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DISTRIBUTION OF POTASSIUM FRACTIONS IN DIFFERENT LAND USE SYSTEMS IN SOME SOIL SERIES OF WEST BENGAL

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ABSTRACT

Soil samples were collected from three soil depths viz., 0-15, 15-30 and 30-45 cm, under six ecosystems of two soil series from Paschim Medinipur district under Red and Laterite Zone of West Bengal to study the distribution of potassium forms. Irrespective of soil series and depth the sequential order of different potassium fractions were non-exchangeble K > available K > exchangeble K > water soluble K. All K fractions were higher in surface layer than that subsurface layer. In Jhargram soil series water soluble K ranges from 1.01 to 1.31, exchangeable K 5.46 to 7.89, while available K is more in fallow lands. Irrespective of land use systems, available and exchangeable K were strongly positively correlated (r = 0.990). In saripabasa soil series water soluble K ranges from 2.42 to 3.54, exchangeable K 15.67 to 54.22, while available K is more in low land rice ecosystem. Irrespective of land use systems, available and exchangeable K were strongly positively correlated (r = 1.00), available K was positively correlated with OC (r = 0.623), water soluble K (r = 0.459).

INTRODUCTION

Potassium (K) is essential for the growth and development of plants, acts as a root booster, stalk strengthener, food synthesizer, sugar and starch transporter, protein builder, wilt reducer and disease retarder in plants, besides many other functions, hence, is most important in stabilizing crop yields. In soil K exists in different forms viz., water soluble, exchangeable, non-exchangeable and reserve. Distribution of these forms in soil depends on parent material, degree of weathering, K gains through manures and fertilizers and losses due to crop removal, erosion and leaching (Lalitha and Dhakshinamoorthy, 2014). The dynamics of potassium in soil depends on the magnitude of equilibrium among various forms and mainly governed by the physicochemical properties of soil. The distribution of K forms in the soil and the equilibrium between them determine the K status of the soil and the potential of K supply to plants (Pavlov, 2007).

The readily available K constitutes only 1 to 2 % of total K and exists in soil in two forms, viz., solution and exchangeable K adsorbed on soil colloidal surface (Brady and Weil, 2002). The amount of K in the soil solution phase is often too small to meet the requirement of crop plants in a particular growing season. Thus, a continuous renewal of K in the soil solution is essential to meet the requirement of the plants (Singh *et al.*, 2004). The readily available or water soluble K has been reported to be a dominant fraction in the initial stage while exchangeable and non-exchangeable K contribute more in the later stages of crop growth (Subehia *et al.* 2003).

The equilibrium between soluble K and the exchangeable K is fast and is established within few minutes, but that between the exchangeable and the non-exchangeable K is much slower, requiring a few days or even few weeks (Sanyal and Majumdar, 2001). This equilibrium can get disturbed by the removal of K from the soil solution by the plants or through leaching and even also by the addition of K to the soil by the fertilizers, crop residues and also possibly through irrigation.

Thus, it is quite evident that soils having same content of total K may vary widely in potash supplying capacity depending upon the distribution of the different forms of K. Therefore for estimating the potash supplying power of the soils, it is necessary to study the distribution and characterisation of different forms of K in the given soil samples.

Keeping all these things in mind, present study was emphasised on potassium fractions in different land use systems.

MATERIALS AND METHODS

Soil samples were collected from six ecosystems viz. Rice up land (L1), Rice medium land (L2), Rice low land (L3), Fallow land (L4), Eucalyptus forest (L5), Mango orchard land (L6) from three depths (0-15cm, 15-30 cm and 30-45cm) of Jhargram and Saripbasa series of West Medinipur district of West Bengal. Soil properties of different ecosystems have given in Table 1.

Soil samples were air-dried, ground to pass through a 2-mm sieve and analysed for pH, in soil suspensions (soil:water :: 1:2.5) as determined by Jackson(1973), Electrical conductivity of soil suspensions (soil:water :: 1:2) measured with conductivity meter, CEC was determined by Schollenberger and Simon (1945), soil texture by Hydrometer method (Bouyoucos, 1962) method, Organic carbon was determined by following the wet digestion method of Walkley and Black as described by Jackson (1973). Water soluble K (ppm) was determined in a 1:5: soil:water extract by the method adopted by USSLS (1954), Exchangeable K (ppm) was extracted by leaching with neutral 1(N) NH4OAC as described by Pratt (1965), Non-exchangeable K(ppm)was extracted by boiling with 1(N) HNO3(Wood and Deturk, 1941), Available K(ppm) was determined by adding water soluble K and exchangeable K.

