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# Studies on distribution of potassium fraction in surface and sub-surface layers of black soils

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**Abstract**
The potassium dynamics in black soils of maize growing areas of Haveri district, Karnataka was studied in UAS, Dharwad during 2016-17. Potassium exists in soil in different forms such as water soluble, exchangeable, non-exchangeable, lattice K. The available potassium on an average obtained highest in both the depths (529.53 kg $ha^{-1}$ and 327.04 kg $ha^{-1}$ in surface and sub-surface depths, respectively). The surface samples recorded high available potassium compared to sub-surface layer. The water soluble K of black soils ranged from 2.83 to 8.13 mg $kg^{-1}$ in surface with a mean of 4.60 mg $kg^{-1}$. The water soluble potassium in sub-surface layer varied from 2.00 to 6.23 mg $kg^{-1}$ with a mean of 3.67 mg $kg^{-1}$. The black soils exchangeable potassium varied from 48.92 to 100.96 mg $kg^{-1}$ in surface and 36.90 to 78.40 mg $kg^{-1}$ in sub-surface. The trend of decrease in water soluble and exchangeable K was noticed in these soils from surface to sub-surface layers. The non-exchangeable potassium of black soils in surface samples varied from 566.37 to 790.84 mg $kg^{-1}$. The non-exchangeable potassium varied from 622.17 to 865.43 mg $kg^{-1}$ in sub-surface. The lattice potassium ranged from 1.38 to 2.03 per cent in surface layer and 1.53 to 2.07 per cent in sub-surface depth. The black soils total potassium ranged from 1.45 to 2.10 per cent in surface and 1.60 to 2.15 per cent in sub-surface layer.

**Keywords:** potassium fraction, sub-surface layers, black soils, potassium fertilizer

## Introduction
As rocks break down into the particles of sand, silt and clay that make up soil, potassium and other elements are released and may become available to plants. It is important to assess the quantity of potassium in the soil solution and the readily available pool to ascertain whether or not to apply potassium fertilizer. Any increase or decrease in the amount of potassium in soil will show a direct effect on the plants growth. Information on the availability of potassium in soil of certain area may provide valuable information for agricultural needs. Therefore, it is important to understand the K status in the soil. Many tropical and subtropical soils are poor in mobile compounds of phosphorus, nitrogen and to a lesser extent potassium. The potassium content in tropical soils differ depending on the extent of weathering of their mineral part; the greater is the level of weathering, the lower is the content of potassium in the soil. Potash fertilizers are not effective for all soils and therefore before their application it is necessary to assess the amount of potassium in the soils which is to be fertilized and the degree of availability to plant. The K fertilization should be based on knowledge of quantity of K in various types and sub types of soils and not on general specifications based on crop requirement. Potassium is the major nutritional elements for plants and enrichment of K in exchange sites due to fertilizers can be expected. Therefore, it is important to understand the role and its position in exchange complex with is expressed as exchangeable K. Since, the non exchangeable potassium tends to become slowly available to crop plants due to shift in equilibrium, it becomes difficult to assess the potassium status of soils from exchangeable and water soluble content per se. For potassium supplying power in proper appraisal of soils, it is imperative to know the magnitude of different form of potassium and its dynamics in soils. Since, the non-exchangeable potassium tends to become slowly available to crop plants due to shift in equilibrium, it becomes difficult to assess the potassium status of soils from exchangeable and water soluble content per se. For potassium supplying power in proper appraisal of soils, it is imperative to know the magnitude of different form of potassium and its dynamics in soils. Therefore, an immense study was undertaken in hungry maize growing soils with special reference over its type and distribution of potassium in black soil type of Haveri district, Karnataka.

