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Fixation of Phosphate and Potassium as influenced by Soil Type

by

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Introduction : The primary, major elements, N, P and K play a prominent part in relation to the principles and practices of plant nutrition. Ironically enough, due to their 'fixation' in the soil to a certain extent, the availability of these elements to the crop is also affected to a certain extent by their fixation-release pathway, that is characteristic of a given soil. The ability to fix and release nutrients coexists in any soil although there may be marked degree of variation between soils. Studies of fixation of elements is of interest in clay mineralogy from the standpoint of structure and alteration of minerals and in soil-plant relationships in connection with their availability to plants.

The factors affecting the fixation of nutrients are both intrinsic and extrinsic. The parent material of the soil, clay content and its mineral make up, degree of saturation, pH and the organic matter level are some of the intrinsic factors. Some of the extrinsic factors which influence the determined fixing capacity of a soil are the type of salt added, the nature of coions, the concentration range employed, time of equilibration, temperature, moisture level and operations such as complete drying, alternate wetting and drying or drying and heating. The variation in fixing capacity of P and K by two contrasting soil types is discussed in this paper.

Materials and Methods : Gangetic alluvial soil sample from Delhi and black soil sample from Coimbatore were used. The samples were air dried, ground and passed through 1 mm sieve.

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The P fixation capacity was determined as follows. To a set of 2.5 g of soil samples taken in 100 ml flasks was added 1 ml of $Ca(H_2PO_4)_2$ H_2O solution. The P solutions were prepared to give 0, 25, 50, 75, 100, 125, 150, 200, 250 and 300 ppm of P. The flasks were corked and set aside to equilibrate for 96h at room temperature and the extractable P in the soil samples was obtained by using Olsen's method. P in the extracts was determined by the molybdenum - blue method using a Klett-Summerson Photoelectric colorimeter. The P fixing capacity of the soil was calculated from the amount of extractable P in the control and treated samples and the amount of added P.

The K fixing capacity of the soil was determined by using 5 g samples and a soil : solution ratio of 1:2, equilibrated for 72 h at room temperature. K was added in the form of Kcl solution and the levels added was upto 3920 kg/ha of K for Delhi soil and 3240 kg/ha of K for Coimbatore soil. For both soils the K fixation capacity was estimated under wet condition and alternate wetting and drying condition. For wet fixation, the required amounts of KCl solution and distilled water were added to the soil samples taken in 100 ml flasks, stoppered and left for equilibration. For fixation under alternate wetting and drying condition, the soil samples were taken in porcelain basins. Half of the required amount of KCl and distilled water. were added, mixed well and allowed to dry under shade for 24 hours. After drying, 1/4th of the required amount of KCl solution and distilled water were added, mixed well and allowed to dry under shade for 24 hours. The remaining 1/4th of the required amount of KCl and distilled water were added to the dry soil samples, mixed well and again allowed to dry under shade for 24 hours.

In both cases, the extractable K at the end of equilibration was obtained by shaking the samples for 5 min. with 25 ml of neutral $N.NH_4$ OAC. The filtrates were analysed for K using a systronix flame photometer. The K fixation capacity was calculated in the same way as P fixation capacity.

Results and Discussions: The data regarding the P fixation capacity of the two soils are given in Table 1.

The black soil of Coimbatore shows a higher percent P fixation than the alluvial soil of Delhi, at all levels of added P. The clay fraction of the soil is the seat of P fixation and P is fixed mainly due to adsorption, isomorphus replacement and double-decomposition reaction involving solubility product relations (Kardos, 1964). The mean percent P fixing capacity of the Delhi and Coimbatore soils is 37 and 65 respectively. Such a difference can be related to the pH and clay content of the two soils. They do not vary much in their pH (1:2.5 soil-water ratio). The pH of the Coimbatore soil is

8.1 while that of the Delhi soil is 7.9. But the clay content of the two soils varies by a factor of about four. Texturally, Coimbatore soil is a clayey soil having 52% clay while Delhi soil is a sandy loam having only 14% clay. Hence the difference in the quantity and quality of clay of the two soils may be the single main factor in their marked variation for P. fixation.

