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Contributions of the Mechanical Fractions of the Soil and its Organic Matter towards Potash fixation*

by

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Introduction: Perhaps the first use of the world "fixation" was in reference to nitrogen, following the famous discovery of Hellriegel and Willfarth. Fixation was later on applied to immobilization of phosphorus by soil. Now the importance of potash-fixation on the lines of nitrogen and phosphate-fixation has been fully appreciated and investigated. Accordingly the phenomenon of potash-fixation was studied on our soils.

Historical: Studies relating to potash-fixation by soils have been made by Raney and Hoover (1947), Walsh and Cullinan (1945), Attoe (1947), Ayres (1941) Hauser (1941), Martin (1946), Volk (1938), Jacob (1940), Page (1944), and Joffe and Levine (1947). But little work has been done to determine those fractions of the soil that are more active in potash-fixation.

Pathak, Shrikhande and Mukerji (1950) studied the potash-fixing capacity of the different mechanical fractions of the soil and its organic matter. They observed that potash-fixation was exhibited by all the three mechanical fractions of the soil and also that organic matter depressed potash-fixation. Gourley and Wander (1919), Sturgis and Moore (1939), Walker and Sturgis (1940) and Worsham and Sturgis (1942) have also pointed out from field experiments that organic matter exerts a depressive effect on potash-fixation. Worsham and Sturgis (1942) observed that potash-fixation in soil varied from 0·0 to 209 ppm. in Portland silt loam and Sharkey clay loam. Comparison of potash fixed in A and B horizons of all the soils showed an increase of fixation in the B horizon. The addition of organic matter decreased the fixation of potash by 6 to 41 ppm. Jaffe and Kolodny (1937) have recorded that the quantity of potash fixed varied from 0·31 to 2·4 mg. and that organic matter is not capable of fixing potash. Martin (1946), working with arid soils, could not attribute fixation to the presence of organic matter and Joffe and Levine (1947) also found that the addition of organic

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matter depressed fixation. They also observed that when potassium acetate was added 17·7 mg. potash was fixed as compared to 13·7 mg. with potassium chloride. Similar differences in the amount of potash fixed with different potash-salts have been recorded by DeTurk, Wood and Bray (1943). They studied potash fixation in corn belt soils and observed that the addition of potash as phosphate resulted in greater fixation than addition of equivalent amounts as chloride. The amount of potash fixed as phosphate was 1½ to 2 times greater than the amount of potash fixed as chloride. Sturgis and Moore (1939) studied potash-fixation in Louisiana soils and reported little fixation of potash when applied as potassium chloride. Raney and Hoover's (1947) results on potash-fixation with potassium chloride and dipotassium phosphate also indicate differences in potash-fixation with different potash salts.

Some of the above observations, particularly the effect of organic matter on the potash fixing capacity of the different mechanical fractions of the soil were investigated here with potassium chloride and dipotassium phosphate.

Plan of Investigations: Composite samples of soil were taken from different locations in an acre of the manured and unmanured plots from the Kanpur Agricultural College Students' Farm. Six randomised places were located for profile digging. Samples were collected separately from the manured and unmanured plots from 0–6", 6"–1' and 1'–2' from each of the six profiles. After thorough mixing the various mechanical fractions of the soils were isolated and kept for analysis.

The soils and their mechanical fractions were shaken for 6 hours in an end-on shaker with potash-solution containing 5·0 mg. K_2O per ml. of solution. Ratio of soil to solution was adjusted to 1 : 10. After shaking they were filtered and 5 ml. of the clear filtrates were then used for the estimation of potash.

Methods of analysis: 1. *Mechanical analyses:* Pretreatment and dispersion were affected according to the recommendations of the International Society of Soil Science (Wright 1939) followed by pipette sampling for silt and clay fractions. 2. *Potash* was estimated volumetrically by the cobaltinitrite method (Wright 1939).

Experimental Results: Mechanical composition of the soil is recorded in table 1 and potash fixing capacity in table 2.

TABLE 1
Mechanical composition of the soil

	Manured			Unmanured		
	0—6"	6"—1'	1'—2'	0—6"	6"—1"	1'—2'
Clay	13·35	21·45	29·33	13·84	20·17	26·63
Silt	20·10	21·90	21·22	21·54	22·50	22·88
Sand	66·00	55·60	47·90	63·84	56·15	48·75

TABLE 2
Potash-fixing capacity of the various fractions as K_20 in mgm.

