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


## Abstract

A study on distribution of different Potassium (K) forms in Brown Sarson growing soils was undertaken indistrict Kupwara, Kashmir. 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***: Correlation, Potassium fractions, physico-chemical properties.

## 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 [17]. 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[15]and among these soil solution K and exchangeable K is important in terms of availability to plants [6]. Non-exchangeable and mineral K are slowly available forms. There exists a dynamic equilibrium between forms of potassium [20] 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 [28]. However, the application of soil potassium for nutrient requirement of crops is mostly neglected by farmers in India due to its increasing cost [26]. There exists negative balance of this element which is increasing interest in the non-exchangeable or fixed forms of potassium. The soils of Kashmir 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 needan adequate amount of potassium for better yield and quality [31]. Although brown Sarson forms an important Rabi crop of Kashmir valley, farmers of study area are reluctant towards application of potassium and give preference to nitrogen and phosphorus fertilizers only.Knowledge of different forms of potassium in soil together with their distributionwould be of great relevance in assessingthe long term availability of K to crops in general [25]and in formulating a sound basis offertilizer recommendation for brown Sarson crop. Therefore, it is important to study relationship between soil properties and K fractions in addition to its distribution in different forms. Hence present study was planned to get insights into potassium fractions in brown sarson growing soils of District Kupwara in Kashmir valley.

## Material and methods

The study was conducted in District Kupwara which lies towards 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. The Soil pH, electrical conductivity (EC) and cation exchange capacity (CEC) was determined by standard procedure laid down by Jackson [12].The Organic carbon (OC) was analyzed by oxidation of organic matter by potassium dichromate as laid down by Walkley and Black [32]. The particles size analysis was performed by method given by Piper [22]. Water soluble potassium was determined by shaking 1:5 mixture of soil and water for 5 minutes an quantifying K of saturation past extract. Available K was estimated by 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 [8]. Fixed K was extracted from soil by boiling with 1 N $HNO_3$ and Total K was extracted by using HF-$HClO_4$ in a platinum crucible following procedure of Pratt [23].Lattice K was determined by subtracting 1 N $HNO_3$ soluble K from the total K.

## 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 loamy texture with per cent sand 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.*[10] 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 value 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 range 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.* [4] 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 [33]. 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.*[5] and Ahad *et al.* [3] while quantifying organic carbon content in soils of district Kupwara. The cation exchange capacity ranged from 16.90 to 19.96 C mol ($p^+$) in upper belts kg $^{-1}$17.21 to 20.57 C mol ($p^+$) kg $^{-1}$ in lower belts. Higher value of CEC in lower belts may be due to higher amount of organic matter present in lower beltsas it is well established fact that presence of organic matter in soil has a positive impact on its CEC [24].

*Forms of potassium*

The water soluble K ranged from 5.50 to 11.50 mg kg$^{-1}$with a mean value of 7.35 mg kg$^{-1}$for upper belts and 7.70 mg kg$^{-1}$for lower belts. Available -K ranged from 27.09 to 149 mg kg $^{-1}$ with mean 54.10 and 57.00 mg kg $^{-1}$ 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 [34]. Similar results were also reported by Irshad *et al.*[10] 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. $HNO_3$ extractable -K ranged from 304-876 mg kg$^{-1}$ with a mean value of 463 and 484 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 [33]. The results are also substantiated by findings of Irshad *et al.* [10]

while studying the soils of Ganderbal Kashmir. The value of exchangeable-K ranged from 21.55 to 134.5 mg kg $^{-1}$ with a mean value of 46.70 mg kg $^{-1}$ for upper belts and 49.30 mg kg $^{-1}$ for lower belts (Table 2). Irshad *et al*. [10] 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 [11]. Non exchangeable-K showed similar trend with a range of 318-556 mg kg $^{-1}$ in upper belts and 264-736 mg kg $^{-1}$with a mean value of 408.9mg kg $^{-1}$and 424.29 mg kg $^{-1}$ in upper and lower belts respectively. The amount of Lattice -K ranged from 10651 to 15193 mg kg $^{-1}$with a mean value of 12315 mg kg $^{-1}$for upper belts and 12200 for lower belts (Table 2). The decrease in amount of clay with decrease in altitude may be due to lesser amount of clay present in lower belts [21].Higher amount of lattice-K in higher altitude may also be due to mineralogical make up and degree of weathering. Bashir *et al*. [7] reported similar trend for lattice potassium while studying distribution of different forms of potassium in temperate regions of Kashmir. Talib and Verma [31] while studying Kashmir soils in a toposequence have also reported similar trend. Total K in soils ranged from 11022 to 16032 mg kg $^{-1}$with a mean value of 12778 mg kg $^{-1}$for upper belts and 12684 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 is reported byMushtaq and Raj [18].The results are also in accordance with results obtained by Abdul *et al*. [1]

