

# Potassium forms in Brown Sarson growing soils in District Kupwara, Kashmir

## Abstract

Distribution of different forms of potassium and their correlation with soil physico-chemical properties was studied in Brown Sarson growing soils of district Kupwara. The study was carried out to pave a way for drafting proper fertilization plan keeping in view the importance of potassium for crops and reluctance of farmers in applying the same. The study area was divided into two regions i: e upper belt and lower belt and surface soil samples (0-25 cm), ten from each belt were collected for analysis. The soil samples collected were studied for potassium forms and physico-chemical properties. The soils analyzed were clay loam to loamy in texture and acidic to neutral in reaction. The organic carbon content was higher in lower belts as compared to upper belts. The potassium fractions followed an order total-K > lattice-K > acid soluble-K > non exchangeable-K > available-K > exchangeable-K > water soluble-K. All forms of K were positively correlated to organic carbon, cation exchange capacity and clay content and negatively correlated with pH and calcium carbonate.

**Key words:** Brown Sarson, Soils, Potassium fractions, physico-chemical properties, Correlation.

## Introduction

Potassium (K) is the essential macro plant nutrient element that plays a vital role in all metabolic activities like enzyme activation, protein synthesis, ion absorption & transport, photosynthesis and respiration [1]. It is one of the most abundant nutrients in soil with its amount depending upon parent material, degree of weathering, fertilizer application, leaching and erosive losses. Potassium occurs mainly in four different forms soil solution K, exchangeable K, fixed K, structural K [2] and among these soil solution K and exchangeable K is important in terms of availability to plants [3]. Non-exchangeable and mineral K are slowly available forms. There exists a dynamic equilibrium between forms of potassium [4] but the actual amount of potassium that occurs in solution form is very low and must be replenished by exchangeable form or by some other means [5]. However, the application of soil potassium for nutrient requirements of crops is mostly

neglected by farmers in India due to its increasing cost [6]. There exists a negative balance of this element which is increasing interest in the non-exchangeable or fixed forms of potassium. The

s o i l s o f K a s h m i r

owing to the predominance of K-rich illitic minerals are abundant in potassium. But unfortunately only a small portion of it becomes available to the plants especially under temperate climatic conditions of Kashmir. The deficiency of it causes a great reduction to yield in most of the crops especially in crops like Brown Sarson that need an adequate amount of potassium for better yield and quality [7]. Although brown Sarson forms an important Rabi crop of Kashmir valley, farmers of the study area are reluctant towards application of potassium and give preference to nitrogen and phosphorus fertilizers only. Now the need of time is to get a deep insight about the need for external application of potassium fertilizer to and what quantity of fertilizer must be applied in brown Sarson growing areas. Knowledge of different forms of potassium in soil together with their distribution would be of great relevance in assessing the long term availability of K to crops in general [8] and in formulating a sound basis of fertilizer recommendation for brown Sarson crop. Not only fractions but, it is important to study the relationship between soil properties and K fractions in addition to its distribution in different forms because the dynamics of potassium in soils is governed by physico-chemical properties of soils. Hence, the present study was planned to get insights into potassium fractions in brown sarson growing soils of District Kupwara in Kashmir valley.

## **Materials and methods**

The study was conducted in District Kupwara which lies in the north of Kashmir Valley. The area was divided into upper belts ranging from 1650-1850 meters above mean sea level (amsl) and lower belts ranging from 1550-1650 meters amsl. The composite samples were analyzed for various physico chemical properties and different forms of potassium replicated three times. The Soil pH, electrical conductivity (EC) and cation exchange capacity (CEC) were determined by standard procedure laid down by Jackson [9]. The Organic carbon (OC) was analyzed by oxidation of organic matter by potassium dichromate as laid down by Walkley and Black [10]. The particles size analysis was performed by method given by Piper [11]. Water soluble potassium was determined by shaking 1:5 mixture of soil and water for 5 minutes and quantifying K of saturation past extract. Available K was estimated by a procedure laid down by Jackson [12] after shaking soil with 1 N ammonium acetate (pH 7.0). Exchangeable K was obtained by subtracting water-soluble K from available K [13]. Fixed K was extracted from soil by boiling with 1 N HNO<sub>3</sub> and Total K was extracted by using HF-HClO<sub>4</sub> in a platinum crucible following procedure of Pratt [14].

Lattice K was determined by subtracting 1 N HNO<sub>3</sub> soluble K from the total K. The data was subjected to descriptive analysis and correlation was worked in OPSTAT software.