Duncan's multiple range test (DMRT) at 5% was followed to compare the treatment means. DMRT and CD test results will be displayed beside the mean values using different set of alphabets, where similar alphabets denote homogenous means resulted by DMRT at 5% level of significance.

RESULTS AND DISCUSSION

Soil physicochemical properties

The pH values of the individual soils under the available ecosystems and depths were also analysed individually. In Jhargram soil the pH differed under different ecosystems and followed the order: Orchard (6.36) H″ Rice Upland (6.34) H″ Rice Low Land (6.33) H″ Rice Medium Land (6.22) > Forest (5.50) > Fallow (5.20) (table 2). In Saripbasa soil series different ecosystems and combined effect of different ecosystems and depth of sampling significantly influenced the soil pH. While in forest soil the pH was the lowest (5.38), it was the highest in Rice Medium Land (6.54) (Table 4). In both the soil series forest and fallow land use systems showed slight low pH as compared to other land use systems. Excess leaching of bases from the soil profile due to heavy rainfall might be caused acidity in these soils (Sharma and Singh, 2002).

Irrespective of ecosystem and depth of soil sampling the pH of Jhargram soil was significantly positively correlated with OC (r=0.285), Ws_K (r= 0. 415) and NEx_K (r=0.525) (Table 3) and of Saripbasa soil series was significantly positively correlated with OC (r=0.397), Ws_K (r= 0.501), Ex_K (r=0.654), NEx_K (r=0.308) and Av_K (r=0.661) (Table 5).

In Jhargram soil series the soil EC differed under different ecosystems ranging from 0.05 and 0.07 (table 2). The lowest EC was observed under orchard (0.05) with comparable EC under forest (0.06) and the other ecosystems had comparable EC values (0.07). In Saripbasa soil series Rice Medium Land the EC was the lowest (0.06), it was the highest in Orchard system (0.08) (table 4). Similarly the lowest soil EC was recorded in 15-30 cm soil depth under fallow land use system (0.05), the highest was observed in 15-30 cm soil depth under orchard (0.09). Less accumulation of soluble salts in soil profile might be due to leaching of soluble salts, releases during weathering of soil forming minerals with sufficient water received by high rainfall (Sharma, 2013).

Irrespective of ecosystem and depth of soil sampling the EC of Jhargram soil series was significantly negatively correlated with NEx_K (r=-0.280) (Table 3), and of Saripbasa soil series was significantly positively correlated with Ws_K (r= 0.308) and significantly negatively correlated with and NEx_K (r=-0.309) (Table 5).

In Jhargram soil series the soil OC differed under different ecosystems and followed the order: Forest (0.503) > Rice Medium Land (0.464) H″ Rice Upland (0.424) H″ Rice Low Land (0.428) > Orchard (0.308) > Fallow (0.229) (table 2). Distribution of OC were significantly different across the three depths of sampling and followed the order: 0-15 cm (0.433) > 15-30 cm (0.393) > 30-45 cm (0.361). In Saripbasa soil series forest soil OC was the lowest (0.38), it was the highest in Rice lowland (0.53) (Table 4). Under different ecosystems the OC followed the order: Rice Low Land (0.533) H″ Fallow (0.518) H″ Rice Medium Land (0.512) > Rice Upland (0.462) > Orchard (0.418) > Forest (0.38). Wide variation in SOC accumulation under different land use systems has also been reported by Singh *et al.* (2006). Distribution of OC were significantly different across the three depths of sampling and followed the order: 0-15 cm (0.488) > 15-30 cm (0.474) > 30-45 cm (0.449). Similarly the lowest soil OC was recorded in 30-45 cm soil depth under fallow land use system (0.347), the highest was observed in 15-30 cm soil depth under Rice lowland (0.547).

Irrespective of ecosystem and depth of soil sampling the OC content of Jhargram soil series was significantly positively correlated with pH (r=0.285) and Ws_K (r= 0.633) (Table 3) and of Saripbasa soil series was significantly positively correlated with pH (r=0.397), Ws_K (r= 0. 549), Ex_K (r=0.614), NEx_K (r=0.404) and Av_K (r=0.623) (Table 5).

