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An Incubation Study on the Fixation of NH_4, P and K by a Laterite Soil under Two Different Moisture Levels

K. M. RAMANATHAN[1], HONORA J. FRANCIS,[2] S. SUBBIAH[3] and K. K. KRISHNAMOORTHY[4]

The results of a laboratory incubation study with laterite soil on the fixation of major plant nutrients showed that with increase in the concentrations of added NH_4, P and K the fixation of the respective nutrients also increased. The fixation of NH_4 was maximum under constant moisture level, while the fixation of K was maximum under alternate wetting and drying. The fixation of P was not influenced by the changes in mointure levels. The NH_4 fixation in the laterite soil was not affected by the presence of K, while K fixation was maximum irrespective of levels of nitrogen added. Fixation of the respective nutrients increased with increase in the period of incubation.

A considerable amount of added nutrients undergo fixation depending upon the amount and nature of clay size fractions present in soil (Kardos, 1965). Since the ionic diameters of K and NH_4 are very close and the mechanism of lattice fixation of these two ions are similar, their availability in soils is somewhat interdependent (Raju and Mukhopadhyay, 1973). The P fixation in soils is influenced by a number of factors, such as pH, sesquioxides, $CaCo_3$, moisture and clay contents. Higher correlation between iron and clay with P fixation was observed by many workers (Rajagopal and Idnani, 1963; Biddappa and Venkata Rao, 1973). The specific objective of the present study is to find out the nutrient fixing power of a laterite soil under two different moisture levels.

MATERIAL AND METHODS

Laterite soil from Coonoor of Nilgiris District was chosen for the study. The soil is a sandy clayloam. The exchange characteristics of the soil are as follows :

Cation exchange capacity	...	7.90 me/100 g of soil
Exchangeable calcium	...	2.80 me/100 g of soil
Exchangeable magnesium	...	0.80 me/100 g of soil
Exchangeable potassium	...	2.25 me/100 g of soil
Exchangeable sodium	...	0.65 me/100 g of soil
Exchangeable hydrogen	...	1.40 me/100 g of soil

The silica sesquioxide ratio of the soil was 1 26

*Department of Soil Science and Agricultural Chemistry Tamil Nadu Agricultural University, Coimbatore-3.

Five hundred grams of air dried soil sieved through 2 mm sieve was taken in beakers. The major nutrients N — P_2O_5 and K_2O were added at 0—100—200, 0—25—50 and 0—100—200 ppm respectively in all the possible combinations as ammonium sulphate, superphosphate and muriate of potash. The experiment was conducted with two different moisture levels One set was maintained at constant moisture level (about 30 per cent) roughly corresponding to field capacity by weighing the jars containing the soil everyday and adding distilled water to replenish the evaporation loss. The second set was subjected to alternate wetting and drying at room temperature roughly corresponding to the conditions existing in the field. The calculated quantities of the nutrient solutions and water were added to the soil in the jars and thoroughly mixed and left for equilibration. The first set of samples were drawn from each treatment 24 hours after the addition of nutrient solutions and thereafter at an interval of 30, 60 and 90 days. The soil samples were analysed for available N, P and K employing appropriate methods (Subbiah and Asija, 1956; Olsen *et al.* 1954 and Stanford and English, 1949). The amount of nutrients fixed in 24 hours, 30, 60 and 90 days were calculated and statistically analysed and the results are presented in Table 1.

RESULTS AND DISCUSSION

From the results it is noted that the fixation of all the three nutrients viz. NH_4, P and K increased with with increase in the doses of the respective nutrients. This of course could be the natural phenomenon that would take place until all the exchange sites are completely occupied by the ions of the added nutrients as a result of increase in concentration leading to gradual saturation. Several workers have reported increased fixation of plant nutrients with increase in dosages. Bakheitsaid (1973) noted increased fixation of NH_4 with increase in NH_4 dose. Chatterjee and Datta (1951) found that the amount of P fixation increased with increase in the concentration of added phosphoric acid. Increasing amount of K fixation with increased application of K has been reported by McLean and Simon (1958) and Grewal and Kanwar (1967).

The fixation of NH_4 was more under constant moisture level than under alternate wetting and drying conditions. This trend was maintained under all levels of N, P and K and under all the four stages of sampling. Bower (1950) observed that the fixation of NH_4 was higher under moist conditions. It is apparent from the data that NH_4 is more readily fixed than K when both are added in equivalent amounts possibly due to the higher bonding energy of NH_4 over K. Similar observations were also made by Kar *et al.* (1975) while studying the fixation characteristics of some acid soils of West Bengal. The constant moisture level (about 30 per cent) maintained for the present study probably increased the specific characteristics of the clay minerals thus creating a condition for maximum fixation of NH_4 (Ramanathan *et al.* 1973). The fixation of ammonium increased significantly with increase

in concentration and incubation period. Of the total amount of NH_4 fixed in three months, 29.60 per cent was fixed in 24 hours, 55.70 per cent in 30 days and 83.60 per cent in 60 days and a gradual flattening of the fixation was observed afterwards.