## Results and Discussion

### *Physico Chemical Properties*

All the soils analyzed were fine textured (loamy to clayey). In soils of upper belts (1650-1850 amsl) sand, silt and clay fractions ranged from 23.56% to 37.00 %, 38.0% to 44% and 22.19 % to 37.67% respectively (Table 1). In case of lower belts most of soils had a loamy texture with sand percentage ranging from 22 to 50 %, silt from 20 to 46 % and clay from 16.75 to 32 %. Similar results were reported by Irshad *et al.* [15] while studying soils in altitudes ranging from 1580 to 3000m above mean sea level in district Ganderbal of North Kashmir. All the soils were acidic to neutral with pH ranging from 5.30 to 6.80 with mean a value of 6.09 for upper belts and 6.01 for lower belts (Table 1). This decrease in soil pH with decreasing altitude might be attributed to presence of higher organic matter in lower belts which releases organic acids on decomposition. The EC of the soils in general was of normal value with a range of 0.11 to 0.15. The mean value of EC was 0.14 and 0.15 in upper and lower belts respectively (Table 1). Alaie *et al.* [16] reported similar results for soil EC in some soils of North Kashmir. It exhibited a decreasing trend with increase in elevation, which may be attributed to leaching of soluble salts from higher elevation [17]. The organic carbon content in soils ranged from 1.03-2.29 % in upper belts and 1.66-2.32 in lower belts. The mean value of organic carbon was 1.57 % for upper belts and 1.96 % for lower belts. Similar results were reported by Baba *et al.* [18] and Ahad *et al.* [19] while quantifying organic carbon content in soils of district Kupwara. The cation exchange capacity ranged from 16.90 to 19.96 C mol (p<sup>+</sup>) in upper belts kg<sup>-1</sup> 17.21 to 20.57 C mol (p<sup>+</sup>) kg<sup>-1</sup> in lower belts. The higher value of CEC in lower belts may be due to the higher amount of organic matter present in lower belts as it is well-established fact that presence of organic matter in soil has a positive impact on its CEC [20].

### *Forms of potassium*

The water-soluble K ranged from 5.50 to 11.50 mg kg<sup>-1</sup> with a mean value of 7.35 mg kg<sup>-1</sup> for upper belts and 7.70 mg kg<sup>-1</sup> for lower belts. Available -K ranged from 27.09 to 149 mg kg<sup>-1</sup> with mean 54.10 and 57.00 mg kg<sup>-1</sup> for upper and lower belts respectively (Table 2). The higher value for available K in lower belts may be attributed to presence of illitic clays as earlier reported by Wani [21]. Similar results were also reported by Irshad *et al.* [22] while studying the soils of North

Kashmir. The increased amount of water-soluble K which forms the part of available K) in lower belts is due to presence of more available K at this elevation.  $\text{HNO}_3$  extractable -K ranged from 304-876  $\text{mg kg}^{-1}$  with a mean value of 463 and 484  $\text{mg kg}^{-1}$  for upper and lower belts respectively. The higher content of fixed -K in soils may be attributed to illitic clays in soils of Kashmir as already studied by Wani [23]. The value of exchangeable-K ranged from 21.55 to 134.5  $\text{mg kg}^{-1}$  with a mean value of 46.70  $\text{mg kg}^{-1}$  for upper belts and 49.30  $\text{mg kg}^{-1}$  for lower belts (Table 2). Irshad *et al.* [24] reported similar findings while studying various geochemical forms of potassium in soils of North Kashmir. Lower belts were having higher amount of exchangeable K which may be due to higher amount of organic matter which might have retained more K ions at exchange sites [25]. Non-exchangeable-K showed similar trend with a range of 318-556  $\text{mg kg}^{-1}$  in upper belts and 264-736  $\text{mg kg}^{-1}$  with a mean value of 408.9  $\text{mg kg}^{-1}$  and 424.29  $\text{mg kg}^{-1}$  in upper and lower belts respectively. The amount of Lattice -K ranged from 10651 to 15193  $\text{mg kg}^{-1}$  with a mean value of 12315  $\text{mg kg}^{-1}$  for upper belts and 12200 for lower belts (Table 2). The decrease in amount of clay with a decrease in altitude may be due to lesser amount of clay present in lower belts [26]. Higher amount of lattice-K in higher altitude may also be due to mineralogical make up and degree of weathering. Bashir *et al.* [27] reported similar trend for lattice potassium while studying distribution of different forms of potassium in temperate regions of Kashmir. Talib and Verma [28] while studying Kashmir soils in a toposequence have also reported similar trend. Total K in soils ranged from 11022 to 16032  $\text{mg kg}^{-1}$  with a mean value of 12778  $\text{mg kg}^{-1}$  for upper belts and 12684  $\text{mg kg}^{-1}$  for lower belts (Table 2). The higher content in higher altitudes is due to presence of illite, mica and feldspars which are the potential potassium-bearing minerals reported by Mushtaq and Raj [29]. The results are also in accordance with results obtained by Abdul *et al.* [30]

