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Dynamics of potassium in selected black soil type of Haveri district, Karnataka

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Abstract
Potassium in soil exists in four forms such as water soluble, exchangeable, non-exchangeable and lattice potassium were studied in twenty representative randomly collected maize growing soils of Haveri district, Karnataka. The soils varied appreciably in their physico-chemical properties depending on nature and amount of parent material. The available potassium in black soil varied from 322.56 to 752.64 kg ha^{-1} in surface layer. The higher value of available potassium indicated that these soils were added with sufficient quantities of potash fertilizers. 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 reason for higher water soluble K in black soil was mainly due to intensive weathering of K bearing minerals and also due external application water soluble K fertilizers under intensive farming system. The higher exchangeable potassium at surface zone was mainly due to the fact that these 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. The non-exchangeable potassium of black soils in surface samples varied from 566.37 to 790.84 mg kg^{-1}. The black soils ranged lattice potassium of 1.38 to 2.03 per cent in surface layer. The type and nature of parent material present and degree of weathering are important for the rich lattice potassium content in the soils. The black soils total potassium ranged from 1.45 to 2.10 per cent. The higher values of total K obtained were mainly because of high lattice K concentration. Based on degree of weathering, type and amount of clay and fertilizer that has been applied, the various forms of potassium varied among the samples.

Keywords: Dynamics of potassium, black soil, intensive weathering

1. Introduction

Potassium is often absorbed by plants in amounts equal to or greater than nitrogen, which has drawn an attention of several research scientists to understand its behaviour in different soils and study the crop response to applied potash fertilizers. Lot of research works have been carried out to know its distribution and transformation in different soils and the availability indices for potassium for predicting crop response to application of potash fertilizers under field condition. A thorough understanding of potassium status in the soil could be possible only by measurement of several parameters that are related to its different forms in the soil solution and the solid phase of soil. Therefore, to understand the dynamics of potassium in soils which involves forms and distribution of potassium availability to the crop is very much essential for efficient management of K for sustainable crop production. 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. Soil solution K is the form of K that is directly taken up by plants and microbes and also is the form most subject to leaching in soils. Levels of soil solution K are generally low, unless recent amendments of K have been made to the soil. Exchangeable K is the portion of the soil K that is electrostatically bound as an outer-sphere complex to the surfaces of clay minerals and humic substances. It is readily exchanged with other cations and also is readily available to plants. The exchangeable K content follow the order of clay per cent along with silt fraction: black soil followed by red, alluvial and laterite soils. Non-exchangeable K differs from mineral K in that it is not bonded within the crystal structures of soil mineral particles. It is held between adjacent tetrahedral layers of dioctahedral and trioctahedral micas, vermiculites and intergraded clay minerals such as chloritized vermiculite.

Potassium get fixed because of binding forces between K and the clay surfaces are greater than the hydration forces between individual K^+ ions. This results in a partial collapse of the crystal structures and the K^+ ions are physically trapped to varying degrees, making K release slow and diffusion controlled process. Lattice K is generally assumed to be only slowly available to plants; however, the availability is dependent on the level of K in the other forms, and the degree of weathering of the feldspars and micas constituting the mineral K fraction. Most of the total K in soils is in the mineral form, mainly as K-bearing primary minerals such as muscovite, biotite and feldspars. Common soil K-bearing minerals, in the order of availability of their K to plants are biotite, muscovite, orthoclase and microcline. 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. Maize is grown in temperature between 18°C and 27°C during the day and around 14°C during the night. Maize is grown mostly in regions having annual rainfall between 60 and 110 cm. But it is also grown in areas having rainfall of about 40 cm. Maize grows on a wide range of soils, ranging from temperate podzols to the leached red soils of the tropics. But, the best suitable soil for maize is deep, rich soils of the sub-tropics, where there is abundant nitrogen and potassium. Karnataka accounts for 6 per cent area and 12 per cent of production share. The area under maize in Northern Karnataka is 52 per cent. The area under maize in Haveri district is 1,48,204 ha, with a production of 4,56,842 tonnes with an average productivity of 3,460 kg ha^{-1} (Anon., 2015) [2]. The adoption of hybrid maize varieties, exhaustive nature of the crop, new cultural practices and their interrelationships with nutrient supply have resulted in the application of ever increasing amounts of fertilizers in Karnataka. More fertilizers probably used for maize than for any other annual crop, and this in turn have given rise to new basic problems not considered previously. In Karnataka, the maize growing area is increasing rapidly, adoption of nutrient management practices in general and K nutrient management in particular is need of the hour. Hence, an immense study on K dynamics under maize cropping system of black soil type was studied.

