt loam (8, p. 26). This soil, overlying beds of sand and gravel, is to be regarded as of alluvial origin deposited from slowly running water issuing from the foot of the retreating ice sheet. It shows an acid reaction and is relatively low in total potash.

Soil D, from near Worthington, would be classified as Barnes silt loam and is representative of a large area of well-drained soil developed on the late Wisconsin drift sheet. It is calcareous, as are all of the soils of this type, and being a prairie soil is relatively high in organic matter.

Soil E is a silt loam from the loess near Caledonia in southeastern Minnesota, and would be classified as Knox silt loam. It is poorly supplied with organic matter, is of a strongly acid character, and is high in total potash.

With the exception of sample C, the soils represent composites of 50 individual samples from the surface foot, 10 taken from each of 5 different virgin fields. Soil C was collected from the surface 6 inches of a small field on University Farm that had been in forest plantation for about 30 years.

PREPARATION OF THE SAMPLES

The air-dried soils were reduced with a rubber pestle so as to pass a 2-mm. sieve. Two 1,000-gm. portions of each were weighed out; 10 gm. of pulverized gypsum were sifted over one, placed on a sheet of oil-cloth, and the whole was thoroughly mixed. Enough water was sprinkled over each portion to raise the moisture content to about two-thirds the moisture equivalent, after which they were again thoroughly mixed and finally transferred to glass jars of known weight, and enough water added to raise the moisture content to the moisture equivalent. The jars were kept loosely covered with glass plates to prevent excessive evaporation and allowed to remain in an attic storeroom from February 15 until May 15, 1917. At the end of six weeks the jars were weighed and water added to each until the weight was equal to that at the time they were first put aside. The temperature of the storeroom during this period of exposure varied from 10.5° to 18° C. After this the soils were removed from the jars, spread out upon sheets of oilcloth and allowed to become air-dry when they were passed through a 2-mm. sieve and placed in ordinary Mason jars in which they were kept until the analyses could be begun in the following December.

Four hundred gm. of the air-dried soil were weighed out and placed in a 7-liter bottle and treated with 4,000 c. c. of distilled water. At half-hour

intervals for eight hours the contents of the bottles were thoroughly mixed by vigorous shaking. In the case of the pair of soils from each area the two bottles, the one with the treated and the other with the untreated soil, were placed side by side and shaken at the same time, thus insuring the same degree of agitation and extraction. Then they were allowed to stand for 48 hours, or longer if the most of the clay particles had not settled within that time. Then 3,000 c. c. of the supernatant liquid from each was decanted and filtered. Owing to the presence of colloidal clay in the filtered solutions, especially those from the untreated soils, it was necessary to remove this, which was easily accomplished by bringing the solution to the boiling point, adding 0.5 gm. of aluminium chlorid and 5 c. c. of ammonium-hydroxid solution. The flocculated precipitate of aluminium hydroxid on settling removed from suspension the clay particles. After the solutions had been allowed to stand for several minutes, they were passed through ordinary filter papers, giving clear filtrates. The filtrate thus prepared from each soil and representing a definite quantity of this was then analyzed for potash according to the well-known chloroplatinate method, in which the potassium is weighed as potassium chloroplatinate.

TABLE II.—Effect of gypsum upon amount of water-soluble potash

Soil.	Weight of soil corresponding to soil extract used for determination.	Determination.	Untreated soil.		Treated soil.		Increase in potash due to gypsum.
			Weight of potassium chloroplatinate.	Percentage of potash.	Weight of potassium chloroplatinate.	Percentage of potash.	
	Gm.		Gm.		Gm.		Per cent.
A.....	150	1	0.0262	0.00338	0.0327	0.00422	.....
A.....	150	2	.0269	.00347	.0311	.00401	.....
Average.....			.0266	.00343	.0319	.00413	0.00070
B.....	80	1	.0160	.00387	.0260	.00629	.....
B.....	80	2	.0149	.00361	.0257	.00621	.....
Average.....			.0155	.00374	.0259	.00626	.00252
C.....	150	1	.0198	.00255	.0309	.00399	.....
C.....	150	2	.0196	.00252	.0297	.00383	.....
Average.....			.0197	.00254	.0303	.00391	.00137
D.....	80	1	.0098	.00237	.0208	.00503	.....
D.....	80	2	.0112	.00271	.0178	.00431	.....
Average.....			.0105	.00254	.0193	.00467	.00213
E.....	80	1	.0180	.00436	.0362	.00876	.....
E.....	80	2	.0200	.00489	.0336	.00813	.....
Average.....			.0190	.00462	.0349	.00845	.00383

In Table II are reported the amounts of soil equivalent to the solution used for each determination, the weight of the potassium chloroplatinate (K_2PtCl_6), and the percentage of the potassium computed as potash (K_2O). Duplicate determinations are reported to show the degree of concordance. The amount of chloroplatinate in each determination was so large as to eliminate the large experimental errors of weighing that occur when only small amounts of soil are employed, while the duplicates in all cases are closely concordant. A blank determination was made with the same kind and quantities of reagents as were used in the actual analyses and the proper corrections made; the gypsum was analyzed and was found to be quite free of potash.

In the case of each soil there is shown a marked increase, due to the addition of the gypsum. The greatest increase was found in the case of soil E in which the gain amounted to over 80 per cent and the least in the case of soil A 20 per cent. While the amount of gypsum employed in the experiment, 1 per cent, equivalent to 10 tons per acre, was much larger than is used in field practice, it would be surprising, in view of the results obtained, if a light application did not cause an appreciable increase in the water-soluble potash.

SUMMARY

Various Minnesota soils when mixed with 1 per cent of gypsum, raised to a point approximating the moisture equivalent, and kept in this condition for three months showed marked increases in the content of water-soluble potash.

The results in previously reported experiments by various investigators in which the action of gypsum has not been found to cause such an increase may be due to the conditions of contact between the soil and gypsum that they have employed being unlike those that obtain in the field.

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