In order to assess the influence of soil properties on various forms of K, coefficients of correlation were worked out. Water-soluble K, available K, Exchangeable and non-exchangeable K showed a significant negative relationship with soil pH with value of coefficient “r” -0.823\*\*, 0.695\*\*, -0.676\*\* and -0.644\*\* respectively (Table 3). Khadka *et al.* [31] reported similar results while studying the relationship between available potassium and soil pH. Earlier Singh and Mishra [32] had obtained similar results while studying soils of Varanasi. Other forms of potassium had a positive but non-significant relationship with soil pH. All forms of potassium were non-significantly correlated to EC, while as positive correlation of CEC with all forms of potassium

could be found with correlation coefficient having values 0.780\*\* for water soluble K, 0.682\*\* for available K, 0.591\*\* for HNO<sub>3</sub> soluble- K, 0.667\*\* for exchangeable K, 0.557\* for non exchangeable K, 0.573\*\* for lattice K and 0.532\* for Total K (Table 3). Kundu *et al.* [33] reported similar results while studying potassium forms in soils of West Bengal. Likewise Bashir *et al.* [34] reported similar results and attributed it to property of colloidal fractions (clay and humus) to act as primary reservoirs of exchangeable potassium as these fractions are amenable for inducing CEC [35]. Significant positive correlation of organic carbon with water soluble K (r=0.656\*\*), Available K (r=0.518\*), HNO<sub>3</sub> soluble K (r=0.483\*), non exchangeable-K (r=0.465\*) and lattice K (r=0.511\*) was reported (Table 3) and the result was in agreement with finding of Elbaalawy *et al.* [36]. Significant correlation with organic carbon content in soils may be explained by the increasing exchange surfaces available for the positively charged K ions. It was reported in many studies that potassium forms have a positive correlation with clay content. Some of the researches substantiating the statement are Kaskar *et al.* [37], Abu-taleb *et al.* [38] same was reported in an investigation where clay content had a positive correlation with water soluble K (r= 0.510\*), available K (r=0.480\*) and exchangeable K (r=0.473\*).

## Conclusion

It was concluded from the study that lower belts of the region had higher content of all forms of potassium as compared to higher belts. There was a wide variability in potassium forms between higher and lower altitude that was attributed to variation in physico-chemical properties of soil in these areas and mineralogy. All forms of K were positively correlated with CEC, OC and clay content. However there was a negative correlation between soil pH and Potassium form. It is therefore necessary to take into consideration all physico- chemical properties of the site before formulating a fertilizer recommendation.

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Table 1: Particle size distribution and physico-chemical properties of soils in Brown Sarson growing soils of district Kupwara, Kashmir.

<b>Location</b>	<b>Sand %</b>	<b>Silt %</b>	<b>Clay %</b>	<b>Textural class</b>	<b>pH (1:2.5)</b>	<b>EC (dSm<sup>-1</sup>)</b>	<b>CEC Cmol(p<sup>+</sup>) Kg<sup>-1</sup></b>	<b>OC (%)</b>
Chalipora	25.0	43.0	32.0	CL	6.4	0.11	17.19	1.51
Badarhar	24.0	44.0	30.0	CL	5.7	0.15	19.90	2.21
Khahipora	26.0	43.0	31.0	CL	5.4	0.13	19.23	2.29
Nabadzabi	35.0	40.0	25.0	L	5.8	0.12	18.01	1.96
Bahadurpore	34.0	38.0	28.0	L	6.7	0.16	17.01	1.03
Badrkali	34.0	39.0	27.0	L	6.7	0.20	17.15	1.19
Zachaldara	23.56	38.77	37.67	Cl	5.4	0.13	19.96	2.20
Nagranahar	36.39	42.44	22.19	L	6.0	0.15	17.05	1.16
Shatigam	37.00	39.80	23.20	L	6.3	0.14	17.96	1.07
Ahgam	36.20	40.60	23.20	L	6.5	0.16	16.90	1.10
<b>Range</b>	23.56- 37.0	38.0-44.0	22.19-37.67		5.4-6.7	0.11-0.20	16.90-19.96	1.03-2.29
<b>Mean</b>	31.115	40.86	27.92	-	6.09	0.145	18.03	1.57
Ujroo	22.00	46.00	32.00	CL	5.3	0.16	20.10	2.32
Khano -Babgund	50.0	20.0	30.0	L	5.3	0.11	20.57	2.20
Yunus	24.0	44.0	30.0	CL	5.7	0.20	20.22	2.26
Hanwara	25.0	45.0	30.0	CL	6.3	0.14	18.29	1.87
Kachri	28.0	40.4	31.6	CL	6	0.14	18.42	1.92
<b>LOWER BELTS</b> Yaroo	27.0	42.0	31.0	CL	6.6	0.11	17.21	1.75
Chotipora	36.0	37.00	27	L	6.8	0.19	17.76	2.01
Langate	43.80	36.20	20.00	L	5.6	0.20	19.97	2.03
Khoro	45.20	34.10	20	L	6.3	0.14	18.05	1.66
Wadipora	44.29	38.96	16.75	L	6.2	0.14	18.00	1.67
<b>Range</b>	22.0-50.0	20.0-46.0	16.75-32.0		5.3-6.8	0.11-0.20	17.21-20.57	1.66-2.32
<b>Mean</b>	34.52	38.36	26.83	-	6.01	0.15	18.86	1.96
<b>Range</b>	22-50	20-46	16.75-37.67		5.3-6.8	0.11-0.20	16.90-20.57	1.03-2.29
<b>Overall mean</b>	32.82	39.6	27.38	-	6.05	0.149	18.45	1.77
<b>SE</b>	1.88	1.24	1.15		0.11	0.006	0.28	0.10