2. Material and Methods

The surface samples of depth 0-20 cm 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) [7]. It was determined in 1:2.5 soil: water suspension after obtaining supernatant as described by Jackson (1973) [7] using conductivity meter. Organic carbon was determined by Walkley and Black's wet oxidation method as described by Piper (1996) [12]. 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) [7]. 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) [7]. Available potassium was determined by extracting soil with neutral normal ammonium acetate and the contents of K in solution and was estimated by flame photomethery (Jackson, 1973) [7].

Different forms of potassium was estimated by,

2.1. 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.

2.2. Exchangeable potassium

Exchangeable potassium was determined by extracting with *N N* NH_4OAc solution as outlined by Knudsen *et al*. (1982). 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.

2.3. Non exchangeable potassium

The boiling 1*N* HNO_3 method as outlined by Knudsen *et al*. (1982) 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.

2.4. Total potassium

Total potassium content was determined by digesting the samples with hydrofluoric acid in a closed vessel (Lim and Jackson, 1982) [11]. 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.

2.5. Lattice potassium

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

3. Results and Discussion

The available potassium in black soils varied from 322.56 to 752.64 kg ha^{-1} in surface with a mean of 529.53 kg ha^{-1}. The highest available potassium was obtained in Jogihalli-4 and corresponding lowest value in Hangal soil. The black soils were high in available potassium. The high value of potassium at surface depth indicated that these soils were added with sufficient quantities of potash fertilizers. The higher values of might be due to dominance of potassium rich micaceous and feldspar minerals. Similar results were obtained by Ravikumar (2004) [13] 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 was lowest in Hangal soil and highest in Rattihalli-5 soil. Black soils recorded higher water soluble K due to intensive weathering of K bearing minerals and also due external application water soluble K fertilizers under intensive farming system. The results were in corroboration with Lakaria *et al.* (2012) [10]. The black soils exchangeable potassium varied from 48.92 to 100.96 mg kg^{-1} in surface and varied with a mean of 56.00 mg kg^{-1}. In the surface depth, exchangeable potassium was recorded highest in Rattihalli-6 soil and lowest in Hangal soil. Black soils studied were high with respect to exchangeable potassium which 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. The results are in corroboration with Hebsur (1997) [6] and Jagadeesh (2003) [8]. The non-exchangeable potassium of black soils in surface samples varied from 566.37 to 790.84 mg kg^{-1} with a mean of 686.49 mg kg^{-1}. The non-exchangeable potassium recorded lowest in Kaginelli soil and highest in Jogihalli-4 soil. The non-exchangeable K of lower values was due to release of potassium from reserve pool to compensate the loss of water soluble and exchangeable K by plant uptake. The increase in non-exchangeable potassium at could be attributed to adsorption and fixation of K by clay particles. The similar findings were obtained by Kundu *et al.* (2014) [9]. The lattice potassium ranged from 1.38 to 2.03 per cent with a mean of 1.82 per cent. The highest was recorded in Rattihalli-6 soils and lowest in Bankapur-1 soils. The black soils showed very high lattice 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) [5]. The total potassium ranged from 1.45 to 2.10 per cent with mean of 1.16 per cent. The lowest total potassium was recorded in soils of Bankapur-1 and highest in Rattihalli-6 soil. The high total K of black soils was 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 Abdul *et al.* (2013) [1].