## Material and Methods
The surface and sub-surface samples of depth 0-20 cm and 20-50 cm, respectively were collected based on predominance of soil type (black) and dominance of cropped area under

maize of Haveri district and studied during 2016-17 at UAS, Dharwad. The net cultivated area of the district is 17,488 ha (Anon., 2015) [2]. The annual rainfall of the region is 792.70 mm (Anon., 2015) [2]. The study location lies between the coordinates of 14˚ N to 75˚ E. The soil samples collected were air dried in shade, gently ground using wooden pestle and mortar and passed through 2 mm sieve. The sieved samples were preserved in polythene plastic covers for further analysis. Soil reaction was determined in 1:2.5 soil water suspension after stirring for 30 minutes using a pH meter (Jackson, 1973) [8]. It was determined in 1:2.5 soil: water suspension after obtaining supernatant as described by Jackson (1973) [8] using conductivity meter. Organic carbon was determined by Walkley and Black's wet oxidation method as described by Piper (1996) [13]. The per cent distribution of particles of different size *viz.*, sand, silt and clay was determined by mechanical analysis using Bouyoucos Hydrometer method (Jackson, 1973) [8]. Soils (50 g) were shaken with 100 ml of 5 per cent solution of sodium hexa meta phosphate. Later, per cent silt and clay was estimated by hydrometer and per cent sand was calculated by subtracting silt and clay from 100. The exchangeable calcium and magnesium were determined in the neutral normal ammonium acetate the aliquot of the extract was titrated against standard versenate solution and sodium and potassium were determined by flame photometry (Jackson, 1973) [8]. Available potassium was determined by extracting soil with neutral normal ammonium acetate and the contents of K in solution and was estimated by flame photometery (Jackson, 1973) [8].
Different forms of potassium was estimated by,

**1. Water-soluble potassium**
Water-soluble potassium was determined in 1:5 soil-water suspension after shaking for two hours and allowing to stand for an additional 16 hours (Black, 1965) [3]. The potassium in the extract was determined by flame photometer.

**2. Exchangeable potassium**
Exchangeable potassium was determined by extracting with *N N* $NH_4OAc$ solution as outlined by Knudsen *et al*. (1982) [10]. Ten grams of soil sample was shaken with 25 ml of *N N* $NH_4OAc$ solution for ten minutes and then centrifuged. The clear supernatant liquid was decanted into 100ml volumetric flask. Three more additional extractions were made in the same manner and the combined extract was diluted to volume with $NH_4OAc$. The K content in the extract was determined by flame photometer. The water soluble K was subtracted from $NH_4OAc$-K to get the exchangeable potassium content of the soil.

**3. Non exchangeable potassium**
The boiling 1*N* $HNO_3$ method as outlined by Knudsen *et al*. (1982) [10] was followed for determination of non-exchangeable K in soil.
Two and half gram of finely ground soil was boiled gently with 25 ml of 1*N* $HNO_3$ for 10 minutes. The content was filtered and the filtrate was collected in a 100 ml volumetric flask. The soil was then washed four times with 15 ml portions of 0.1 *N* $HNO_3$. After making up volume and mixing, the potassium content in the extract was determined using flame photometer. The quantity of K obtained with the $NH_4OAc$ extract was subtracted to get the non-exchangeable potassium content in the soil.

**4. Total potassium**
Total potassium content was determined by digesting the samples with hydrofluoric acid in a closed vessel (Lim and Jackson, 1982) [12]. 200 mg of finely ground soil sample was transferred into 250 ml wide mouth polypropylene bottle. Two ml of aqua regia was added to disperse the samples. Later 10 ml hydrofluoric acid was added by means of plastic pipette and after capping the bottle the contents were shaken to dissolve the sample for a period of 8 hours. The white residue remaining after the treatment was dissolved in 100 ml of saturated $H_3BO_3$ solution. The contents were diluted and final volume was made to 250 ml and subsequently used for analysis of total potassium by flame photometer.

**5. Lattice potassium**
The lattice potassium was computed as difference between total potassium and the sum of water soluble, exchangeable and non-exchangeable K fractions.