Table 2: Different forms of Potassium in Brown Sarson soils in District Kupwara, Kashmir

	Location	Water soluble K (mg kg <sup>-1</sup> )	Available K (mg kg <sup>-1</sup> )	HNO <sub>3</sub> Soluble K (mg kg <sup>-1</sup> )	Ex. K (mg kg <sup>-1</sup> )	Non Ex K (mg kg <sup>-1</sup> )	Lattice K (mg kg <sup>-1</sup> )	Total K (mg kg <sup>-1</sup> )
UPPER BELTS	Chalipora	5.5	34	352	28.5	318	12497	12849
	Badarhar	9	67.5	522	58.5	454.5	12939	13461
	Khahipora	11	70	626	59	556	13594	14220
	Nabadzabi	6.5	53.5	435	47	381.5	12555	12990
	Bahadurpore	6.5	38	376	31.5	338	11256	11632
	Badrkali	5.5	37	389	31.5	352	12382	12771
	Zachaldara	11	90	587	79	497	12952	13539
	Nagranahar	7	38	450	31	412	11816	12266
	Shatigam	5.5	48.5	406	43	357.5	11121	11527
	Ahgam	6	64.5	487	58.5	422.5	12039	12526
	<b>Range</b>	5.5 -11.0	34 - 90	352 - 626	23.5 – 79.0	318-556	11121-13594	11527-14220
<b>Mean</b>	7.35	54.10	463.0	46.70	408.9	12315	12778	
LOWER BELTS	Ujroo	13	103	839	90	736	15193	16032
	KhanoBabgund	14.5	149	876	134.5	727	15069	15945
	Yunus	8	63	380	55	317	10651	11031
	Hanwara	6.5	47.5	462	41	414.5	11977	12439
	Kachri	6.5	40	304	33.5	264	10718	11022
	Yaroo	7.5	60.5	463	53	402.5	11939	12402
	Chotipora	5.5	32.5	395	27	362.5	11705	12100
	Langate	8	46	403	38	357	12551	12954
	Khoro	5.5	27.05	325	21.55	297.95	10918	11243
	Wadipora	5.5	30.5	395	25	364.5	11281	11676
	<b>Range</b>	5.5-14.5	27.05-149	304-876	21.55-134.5	264-736	10651-15193	11022-16032
<b>Mean</b>	8.05	59.05	484.2	46.80	424.29	12200.2	12684.4	
<b>Overall Range</b>	5.5-14.5	27.09-149	304-876	21.55-134.5	264-736	10651-15193	11022-16032	
<b>Overall Mean</b>	7.7	57.0	473.6	49.30	416.5 28.43	12257.65	12731 313.74	
<b>SE</b>	0.60	6.58	34.38	5.73		282.02		

Ex. K = exchangeable K ; Non Ex K= Non exchangeable K

Table 3: Correlation between Soil Properties and Potassium Forms

	Water soluble K	Av. K	HNO <sub>3</sub> Soluble K	Ex. K	Non- Ex. K	Lattice K	Total K
pH	-0.823 <sup>**</sup>	-0.695 <sup>**</sup>	0.389	-0.676 <sup>**</sup>	-0.644 <sup>**</sup>	0.360	0.365
EC	-0.218 <sup>NS</sup>	-0.285 <sup>NS</sup>	-0.268	-0.289	-0.258	-0.214	-0.220
CEC	0.780 <sup>**</sup>	0.682 <sup>**</sup>	0.591 <sup>**</sup>	0.667 <sup>**</sup>	0.557 <sup>*</sup>	0.573 <sup>**</sup>	0.532 <sup>*</sup>
OC	0.656 <sup>**</sup>	0.518 <sup>*</sup>	0.483 <sup>*</sup>	0.500	0.465 <sup>*</sup>	0.511 <sup>*</sup>	0.510 <sup>*</sup>
Clay	0.510 <sup>*</sup>	0.480 <sup>*</sup>	0.389	0.473 <sup>*</sup>	0.359	0.360	0.365