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EFFECT OF AMOUNT AND TYPE OF CLAY MINERALS ON POTASSIUM FIXATION IN SOME ALLUVIAL SOILS OF PAKISTAN

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Eight soil series varying in amount and type of clay Minerals were used to see K–fixation behaviour under alternate wetting and drying conditions. mineral identity in the clays was established by X–ray diffractometry. Illite was the major mineral in all the soil series. The relative quantity of other 2:1 type clay minerals i. e. montmorillonite, vermiculite and chlorite was variable. Potassium was applied at the rates of 50, 100 and 150 mg K_2O kg^{-1} soil taken in plastic beakers. After completing four alternate wetting and drying cycles, the amount of K–fixed was determined. Illite was found to be the major fixer of fertilizer K. There was an increasing trend of K fixation with increasing K application and clay content in soils. Other 2:1 type clay minerals did not show a significant effect on K- fixation.

INTRODUCTION

Fixed potassium in soil is taken as that amount of potassium which is trapped in nonexchangeable form in the lattice of mineral crystals such as of weathered mica. The importance of the retention of potassium from solutions by the secondary clay products of weathering can be guaged from the fact that the concentration of potassium in sea water is less than one tenth that of sodium, though the primary rocks of the earth crust contain potassium and sodium in roughly equal amount (Loughnan, 1969). Potassium fixation process has been regarded as the reverse of the weathering reaction "mica → illite → vermiculite → montmirollonite" (Jackson,1964) of the weathering process. Much work have been done abroad on this aspect of soil K but relatively very few studies have been conducted in Pakistan. Potassium fixation by soil has been found to increase with clay content (Shakir, 1984; and Hussain *et al.*, 1986). However, the fixation and release of K are largely a function of the clay mineralogy of soil. The aim of the present study was to assess the effect of the amount and type of clay minerals on K fixation in some alluvial soils of the Indus plain.

MATERIALS AND METHODS

Profiles of eight soil series (Table 1) were exposed at the selected locations and were described with the technical help of the Soil Survey Staff, Lahore. Bulk soil samples were collected from Ap, B and C horizons for physical, chemical and mineralogical analyses.The soil samples were air–dried, crushed and passed through 2mm sieve. Soil surface (0–15) samples were used for the present study.

The clay fraction (< 0.002 mm) of the soils was separated following the removal of organic matter and iron oxide by the methods described by Jackson (1979). The separated clay was then concentrated by flocculating with 1N NaCl solution. After discarding the supernatant solution, clay was washed free of salts with distilled water and then with acetone and preserved in plastic tubes. Clay samples (50 mg) were taken into each of 100 ml of centrifuge tubes for Mg saturation and glycolation, K saturation and heating, and Li saturation and intercalation with dimethyl sulfoxide (DMSO) (Jackson, 1979). Clay mineralogy was investigated in the oriented specimens by X–ray diffraction using Cuα radiation. To determine K fixation, 200g samples of the

Table 1. Description of the Soil Series Used.

Soil series	Sand	Silt	Clay	Textural class	Classification	
					Order	Family
Pindorian	58	30	12	Loam	Inceptisols	Coarse–loamy, mixed, hyper thermic, Udic Haplustaf.
Wazirabad	76	12	12	Sandy loam	Alfisols	–do–
Bhalwal	24	60	16	Silty clay loam	Aridisols	Fine – silty mixed, hyperthermic Ustollic Haplorgid.
Eminabad	35	47	18	Silty clay loam	Vertisols	Coarse-loamy, mixed, calcareous hyperther-mic typic Natrustalf.
Gujranwala	35	45	20	Silty clay loam	Inceptisols	Fine–loamy, mixed, hyperthermic Udic Haplustalf.
Lyallpur	27	53	20	Silty clay loam	Aridisols	Fine–silty, mixed, hyperthemic Ustalfic Haplorgid.
Kamoke	25	35	40	Loamy clay	Inceptisols	Fine–silty mixed, noncalcareous, hyperther mic Typic Ustochrept.
Pacca	18	37	45	Loamy clay	Aridisols	Fine, mixed, hyperthermic, Ustollic Camborthid.

respective soils were added to 400 ml beakers and potassium (as K_2SO_4) was added at the rates of 50, 100 and 150 mg kg^{-1} soil. The soils were saturated with water and then air dried. Four wetting and drying cycles were completed and K was extracted with 1 N NH_4OAc. The amount of k not extracted with 1 N NH_4OAc was assumed as fixed–K.

RESULTS AND DISCUSSION

The mineralogical composition of the soil clay fraction (Table 2) indicated that illite was the predominant mineral in all the soil series. The occurrence of other 2:1 type minerals was variable: the Lyallpur, the Pacca and the Eminabad series showed the presence of chlorite and montmorillonite, the Pindorian, the Kamoke and the Gujranwala series had montmorillonite and vermiculite, the Wazirabad had vermicultire while the Bhalawal had only chlorite as the other important clay mineral. Kaolinite was present in all the series from traces to minor quantity.