**Results and Discussion**
The available potassium in black soil varied from 322.56 to 752.64 kg $ha^{-1}$ in surface layer and 224.00 to 592.80 kg $ha^{-1}$ in sub-surface layer. The highest available potassium for both surface and sub-surface soils was obtained in Jogihalli-4 and corresponding lowest value in Hangal soil. The mean values of available potassium were 529.53 327.04 kg $ha^{-1}$ and 327.04 kg $ha^{-1}$ in surface and sub-surface layers, respectively. The black soils were high in available potassium in surface layer but it varied in sub-surface from medium to high. The surface high value of potassium indicated that these soils were added with sufficient quantities of potash fertilizers. The higher values of sub-surface depth might be due to dominance of potassium rich micaceous and feldspar minerals. Similar results were obtained by Ravikumar (2004) [14] and Deshmukh (2012) [4]. The water soluble K of black soils ranged from 2.83 to 8.13 mg $kg^{-1}$ in surface with a mean of 4.60 mg $kg^{-1}$. The water soluble potassium in sub-surface layer varied from 2.00 to 6.23 mg $kg^{-1}$ with a mean of 3.67 mg $kg^{-1}$. The water soluble potassium in surface layer was lowest in Hangal soil and highest in Rattihalli-5 soil. The highest sub-surface water soluble K was recorded in Jogihalli-4 soil and lowest in Devihosur soil. The exchangeable potassium varied from 48.92 to 100.96 mg $kg^{-1}$ in surface and 36.90 to 78.40 mg $kg^{-1}$ in sub-surface. In the surface depth, exchangeable potassium was recorded highest in Rattihalli-6 soil and lowest in Hangal soil. The highest exchangeable potassium in sub-surface layer was recorded in Jogihalli-4 soil and lowest in Hangal soil. The mean content of exchangeable K was 56.00 mg $kg^{-1}$ and 46.81 mg $kg^{-1}$ in surface and sub-surface layers, respectively. Black soils studied were high with respect to exchangeable potassium at surface zone was mainly due to the fact that the black soils had good amount of organic matter content which might have retained more K ions at exchange sites and also potassium retained through external source (Hebsur, 1997 and Jagadeesh, 2003) [7, 9]. The decrease in content of exchangeable K at sub-surface zone was mainly due to capillary action of K ions from sub-surface to surface sites and decreased exchange sites and increased compactness at lower depth (Divya *et al*., 2016) [5]. The non-exchangeable potassium of black soils in surface samples varied from 566.37 to 790.84 mg $kg^{-1}$. The non-exchangeable potassium varied from 622.17 to 865.43 mg $kg^{-1}$ in sub-surface. The surface non-exchangeable potassium recorded lowest in Kaginelli soil and highest in Jogihalli-4 soil. The sub-surface non-exchangeable potassium recorded lowest in Bankapur-2

soil and highest in Jogihalli-4 soil. The non-exchangeable K in surface soils was low compared to sub-surface layer. However, the non-exchangeable K content was more at both the depths and this may be because of nature and amount of clay present in black. The increase in non-exchangeable potassium at sub-surface may be attributed to adsorption and fixation of K removed from surface through leaching soils (Hebsur and Gali, 2011 and Kundu *et al*., 2014) [6, 11]. The black soils ranged lattice potassium of 1.38 to 2.03 per cent in surface layer and 1.53 to 2.07 per cent in sub-surface depth. The highest was recorded in Rattihalli-6 soils and lowest in Bankapur-1 soils for surface depth. The lowest lattice K in sub-surface depths was recorded in Bankapur-1 soil and that of highest in Jogihalli-4 soil. The black soils recorded very high lattice K at both the depths and it may be due to fact that these soils might have been derived from very rich reserves of K bearing minerals. The type and nature of parent material present and degree of weathering are important for the rich lattice potassium content in the soils. Similar results were obtained by Hebsur and Gali (2011) [6]. The high total K of black soils may be because of potassium rich parent material present and their quantity present in soil. The higher values of total K obtained were mainly because of high lattice K concentration. The results are on par with results obtained by Jagadeesh (2003) [9] and Abdul *et al*. (2013) [1].