	Manured				Unmanured			
	0—6"	6"—1'	1—2'	Mean	0—6"	6"—1'	1—2'	Mean
Clay	4·63	7·56	8·79	6·99	5·29	7·29	8·92	7·16
Silt	8·77	4·73	7·17	6·89	10·70	3·96	5·04	6·56
Sand	0·26	0·22	0·30	6·26	0·37	0·31	0·31	0·33

The data in table 2 indicate that potash fixing capacity is not restricted to the clay fraction alone; on the contrary, the surface silt fraction of plot has shown greater potash fixing capacity than the surface clay fraction. Potash fixing capacity of clay for the manured plot varies from 4·6 to 8·8 mg %. Silt fraction has a large potash fixing capacity and is on the average 6·89 mg % for the silt of the manured soil and 6·56 mg % for unmanured soil. Potash fixing capacity of sand, however, was found to be very small in both manured and unmanured soils. When these different fractions are compared amongst themselves for potash fixation from both the soils it will be noticed that the clay, silt and sand of the unmanured soil has greater potash fixing capacity.

From the mechanical analysis in table 1 and the corresponding potash fixing capacity in table 2 the contribution from the various fractions, deviod of organic matter, has been calculated. These calculated values along with the potash fixing capacity of the original and H_20_2 treated soil are shown in table 3.

TABLE 3
Calculated potash fixing capacity of the soil and the contribution of different fractions free of organic matter in mg. %

	0—6"	6"—1'	1'—2'	0—6"	6"—1'	1'—2'
A. Untreated soil	1·271	1·662	3·428	2·306	1·637	2·848
B. Soil after oxidation of O. M. with H_20_2	2·091	2 240	3·820	2·963	2·057	3·078
C. Clay	0·618	1·622	2·577	0·732	1·467	2·376
Silt	1·762	1·035	1·522	2·305	0·891	1·154
Sand	0·170	0·137	0·142	0·238	0·176	0·151
Total from primary particles	2·550	2·791	4·241	3·275	2·534	3·681
D. K-fixing capacity of soil if clay is the only active fraction	0·618	1.622	2·577	0·732	1·467	2·376

It is interesting to note from the data in table 3 that the potash-fixing capacity as found by actual analysis (B) is lower than the sum of the calculated potash-fixing capacity of the different fractions (C). This difference between the two values though small, is still significant; this may be due to the interaction between the different minerals present in the sand. silt and clay lattice.

Potash-fixing capacity of the surface layer of the untreated and $H_2,0_2$ treated soil of the unmanured plot is greater than that of the manured one. This may be due to the inhibitive action of organic matter on potash-fixation as indicated before. By comparing the figures in table 3 for the untreated soil (A) and H_20_2 treated soil (B), the depression due to organic matter on potash-fixation is more clearly brought out. All the values for (B) are greater than the corresponding values for (A).

The decrease in potash-fixing capacity due to organic matter is expressed as the difference between the potash-fixed before and after H_20_2 treatment of the soil. For the manured plot the value lies between —0·39 to —0·82 mg % and for the unmanured plot between —0·23 to —0·65 mg %. This agrees with the observations of Worsham and Sturgis (1942) who observed an adverse effect of organic matter on potash fixation by 6 to 4·1 p.p.m. i. e. 0·5 to 4·1 mg %.

When allowance is made for the potash-fixing capacity of sand, silt and clay in the potash-fixing capacity of the untreated soil, a value is obtained which is expressed in table 4 as the potash-fixing capacity calculated from primary particles (Y). Neglecting the potash-fixing capacities of silt and sand and assuming that fixation occurs only in clay the value obtained is expressed as potash-fixing capacity of the organic matter (Z). If the entire potash-fixing capacity were due to clay alone, the potash-fixing capacity of organic matter should have been positive, but apparently this is not the case as is seen from tables 4 and 5.