Regarding the fixation of P, an earlier observation (Ramanathan *et al.* 1973) that P fixation is not influenced by the two moisture conditions is confirmed for laterite soil also. There was significant increase in the P fixation with increase in the concentration of added P and period of incubation. Of the total amount of P fixed the percentages of P fixation were 42.0, 69.8 and 83.4 for 24 hours, 30 days and 60 days respectively which were always higher than the values of N and K fixation. In the P fixation a fast reaction was seen within 24 hours. The subsequent reaction was slow and almost linear up to 60 days. This might be due to the presence of exchangeable Al, causing a rapid P fixation at the initial stage and the non-exchangeable Al at later stages as the soil was a laterite one with preponderance of the inorganic amorphous clay like oxides of Fe and Al in various degree of hydration as reported by Jai Prakash and Bhaskar (1974).

The fixation of K was more under alternate wetting and drying in contrast to NH_4 conforming to earlier reports of Ramanathan *et al.* (1973). The increased addition of K increased the quantity of K in the exchange complex which in turn increased the fixed K. The reaction to attain equilibrium between the different forms of K is speeded up by the expansion and contraction caused by alternate wetting and drying as observed by Talibudeen (1972). The mechanism of K fixation is also explained to be the result of precipitation of K in the interior of the clay lattices (Mehrotra *et al.* 1972). Further it may also be possible, that as a result of adsorption of NH_4 particularly on the edges of the clay colloid might entrap the already fixed K thus preventing the release of adsorbed K. Pratt and Goulben (1957) and Davis (1972) reported that the entrapment of K ion in the exchange sites reduced the CEC of the soil. Thus the increased fixation of K on alternate wetting and drying possibly reduced the fixation of NH_4 as a result of reduction in the site for fixation.

The above observations clearly showed that the ability of one ion getting fixed in preference to other or one ion forcing the other to get entrapped or released are influenced by moisture conditions. Hence under constant moisture level, the NH_4 fixation was high, while the K fixation was enhanced under alternate wetting and drying.

The influence of NH_4 on the fixation of K was not well pronounced. The fixation of K increased with increase in the concentration of added K under both the moisture levels. There was a progressive increase in the fixation of K throughout the incubation period. Out of the total amount of K fixed over a period of three months 26.0 per cent was fixed in 24 hours, 60.8 per cent in 30 days

and 85 per cent in 60 days which is however in contrast to the inference of Grewal and Kanwar (1967) who observed that nearly 90 per cent of K was fixed in one day and equilibrium was established in seven days in Punjab soil.

In conclusion it may be stated that the results from these studies have clearly shown the nutrient fixing power of a laterite soil under two different moisture levels. The range of fixation of NH_4 and K was almost similar and that of P fixation was faster in the initial stage and slowed down as the period of incubation was advanced.

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TABLE I UMMARY OF STATISTICAL ANALYSIS

(Mean values of N, P and K fixed in ppm)

1. NITROGEN

	Moisture I	Moisture II	S. E.	C. D.
Mean	67.47	64 01	0.44	0.87

	N_0	N_1	N_2	S. E.	C. D.
Mean	4 98	69.33	122.90	0 54	1.06

	K_0	K_1	K_2	S. E.	C. D.
Mean	64.47	65.88	66.86	0.54	1.06

S_1	S_2	S_3	S_4	S. E.	C. D.
14.74	54.51	81.75	97.74	0.62	1.22

II. PHOSPHORUS

	P_0	P_1	P_2	S. E.	C. D.
Mean	1.33	9 65	16.37	0.38	0.076

	S_1	S_2	S_3	S_4	S. E.	C. D.
Mean	5.19	8.62	10.30	12,34	0.045	0.089

III. POTASSIUM

	Moisture I	Moisture II	S. E.	C. D.
Mean	67.36	72.26	0.42	0.82

	K_0	K_1	K_2	S. E.	C. D.
Mean	12.78	72.99	126.67	0.51	0.99

	S_1	S_2	S_3	S_4	S. E.	C. D.
Mean	27.22	63.33	86.61	104,07	0.59	1.15

S_1, S_2, S_3 and S_4 represent the stage of sampling viz., 24 hours, 30, 60 and 90 days of incubation.