Environment & Ecology 27 (2) : 617—620, 2009
 ISSN 0970-0420

Forms of Potassium, their Distribution and Relationships with Soil Properties of Eastern Plain of Rajasthan

K. K. YADAV[1], D. P. S. DUDI AND N. SINGH

Department of Agricultural Chemistry and Soil Science, Maharana Pratap University of Agricultural & Technology Udaipur 313001, Rajasthan,India
[1]Department of Soil and Water Engineering, College of Technology and Engineering, MPUAT Udaipur 313001, Rajasthan, India

Abstract

Forms of potassium, their distribution and relationship with soil properties were investigated in four soil profiles representing eastern plain of Rajasthan. The mean value of water soluble, exchangeable, available, non-exchangeable, nitric acid soluble, lattice and total K were 10.29, 242.22, 254.58, 1464.87, 1707.28, 1927.76 and 3634.84 mg/kg of soil, respectively. Mean and the per cent contribution of these forms were 0.28, 6.66, 7.00, 40.30, 46.97, 53.04 towards total K. Water soluble K decreased whereas exchangeable, available, non-exchangeable K, lattice R and total K increased with soil depth. Non-exchangeable K, lattice K and total K were mainly contributed by the clay fraction in soil. All the forms of K, except water soluble K, were positively correlated with each other while water soluble K was negatively correlated with others. All the forms of soil potassium were correlated, indicating the existence of dynamic equilibrium among them.

Key words : Forms of soil potassium, Dynamic equilibrium, Correction, Eastern plain of Rajasthan.

Soil potassium exists in various forms, viz. water soluble, exchangeable, non-exchangeable and parts of the crystal lattice of minerals. The three forms are exists in a dynamic equilibrium with each other and are important for the growth of higher plants and microbes. Lattice K in the crystal structure of the minerals is released slowly during chemical weathering and subsequently becomes available to the plant. Knowledge on different forms of K is, therefore, essential to have information on the K supplying capacity of the soils. Since deep rooted crops absorb nutrients from the deeper part of the soil, information on various forms of K in the sub-surface horizons is also desirable to know their K supplying capacity. Literature in this respect is still inadequate for Rajasthan soils. An attempt was therefore made in the present investigation to study the vertical distribution of various forms of K in Rajasthan soils.

Methods

Soil profiles were selected from eastern plain is located between $24^0 45'$ to $27^0 50'$ N latitude and $73^0 30'$ to $78^0 17'$ E longitude. The details of the soils and their important properties are presented in Table 1. The soil samples were analyzed for pH, EC, particle size distribution, organic carbon, calcium carbonate and cation exchange capacity. Water soluble K was determined from 1:5 soil water extract (1). Available K determined from 1:5 soil : 1N NH_4OAC (pH 7.0) extract, were determined following the method described by Jackson (2), whereas exchangeable K and non-exchangeable K fractions were determined by standard methods (3). Lattice K was determined as the difference between total K and 1N HNO_3 extractable K. Total K was determined by digesting the soil sample with perchloric and hydrofluoric acids as mentioned by Jackson (2). The estimation of K in all the cases was done by flame photometrically.

Results and Discussion

The data on various parameters, viz. physico-chemical properties, forms of soil potassium, correlation among different forms of K and relationship between forms of K and soil properties are presented in Tables 1, 2, 3 and 4, respectively.

Physico-Chemical Properties of Soils

The physico-chemical properties of soils are pre-

Table 1. Physico-chemical characteristics of selected soil profiles of eastern plain of Rajasthan. *1 : 2.5 soil : water suspension.