TABLE 1. *Fixation of phosphorus*

Amount of P added (ppm)	Amount of P extracted (ppm)		P fixation capacity (%)	
	Coimbatore soil	Delhi soil	Coimbatore soil	Delhi soil
0	6.4	18.0		
25	9.0	14.4	64.0	42.4
50	12.5	23.2	76.0	53.6
75	25.6	40.0	65.9	46.7
100	29.6	70.0	70.4	30.0
125	35.6	76.0	71.5	39.2
150	53.6	100.0	64.3	33.3
200	71.6	138.0	64.2	31.0
250	113.6	164.0	54.5	34.4
300	118.6	220.0	60.4	26.7
350	149.6	232.0	57.2	33.7
Mean			64.8	37.1

When the extractable P is plotted against the added P, the presence of an inflexion point above which there is an abrupt increase in the extractable P is looked for. The amount of P to be added to correspond to this point is looked for. The amount of P to be added to correspond to this point is the dose required to more than over come the effect of fixation of P. An inference of this kind is useful in choosing levels of P to be tried with soils in crop response-fertilizer use experiements. A plot of the P fixation data for the two soils showed a near linear relationship between the amount of P added and extracted, without any inflexion point (Fig. 1). In such cases, the slope of the straight line can be used to calculate the amount of P required to be added to correspond to desired levels of available P. The slope of the line (extracted P/and P) is 0.43 for Coimbatore soil and 0.70 for Delhi Soil.

The K fixation data for the soils under two conditions of determination are given in Table 2.

Currently, fixed K in soils is defined that part of the added K which is not readily replaceable by the usual cation exchange reactions, through neutral salts especially NH_4OAc (Agarwal, 1960). According to recent concepts, the process of K fixation in the order of importance are by entrapping of K ions between the lattice layer (Vermiculite), by substitution on valence places resulting from Si/Al replacement (zeolite, permutite, intermediates), by restoration of K ions in superficially weathered minerals (illite, feldspars) and by locking up K ions in small holes or canals in Zeolites, permutites, amorphous material (Schuffelen and VanDer Marel, 1955). Under both the conditious of determination the mean percent of K fixing capacity of Delhi soil is higher (15.2, 23.9) than that of Coimbatore soil (11.6, 16.4).

