POTASSIUM FIXATION BY SOME SOILS

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A laboratory experiment was carried out on the fixation of K by two soils. Sandy clay loam fixed more K than sandy loam, both under wet and dry conditions. This indicates that fine textured soils fix more K than coarse textured soils provided the nature of clay does not change. On drying the K fixed increased from 2.30 to 3.16 and from 1.67 to 2.48 me./100 g. of sandy clay loam and sandy loam, respectively after an incubation period of 8 weeks when K was applied at the rate of 30 me./100 g. of soil. Potassium also increased with increase in the period of incubation and the major part of fixation occurred during the first incubation period. Although the absolute amount of K fixed increased, the percentage of applied K decreased with an increase in the amount of K applied. Alternate wetting and drying of unfertilized soils resulted in a slight increase of exchangeable K.

INTRODUCTION

It has long been recognized that a very important relationship exists between potassium fixation by soil and plant nutrition. Though water soluble and exchangeable K is readily available but fixed K is not so readily available to the growing crops, with time it may become available. Fixation also minimizes the drainage losses of potassium fertilizers after application to the soil. Thus K fixation plays an important role in both economy of K fertilizers and plant nutrition.

The term fixed K has been variously defined by workers. Scheffer and Schachtschabel (1967) defined it as that portion of added K which is not replaced by NH_4 ions when potash treated soil is extracted with normal ammonium acetate solution. It has been found that K fixation increased with an increase in the amount of K applied under moist conditions and fixation further increased when the treated soil was subjected to alternate wetting and drying (Volk, 1934; Attoe, 1946; Scheffer and Schachtschabel, 1967). Backett and Nafady (1967) reported that soil fixed about 0.3, 0.7 and 2.7 me. of K/100 g. of soil after 60 days of incubation, when the amount of K applied was 0.5, 1.0 and 5.0 me./100 g. of soil. Graham and Lopez (1969) and Ahmad and Davis (1970) reported that both concentration of added K and time were important in causing fixation. Miller and Turk (1956) claimed that K fixation capacity of the soils was related to the particle size distribution and percentage of mineral matter present in the

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soil. Fixation of added K was attributed to vermiculite under wet conditions and montmorillonite under dry conditions (Hirekerur, 1965). Drying of unfertilized soils resulted in an increase of exchangeable K (Attoe, 1946). Freezing and thawing appeared to produce similar results (Graham and Lopez, 1969). The present study reports the results on K fixation by two soils as affected by concentration of K applied and period of incubation as well as wet fixtion vs dry fixation.

MATERIAL AND METHODS

Two texturally different surface soils were investigated : a sandy clay loam and the other sandy loam. These were air dried, ground, passed through 10 mesh sieve and mixed thoroughly. Physicochemical properties of the soils used in this experiment are given in Table 1. Two hundred grams of each soil

TABLE 1. *Physico-chemical properties of soils.*

		Sandy clay loam	Sandy loam
Clay (per cent)	..	21.4	16.4
Silt (per cent)	..	26.6	19.6
Sand (per cent)	...	52.0	64.0
Saturation percentage	..	38.2	34.4
pH_s	..	8.0	7.8
$EC_e \times 103$	..	2.6	2.3
Organic matter (per cent).		0.87	0.71
Exchangeable (Ca+Mg.), me. /100 g. (By difference)	..	10.53	7.52
Exchangeable K, me./100 g.	..	0.74	0.59
Exchangeable Na, me./100 g.		0.40	0.38
CEC, me./100 g.		11.67	8.49
Total K, me./100 g.	..	12.2	9.1

*Abbreviations used in this table are as follows:

pH_s=pH of saturated soil paste.

$EC_e \times 10^3$=Electrical conductivity of saturation extract in millimhos/.cm. at 25°C.

CEC=Cation exchange capacity.

Ca+Mg (By difference)=CEC—Exchangeable (Na+K), all expressed as me./100 g. of soil.

were taken in each polyethylene bottle and then K_2SO_4 was added at the rate of 0, 5, 10, 20 and 30 me. of K/100 g. of soil and mixed thoroughly. Distilled water was added to bring the moisture level to approximately field capacity (half of the saturation percentage). The total number of bottles was 90 for each soil. The soil in 45 bottles was maintained at above mentioned moisture level and the soil in the other 45 bottles was subjected to alternate wetting and drying under room temperatures. Incubation was done for 4, 6 and 8 weeks. Two, three and four alternate wetting and drying cycles were completed in 4, 6 and 8 weeks, respectively. After incubation soil samples were taken and soil K was extracted with neutral normal ammonium acetate solution. Potassium fixed was equal to : K initially extractable with neutral *N* NH_4OAc + K added — K extractable with neutral *N* NH_4OAc after fixation. All other soil analyses were done according to the methods described by U.S. Salinity Laboratory Staff (1954), except particle size analysis and organic matter which were determined by the methods of Moodie *et al.* (1959). A completely randomized design with three repeats was used and incubation was done under laboratory conditions.

RESULTS AND DISCUSSION

Data presented in Table 2 show that K fixation increased in both soils with increasing applications of K fertilizer. After 4 weeks incubation under moist conditions, 0.63, 0.85, 1.23 and 1.55 me. of K/100 g. of soil were fixed when the amounts applied were 5, 10, 20 and 30 me./100 g. of sandy clay loam soil. For sandy loam the figures were slightly lower. Potassium fixation was found to increase with increasing applications of potassium, probably because greater the amount of potassium in solution, the greater the exchangeable form of K, which in turn gives higher fixation until the exchange complex is saturated with K.

