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Distribution of Forms of Potassium in Surface and Sub-Surface Horizons of Some Entisol Profiles of West Bengal

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Abstract

Distribution of different forms of potassium viz. water soluble, exchangeable, non-exchangeable and their dependence on soil pH, clay content and cation exchange capacity in surface and sub-surface soils of 13 soil series of West Bengal under the order entisol, was studied. Water soluble and exchangeable potassium content in surface horizons was higher than subsurface horizons. All 13 soil series except four showed similar trend in non-exchangeable potassium content. Different forms of potassium viz. water soluble, exchangeable, available, non-exchangeable and potassium fixing capacity of surface and sub-surface soils were positively correlated with soil pH, clay content and cation exchange capacity ; 61.9% of the surface soil samples belong to medium low category (2.01 to 3% potassium saturation), 30.8% to low category (≤ 2% K saturation) and 7.3% to medium saturation category.

Key words : Potassium forms, Entisol profiles, Surface horizon, Sub-surface horizon.

The dynamic equilibrium reactions amongst water soluble potassium, the component of potassium which is directly taken up by plants ; exchangeable potassium, held by negative charge sites on clay particles ; non-exchangeable potassium, the fraction trapped between layers of expanding lattice clays and the lattice potassium, the component of soil potassium which is an integral part of primary minerals profoundly affect potassium uptake during plant growth. The fertility investigation on the basis soil series serves as a better scientific approach than that of administrative units like district, block or mouza. Generated information on a series can be more confidently expanded to similar areas in other locations. Lack of adequate series-wise potassium distribution in soils of West Bengal led the authors to investigate the distribution of forms of potassium viz. water soluble, exchangeable, available and non-exchangeable in surface and sub-surface soils of 13 soil series of West Bengal under the order entisol.

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Methods

Soil samples from the surface (0—25 cm) and the corresponding sub-surface (> 25—50 cm) were collected from profiles representing 13 identified soil series (NBSS and LUP, Kolkata) of West Bengal under the order entisol. The relevant physical and chemical properties of soils are presented in Table 1. Different forms of potassium i.e. water soluble potassium (1), neutral normal ammonium acetate extractable potassium representing exchangeable potassium and 1 N nitric acid extractable potassium representing non-exchangeable potassium (2) were determined. Potassium fixing capacity, pH (1 : 2.5), organic carbon and texture were determined by the method adopted by Jackson (3) and cation exchange capacity was determined by the standard methods (4). Correlation coefficient were also computed to determine linear relationship between forms of potassium and potassium fixing capacity along with some relevant physical and chemical characteristics of the soils.

Based on percent potassium saturation soils were classified as low (≤ 2% K saturation), medium low (2.01 to 3% potassium saturation), medium (3.01 to 4% potassium saturation) and high (4.01 to 5% potassium saturation). Similarly based on cation exchange capacity soils were divided into three categories as group A (<5 me / 100 g), group B (5 to 10 me / 100 g) and group C (> 10 me / 100 g). An attempt was made to categorize the surface soils on the basis of these concepts.

Table 1. Some relevant physical and chemical properties of the surface and the corresponding sub-surface soils of 13 identified soil series under the order entisol.

Soil series	Depth	pH	Organic carbon (%)	Mechanical Analysis Sand (%)	Silt (%)	Clay (%)	CEC (meq/ 100 g)	Fixing capacity of applied potassium (meq/ 100 g)
Bamundanga	0—25	6.80	0.83	14.2	54.6	31.3	16.08	1.584
	25—50	6.75	0.51	10.3	61.3	28.4	14.40	1.584
Kaliganj	0—25	7.00	0.62	18.7	66.1	13.2	6.97	1.245
	25—50	7.30	0.39	15.3	71.1	12.6	6.90	1.124
Muralipukur	0—25	6.80	0.94	23.8	56.7	19.5	9.15	1.132
	25—50	6.80	0.75	22.9	60.7	16.4	8.80	0.953
Gopalnagar	0—25	7.80	0.93	6.1	70.4	22.3	11.41	1.811
	25—50	7.65	0.64	10.4	74.3	15.3	7.60	1.497
Jules	0—25	6.50	0.71	26.0	55.5	18.5	8.32	1.358
	25—50	6.60	0.32	29.0	58.4	12.6	7.51	1.171
Gunjaria	0—25	6.20	0.67	49.3	38.2	18.5	6.27	1.132
	25—50	6.40	0.35	42.4	43.4	19.2	8.10	0.792
Jatiarali	0—25	5.00	1.59	60.6	29.9	9.5	3.84	0.453
	25—50	5.70	0.67	64.1	31.4	4.5	2.80	0.260
Khagrabari	0—25	5.40	0.99	7.3	81.1	11.6	4.96	0.226
	25—50	5.60	0.39	12.0	80.8	7.2	3.81	0.113
Chanjpara	0—25	5.70	1.05	22.6	66.2	11.0	4.43	0.339
	25—50	6.20	0.70	23.3	64.1	12.6	6.32	0.679
Mahisbathan	0—25	5.70	1.73	52.3	35.1	12.6	5.46	0.679
	25—50	5.90	0.90	66.3	23.1	10.6	4.82	0.453
Pundibari	0—25	5.80	0.97	65.8	22.1	12.1	4.80	0.679
	25—50	6.00	0.82	62.9	24.0	13.1	6.34	0.566
Baratia	0—25	5.70	0.78	76.0	11.0	13.0	5.80	0.905
	25—50	5.90	0.72	74.0	11.8	14.2	6.40	0.571
Posagarh	0—25	5.00	0.86	64.0	24.0	12.0	3.95	0.679
	25—50	5.20	0.72	60.2	26.0	13.8	4.55	0.550