Fig. I. FIXATION OF PHOSPHORUS

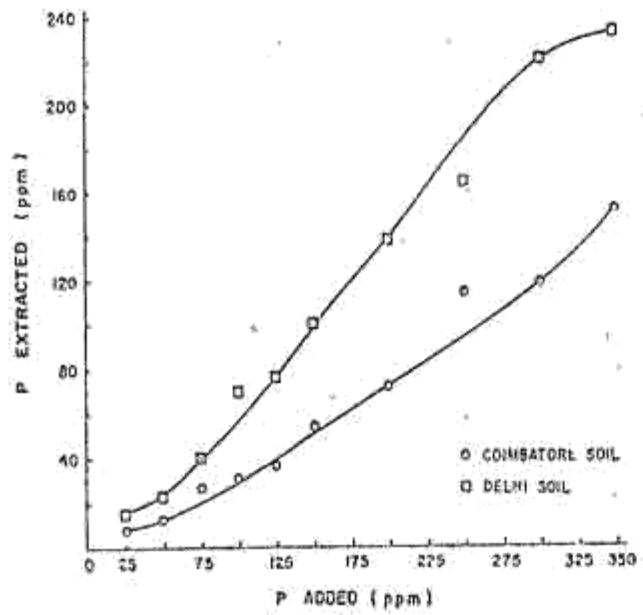


TABLE 2. *Fixation of Potassium*

K added (kg/ha)	Alluvial Soil (Delhi) K extracted (kg/ha) Wet condition	Alluvial Soil (Delhi) K extracted (kg/ha) Alternate wetting & drying	Alluvial Soil (Delhi) K fixation capacity % Wet condition	Alluvial Soil (Delhi) K fixation capacity % Alternate wetting & drying	K added (kg/ha)	Black Soil (Coimbatore) K extracted (kg/ha) Wet condition	Black Soil (Coimbatore) K extracted (kg/ha) Alternate wetting & drying	Black Soil (Coimbatore) K fixation capacity % Wet condition	Black Soil (Coimbatore) K fixation capacity % Alternate wetting & drying
0	274	130			0	564	184		
61	48	58	21.4	6.2	30	23	29	21.6	2.6
92	78	85	14.5	7.4	60	47	45	21.6	25.0
122	118	80	3.8	34.6	90	71	73	21.0	18.8
245	196	178	20.0	27.3	120	113	84	5.4	30.0
490	362	270	26.1	44.9	360	351	263	2.5	26.9
980	864	820	11.4	16.3	1080	1043	974	3.4	9.8
1960	1817	1420	7.3	27.5	3240	3061	3183	5.5	1.7
3920	3254	2870	16.9	26.8					
Mean			15.2	23.9				11.6	16.4

The quantity of clay in the soil as such is of limited value as an index of K fixation/g. of clay may differ enough from one soil to another as observed in the present case. Thus, although Coimbatore soil contains about four times the amount of clay in Delhi soil, K fixation in Delhi soil is of higher order emphasizing the improtance of the nature of clay minerals. The alluvial soil of Delhi is known to be dominated by illitic clay and the black soil of Coimbatore is reported to be high in montmorillonites. Wear and White (1951) pointed out that beidellite, hydrous mica (illite) and vermiculite clay have relatively more tetrahedral charges than montmorillonites and should therefore be able to hold more K in a fixed condition. Using the available and total K_2O values, Ramamoorty *et. al.* (1952) reviewed the potassium availabiiity of Indian soils in relation to their geological origin. They pointed out that gangetic alluvium and those soils bordering the vindhyan system have generally low K availability or high fixation capacity while soils formed from crystalline gneiss or coastal alluvium bordering cretaceous or the Gondwana systems have high K availability or low fixation capacity. The two soils used in the present study belong to the above mentioned two differing categories.

In both soils the mean K fixation capacity is higher under alternate wetting and drying condition than under wet condition. Several workers have observed more K fixation under alternate wetting and drying. This is due to the strong attraction offered by adsorbed K which precludes expansion of the crystal lattice and re-entrance of water.

In the untreated samples, there is a greater reduction of extracted K under alternate wetting and drying condition in Coimbatore soil (67.4%) while it is only 52.6% in Delhi soil. This may be related to the initial K saturation percentage of the two soils. The KSP of Coimbatore soil is 2.78 while that of Delhi soil is 4.73 and hence fixation under alternate wetting and drying is more in Coimbatore soil. Chaminade (1936) concluded that control samples of soils having a degree of K saturation above 4.5% fixed little or no K and those with K saturation below 4% were definite K fixers.

The relationship between K extracted and K added followed a linear trend without showing any inflexion point, although the maximum concentration of added K is of a very high magnitude (Fig. 2 and 3). Similar to P fixation curve, the slope of the straight line can be used to calculate the amounf of K needed to be added for any desired value of extracted K. The calculated slopes (extracted K added K) and wet condition and alternate wetting and drying condition for the Coimbatore soil are 0.94 and 0.87 respectively. Similar figures for the Delhi soil are 0.85 and 0.72.

