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Distribution of different forms of potassium under temperature conditions of Kashmir

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Abstract

A study was conducted in temperate conditions of Kashmir valley to study the distribution of different form of potassium. Surface soil samples were collected from two different agro-climatic zones of district Anantnag i.e. High altitude zone (1965-1850 msl) and low altitude zone (1540-1695 msl). Surface soils were fine textured ranging from clay loam to silty clay loam with organic carbon content varying from 0.61-1.73%. Water soluble K ranged from 0.010-0.038 [cmol(p^+)kg^{-1}], available K ranged from 0.134-0.313 [cmol(p^+)kg^{-1}], Exchangeable K ranged from 0.124-0.275 [cmol(p^+)kg^{-1}], Boiling HNO_3 K ranged from 1.568-2.938 [cmol(p^+)kg^{-1}], Non exchangeable K ranged from 1.434-2.625 [cmol(p^+)kg^{-1}] and Lattice K ranged from 29.730-51.859 [cmol(p^+)kg^{-1}]. The total potassium content in these soils varied from 31.60-54.50 [cmol(p^+)kg^{-1}]. Available potassium was positively and significantly correlated with organic carbon (r=0.960)*, cation exchangeable capacity (r=0.874)* and clay (r=0.642**) and was negatively correlated with $CaCo_3$ (r=0.740*), sand (r=-0.365*) and silt (r=-0.734*).

Highlights

- Total potassium content in these soils varied from 31.60-54.50 [cmol(p^+)kg^{-1}].
- Available potassium was positively and significantly correlated with organic carbon , cation exchangeable capacity and clay and was negatively correlated with $CaCo_3$ sand and silt.

Keywords: Kashmir, potassium forms, temperate

Potassium, a component of several minerals is released to soluble and exchangeable forms at widely differing rates. Soil potassium exists in dynamic equilibrium in four forms viz, water soluble, exchangeable, non- exchangeable and lattice K of which the first two are important for the growth of the high plants & microbes. Many researchers have found that different forms of K had positive correlation among themselves (Das *et al.* 2000) but their forms are greatly influenced by different soil properties. Gajbhiye *et al.* (1992) found significant and positive correlation of water soluble, exchangeable and non exchangeable potassium with clay.

The soils of Kashmir owing to the predominance of potassium rich illite minerals are rich in potassium. But unfortunately only a small portion of it becomes available to the plants especially under temperate climatic conditions of Kashmir. Its availability also differs as it is related to physical and chemical structure of soil minerals. The decision to apply potassium fertilizers to a field crop depends on the available potassium status of the soil. Keeping these views, attempts were made to evaluate the available potassium status and different important soil physico-chemical characteristics to elucidate the influences of these attributes on the availability of potassium.

Material and methods

Soil samples in bulk from surface layer (0-20cm) were collected from two agro-climatic zones of district Anantnag i.e. High and low altitudes Aqualfs, udalfs and Aquepts are common soils observed in low altitude. The soils of high altitude areas are commonly classified as ochrepts and udalfs. Some important properties of soils under investigation are given in the (Table 1)

Soils were air dried, ground and passed through a 2mm sieve. Processed soil samples were analyzed for pH and EC in 1:2:5 soil water suspension Jackson (1973), Organic Carbon by wet digestion method Walkley and Black (1934), Cation exchange capacity by centrifuge method Jackson (1973), Soil texture by Pipette method and $CaCo_3$ by rapid titration method Piper (1966).

Available potassium was extracted with normal neutral ammonium acetate Pratt (1982). Water soluble potassium was extracted by distilled water (Jackson 1967), Exchangeable potassium was obtained from the difference between available and water soluble potassium Dhillon *et al.* (1985), Fixed potassium was extracted by 1 N boiling HNO_3 Pratt (1982), Non exchangeable potassium was obtained from the difference between fixed potassium and available potassium. Lattice potassium was obtained from the difference between total potassium and fixed potassium (Sharma and Mishra (1986) and total potassium was determined by wet digestion method using HF-$HClo_4$ Pratt (1982). Potassium in all the extracts was estimated by flame photometer. Simple correlation between important soil properties and different forms of potassium were worked out by standard statistical method Gomez and Gomez (1983).

Results and discussion

Physical and chemical characteristics

The mean and range of physical and chemical properties of the soils are given in (Table 1). The percentage of sand, silt and clay in different soil samples varied from 14.70 to 37.60, 25.28 to 61.10 and 17.30 to 39.25% respectively, according the textural class of these soils varied from clay loam to silty clay loam. The pH of all the soils ranged between 5.95-7.95, electrical conductivity from 0.03 -0.20 dSm^{-1}, soil organic carbon from 0.61-1.73% and C.E.C from 16.40 – 21.85 [cmol(p^+)kg^{-1}]. The calcium carbonate content varied from 0.60-1.50%.