**Table 1:** Details of surface and sub-surface samples collected from different places (black type) of Haveri district, Karnataka

| Sl. No. | Taluk | Location | Latitude | Longitude |
|---|---|---|---|---|
| 1 | Shiggoan | Bankapur-1 | 15° 02' 52.1'' | 75° 15' 16.1'' |
| 2 | Shiggoan | Bankapur-2 | 15° 02' 20.5'' | 75° 15' 55.0'' |
| 3 | Savanur | Karadagi | 15° 01' 21.3'' | 75° 14' 40.0'' |
| 4 | Savanur | Mannangi-1 | 14° 53' 05.3'' | 75° 17' 39.7'' |
| 5 | Savanur | Mannangi-2 | 14° 52' 58.7'' | 75° 17' 37.7'' |
| 6 | Savanur | Savoor | 14° 53' 42.8'' | 75° 17' 28.0'' |
| 7 | Haveri | Haveri | 14° 53' 45.0'' | 75° 27' 54.1'' |
| 8 | Haveri | Devihosur | 14° 53' 40.4'' | 75° 29' 41.7'' |
| 9 | Hangal | Hangal | 14° 59' 13.2'' | 75° 57' 32.5'' |
| 10 | Byadgi | Kaginelli | 14° 51' 28.2'' | 75° 44' 32.0'' |
| 11 | Hirekerur | Rattihalli-1 | 14° 51' 18.2'' | 75° 44' 32.0'' |
| 12 | Hirekerur | Rattihalli-2 | 14° 51' 36.3'' | 75° 39' 36.1'' |
| 13 | Hirekerur | Rattihalli-3 | 14° 51' 21.0'' | 75° 33' 39.4'' |
| 14 | Hirekerur | Rattihalli-4 | 14° 52' 29.9'' | 75° 33' 40.2'' |
| 15 | Hirekerur | Rattihalli-5 | 14° 49' 32.0'' | 75° 33' 42.0'' |
| 16 | Hirekerur | Rattihalli-6 | 14° 49' 34.2'' | 75° 33' 46.0'' |
| 17 | Hirekerur | Jogihalli-1 | 14° 45' 10.6'' | 75° 39' 36.8'' |
| 18 | Hirekerur | Jogihalli-2 | 14° 52' 48.8'' | 75° 30' 33.0'' |
| 19 | Hirekerur | Jogihalli-3 | 14° 52' 52.1'' | 75° 30' 32.2'' |
| 20 | Hirekerur | Jogihalli-4 | 14° 45' 14.0'' | 75° 39' 11.9'' |

**Table 2:** Chemical properties in selected surface and sub-surface black soils of Haveri district

| Sample No. | $pH_{1:2.5}$ | | $EC_{1:2.5}$ (dS m$^{-1}$) | | OC (g kg$^{-1}$) | |
|---|---|---|---|---|---|---|
| | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) |
| 1 | 7.60 | 7.58 | 0.22 | 0.25 | 5.94 | 5.14 |
| 2 | 7.20 | 7.22 | 0.26 | 0.27 | 6.20 | 5.71 |
| 3 | 7.40 | 7.36 | 0.28 | 0.27 | 4.88 | 3.65 |
| 4 | 7.00 | 7.02 | 0.35 | 0.36 | 6.41 | 6.14 |
| 5 | 7.77 | 7.80 | 0.26 | 0.29 | 6.64 | 5.23 |
| 6 | 7.35 | 7.40 | 0.25 | 0.30 | 7.12 | 6.02 |
| 7 | 7.68 | 7.70 | 0.28 | 0.33 | 7.01 | 6.21 |
| 8 | 7.85 | 7.77 | 0.26 | 0.25 | 7.14 | 6.28 |
| 9 | 7.38 | 7.40 | 0.28 | 0.32 | 7.98 | 6.45 |
| 10 | 7.48 | 7.52 | 0.33 | 0.35 | 7.01 | 6.23 |
| 11 | 7.62 | 7.61 | 0.27 | 0.30 | 6.14 | 5.19 |
| 12 | 7.65 | 7.61 | 0.29 | 0.33 | 6.47 | 5.35 |
| 13 | 7.60 | 7.58 | 0.32 | 0.31 | 6.24 | 5.11 |
| 14 | 7.61 | 7.64 | 0.30 | 0.32 | 6.98 | 5.98 |
| 15 | 7.63 | 7.64 | 0.29 | 0.31 | 7.41 | 6.35 |
| 16 | 7.54 | 7.55 | 0.31 | 0.30 | 6.66 | 5.29 |
| 17 | 7.65 | 7.66 | 0.25 | 0.25 | 7.23 | 6.35 |
| 18 | 7.61 | 7.62 | 0.30 | 0.32 | 7.08 | 6.01 |
| 19 | 7.58 | 7.60 | 0.27 | 0.29 | 7.22 | 6.03 |
| 20 | 7.58 | 7.61 | 0.30 | 0.34 | 7.96 | 6.39 |
| Range | 7.00-7.85 | 7.02-7.80 | 0.22-0.35 | 0.25-0.36 | 4.88-7.98 | 3.65-6.45 |
| Mean | 7.53 | 7.54 | 0.28 | 0.31 | 6.78 | 5.70 |
| S.D. | 0.19 | 0.18 | 0.031 | 0.035 | 0.72 | 0.69 |