Results and Discussion

Different forms of potassium viz. water soluble, exchangeable, available and non-exchangeable are presented in Table 2. Water soluble and exchangeable potassium content in surface horizons were in general found to be higher that those in the corresponding sub-surface horizons. Presence of higher amount of water soluble and exchangeable potassium in surface could be due to more intensive weathering, vegetation, release of labile potassium from organic residues, application of potassic fertilizer and upward translocation of potassium from lower depths with capillary rise of ground water on the surface. Similar observation has also been reported for the soils of Andhra Pradesh (5). Non-exchangeable potassium content also showed a general decreasing trend from surface to sub-surface horizon for all soil series except four (Gunjaria, Changpara, Pundibari and Posagarh) where lower non-exchangeable potassium content was recorded in surface horizons compared to sub-surface horizons, may be due to the release of non-exchangeable potassium to compensate the loss of water soluble and exchangeable potassium resulting from potassium uptake by crop plants and leaching losses.

A strong positive and significant relationship between each pair of different forms of potassium was observed for both surface and sub-surface soils in 13 soil series investigated under the order entisol (Table 3). This obviously corroborates the well known dynamic equilibrium relationship among different forms of potassium in soils (6—8).

A strong positive significant relationship be-

Table 2. Distribution of different forms of potassium (me/100 g) in surface and the corresponding sub-surface soils of the series under the order entisol.

Soil series	Depth (cm)	Forms of potassium (meq/100 g soil) Water soluble (a)	Exchangeable (b)	Available (a+b)	Non-exchangeable (c)
Bamundanga	0—25	0.045	0.280	0.325	3.22
	25—50	0.039	0.250	0.289	2.8
Kaliganj	0—25	0.028	0.130	0.158	1.63
	25—50	0.021	0.120	0.141	1.60
Muralipukur	0—25	0.031	0.190	0.221	2.70
	25—50	0.020	0.150	0.170	2.27
Gopalnagar	0—25	0.033	0.160	0.193	2.20
	25—50	0.028	0.105	0.133	1.52
Jule	0—25	0.045	0.210	0.255	2.80
	25—50	0.032	0.190	0.222	2.60
Gunjaria	0—25	0.043	0.270	0.310	2.48
	25—50	0.040	0.250	0.290	3.10
Jatiakali	0—25	0.025	0.085	0.110	1.18
	25—50	0.024	0.076	0.100	1.13
Khagrabari	0—25	0.034	0.110	0.144	1.37
	25—50	0.026	0.120	0.146	1.35
Changpara	0—25	0.024	0.110	0.144	1.37
	25—50	0.025	0.140	0.165	1.84
Mahisbathan	0—25	0.041	0.130	0.171	1.22
	25—50	0.026	0.120	0.146	1.16
Pundibari	0—25	0.032	0.130	0.162	1.73
	25—50	0.028	0.120	0.148	2.09
Baratia	0—25	0.037	0.120	0.157	1.84
	25—50	0.025	0.130	0.155	1.58
Posagarh	0—25	0.018	0.090	0.108	1.14
	25—50	0.016	0.100	0.116	2.14

tween potassium fixing capacity independently with soil pH, clay content and cation exchange capacity was observed in soils of both surface and sub-surface horizons (Table 4). The results are in conformity with those reported by Talele et al. (9), Basumatary and Bordoloi (10).