Potassium fractions

Water Soluble Potassium (Ws_K)

In Jhargram soil the soil Ws_K content differed under different ecosystem and followed the order: Rice Medium Land (1.34)

Table 1: some soil properties of different ecosystems

Soil series	Ecosystem	CEC[cm (p^{+1}) kg^{-1}]	SAND(%)	SILT(%)	CLAY(%)
Jhargram	Rice_Upland (ES1)	6.03	44.0	50.4	5.6
	Rice_Medium_Land (ES2)	5.90	43.8	50.2	6.0
	Rice_Low_Land (ES3)	6.03	43.5	50.3	6.2
	Fallow (ES4)	5.17	44.3	50.5	6.2
	Forest (ES5)	5.34	43.7	49.9	6.4
	Orchard (ES6)	5.80	43.9	49.8	6.3
	Mean	5.71	43.9	50.2	6.1
Saripbasa	Rice_Upland (ES1)	18.40	33.6	34.8	31.6
	Rice_Medium_Land (ES2)	18.20	33.2	35.9	30.9
	Rice_Low_Land (ES3)	17.60	33.2	35.8	32.0
	Fallow (ES4)	17.47	32.7	35.1	32.2
	Forest (ES5)	16.7	32.9	34.6	32.5
	Orchard (ES6)	17.77	32.2	36.2	31.6
	Mean	17.69	33.0	35.4	31.8

Table 2: Different soil properties under different ecosystems and at different depths in Jhargram soil

	pH	EC	OC	WS_K	Ex_K	NEX_K	Avl_K
Ecosystems							
Rice_Upland (ES1)	6.34[a]	0.07[a]	0.444[bc]	1.21[bc]	6.79[b]	16.40[c]	8.00[b]
Rice_Medium_Land (ES2)	6.22[a]	0.07[ab]	0.464[b]	1.34[a]	6.56[c]	20.07[b]	7.90[c]
Rice_Low_Land (ES3)	6.33[a]	0.07[ab]	0.428[c]	1.31[ab]	5.67[e]	16.12[c]	6.98[e]
Fallow (ES4)	5.20[c]	0.07[ab]	0.229[e]	1.01[d]	7.89[a]	14.99[d]	8.89[a]
Forest (ES5)	5.50[b]	0.06[bc]	0.503[a]	1.22[bc]	5.46[f]	14.48[d]	6.68[f]
Orchard (ES6)	6.36[a]	0.05[c]	0.308[d]	1.15[c]	6.27[d]	21.60[a]	7.42[d]
$SE_M\pm$	0.06	0	0.011	0.03	0.07	0.19	0.09
CD(P=0.05)	0.17	0	0.03	0.1	0.21	0.54	0.25
F Test	***	***	***	***	***	***	***
Depth							
0-15 cm (D1)	5.96[a]	0.07[a]	0.434[a]	1.32[a]	7.36[a]	18.38[a]	8.67[a]
15-30 cm (D2)	6.01[a]	0.07[a]	0.393[b]	1.17[b]	6.51[b]	17.34[b]	7.67[b]
30-45 cm (D3)	6.00[a]	0.07[a]	0.361[c]	1.14[c]	5.45[c]	16.11[c]	6.59[c]
SE±	0.04	0	0.007	0.02	0.05	0.13	0.06
CD(P=0.05)	0.12	0	0.021	0.07	0.14	0.38	0.17
F Test	NS	NS	***	***	***	***	***

Significance of F test; NS- non significant, *- significant at 5%, ***- significant at <1% level

Table 3: Interrelationship among different soil properties (Pearson's correlation) in Jhargram soil

	pH	EC	OC	WS_K	Ex_K	NEX_K	Av_K
pH	1	0.048	.285*	.415**	-0.245	.525**	-0.183
EC		1	0.028	-0.03	0.14	-.280*	0.133
OC			1	.633**	-0.253	-0.011	-0.162
WS_K				1	0.046	.309*	0.183
Ex_K					1	0.202	.990**
NEX_K						1	0.242
Av_K							1

**. Correlation is significant at the 0.01 level (2-tailed);*. Correlation is significant at the 0.05 level (2-tailed)

H" Rice Low Land (1.31) H" Forest (1.22) H" Rice Upland (2.21) H" Orchard (1.15) > Fallow (1.01) (table 2). Distribution of Ws_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (1.32) > 15-30 cm (1.17) H" 30-45 cm (1.14). These finding are similar with Naik *et al.*, 2014.