TABLE 4

Decrease in potash-fixing capacity due to organic matter in mgm per 100 gm soil

		Manured			Unmanured		
		0 —6″	6″ —1′	1′ —2′	0 —6″	6″ —1′	1′ —2
Org. carbon in soil		0·448	0·224	0·104	0·251	0·213	0·182
* Org. matter in soil		0·771	0·385	0·334	0·432	0·366	0·313
X	A—B	—0·820	—0·578	—0 394	—0·657	—0·420	—0·230
Y	A—C	—1·279	—1·132	—0·813	—0·969	—0·879	—0·833
Z	A—C	0·653	0·040	0·851	1·574	0·170	0·472

* (organic carbon X 1·72 = Organic matter)

The values denoted by X and Y in table 4 are greater for the manured plot than for the unmanured. This indicates some relationship between the organic matter content and depression in the potash-fixing capacity. When items X, Y and Z in table 4 are expressed on 100 gm. organic matter as in table 5, a clearer picture of the decrease in the potash-fixing capacity due to organic carbon is obtained.

TABLE 5

Potash-fixing capacity in mgm per 100 gm of organic matter

	Manured			Unmanured		
	0 —6″	6″ —1′	1′ —2′	0 —6″	6″ —′	1′ —2′
Soil after H_2O_2 treatment	—106	—150	—111	—152	—115	—74
If clay is the only active fraction	85	10	255	364	46	151
From primary particles	—166	—295	—243	—224	—246	—266

The values recorded for H_2O_2 treated soil and those derived from the sum of the primary particles are negative ranging between —74 to —150 mg%. These values do not conform to the figures for potash-fixing capacity of organic matter after removal of the organic matter by H_2O_2 oxidation and after assuming clay to be the sole active agent. It is only after allowing for the contribution for potash-fixation by sand, silt and clay also, that we obtain figures (shown as from primary particles in table 5) which appear more correct.

When the potash-fixing capacity of the untreated soil was studied with the same concentration of potash as di-potassium phosphate as in the previous experiment, it gave a different result. Table 6 gives the result of potash-fixation by di-potassium phosphate. Similar figures for potassium chloride treatment are included for comparison.

TABLE 6

Effect of anion on potash-fixing capacity of soil in mgm%

	Manured			Unmanured		
	0 —6″	6″ —1′	1′ —2″	0 —6″	6″ —1′	1′ —2′
KCl	1·271	1·962	3·428	2·309	1·637	2·845
K_2HPO_4	1·834	2·405	4·565	3·654	2·397	4·053

The data in table 6 indicate that a larger part of the potash was fixed when added as phosphate than when it was added as chloride as observed by De Turk, Wook and Bray (1943), Sturgis and Moore (1939) and Raney and Hoover (1947) who obtained 1½ to 2 times greater fixation of potash when applied as dipotassium phosphate than when applied as potassium chloride. This has been attributed to the linkage of phosphate-ion with some of potash-ion to the colloidal particles, besides its absorption by the replacement of OH ion of the clay colloid. Hence the association of potash-ion in di-potassium phosphate resulted in increasing the amount of potash fixed by nearly 1½ times as compared to chloride.

Discussion: The earlier concepts of soil activity were for the most part, based upon analyses of, or experiments with, the whole soil. It was only clay, besides organic matter, which has long been considered to take part in the fertility of soil. The coarser silt and sand fractions were considered until recently as almost inert. But the potash-fixing capacity of the coarser particles of the soil, particularly silt, and mechanical analysis which shows on an average 20–60% of silt and sand in the soil respectively, suggest that silt and fine sand fractions can now no longer be ignored in assessing the total activity of soils.

From the practical and economic point of view, the question naturally arises as to what is the value of potash that has been fixed in the soil. Fixation interferes with the immediate utilization of potash fertilizers by crops. Not all of the potash applied to the soil is ordinarily taken up by the first crop, and fixation, therefore, decreases the loss of unused potash in drainage water. This protection against leaching following large potash-application, is a certainty. Application of heavy doses of potash results in the building up of the colloid held potash reserve which is a reservior from which supplies of available potash for crop production are derived year by year. According to Seatz and Winters (1943) the exchangeable potash remains in equilibrium with potassic soil minerals and that when the degree of potash saturation of the colloids is altered by manuring and cropping, it tends to be fixed and released respectively.

Summary: Potash-fixing capacity of the soil, original and H_2O_2 treated, and its mechanical fractions was tested. It was found out that all the three mechanical fractions showed potash fixation. The silt fraction showed a higher potash fixing capacity which was as high as that of clay. On the surface greater activity was shown by the unmanured plot than the manured one. Potash fixing capacity of H_2O_2 treated soil was higher than the untreated soil. It was also observed that the soil showed greater potash fixation when it was applied as potassium chloride.

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