**Table 3:** Particle size distribution in selected surface and sub-surface black soils of Haveri district

| Sample No. | Sand | Silt | Clay | Textural class | Sand | Silt | Clay | Textural class |
|---|---|---|---|---|---|---|---|---|
| | (%) | | | | (%) | | | |
| | Surface (0-20 cm) | | | | Sub-surface (20-50 cm) | | | |
| 1 | 29.80 | 21.80 | 47.45 | c | 28.50 | 23.11 | 48.28 | c |
| 2 | 41.34 | 18.50 | 38.97 | cl | 37.05 | 20.65 | 41.12 | c |
| 3 | 35.86 | 20.14 | 42.45 | c | 34.35 | 21.25 | 42.85 | c |
| 4 | 31.62 | 23.15 | 44.11 | c | 28.60 | 25.74 | 45.31 | c |
| 5 | 43.14 | 19.27 | 37.21 | cl | 39.74 | 20.24 | 39.54 | c |
| 6 | 33.49 | 20.35 | 45.78 | c | 30.10 | 21.47 | 47.14 | c |
| 7 | 39.78 | 21.01 | 39.10 | cl | 39.74 | 20.10 | 40.00 | c |
| 8 | 30.25 | 24.17 | 44.30 | c | 27.32 | 25.04 | 46.00 | c |
| 9 | 33.50 | 23.14 | 42.74 | c | 28.03 | 25.00 | 45.88 | c |
| 10 | 38.56 | 19.31 | 41.85 | c | 36.71 | 20.15 | 42.55 | c |
| 11 | 32.01 | 20.47 | 46.74 | c | 28.10 | 22.31 | 48.24 | c |
| 12 | 28.63 | 25.10 | 45.97 | c | 31.01 | 20.96 | 47.03 | c |
| 13 | 39.76 | 19.94 | 40.25 | c | 32.88 | 23.41 | 43.00 | c |
| 14 | 34.66 | 21.98 | 41.97 | c | 32.92 | 23.89 | 42.95 | c |
| 15 | 32.22 | 23.80 | 42.50 | c | 30.78 | 20.98 | 46.92 | c |
| 16 | 33.30 | 22.79 | 42.70 | c | 31.64 | 24.86 | 43.10 | c |
| 17 | 33.02 | 22.94 | 42.95 | c | 29.85 | 21.85 | 46.85 | c |
| 18 | 32.83 | 20.63 | 46.48 | c | 30.19 | 21.92 | 47.66 | c |
| 19 | 32.18 | 23.81 | 42.46 | c | 30.06 | 24.97 | 44.78 | c |
| 20 | 25.53 | 25.47 | 48.89 | c | 22.45 | 26.14 | 50.87 | c |
| Range | 25.53-43.14 | 18.50-25.47 | 37.21-48.89 | Clay loam to clay | 22.45-39.74 | 20.10-26.14 | 39.54-50.87 | Clay |
| Mean | 34.07 | 21.88 | 43.24 | | 31.47 | 22.70 | 45.00 | |
| S.D. | 4.47 | 2.04 | 3.03 | | 4.28 | 2.03 | 3.01 | |

cl- Clay loam
c- Clay

**Table 4:** Exchangeable potassium percentage, potassium adsorption ratio, CEC and available $K_2O$ in selected surface and sub-surface black soils of Haveri district