Irrespective of ecosystem and depth of soil sampling the Ws_K content of Jhargram soil series was significantly positively correlated with pH (r=0.415), OC (r=0.633) and NEx_K (r=0.309) (Table 3).

In Saripbasa soil series, in orchard ecosystem the Ws_K was the lowest (2.42), it was the highest in Rice medium land ecosystem (3.54) (table 4). Under different ecosystem the Ws_K followed the order: Rice Medium Land (3.54) > Rice Low Land (3.26) H" Rice Upland (3.18) > Fallow (2.78) H" Forest (2.72) > Orchard (2.42). Distribution of Ws_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (3.17) > 15-30 cm (2.99) > 30-45 cm (2.79).

Irrespective of ecosystem and depth of soil sampling the Ws_K content of Saripbasa soil series was significantly positively correlated with pH (r=0.501), OC (r=0.549), Ex_K (r=0.431), NEx_K (r=0.591) and Av_K (r=0.459) and significantly negatively correlated with EC (r=-0.308) (Table 5).

Exchangeable Potassium (Ex_K)

In Jhargram soil series the soil Ex_K content differed under different ecosystems and followed the order: Fallow (7.89) > Rice Upland (6.79) > Rice Medium Land (6.56) > Orchard (6.27) > Rice Low Land (5.67) > Forest (5.46) (table 2). Distribution of Ex_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (7.36) > 15-30 cm (6.51) > 30-45 cm (5.45). These finding are similar with Naik *et al.*, 2014.

Irrespective of ecosystem and depth of soil sampling the Ex_K content of Jhargram soil series was significantly positively correlated with Av_K (r=0.990) (Table 3).

In Saripbasa soil series in fallow land ecosystem the Ex_K was the lowest (15.67), it was the highest in Rice Lowland ecosystem (54.22) (table 4). Under different ecosystem the Ex_K followed the order: Rice Low Land (54.22) > Rice Upland (38.00) > Orchard (35.00) H" Rice Medium Land (34.11) > Forest (25.56) > Fallow (15.67).Distribution of Ex_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (37.39) > 15-30 cm (32.56) > 30-45 cm (31.33).

Irrespective of ecosystem and depth of soil sampling the Ex_K content of Saripbasa soil series was significantly positively correlated with pH (r=0.654), OC (r=0.614), Ws_K (r= 0. 431), NEx_K (r=0.430) and Av_K (r=0.444) (Table 5).

Available Potassium (Av_K)

In Jhargram soil series the soil Av_K content differed under different ecosystems and followed the order: Fallow (8.89) > Rice Upland (8.00) > Rice Medium Land (7.90) > Orchard (7.41) > Rice Low Land (6.97) > Forest (6.70) (table 2).

Table 4: Different soil properties under different ecosystems and at different depths in Saripabasa soil series

	pH	EC	OC	WS_K	Ex_K	NEx_K	Av_K
Ecosystem							
Rice_Upland (ES1)	6.46[a]	0.07[ab]	0.46[c]	3.18[b]	38.00[b]	251.11[d]	41.18[b]
Rice_Medium_Land (ES2)	6.54[a]	0.06[c]	0.51[b]	3.54[a]	34.11[c]	357.78[a]	37.65[c]
Rice_Low_Land (ES3)	6.21[b]	0.07[abc]	0.53[a]	3.26[b]	54.22[a]	337.78[b]	57.48[a]
Fallow (ES4)	5.65[d]	0.08[bc]	0.52[e]	2.72[d]	25.56[e]	260.00[c]	28.28[e]
Forest (ES5)	5.38[c]	0.06[a]	0.38[ab]	2.78[c]	15.67[d]	285.56[d]	18.44[d]
Orchard (ES6)	6.19[b]	0.08[a]	0.42[d]	2.42[e]	35.00[c]	291.11[c]	37.42[c]
F Test	***	*	***	***	***	***	***
$SE_M \pm$	0.032	0	0	0.042	0.428	5.112	0.419
CD(P=0.05)	0.091	0	0	0.121	1.227	14.662	1.201
Depth							
0-15 cm (D1)	6.08[a]	0.07[a]	0.488[a]	3.17a	37.39[a]	329.44[a]	40.56[a]
15-30 cm (D2)	6.03[a]	0.07[a]	0.474[b]	2.99[b]	32.56[b]	291.11[b]	35.54[b]
30-45 cm (D3)	6.10[a]	0.07[a]	0.449[c]	2.79[c]	31.33[c]	271.11[c]	34.12[c]
F Test	NS	NS	***	***	***	***	***
$SE_M \pm$	0.02	0	0	0.03	0.3	3.61	0.3
CD(P=0.05)	0.06	0	0	0.09	0.87	10.37	0.85