Soil series (Dist)	Genetic horizon	Depth (cm)	pH*	EC* (dS/m)	Org. C (g/kg)	$CaCO_3$ (g/kg)	CEC [cmol] (P^+)/kg	Particle size distribution (%) Sand	Silt	Clay
Ulela	A	0-16	8.39	0.32	6.2	4.0	14.4	60.5	18.8	19.7
(Bhilwara)	BW	16-37	7.62	0.28	5.4	9.0	16.8	63.1	23.8	13.1
	C	37-70	7.68	0.24	3.2	16.0	17.1	73.0	11.8	15.2
Changeri	Ap	0-16	8.20	0.24	8.1	22.0	12.9	69.6	13.2	17.2
(Udaipur)	BWI	16-46	8.20	0.29	6.8	36.0	13.6	68.0	8.5	23.5
	BC	46-65	8.50	0.32	5.5	39.0	14.7	68.3	6.9	24.8
Kotri	Ap	0-20	8.44	1.60	6.8	4.20	39.8	22.1	23.2	54.7
(Bhilwara)	A2	20-48	8.48	5.40	5.6	45.0	42.9	18.0	22.8	59.2
	Bss	48-75	8.64	5.60	4.6	108.0	43.6	19.4	25.4	55.2
	2CKI	75-100	8.25	3.20	3.5	224.0	44.0	46.0	16.4	37.6
	2CK2	100-115	8.33	2.30	2.1	66.0	43.4	68.9	15.3	15.8
Kapasan	Ap	0-22	8.42	0.29	6.0	13.0	37.5	26.5	24.8	48.7
(Chittorgarh)	A2	22-58	8.35	0.28	5.5	22.0	40.1	25.4	26.5	48.1
	BWI	58-86	8.44	0.35	3.3	28.0	40.5	27.0	26.6	46.4
	BW2	86-104	7.88	0.25	3.2	17.0	42.2	30.4	27	42.6
	BC	104-135	7.66	0.34	3.0	34.0	43.8	30.9	27.5	41.6
	Mean		8.22	1.33	4.9	42.64	31.7	44.8	19.9	35.2
	Range		(7.62-8.64)	(0.24-5.60)	(2.1-8.1)	(40.0-224.0)	(12.9-44.0)	(18.0-73.0	(6.9-27.5)	(13.1-59.2)
	CV (%)		3.97	138.78	34.64	126.51	42.81	48.10	35.03	46.41

sented in Table 1. Sand, silt and clay content of four profiles samples varied from 25.2 to 77.9, 6.8 to 42.1 and 12.2 to 36.2% , respectively. Organic carbon content varied widely from 2.1 to 8.1 g/kg of soil and it decreased with depth of profile increased. The pH ranged from 7.62 to 8.64 and the electrical conductivity varied from 0.24 to 5.60 dS/m. Cation exchange capacity varied from 12.9 to 44.0 C mol/(P^+)/kg while

Table 2. Different forms of potassium in selected soil profile of eastern plain of Rajasthan (mg/kg soil).

Series (Dist.)	Genetic horizon	Depth (cm)	Water soluble	Exchang-eable	Available	Non-exchangeable	Nitric acid soluble	Lattice	Total
Ulela	A	0-16	19.1	170.2	191.1	1125.4	1295.6	1619.8	2915.4
(Bhilwara)	BW	16-37	18.2	173.4	194.3	1137.0	1310.4	1667.8	2978.2
	C	37-70	16.4	177.3	197.2	1140.4	1317.7	1674.9	2992.6
Changeri	Ap	0-16	17.2	175.2	194.6	1103.1	1278.3	1643.1	2921.4
	BWI	16-46	15.4	177.8	196.8	1118.0	1295.8	1686.4	2982.2
	BC	46-65	12.9	182.2	197.1	1138.7	1320.9	1693.4	3014.3
Kotri	Ap	0-20	8.7	262.5	271.4	1638.8	1901.3	2092.2	3993.5
(Bhilwara)	A2	20-48	7.0	278.1	285.3	1680.3	1958.4	2044.8	4003.2
	Bss	48-75	5.7	281.4	287.3	1698.2	1979.6	2045.0	4024.6
	2CKI	75-100	4.2	292.2	298.1	1718.0	2010.2	2204.0	4214.2
	2CK2	100-115	3.8	290.2	297.0	1712.3	2002.5	2107.8	4110.3
Kapasan	Ap	0-22	9.5	270.4	282.2	1592.0	1862.4	1947.0	3809.4
(Chittorgarh)	A2	22-58	8.2	276.6	286.0	1624.7	1901.3	2091.5	3992.5
	BWI	58-86	6.8	284.2	293.1	1658.9	1943.1	2067.2	4010.3
	BW2	86-104	6.2	290.2	299.7	1667.7	1957.9	2144.4	4102.3
	BC	104-135	5.4	293.6	302.1	1684.4	1978.0	2115.1	4093.1
	Mean		10.29	242.22	254.58	1464.87	1707.28	1927.76	3634.84
	Range		(3.80-19.10)	(170.20-293.60)	(191.10-302.10)	(1103.10-1718.00)	(1278.30-2010.20)	(1619.80-2204.00)	(2915.40-4214.20)
	CV (%)		51.99	22.13	18.90	18.58	19.06	11.30	14.88