Table 2. Mineralogy of soil clay (< 2 um) fraction of surface soils

Soil series	Illite	Smectite	Chlorite	Vermiculite	Kaolinite
Pindorian	3	2	–	1	1
Wazirabad	3	–	–	2	2
Bhalwal	4	–	2	–	1
Eminabad	3	1	1	–	2
Gujranwala	4	3	–	2	2
Lyallpur	3	1	2	–	1
Kamoke	4	2	–	2	2
Pacce	3	3	2	–	1

Legend 4 = Dominant 2 = Minor

3 = Major 1 = Traces

Potassium fixation

The results obtained (Table 3 and Fig. 1) indicated that the fixation increased with increasing clay content in the soil and with increasing rates of its application. However, when the amount of potassium fixed was calculated as percentage of that applied to the soil, it was found that it decreased as the rate of potassium application increased. Significant positive correlations, i.e. r = 0.480, 0.920, and 0.844 at K application levels of 50, 100 and 150 mg kg^{-1}, respectively, were obtained between the amount of potassium and the quantities of .clay in the various soil series. Similar results were obtained by Amu (1969), Qureshi (1979), Chaudhri and Jain (1979) and Hussain *et al.* (1986). Illite being the predominant clay mineral in all the cases the difference in K fixation could not be related to clay mineralogy of these soils. However, because of the variation in the amount of clay, and hence variation in the total amount of illite, the amount of potassium fixed by different soils varied. Grewal and Kanwar (1967) suggested illite as the mineral responsible for potassium fixation. But, in an other study, they (1973) found that illite and montmorillonite (biedillibe) clay minerals were responsible for potassium fixation. Actually in some soils only those montmorillonites fix potassium which have a high charge density and

Table 3. Fixation of potassium in different soil series as a function of rate of K application

Soil series	Clay	Original level of K	Rate of potassium application ($mg\ kg^{-1}$)					
			50		100		150	
	(%)	($mg\ kg^{-1}$)	Fixed ($mg\ kg^{-1}$)	Fixed (%)	Fixed ($mg\ kg^{-1}$)	Fixed (%)	Fixed ($mg\ kg^{-1}$)	Fixed (%)
Pindorian	12	80	21	42	32	32	40	27
Wazirabad	12	100	20	40	27	27	35	23
Bhalwal	16	97	32	64	41	41	57	33
Eminabad	18	110	35	70	41	41	57	38
Gujranwala	20	120	35	70	43	43	57	38
Lyallpur	20	110	33	66	43	43	58	39
Kamoke	40	180	40	80	56	56	70	47
Pacca	45	178	43	86	55	55	66	44
Mean			32.4	64.7	42.2	42.2	55	36.1

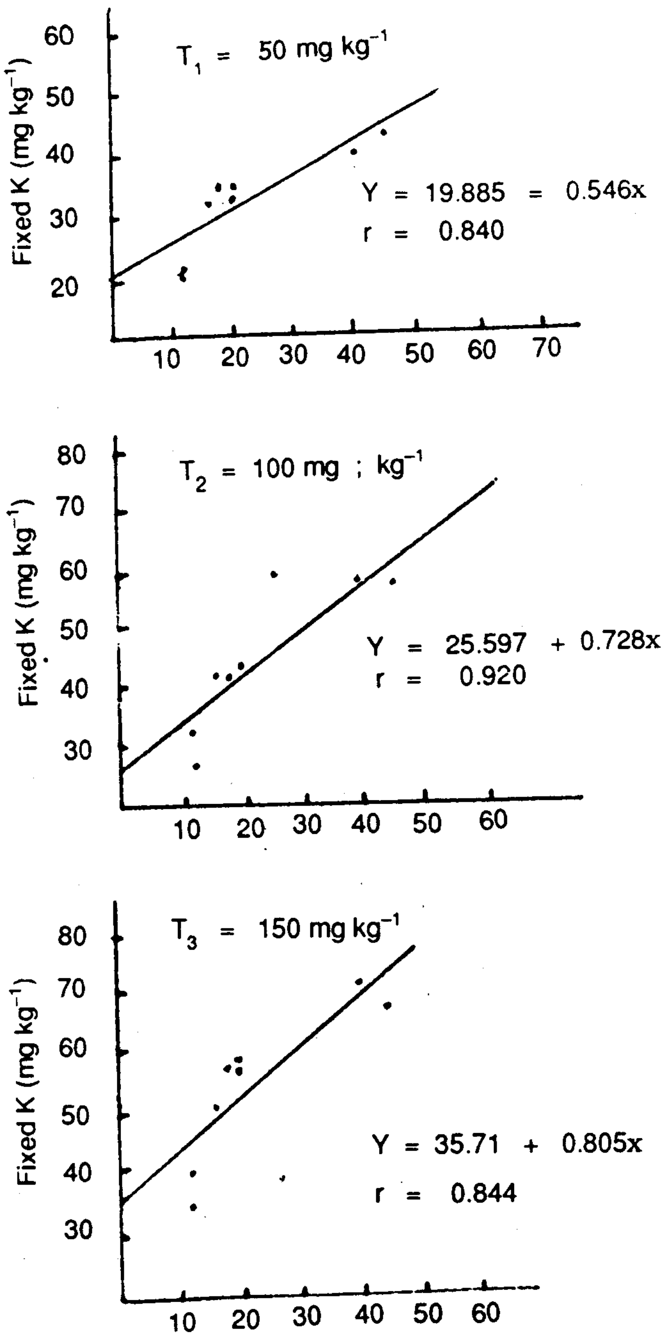

Fig. 1. Relationship between clay content and amount of K fixed.

probably wedge positions (nearly mica–like zones) (Schwertman,1962).. Arifin *et al.* (1973) found that potassium absorption by the wedge–zones in the interlayer surfaces of the weathered mica was the controlling factor of potassium fixation in acid soils. From the results of the present study and the discussion, it can be concluded that illite is the main fixer of fertilizer potassium.

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