| Sample No. | Exchangeable potassium percentage | | Potassium adsorption ratio | | CEC [cmol $(p^+)$ $kg^{-1}$] | | Available $K_2O$ (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) |
| 1 | 5.55 | 4.76 | 1.74 | 1.32 | 44.98 | 47.84 | 430.28 | 344.00 |
| 2 | 9.43 | 6.60 | 2.24 | 0.89 | 27.14 | 30.14 | 426.64 | 268.87 |
| 3 | 8.71 | 9.02 | 1.65 | 0.95 | 35.45 | 38.78 | 452.81 | 324.21 |
| 4 | 7.81 | 5.11 | 1.95 | 0.76 | 40.16 | 42.27 | 483.84 | 313.66 |
| 5 | 10.65 | 8.76 | 1.58 | 0.99 | 23.64 | 26.34 | 376.32 | 298.10 |
| 6 | 4.70 | 3.96 | 1.52 | 1.03 | 42.54 | 45.65 | 420.08 | 319.60 |
| 7 | 12.36 | 8.94 | 2.27 | 1.50 | 24.26 | 27.39 | 483.84 | 368.20 |
| 8 | 8.29 | 5.42 | 1.64 | 0.78 | 42.21 | 46.05 | 489.27 | 313.60 |
| 9 | 4.82 | 3.44 | 1.00 | 0.77 | 41.89 | 44.95 | 322.56 | 224.00 |
| 10 | 7.57 | 6.26 | 2.06 | 1.52 | 33.14 | 35.76 | 432.08 | 366.31 |
| 11 | 9.03 | 6.53 | 2.16 | 1.28 | 44.25 | 46.82 | 645.12 | 448.00 |
| 12 | 6.05 | 5.64 | 3.28 | 2.40 | 42.27 | 44.08 | 645.12 | 494.20 |
| 13 | 9.16 | 7.89 | 3.34 | 1.66 | 32.74 | 36.75 | 591.36 | 443.04 |
| 14 | 6.54 | 4.79 | 2.75 | 1.98 | 38.18 | 42.74 | 537.60 | 413.60 |
| 15 | 9.58 | 7.03 | 3.58 | 2.04 | 41.85 | 44.06 | 722.64 | 488.85 |
| 16 | 10.69 | 7.91 | 2.71 | 0.86 | 42.06 | 43.94 | 698.88 | 403.24 |
| 17 | 7.35 | 5.74 | 2.55 | 1.03 | 41.21 | 44.58 | 591.36 | 358.40 |
| 18 | 5.85 | 4.25 | 1.92 | 1.24 | 43.86 | 47.24 | 483.84 | 393.67 |
| 19 | 7.11 | 4.71 | 2.51 | 1.81 | 42.18 | 43.72 | 596.15 | 463.62 |
| 20 | 9.57 | 6.65 | 2.59 | 1.97 | 46.78 | 52.61 | 752.64 | 592.80 |
| Range | 4.70-12.36 | 3.44-9.02 | 1.00-3.58 | 0.77-2.40 | 23.64-46.78 | 26.34-52.61 | 322.56-752.64 | 224.00-592.80 |
| Mean | 8.04 | 6.17 | 2.25 | 1.34 | 38.53 | 41.58 | 529.53 | 327.04 |
| S.D. | 2.08 | 1.68 | 0.67 | 0.49 | 6.88 | 7.00 | 120.65 | 82.35 |

**Table 5:** Exchangeable cations in selected surface and sub-surface black soils of maize growing areas of Haveri district