Table 3. Correlation coefficients among different forms of K. *Significant at the 5% level, **Significant at the 1% level.

Forms of K	WS-K	EX-K	AV-K	NON. EX-K	HNO_3K	Lattice K	Total K
Water soluble K		– 0.900**	– 0.873**	– 0.803**	– 0.826**	– 0.242	– 0.818**
Exchangeable K			0.996**	0.889**	0.915**	0.280	0.915**
Available K				0.899**	0.923**	0.268	0.913**
Non-exchangeable					0.998**	– 0.159	0.669*
HNO_3-K						– 0.104	0.709**
Lattice K							0.627*

calcium carbonate ranged between 0.40 to 22.4% (Table 1).

Water Soluble K

Water soluble K ranged from 3.80 to 19.10 mg/kg with an average mean value of 10.29 mg/kg. This form represented 0.28% of total K. The coefficient of variability was 51.99% (Table 2). The concentration of water soluble K decreased in all the profiles with depth increase. Similar results were also reported by Das et al. (4). Relatively higher concentration of water soluble K in surface horizon is likely due to intense cropping, high organic carbon content and release of labile K from organic residues (5).

Exchangeable K

The exchangeable K represent the fractions of K, which is adsorbed on external and accessible internal surfaces. Exchangeable K varied from 170.20 to 293.60 mg/kg with a mean value of 242.22 mg/kg in four profiles of soil. The coefficient of variability was 22.13% (Table 2). The mean exchangeable K was lowest in horizon of Ulela soils series due to intense cropping and weathering of these soils. Maximum exchangeable K was recorded in BC horizon of Kapasan soil series. This is due to fine texture and substantial qualities of clay minerals. The similar trend was also observed by Das et al. (4).

Available K

Available K was increased with the increase of depth. It ranged between 191.10 to 302.10 mg/kg with an mean value of 254.58 mg/kg of soil. The coefficient of variability was 1890% (Table 2). Similar observation has been reported by Venkatesh and Satyanarayana (6) and Das et al. (7).

Non-Exchangeable K

Non-exchangeable K is generally considered as slowly released nutrient available to the plant under stress conditions. Non-exchangeable K in different profiles ranged from 1103.10 to 1718.00 mg/kg with a mean value of 1464.87 mg. The non-exchangeable K increased with the depth except $2CK_2$ horizon (1712.3 mg/kg) of Kotri soils series (Table 2). Similar values are reported by Sharma (8).

Lattice K

Lattice K in the different profiles ranged from 1619.80 to 2204.00 mg/kg with an average value of 1927.76 mg/kg. Lattice K increased with profiles depth except in horizon $2CK_2$ in Kotri and BC horizon in Kapasan soil series of eastern plain (Table 2). Similar results were also reported in laterite soil of Orissa (4). This form was generally higher in all the soils. The comparable values of lattice K were reported by Venkatesh and Satyanarayana (6) for black soils of Karnataka. This form of K constituted, on an average 53.03% of total K.