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 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.*[14] reported similar results while studying relationship between available potassium and soil pH.Earlier Singh and Mishra [29] 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 $HNO_3$ 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*. [16] reported similar results while studying potassium forms in soils of West Bengal. Likewise Bashir *et al.*[7] 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 [30]. Significant positive correlation of organic carbon with water soluble K (r=0.656**), Available K (r=0.518*), $HNO_3$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.*[9]. 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.*[13], Abu-taleb *et al.* [2] same was reported in present 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 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 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.

| | **Location** | **Sand %** | **Silt %** | **Clay %** | **Textural class** | **pH (1:2.5 )** | **EC ($dSm^{-1}$)** | **CEC $Cmol(p^{+})\ Kg^{-1}$** | **OC (%)** |
|---|---|---|---|---|---|---|---|---|---|
| | 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 |
| | **Range** | 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 |
| | **Mean** | 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 |
| **LOWER** | Yaroo | 27.0 | 42.0 | 31.0 | CL | 6.6 | 0.11 | 17.21 | 1.75 |
| **BELTS** | 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 |
| | **Range** | 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 |
| | **Mean** | 34.52 | 38.36 | 26.83 | - | 6.01 | 0.15 | 18.86 | 1.96 |
| | **Range** | 22-50 | 20-46 | 16.75-37.67 | | 5.3-6.8 | 0.11-0.20 | 16.90-20.57 | 1.03-2.29 |
| | **Overall mean** | 32.82 | 39.6 | 27.38 | - | 6.05 | 0.149 | 18.45 | 1.77 |
| | **SE** | 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$^{-1}$) | Available K (mg kg$^{-1}$) | $HNO_3$ Soluble K (mg kg$^{-1}$) | Ex. K (mg kg$^{-1}$) | Non Ex K (mg kg$^{-1}$) | Lattice K (mg kg$^{-1}$) | Total K (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **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 |
| | **Range** | 5.5 -11.0 | 34 - 90 | 352 - 626 | 23.5 – 79.0 | 318-556 | 11121-13594 | 11527-14220 |
| | **Mean** | 7.35 | 54.10 | 463.0 | 46.70 | 408.9 | 12315 | 12778 |
| **LOWER BELTS** | Ujroo | 13 | 103 | 839 | 90 | 736 | 15193 | 16032 |
| | Khano Babgund | 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 |
| | **Range** | 5.5-14.5 | 27.05-149 | 304-876 | 21.55-134.5 | 264-736 | 10651-15193 | 11022-16032 |
| | **Mean** | 8.05 | 59.05 | 484.2 | 46.80 | 424.29 | 12200.2 | 12684.4 |
| | **Overall Range** | 5.5-14.5 | 27.09-149 | 304-876 | 21.55-134.5 | 264-736 | 10651-15193 | 11022-16032 |
| | **Overall Mean** | 7.7 | 57.0 | 473.6 | 49.30 | 416.5 28.43 | 12257.65 | 12731 313.74 |
| | **SE** | 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 | $HNO_3$Soluble K | Ex. K | Non- Ex. K | Lattice K | Total K |
|---|---|---|---|---|---|---|---|
| pH | -0.823** | -0.695** | 0.389 | -0.676** | -0.644** | 0.360 | 0.365 |
| EC | -0.218NS | -0.285NS | -0.268 | -0.289 | -0.258 | -0.214 | -0.220 |
| CEC | 0.780** | 0.682** | 0.591** | 0.667** | 0.557* | 0.573** | 0.532* |
| OC | 0.656** | 0.518* | 0.483* | 0.500 | 0.465* | 0.511* | 0.510* |
| Clay | 0.510* | 0.480* | 0.389 | 0.473* | 0.359 | 0.360 | 0.365 |