| Sample No. | $Ca^{2+}$ | | $Mg^{2+}$ | | $K^{+}$ | | $Na^{+}$ | | Sum of exchangeable cations | |
|---|---|---|---|---|---|---|---|---|---|---|
| | [cmol ($p^+$) $kg^{-1}$] | | | | | | | | | |
| | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub- surface (20-50 cm) |
| 1 | 27.60 | 28.40 | 12.40 | 15.60 | 2.50 | 2.28 | 1.30 | 1.26 | 43.80 | 47.54 |
| 2 | 16.80 | 20.00 | 5.20 | 6.40 | 2.56 | 1.99 | 1.23 | 1.73 | 25.79 | 30.12 |
| 3 | 20.80 | 21.40 | 7.80 | 9.20 | 3.09 | 3.50 | 1.17 | 1.71 | 32.86 | 35.81 |
| 4 | 26.40 | 28.60 | 8.20 | 9.40 | 3.14 | 2.16 | 1.35 | 1.61 | 39.09 | 41.77 |
| 5 | 12.80 | 14.40 | 6.00 | 6.40 | 2.52 | 2.31 | 0.44 | 1.21 | 21.76 | 24.32 |
| 6 | 25.60 | 27.60 | 12.00 | 12.40 | 2.00 | 1.81 | 0.45 | 1.30 | 40.05 | 43.11 |
| 7 | 14.00 | 16.00 | 5.40 | 7.60 | 3.00 | 2.45 | 0.49 | 1.31 | 22.89 | 27.36 |
| 8 | 24.20 | 27.20 | 10.40 | 12.00 | 3.50 | 2.50 | 0.45 | 0.56 | 38.55 | 42.26 |
| 9 | 26.80 | 28.60 | 10.00 | 12.80 | 2.02 | 1.55 | 0.43 | 0.44 | 39.25 | 43.39 |
| 10 | 20.40 | 21.20 | 7.80 | 9.80 | 2.51 | 2.24 | 1.24 | 1.33 | 31.95 | 34.57 |
| 11 | 27.60 | 29.60 | 9.40 | 10.60 | 4.00 | 3.06 | 1.31 | 1.72 | 42.31 | 44.98 |
| 12 | 13.60 | 15.20 | 7.60 | 8.80 | 2.56 | 2.49 | 0.45 | 0.82 | 24.21 | 27.31 |
| 13 | 20.40 | 22.80 | 5.60 | 7.60 | 3.00 | 2.90 | 1.24 | 1.38 | 30.24 | 34.68 |
| 14 | 25.60 | 27.40 | 7.80 | 9.60 | 2.50 | 2.05 | 0.42 | 0.52 | 36.32 | 39.57 |
| 15 | 25.40 | 27.60 | 8.80 | 10.40 | 4.01 | 3.10 | 1.36 | 1.73 | 39.57 | 42.83 |
| 16 | 26.10 | 29.20 | 8.20 | 5.60 | 4.50 | 3.48 | 0.46 | 1.35 | 39.26 | 39.63 |
| 17 | 27.20 | 29.20 | 7.80 | 9.20 | 3.03 | 2.56 | 1.38 | 1.74 | 39.41 | 42.7 |
| 18 | 28.00 | 31.40 | 9.60 | 8.80 | 2.57 | 2.01 | 1.32 | 1.32 | 41.49 | 43.53 |
| 19 | 25.20 | 27.40 | 10.10 | 10.60 | 3.02 | 2.06 | 1.41 | 1.33 | 39.61 | 41.39 |
| 20 | 28.20 | 32.60 | 10.00 | 12.20 | 4.48 | 3.50 | 1.73 | 1.76 | 44.41 | 50.06 |
| Range | 12.80-28.20 | 14.40-32.60 | 5.20-12.40 | 5.60-15.60 | 2.00-4.50 | 1.55-3.50 | 0.42-1.73 | 0.44-1.76 | 21.76-44.41 | 24.32-50.06 |
| Mean | 23.13 | 25.29 | 8.50 | 9.75 | 3.02 | 2.50 | 0.98 | 1.31 | 35.64 | 38.84 |
| S.D. | 5.14 | 5.46 | 2.03 | 2.45 | 0.73 | 0.57 | 0.45 | 0.42 | 7.13 | 7.09 |

**Table 6:** Forms and distribution of potassium in surface and sub-surface layers of selected black soil type in Haveri district