Table 1: Details of soil 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: Physico-chemical properties in selected maize growing black soils of Haveri district, Karnataka

Sample No.	$pH_{1:2.5}$	$EC_{1:2.5}$ (dS m^{-1})	OC (g kg^{-1})	Sand	Silt	Clay	EPP	CEC	Sum of Exch. Cations	PAR	Available K_2O (kg ha^{-1})	Textural class
				%				[cmol (p^+) kg^{-1}]				
1	7.60	0.22	5.94	29.80	21.80	47.45	5.55	44.98	43.80	1.74	430.28	c
2	7.20	0.26	6.20	41.34	18.50	38.97	9.43	27.14	25.79	2.24	426.64	cl
3	7.40	0.28	4.88	35.86	20.14	42.45	8.71	35.45	32.86	1.65	452.81	c
4	7.00	0.35	6.41	31.62	23.15	44.11	7.81	40.16	39.09	1.95	483.84	c
5	7.77	0.26	6.64	43.14	19.27	37.21	10.65	23.64	21.76	1.58	376.32	cl
6	7.35	0.25	7.12	33.49	20.35	45.78	4.70	42.54	40.05	1.52	420.08	c
7	7.68	0.28	7.01	39.78	21.01	39.10	12.36	24.26	22.89	2.27	483.84	cl
8	7.85	0.26	7.14	30.25	24.17	44.30	8.29	42.21	38.55	1.64	489.27	c
9	7.38	0.28	7.98	33.50	23.14	42.74	4.82	41.89	39.25	1.00	322.56	c

10	7.48	0.33	7.01	38.56	19.31	41.85	7.57	33.14	31.95	2.06	432.08	c
11	7.62	0.27	6.14	32.01	20.47	46.74	9.03	44.25	42.31	2.16	645.12	c
12	7.65	0.29	6.47	28.63	25.10	45.97	6.05	42.27	24.21	3.28	645.12	c
13	7.60	0.32	6.24	39.76	19.94	40.25	9.16	32.74	30.24	3.34	591.36	c
14	7.61	0.30	6.98	34.66	21.98	41.97	6.54	38.18	36.32	2.75	537.60	c
15	7.63	0.29	7.41	32.22	23.80	42.50	9.58	41.85	39.57	3.58	722.64	c
16	7.54	0.31	6.66	33.30	22.79	42.70	10.69	42.06	39.26	2.71	698.88	c
17	7.65	0.25	7.23	33.02	22.94	42.95	7.35	41.21	39.41	2.55	591.36	c
18	7.61	0.30	7.08	32.83	20.63	46.48	5.85	43.86	41.49	1.92	483.84	c
19	7.58	0.27	7.22	32.18	23.81	42.46	7.11	42.18	39.61	2.51	596.15	c
20	7.58	0.30	7.96	25.53	25.47	48.89	9.57	46.78	44.41	2.59	752.64	c
Range	7.00-7.85	0.22-0.35	4.88-7.98	25.53-43.14	18.50-25.47	37.21-48.89	4.70-12.36	23.64-46.78	21.76-44.41	1.00-3.58	322.56-752.64	Clay loam to clay
Mean	7.53	0.28	6.78	34.07	21.88	43.24	8.04	38.53	35.64	2.25	529.53	
S.D.	0.19	0.031	0.72	4.47	2.04	3.03	2.08	6.88	7.13	0.67	120.65	