Table 5: Interrelationship among different soil properties (Pearson's correlation) in Saripbasa soil series

	pH	EC	OC	WS_K	Ex_K	NEx_K	Av_K
pH	1						
EC	-0.016	1					
OC	.397**	-0.064	1				
WS_K	.501**	-.308*	.549**	1			
Ex_K	.654**	0.072	.614**	.431**	1		
NEx_K	.308*	-.309*	.404**	.591**	.430**	1	
Av_K	.661**	0.06	.623**	.459**	1.000**	.444**	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed)

Distribution of Av_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (8.67) > 15-30 cm (7.67) > 30-45 cm (6.58). While in orchard ecosystem at 30-45 cm soil depth the Av_K content was the lowest (5.55), it was the highest in Rice Upland ecosystem at 0-15 cm soil depth (10.13).

Irrespective of ecosystem and depth of soil sampling the Av_K content of Jhargram soil series was significantly positively correlated with Ex_K (r=0.990**) (Table 3).

In Saripbasa soil series different ecosystems, depth of soil sampling and combined effect of different ecosystem and depth of sampling significantly influenced the soil Av_K content of soils. While in fallow land ecosystem the Av_K was the lowest (18.44), it was the highest in Rice Lowland ecosystem (57.48) (table 4).Under different ecosystem the Av_K followed the order: Rice Low Land (57.48) > Rice Upland (41.18) > Rice Medium Land (37.65) H″ Orchard (37.42) > Forest (28.28) > Fallow (18.44). Distribution of Av_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (40.56) > 15-30 cm (35.54) > 30-45 cm (34.12). These findings were similar with Naik., 2014. Similarly the lowest soil Av_K was recorded in 30-45 cm soil depth under fallow land ecosystem (15.70) and the highest was observed in 0-15 cm soil depth under Rice Lowland ecosystem (60.77).

Irrespective of ecosystem and depth of soil sampling the Av_K content of Saripbasa soil series was significantly positively correlated pH (r=0.661), OC (r=0.623), Ws_K (r= 0. 459), Ex_K (r=1.00) and NEx_K (r=0.444) (Table 5).

Non-Exchangeable Potassium (NEx_K)

In Jhargram soil series the soil NEx_K content differed under different ecosystems and followed the order: Orchard (21.6) > Rice Medium Land (20.07) > Rice Upland (16.40) H″ Rice Low Land (16.10) > Fallow (15.00) H″ Forest (14.5) (Table 2). Distribution of NEx_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (18.40) > 15-30 cm (17.30) > 30-45 cm (16.10). In Saripbasa soil series, in Rice Medium land ecosystem (357.78) (table 4).Under different ecosystem the NEx_K followed the order: Rice Medium Land (357.78) > Rice Low Land (337.78) > Orchard (291.11) H″ Fallow (285.56) > Forest (260.00) H″ Rice Upland (251.11). Distribution of NEx_K across the three depths of sampling were significantly different and followed the order: 0-15 cm (329.44) > 15-30 cm (291.11) > 30-45 cm (271.11). These finding are similar with Naik *et al.*, 2014.

Irrespective of ecosystem and depth of soil sampling the NEx_K content of Jhargram soil series was significantly positively correlated with pH (r=0.525) and Ws_K (r= 0. 309) (Table 3), of Saripbasa soil series NEx_K content was significantly positively correlated with pH (r=0.308), OC (r=0.404), Ws_K (r= 0. 591), Ex_K (r=0.430) and Av_K (r=0.444) and significantly negatively correlated with EC (r=-0.309) (Table 5).

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