| Sample No. | Water soluble K (mg $kg^{-1}$) | | Exchangeable K (mg $kg^{-1}$) | | Non-exchangeable K (mg $kg^{-1}$) | | Lattice K (%) | | Total K (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) | Surface (0-20 cm) | Sub-surface (20-50 cm) |
| 1 | 4.60 | 3.67 | 56.00 | 44.81 | 620.67 | 743.90 | 1.38 | 1.53 | 1.45 | 1.60 |
| 2 | 4.96 | 2.10 | 51.00 | 43.66 | 566.67 | 622.17 | 1.59 | 1.69 | 1.65 | 1.78 |
| 3 | 4.01 | 2.46 | 68.20 | 53.42 | 664.92 | 743.42 | 1.53 | 1.64 | 1.60 | 1.73 |
| 4 | 4.83 | 2.09 | 66.80 | 54.93 | 687.53 | 857.82 | 1.63 | 1.76 | 1.70 | 1.85 |
| 5 | 3.40 | 2.34 | 56.01 | 48.27 | 619.24 | 829.06 | 1.61 | 1.69 | 1.68 | 1.78 |
| 6 | 4.48 | 3.23 | 54.80 | 43.62 | 665.67 | 740.21 | 1.71 | 1.79 | 1.78 | 1.88 |
| 7 | 4.79 | 3.43 | 67.25 | 53.60 | 621.30 | 769.48 | 1.66 | 1.77 | 1.73 | 1.85 |
| 8 | 3.91 | 2.00 | 78.42 | 56.00 | 678.91 | 741.66 | 1.83 | 1.90 | 1.90 | 1.98 |
| 9 | 2.83 | 2.26 | 48.92 | 36.90 | 646.38 | 719.39 | 1.63 | 1.76 | 1.70 | 1.83 |
| 10 | 4.64 | 3.74 | 56.04 | 49.60 | 566.37 | 639.87 | 1.56 | 1.64 | 1.63 | 1.73 |
| 11 | 6.40 | 4.00 | 89.60 | 67.20 | 728.80 | 858.13 | 1.78 | 1.88 | 1.85 | 1.98 |
| 12 | 7.40 | 6.03 | 78.41 | 56.00 | 765.40 | 778.96 | 1.67 | 1.76 | 1.75 | 1.85 |
| 13 | 7.20 | 3.88 | 67.20 | 67.20 | 768.14 | 835.02 | 1.62 | 1.74 | 1.70 | 1.83 |
| 14 | 6.98 | 5.23 | 56.18 | 44.80 | 747.70 | 823.40 | 1.97 | 2.04 | 2.05 | 2.13 |
| 15 | 8.13 | 4.91 | 89.60 | 67.20 | 673.15 | 817.49 | 1.96 | 2.02 | 2.03 | 2.10 |
| 16 | 6.58 | 2.17 | 100.96 | 76.40 | 766.02 | 798.65 | 2.03 | 2.04 | 2.10 | 2.13 |
| 17 | 7.20 | 3.00 | 67.20 | 56.00 | 726.35 | 804.40 | 1.90 | 2.02 | 1.98 | 2.10 |
| 18 | 5.78 | 3.78 | 56.21 | 56.05 | 722.12 | 724.02 | 1.68 | 1.84 | 1.75 | 1.93 |
| 19 | 7.31 | 5.45 | 67.20 | 54.80 | 703.65 | 754.25 | 1.68 | 1.78 | 1.75 | 1.87 |
| 20 | 7.84 | 6.23 | 100.33 | 78.40 | 790.84 | 865.43 | 2.00 | 2.07 | 2.08 | 2.15 |
| Range | 2.83-8.13 | 2.00-6.23 | 48.92-100.96 | 36.90-78.40 | 566.37-790.84 | 622.17-865.43 | 1.38-2.03 | 1.53-2.07 | 1.45-2.10 | 1.60-2.15 |
| Mean | 4.60 | 3.67 | 56.00 | 46.81 | 686.49 | 773.34 | 1.72 | 1.82 | 1.79 | 1.90 |
| S.D. | 1.61 | 1.32 | 15.90 | 11.06 | 66.26 | 67.30 | 0.17 | 0.15 | 0.17 | 0.15 |

## Conclusion

The result of the present investigation on potassium dynamics black soils of Haveri district suggests that maximum K content of the soils is in the unavailable form, mostly fixed up within the lattice resulting in very small amount of availability to crop plants. Knowledge of different forms of potassium in soil together with their distribution has greater relevance in assessing the long-term K supplying power of soil to crops and is important in formulating a sound fertilizer program for a given set of soil and crop especially based on soil type rather than generalised method of plant uptake. A future study on parent material and its make-up of the soils may help calibrating the reserve pool of K and the extent of its mining in soils. This may help the planners to formulate an effective potassium fertilizer program in general for a soil, particularly based on soil type.

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