Total K

The amount of total K in different profiles ranged from 2915.40 to 4214.20 mg/kg of soil (Table 2). The highest average value of total K observed in $2CK_1$ horizon of Kotri soil series (4214.2 mg/kg) might be due to the dominance of mica and feldspar as K bearing minerals. Depthwise distribution of total K in the profiles increase with depth except $2CK_2$ horizon in Kotri soil series of Bhilwara.

Correlation Among Different Forms of Soil K

All the forms of soil potassium except water

Table 4. Correlation coefficients between different forms of K and physico-chemical properties of soil. *Significant at the 5% level, **Significant at the 1% level.

Physico-chemical properties of K	WS-K	EX-K	AV-K	NON. EX-K	HNO_3-K	Lattice K	Total K
pH (1 : 2.5)	– 0.273	0.233	0.213	0.271	0.265	0.193	0.237
EC (1 : 2.5) (dSm^{-1})	– 0.504*	0.448	0.428	0.508*	0.499*	0.434	0.475
O.C. (%)	0.590*	– 0.538*	– 0.542*	– 0.508*	– 0.514*	– 0.533*	– 0.524*
$CaCO_3$ (%)	– 0.520*	0.411	0.394	0.427	0.425	0.480	0.449
CEC [cmol (P^+) kg^{-1}]	– 0.951**	0.992**	0.990**	0.998**	0.998**	0.978**	0.995**
Sand (%)	0.652**	– 0.769**	– 0.769**	– 0.789**	– 0.786**	– 0.735**	– 0.769**
Silt (%)	– 0.470	0.654**	0.669**	0.663**	0.663**	0.609*	0.644**
Clay (%)	– 0.666**	0.740**	0.735**	0.762**	0.759**	0.716**	0.745**

soluble K, were positively and significantly correlated with each other while water soluble K was negatively correlated with other forms but lattice K did not show any correlation with the forms of K (Table 3).

Correlation Between Different Forms of K and Soil Properties

The pH did not show any relationship with forms of soil K. Electrical conductivity show positive correlation with non-exchangeable K ($r = 0.508$*) and HNO_3 soluble K ($r = 0.499$*), while negative with water soluble K ($r = -0.504$*). Organic carbon negatively correlated with the forms of K except water soluble K ($r = 0.590$*). Similar trend was also observed in sand (Table 4). Water soluble K negatively correlated with CEC ($r = -0.951$**), and clay ($r = -0.666$**), whereas remains forms of K are positively and significantly correlated with CEC, silt and clay in easter plain (Table 4).

References

1. Hanway J. and H. Heidal. 1952. Soil analysis methods as used in IOWA State College. Soil Testing Lab., IOWA State College of Agric. Bull. 57 : 1—13.
2. Jackson M. L. 1967. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India.
3. Wood L. K. and E. E. Turk De. 1941. The absorption of potassium in soils in non-exchangeable forms. Proc. Soil. Sci Soc. Am. 5 : 152—161.
4. Das P. K., G. C. Sahu and N. Das. 1997. Vertical distribution and release characteristics of potassium in some lateritic soils of Orissa I. Vertical distribution of potassium. J. Pot. Res. 13 : 105—110.
5. Koria R. G., M. S. Patel and B. S. Yadav. 1989. Vertical distribution of forms of potassium in some soil profiles of dry forming area of Saurashtra region of Gujarat. J. Pot. Res. 5 : 47—52.
6. Venkatesh M. S. and T. Satyanarayana. 1994. Status and distribution of potassium in vertisols of North Karnataka. J. Indian Soc. Soil Sci. 42 : 229—233.
7. Das K., D. Sarkar and D. C. Nayak. 2000. Forms of potassium and their distribution in some soils representing red and laterite ecosystem of West Bengal. J. Pot. Res. 16 : 1—6.
8. Sharma R. K. 1999. Potassium releasing characteristics of some aridisols soil series of Rajasthan. Doctoral thesis, Raj. Agril. Univ., Bikaner, Udaipur, India.