Forms of potassium in soils

Water Soluble potassium

The distribution of water soluble potassium ranged from 0.025 to 0.038 and 0.010 to 0.022 [cmol(p^+)kg^{-1}] with a mean value of 0.030 and 0.016 [cmol(p^+)kg^{-1}] in surface soils of high and low altitude (Table 2). The soils from low altitude zone has low water soluble potassium which may be attributed to the accumulation of salt at the surface which might have decreased the water soluble potassium whereas soils of high altitude zone had higher content of water soluble potassium which could be due to higher organic matter which is capable blocking of specific and non – specific binding sites of clay minerals to reduce K fixation. Similar results were also recorded by (Talib and verma 1990). Water soluble K showed significant and positive correlation with NH_4OA_c extractable potassium, (r= 0.991*), non- exchangeable potassium (r=0.989*), 1NHNO_3 (r=0.992*) and exchangeable potassium (r= 0.988*). This indicating the removal of water soluble K directly equilibrated with exchangeable K to meet the crop requirement as reported by (Ram and Prasad 1984).

Water soluble potassium had a significant and positive correlation with clay (r= 0.689**), organic carbon (r=0.983*) and C.E.C (r= 0.867*). Whereas negative correlation with pH (r=0.792*) sand (r=-0.336) and silt (r=-0.738) (Table :3).

Available potassium

Available potassium ranged between 0.212 to 0.313 and 0.134 to 0.190 [cmol(p^+)kg^{-1}] with mean of 0.255 and 0.162 [cmol(p^+)kg^{-1}]for low and high altitude soils, respectively (Table:2).The higher concentration of available potassium in the higher altitude could be attributed to higher organic matter content in these soils. Similar observations were also reported by (Deshmukh *et al.* 1991).

There was a significant and positive correlation of available potassium with all the form of K. (Basumatary and Bordoloi 1992) reported that available potassium in lateritic soils showed positive correlation with non-exchangeable, lattice and total

Table 1: Important physciochemical properties of high and low altitude soils

Physiographic Zone	Location	pH (1:2.5)	EC (dSm^{-1})	O.C (%)	$CaCO_3$ (%)	C.E.C [$cmol(p^+)kg^{-1}$]	Sand	Silt (%)	Clay
High Altitude Zone (1965-1850) msl	*Batakote*	6.60	0.03	1.45	1.20	18.92	22.39	38.36	39.25
	Arow	6.74	0.05	1.73	1.15	21.85	33.78	36.10	30.12
	Pahalgam	5.95	0.10	1.65	1.25	21.08	30.74	33.06	36.20
	Kokernag	6.90	0.09	1.38	1.50	18.01	22.49	39.25	38.26
	Manzgam	6.29	0.06	1.54	1.40	20.42	37.40	25.28	37.32
	Dandipora	6.10	0.05	1.47	1.45	19.10	33.57	36.57	30.18
	Mean	**6.43**	**0.06**	**1.53**	**1.32**	**19.89**	**30.06**	**34.71**	**35.22**
Low Altitude Zone (1540-1965 msl)	*Rambirpora*	7.56	0.20	0.99	0.75	17.87	37.41	40.24	22.35
	Handututu	7.46	0.15	0.75	0.68	16.40	14.70	61.10	17.30
	Seerkanligund	7.70	0.17	0.61	0.66	17.86	29.62	46.18	20.60
	Ogur salia	7.85	0.13	1.05	0.60	18.74	21.16	55.64	23.20
	Panchalpora	7.95	0.11	1.10	0.70	18.98	37.60	44.20	18.20
	Syedpora	7.10	0.14	1.22	0.85	19.95	17.80	46.19	36.01
	Mean	**7.60**	**0.15**	**0.95**	**0.70**	**18.30**	**26.38**	48.92	**22.94**
	Overall mean	**7.01**	**0.10**	**1.24**	**1.01**	**19.10**	**28.22**	**41.81**	**29.08**
	Range	5.95-7.95	**0.03-0.20**	**0.61-1.73**	**0.60-1.50**	**16.40-21.85**	**14.70-37.60**	**25.28-61.10**	**17.30-39.25**

Table 2: Different forms of potassium [$cmol(p^+)kg^{-1}$] in low and high altitude soils

