Short Communication

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Potassium fixation capacity in some mineralogically different rice soils

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ABSTRACT

An incubation experiment on potassium fixation in some mineralogically different rice soils of West Bengal was studied at varying levels of added K. About 6.2 to 42 % of added K was fixed in these soils. Potassium fixation increased with increasing amounts of applied K, however, the percentage of added K fixed decreased gradually. Addition of 15 to 240 mg K kg^{-1} soil, illite and smectite dominant Inceptisols with high available and reserve K resutted in a relatively lower K fixation (4.9 to 39.6 mg kg^{-1} soil) as compared to illite , smectite and chlorite dominant Entisols (5.5 to 41.0 mg kg^{-1} soil) containing moderate available and reserve K. Conversely, kaolinite dominant Alfisol with low available and reserve K registered the lowest amount of K fixation (2.5 to 14.9 mg kg^{-1} soil).

Key words: *Potassium fixation, available and reserve K, mineralogy, rice soils*

Potassium fixation in soil is the phenomenon of conversion of water-soluble and exchangeable K into moderately or slowly available non-exchangeable K, which is not readily taken up by the growing plants (Mortland, 1961). Soil texture, soil reaction, complementary cations, organic matter content, addition of potassic fertilizers, amount and type of clay minerals and moisture regimes are some of the factors affecting K fixation in soils (Rao and Khera, 1995). This process assumes great importance, because it not only regulates the dynamics of different forms of K, but also indicates the soil potentiality for long-term K supply to plants. Fixation of K in soil is not considered completely unfavourable since it helps to conserve the element from leaching loss. Similarly, fixed K becomes available to plants over a longer period upon depletion of water-soluble and exchangeable K (Patra and Debnath, 1998). The variability of K fixation in soil indirectly influences the response of crops to added K (Chakravorty and Patnaik, 1990). The present investigation was undertaken to assess the K fixation capacity in some mineralogically different rice soils of West Bengal with a view to make meaningful K management strategies for higher crop productivity.

Six surface (0-15 cm) soil samples representing three new alluvial soils belonging to Entisols (Alipurduar, Burdwan and Gayeshpur), two old alluvial soils under Inceptisols (Dankuni and Kakdwip) and one red soil under Alfisols (Jhargram) were collected from different locations representing regions of intensive rice based cropping system in West Bengal during winter season of 2004. Soils were processed and analyzed for particle size, organic carbon, pH, EC, CEC and different forms of K (Jackson, 1973). The soils were sandy loam to clay loam in texture with marked variations in pH, electrical conductivity, organic carbon content and cation exchange capacity (Table 1). The water-soluble, exchangeable, non-exchangeable and fixed K reserves in the soils also varied considerably (Table 2). Inceptisols and Entisols possess higher labile and non-labile K reserves as compared to Alfisol. Mineralogically the soils are illitic and smectitic except Jhargram soil which is kaolinitic in nature Potassium fixation was measured in these soils taking portions of 5 g soil sample in duplicate in 50 mL conical flasks to which 5 doses of K @ 15, 30, 60, 120 and 240 mg kg^{-1} in the form of reagent grade KCl added in one mL solution for each gram of soil. The soils were incubated for two weeks at room temperature (28 ±1°C) maintaining the moisture at field capacity. The loss of soil moisture was corrected on alternate days by adding distilled water on weight loss basis. Available K was determined at predetermined intervals by extracting the

Table 1. Important properties of the different rice soils, West Bengal

Location and soil type	P^H (1:2.5)	EC (dSm^{-1})	Organic C (%)	CEC [cmol p$^+$kg^{-1}]	Soil separates (%)			Texture	Dominant clay minerals #(%)
					Sand	Silt	Clay		
Typic Haplaquent									
Alipurduar	6.2	0.15	0.75	7.6	52	34	14	sl	Illite (55), chlorite (28), kaolinite & quartz (trace)
Burdwan	7.3	0.14	0.73	12.3	68	22	10	sl	Illite (32), chlorite (18), smectite (15), kaolinite (10)
Gayeshpur	6.5	0.05	0.30	9.1	80	12	8	ls	Illite (50), smectite (9), chlorite (29), kaolinite (11)
Typic Haplaquept									
Dankuni	7.7	0.44	0.54	15.7	34	34	32	cl	Illite (28), smectite (33), chlorite (17), kaolinite (6)
Kakdwip	8.0	0.21	1.02	14.5	32	36	32	cl	Illite (47), smectite (24), chlorite (7), kaolinite (7)
Typic Haplustalf									
Jhargram	5.0	0.04	0.27	6.8	78	10	12	ls	Kaolinite (60), Illite (17), smectite (6), chlorite (5)

sl : sandy loam, ls : loamy sand, cl : clay loam, # Anonymous (2003)

Table 2. **Different forms of K (mg kg^{-1}) of the different rice soils, West Bengal**

Location and soil type	Water soluble	Exchangeable	Available	Non-exchangeable	Lattice
Typic Haplaquent					
Alipurduar	35.2	81.3	116.5	1036	2905
Burdwan	54.3	147.1	202.4	1947	3718
Gayeshpur	31.1	133.2	164.3	689	4653
Typic Haplaquept					
Dankuni	238.2	962.1	120.3	3492	9228
Kakdwip	62.3	339.0	401.3	3194	7566
Typic Haplustalf					
Jhargram	17.3	45.2	62.5	442	1357

soil with neutral 1N NH_4OAc and K in the extract was estimated using flame photometer. The fixed K of the soil was calculated as:

$$K_{fixed} = K_{applied} + \text{Available K}_{treated} - \text{Available K}_{initial}$$