Fig. 2. BLACK SOIL K-FIXATION
(COIMBATORE)

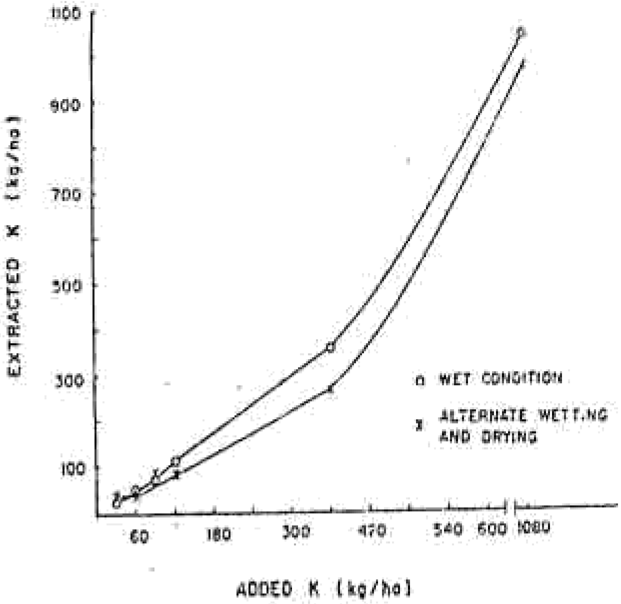
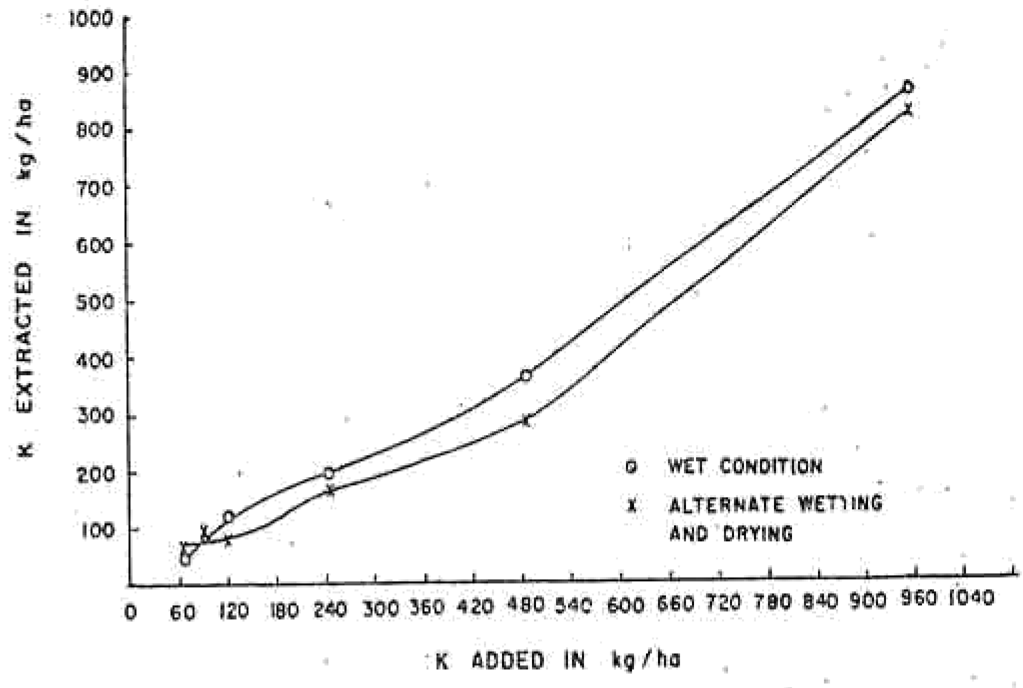


Fig. 3. ALLUVIAL SOIL (DELHI)
K-FIXATION



Summary: The P and K fixation capacity of alluvial soil from Delhi and black soil from Coimbatore were studied. The mean percent P fixing capacity of the Delhi and Coimbatore soils is 37 and 65 respectively. The mean percent K fixing capacity of the Delhi and Coimbatore soils undar wet-condition is 15.2 and 11.6 respectively. Similar values under alternate wetting

and drying condition are 23.9 and 16 4 for the two soils. Coimbatre soil has more P fixing capacity while Delhi soil has more K fixing capacity. The soil type differences in the fixation of P and K are explained in terms of their geological origin, clay content, nature of clay and degree of K saturation. Over the concentration range tried the relationship between the nutrient extracted and nutrient added followed a linear trend for both soils.

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