Physiographic Zone	Location	Water soluble K	NH_4oAc (Available K)	Exchangeable K	Boiling HNO_3 K	Non Exchangeable K	Lattice K	Total K
High Altitude Zone (1965-1850) msl	Batakote	0026	0.223	0.197	2.445	2.222	43.335	45.78
	Arow	0.038	0.313	0.275	2.938	2.625	43.612	46.55
	Pahalgam	0.034	0.285	0.251	2.755	2.470	46.515	49.27
	Kokernag	0.025	0.212	0.187	2.426	2.214	43.954	46.38
	Manzgam	0.030	0.251	0.221	2.641	2.390	51.859	54.50
	Dandipora	0.028	0.246	0.218	2.510	2.264	38.850	41.36
	Mean	0.030	0.255	0.224	2.619	2.364	44.68	**47.30**
Low Altitude Zone (1540-1965 msl)	*Rambirpora*	0.017	0.156	0.139	1.866	1.710	29.730	31.60
	Handututu	0.013	0.140	0.127	1.736	1.596	30.494	32.23
	Seerkanligund	0.010	0.134	0.124	1.568	1.434	33.772	35.34
	Ogur salia	0.018	0.170	0.152	1.988	1.818	37.652	39.64
	Panchalpora	0.020	0.187	0.167	2.146	1.960	35.564	37.71
	Syedpora	0.022	0.190	0.168	2.245	2.055	33.815	36.06
	Mean	**0.016**	0.162	0.146	1.924	1.762	33.500	35.43
	Overall mean	0.023	0.208	0.185	2.272	2.063	39.09	41.36
	Range	0.010-0.038	0.134-0.313	0.124-0.275	1.568-2.938	1.434-2.625	29.73051.859	31.60-54.50

Table 3: Correlations coefficients between different forms of potassium and important properties of soil.

Forms of Potassium	Water Soluble K	NH_4oAc (Available K)	Exchangeable K	Boiling HNO_3 K	Non Exchangeable K	Lattice K	pH	E.C	Organic Carbon	$CaCo_3$	C.E.C	Sand	***Silt***	***Clay***
Total Potassium	0.806*	0.806*	0.805*	0.834*	0.835*	0.999*	-0.741*	-0.786*	0.826*	-0.792*	0.684**	-0.269	-0.794*	0.757*
Lattice Potassium	0.786*	0.787*	0.786*	0.834*	0.816*	-	-0.729*	-0.776*	0.806*	-0.783*	0.666**	-0.264	-0.757*	0.750*
Non Exchangeable Potassium	0.989*	0.972*	0.967*	0.814*	-	-	-0.729*	-0.815*	0.992*	-0.792*	0.840*	-0.287*	-0.739*	0.744*
Boiling HNO_3 Potassium	0.992*	0.979*	0.975*	0.999*	-	-	-0.796*	-0.813*	0.992*	-0.788*	0.848*	-0.298*	-0.741*	0.733*
Exchangeable Potassium	0.988*	0.999*	-	-	-	-	-0.796*	-0.779*	0.954*	-0.736*	0.874*	-0.369	0.732*	0.633*
NH_4oAc (Available Potassium	0.991*	-	-	-	-	-	-0.797*	-0.779*	0.960*	-0.740*	0.874*	-0.365	-0.734*	0.642**
Water Soluble Potassium	-	-	-	-	-	-	-0.792*	-0.771*	0.983*	-0.753*	0.867*	-0.336	-0.738*	0.689**

*Significant at 1%

**Significant at 5%

potassium. Available potassium was significantly and positively correlated with organic carbon (r=0.960*), clay (r=0.642*) and C.E.C (r=0.874*).This is deciphered that this form of K strongly depends upon organic matter content (Singh *et al* 1998).

Exchangeable potassium

Exchangeable potassium ranged between 0.187 to 0.275 and 0.124 to 0.168 [cmol(p^+)kg^{-1}] with a mean of 0.224 to 0.146 [cmol(p^+)kg^{-1}] in high and low altitude soils respectively (Table 2). The higher content of exchangeable potassium in higher altitude soils can be attributed to the addition of K through plant residues, manures and fertilizers. The latter may be relased by the breakdown of carbonates and may be possible reason for higher exchangeable potassium in these soils (Talib and verma 1990).

The exchangeable potassium was positively correlated with non- exchangeable potassium (r=0.967*) that indicated difficulty in replenishment of exchangeable form of potassium from minerals, once available pool of K is duplicated these soils may show potassium deficiency if subjected to continuous cultivation (Mishra and Srivastava 1991).

The exchangeable potassium was significantly and positively correlated with C.E.C (r=0.874*), Organic carbon (r=0.954*) and clay content (r=0.633*) (Table 3). This shows that colloidal fractions (clay and humus) are primary reservoirs of exchangeable potassium as both of these fractions are amenable for inducing C.E.C. (Talib and verma 1990).