Irrespective of varying levels of available and potential K reserves of the soils, available K content consistently increased with increasing levels of K application (Fig.1). The magnitude of increase was higher in those soils having high initial K status. Out of six soils, Dankuni soil containing significant amounts of illite and smectite minerals showed the maximum increase in available K from 1200 to 1401 mg kg^{-1} with the addition of K from 0 to 240 mg kg^{-1} soil. On the contrary, the minimum K availability from 62 to 287.6 mgkg^{-1} soil due to application of same doses of applied K was noticed in Jhargram soil containing kaolinite as the dominant clay mineral. The behavior of other soils in increasing available K status with added K fell in between two. Variations within a group could be due to differences in texture as well as amount of mica-rich minerals (Table 1). According to the increase in available K in soils with applied K, different soil types were arranged in the sequence of Inceptisols > Entisols > Alfisols. Inceptisols and Entisols with larger potential available and fixed K reserves registered the higher availability of K in soil, whereas the lone soil from Alfisols with low available and reserve K recorded the lower soil K availability. This result corroborated with the findings of Rao and Khera (1995) who observed the steep rise of available K in illitic dominant soils with the

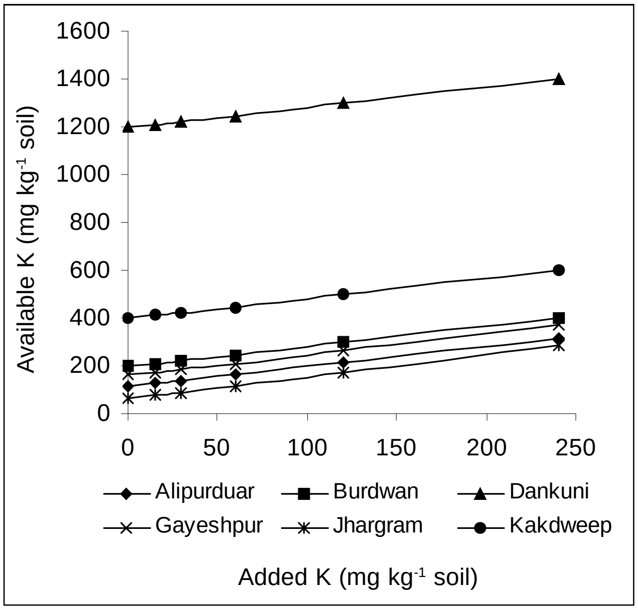

Fig. 1. Relationship between added K and available K in mineralogically different rice soils

incremental doses of applied K.

Soil K-fixation increased with increasing K application rate, however, the percentage of added K fixed decreased gradually (Table 3). This might be attributed to the increase in ionic strength of potassium in solution resulting large proportion of K from labile pool being forced into the inter-lattice position of expanding minerals (Masilamani *et al.*, 1993). On the contrary, the stepwise decrease in per cent K-fixation with increasing levels of K application might be due to the gradual saturation of specific sorption sites (Patel *et al.*, 1989; Singh *et al.*, 1999). Similar observation was reported earlier by Sahu and Gupta (1987). It is presumed that the mechanism of K fixation is preceded by moving the K ions from the edges and surface to the interior of the soil mineral fabric and increasing amount of K influenced the ion diffusion (Chakravorty and Patnaik, 1990). Amount of K fixation with increasing K application rate was, however, variable from soil to soil. Inceptisols with larger available and K reserve showed the K fixation to the extent of 4.9 to 39.6 mg kg^{-1} , while under Entisols containing moderate amounts of available and reserve K recorded relatively a larger quantity of K fixation in the range of 5.5 to 41.0 mg kg^{-1} with K addition from 15 to 240 mg kg^{-1} soil. Alfisol with lower available and native soil K appeared to fix a smaller quantity of applied K ranging from 2.5 to 14.9 mg kg^{-1} with the same K application rates. This difference in K fixation in the soils was ascribed to the variations in soil texture, quantity and composition of clay minerals, native soil K status and K saturation of the inner lattice of micaceous minerals (Patra and Debnath, 1998; Singh *et al.,* 1999).

Results from this study suggest that Entisols and Inceptisols with higher available and reserve K showed moderate K fixation capacity and hence need potassium application at lower doses for crop nutrition. In contrast, Alfisol with low available and reserve K needs to be supplemented with frequent K application at optimum doses for better plant growth. In addition, regular monitoring in the change of the available and reserve K in the soils under intensive rice-based cropping system is also needed for a meaningful K management strategy for higher crop productivity.

Table 3. K fixation and percent K fixed at different levels of added K in the soils

Location and soil type	Added K (mg kg^{-1} soil)				
	15	30	60	120	240
Typic Haplaquent					
Alipurduar	5.5 (36.7)	9.3 (31.0)	15.1 (25.2)	24.5 (20.4)	41.0 (17.1)
Burdwan	5.7 (38.0)	10.5 (35.0)	16.9 (28.2)	23.2 (19.3)	40.6 (16.9)
Gayeshpur	6.3 (42.0)	10.9 (36.3)	17.1 (28.5)	22.9 (19.1)	36.2 (15.1)
Typic Haplaquept					
Dankuni	4.9 (32.7)	8.5 (28.3)	13.9 (23.2)	23.3 (19.4)	39.1 (16.3)
Kakdwip	5.3 (35.3)	8.7 (29.0)	16.1 (26.8)	24.4 (20.3)	39.6 (16.5)
Typic Haplustalf					
Jhargram	2.5 (16.7)	3.9 (13.0)	6.5 (10.8)	10.4 (8.7)	14.9 (6.2)

Figures within brackets indicate percent K fixed

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