TABLE 2. *Potassium fixation under moist conditions (me./100 g.) by sandy clay loam and sandy loam soils.*

K applied (me. /100g.)	Duration in weeks			Mean
	4	6	8	
	Sandy clay loam			
5	0.63	0.77	0.86	0.75
10	0.85	0.97	1.20	1.01
20	1.23	1.69	1.69	1.54
30	1.55	1.88	2.30	1.91
	Sandy loam			
5	0.47	0.68	0.76	0.64
10	0.63	0.77	0.95	0.78
20	0.74	1.05	1.48	1.09
30	1.06	1.46	1.67	1.36

Findings of Volk (1934), Backett and Nafady (1967) and Scheffer and Schachtschabel (1967) are in greement with the results presented here.

The fixation of K increased with an increase in the time of incubation. The fixation of K was 0.85, 0.97 and 1.20 me./100 g. in sandy clay loam after incubation for 4, 6 and 8 weeks when thea dded amount of K was 10 me./100 g. of soil. For sandy loam the figures were slightly less. The major part of fixation in both soils occurred during the first 4 weeks of incubation. Additional potassium fixation during increased incubation period was probably due to the fact that soil particles were in contact with the solution for longer time. This would allow more time for adjustment and rearrangement. The results are in conformity with those of Ahmad and Davis (1970) who found that 6, 20 and 41 ppm of K were fixed after 1, 3 and 5 months when the added amount of K was 50 ppm.

Since the soils were kept moist continuously, the fixation of potassium indicates that these contain micacious minerals such as mica or vermiculite which are responsible for K fixation in wet state. The analytical data of 15 soils of Punjab (McNeal, 1966) show that mica varied from 14 to 40 per cent and vermiculite from 2 to 7 per cent in the clay fraction.

Drying of soil after addition of potassium solution further increased the fixation of potassium in both soils. The potassium fixation after incubation of 4 weeks under moist conditions was 1.55 and 1.06 me.100/ g. of soil (Table 2). It increased (Table 3) to 2.39 and 1.63 me./100 g. of sandy clay loam and sandy loam soils respectively when 30 me. of K/100 g. of soil were applied and then subjected to alternate wetting and drying. Drying implies removal of water and consequently an increase in the concentration of potassium in soil solution. It also implies that the distance between K and the negative charges on crystal lattice is also reduced during dehydration of soil which results in fixation of K by soil in which the negative charges originate in aluminium octahedra. The presence of 0-30 per cent of montmorillonite in Punjab soils (McNeal, 1966) may have caused the fixation of K during alternate wetting and drying in addition to the effect of concentration of K. These results find the support from the work of Volk (1934), Attoe (1946), Scheffer and Schachtschabel (1967), and Ahmad and Davis (1970).

The greater amount of K fixation in sandy clay loam under both moist and dry conditions was probably due to greater clay content as compared with sandy loam soil. As there is variation in clay content of two soils, there are likely to be variations in the amount of minerals, like mica, vermiculite and montmorillonite which are responsible for retaining the potassium in nonreplaceable form. This indicates that finer the texture of the soil, the greater would

TABLE 3. *Potassium fixation under alternate wetting and drying (me./100 g.) in sandy clay loam and sandy loam soils*

K applied (me./100 g.)	Duration in weeks 4	6	8	Mean
		Sandy clay loam		
5	0.85	1.01	1.16	1.04
10	1.10	1.58	1.72	1.47
20	1.80	2.10	2.54	2.15
30	2.39	2.73	3.16	2.76
		Sandy loam		
5	0.70	0.85	1.03	0.86
10	0.89	1.05	1.42	1.12
20	1.31	1.46	1.91	1.52
30	1.63	2.08	2.48	2.06

be its fixation capacity. This seems to be in agreement with the results of Miller and Turk (1956).

Exchangeable K was found to increase when unfertilized soils were subjected to alternate wetting and drying. Data presented in Table 4 show that exchangeable K increased from 0.85 to 1.11 me./100 g. of sandy clay loam and

TABLE 4. *Effect of moist and dry conditions on K fixation or release by unfertilized soils (exch. K me./100 g.)*

Soil		Duration in Weeks 4	6	8
			Moist conditions	
Sandy clay loam	...	0.88	0.85	0.85
Sandy loam	...	0.69	0.69	0.69
			Wetting & Drying	
Sandy clay loam	..	0.99	1.06	1.11
Sandy loam	..	0.79	0.85	0.89

from 0.69 to 0.89 me./100 g. of sandy loam soils after 8 weeks of incubation. Similar results have been found by Attoe (1946) and Graham and Lopez (1969). The results reported in the present study have further confirmed that drying

facilitates the release of K from nonexchangeable to exchangeable form in unfertilized soils, but increases the fixation in K fertilized soils. This is due to the fact that a dynamic equilibrium exists between water soluble, exchangeable and nonexchangeable K. A slow change from one form to another can and does occur, but the rate of change from one to another is enhanced by alternate wetting and drying. This makes possible the fixation and conservation of added soluble K and subsequent release of this element when readily available supply is reduced.

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