Boiling (HNO_3) fixed potassium

The HNO_3 soluble (fixed) potassium varied between 1.568 to 2.938 [cmol(p^+)kg^{-1}] with a higher range of 2.426 to 2.938 [cmol(p^+)kg^{-1}] in high altitude and low altitude soils showed a range of 1.568 to 2.245 [cmol(p^+)kg^{-1}] (Table 2). The higher range of HNO_3 soluble (fixed) potassium in high altitude soils may be due to the presence of higher proportion of potassium bearing minerals.

1 NHNO_3 fixed potassium showed positive and significant correlation with other form of potassium (Table 3). This may be due to the dynamic equilibrium between exchangeable, water soluble and HNO_3 soluble form as reported by Koria *et al.* 1989) in the soils of saurashtra.

1NHNO_3 fixed K exhibited a significant and negative relationship with pH (r=-0.796*) and EC (r=-0.813*) and a positive and significant correlation with organic carbon (r=0.991*), C.E.C (r= 0.848) and clay (r= 0.733). This may be due to higher reserve of potassium. This is in according with the findings of (Sahoo and Gupta 1995) and (Nakashgir *et al*. 1999).

Non- exchangeable potassium

The non exchangeable potassium range from 2.214 to 2.625 [cmol(p^+)kg^{-1}] in high attitude soils (Table 2). The higher content of non-exchangeable potassium in the higher attitude may be attributed due to the presence of higher clay content which could easily fix the potassium particularly in the soils rich in illitic clay minerals. Similar finding are in agreement with those of (Das *et al.* 2000) and (Pal *et al.* 2001). Where as in low altitude soils non exchangeable K varied between 1.434 to 2.055 [cmol(p^+)kg^{-1}] in surface layer which might be due to the release of fixed K to compensate the removal of water soluble and exchangeable K. Similar results were also reported by (Dhillon *et al.* 1985).

As shown (Table 3) non-exchangeable potassium was significantly and positively correlated with HNO_3 boiling potassium (r=0.999*), exchangeable potassium (r=0.967) and available potassium (r= 0.972*) indicating that exchangeable potassium at the time of analysis was likely to be present at equilibrium level and might have correlated with the amount of potassium present in non-exchangeable form as earlier report by (Amiri and Dorudi 1994).

Non exchangeable potassium showed a positive correlation with clay (r=0.744*), organic carbon (r=0.992*) and C.E.C (r=0.840*) (Table3). This might be due to the fact that with an increase in organic matter content in soils the clay humus complex becomes more active thereby providing more exchange sites and acess to potassium and the finding are in agreement with those of (Mongia and Bandhopadhyay 1991).

Lattice potassium

Lattice potassium ranged from 38.85 to 51.85 and 29.73 to 37.65 [cmol(p^+)kg^{-1}] in high and low altitude soils with the overall mean value of 39.09 [cmol(p^+) kg^{-1}] as shown in (Table 2). The decreasing trend of lattice potassium with the decreases in altitude may be attributed to the corresponding amount of clay minerals and organic matter content of these soils (Parker *et al.* 1989). Higher amount of lattice potassium in higher altitude could be attributed to mineralogical make up and degree of weathering.

Lattice potassium showed a positive relationship with available potassium and non-exchangeable with coefficient value of (r=0.787), and (r=0.816*) (Table3).This relationship between different forms of potassium indicated the existence of an equilibrium between these forms and was in agreement with the similar findings of (Talib and verma 1990) and (Nakashgir *et al.* 1999).

The lattice potassium showed positive relationship with clay(r=0.750*) and negative with sand and silt (r=0.264 and -0.757) indicating that lattice potassium was present mainly in the coarser fraction which are not subjected to severe weathering.

Total potassium

The total potassium varied from 41.36 to 54.50 and 31.60 to 39.64 [cmol(p^+)kg^{-1}] with mean of 47.30 and 35.43 [cmol(p^+)kg^{-1}]in high and low altitude soils (Table 2). The higher content in higher altitude may be attributed due to the presence of illite, mica and feldspars as a primary potassium bearing minerals which are capable of releasing large amount of potassium. Similar results were also reported by (Mushtaq and Raj 2008)

Conclusion

Results obtained in the present investigation thus, revealed that distribution of different K forms in surface layer of soils is greatly influenced by soil properties and inter-relationships amongst themselves. The positive correlation with clay (r= 0.757*) showed that some of K^+ adsorbed are on the edge of inner side of lattice, which could be replaced by exchangeable sites. The positive correlation of total potassium with organic carbon (r=0.826*). Further significant positive correlation was observed among the different forms of K indicating the existence of equilibrium among the comparatively easily available forms.

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