Table 3. Correlation coefficient (r) between forms of potassium in surface and the corresponding sub-subsurface soils of the series under the order entisol. *Significant at 5% level, **Significant at 1% level. Figures in parentheses represent correlation coefficient (r) of the sub-surface horizon.

Forms of potassium	Exchangeable	Available	Non-exchangeable
Water soluble	0.788** (0.830**)	0.852** (0.930**)	0.642** (0.550**)
Exchangeable		0.990** (0.990**)	0.900** (0.850**)
Available			0.881** (0.831**)

Table 4. Correlation coefficient (r) between fixing capacity of applied potassium and physico-chemical characteristics of surface and the corresponding sub-surface soils of the series under the order entisol. *Significant at 5% level, ** Significant at 1% level.

Fixing capacity of applied potassium in	pH	Clay	Cation exchange capacity
Surface horizon	0.886**	0.820**	0.808**
Sub-surface horizon	0.804**	0.736**	0.825**

For the surface soils under the order entisol, water soluble potassium though correlated significantly with clay content and cation exchange capacity at 5% level of significance but failed to show statistically significant relationship with pH and silt plus clay content. Exchangeable potassium content of the same soils showed positive significant relations independently with soil pH and silt plus clay content at 5% level of significance, while with clay content and cation exchange capacity at 1% level of significance. Available and non-exchangeable potassium content indicated positive and significant relation with clay and cation exchange capacity at 1% level. Available and non-exchangeable potassium correlated significantly separately with soil pH at 5%

Table 5. Correlation coefficient (r) between different forms of potassium and physico-chemical characteristics of surface and the corresponding sub-surface soils of the series under the order entisol. *Significant at 5% level, ** Significant at 1% level. Figures in parentheses represent correlation coefficient (r) of the sub-surface horizon.

Forms of potassium	Physico-chemical characteristics pH	Silt + clay	Clay	Cation exchange capacity
Water soluble K	0.370 (0.294)	0.196 (0.259)	0.670* (0.570*)	0.530* (0.500*)
Exchangeable K	0.565* (0.280)	0.599* (0.364)	0.825** (0.787**)	0.735** (0.767**)
Available K	0.553* (0.274)	0.357 (0.332)	0.838** (0.775**)	0.72** (0.783**)
Non-exchangeable K	0.671* (0.201)	0.449 (0.261)	0.866** (0.730*)	0.895** (0.633*)

Table 6. Classification of surface sample of 13 soil series based on rating percent of potassium saturation and cation exchange capacity.

Categories based on percent potassium saturation of CEC	Categories based on cation exchange capacity (expressed as percent of total soils) A < 5 meq/ 100 g	B 5—10 meq/ 100 g	C > 10 meq/ 100 g
High category (4.01% to 5% K saturation)	–	–	–
Medium category (3.01% to 4% K saturation)	–	7.30	–
Medium low category (2.01% to 3% K saturation)	38.80	23.10	–
Low category (< 2% K saturation)	–	15.40	15.40

level of significance but not with silt plus clay content. For the sub-surface soils of the series under the order entisol, all forms of potassium did not show any significant relation separately with soil pH and silt plus clay content but showed positive and significant relationship separately with clay content and cation exchange capacity at 5% level for water soluble and non-exchangeable potassium and at 1% level for exchangeable and available forms of potassium (Table 5). Pal and Mukhopadhyay (11, 12) noted significant association of the finer textural component of soil particularly that of clay fraction with different forms of potassium in soil.

The results reveal that 61.9% of the series belonged to medium low category (2.01 to 3% potassium saturation), 30.8% to low category (≤ 2% K saturation) and 7.3% to medium saturation category (Table 6). Out of 61.9% soil series belonging to medium low category 38.8% comes under cation exchange capacity class A (i.e. (< 5 me/ 100 g) and 23.1% comes under class B (i.e. 5 to 10 me / 100 g), whereas the series under low potassium saturation have been found to be equally distributed to cation exchange capacity class B and C (15.4% each).

Conclusion

The results thus show a general decreasing trend in water soluble, exchangeable and non-exchangeable potassium content from surface to sub-surface horizon for most of the soil series under entisol. These forms of potassium are interrelated with each other. Potassium fixing capacity of potassium depends significantly on soil properties like pH, clay content and cation exchange capacity. Water soluble, exchangeable and non-exchangeable potassium contents in soil also depend on soil pH, clay content, silt content and cation exchange capacity, however the degree of dependence, varies from soil to soil and even among the surface and sub-surface horizon.

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