Table 3: Forms and distribution of potassium in selected black soil type of of 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)	Surface (0-20 cm)	Surface (0-20 cm)	Surface (0-20 cm)	Surface (0-20 cm)
1	4.60	56.00	620.67	1.38	1.45
2	4.96	51.00	566.67	1.59	1.65
3	4.01	68.20	664.92	1.53	1.60
4	4.83	66.80	687.53	1.63	1.70
5	3.40	56.01	619.24	1.61	1.68
6	4.48	54.80	665.67	1.71	1.78
7	4.79	67.25	621.30	1.66	1.73
8	3.91	78.42	678.91	1.83	1.90
9	2.83	48.92	646.38	1.63	1.70
10	4.64	56.04	566.37	1.56	1.63
11	6.40	89.60	728.80	1.78	1.85
12	7.40	78.41	765.40	1.67	1.75
13	7.20	67.20	768.14	1.62	1.70
14	6.98	56.18	747.70	1.97	2.05
15	8.13	89.60	673.15	1.96	2.03
16	6.58	100.96	766.02	2.03	2.10
17	7.20	67.20	726.35	1.90	1.98
18	5.78	56.21	722.12	1.68	1.75
19	7.31	67.20	703.65	1.68	1.75
20	7.84	100.33	790.84	2.00	2.08
Range	2.83-8.13	48.92-100.96	566.37-790.84	1.38-2.03	1.45-2.10
Mean	4.60	56.00	686.49	1.72	1.79
S.D.	1.61	15.90	66.26	0.17	0.17

Conclusion

The result of the present investigation on potassium dynamics in maize growing soil of Haveri district suggests that maximum K content of the soils is in the non-exchangeable form, mostly fixed up within the clay lattice rendering very small amount of available to plant. 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. 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. This may help the planners to formulate an effective potassium fertilizer program in general for a soil particularly for a soil type.

References

1. Abdul W, Mehreen G, Muhammad S. Potassium dynamics in three alluvial soils differing in clay contents. Journal of Food and Agriculture. 2013; 25(1):39-44.
2. Anonymous. Haveri district at a glance 2014-2015, *Zilla Panchayat*, Haveri, Karnataka. 2015, 25-27.
3. Black CA. Methods of Soil Analysis Part- II. Chemical and mineralogical properties. Agronomy Monograph No. 9, American Society of Agronomy, Inc. Madison, Wisconsin, USA, 1965, 18-25.
4. Deshmukh KK. Evaluation of soil fertility status from Sangamner area, Ahmednagar district, Maharashtra, India. *Rasayan J*ournal. 2012; 5(3):398-406.
5. Hebsur NS, Gali SK. Potassium dynamics in soils under different cropping systems of Karnataka. Soil Science Research in North Karnataka, 76th Annual Convention Indian Society of Soil Science, Dharwad, 2011, 85-89.
6. Hebsur NS. Studies on chemistry of potassium in sugarcane soils of North Karnataka, *Ph. D. Thesis,* University of Agricultural Sciences, Dharwad, Karnataka (India), 1997.
7. Jackson ML. Soil Chemical Analysis, Prentice Hall of India Private Limited, New Delhi. 1973.
8. Jagadeesh BR. Dynamics of potassium in soils of selected agro-climatic zones of Karnataka. Ph. D. Thesis, University of Agricultural Sciences, Bangalore, Karnataka (India), 2003.
9. Kundu MC, Hazra GC, Biswas PK, Mondal S, Ghosh

GK. Forms and distribution of potassium in some soils of Hooghly district of West Bengal. Journal of Crop and Weed. 2014; 10(2):31-37.
10. Lakaria BL, Sanjib KB, Dhyan S. Different forms of potassium and their contributions towards potassium uptake under long-term maize (*Zea mays* L.)-wheat (*Triticum aestivum* L.) cowpea (*Vigna unguiculata* L.) rotation in an Inceptisol. Communication in Soil Science and Plant Analysis. 2012; 43:936-947.
11. Lim CH, Jackson ML. Dissolution for total elemental analysis In: Methods of Soil Analysis Part II. Chemical and Microbiological Properties. Ed. Page, A.L., American Society of Agronomy, Inc., Soil Science Society of America Inc., Madison, Wisconsin, USA. 1982.
12. Piper CS. Soil and Plant Analysis, Hans Publishers, Bombay, India. 1996.
13. Ravikumar MA. Soil resource characterization of 48A Distributary of Malaprabha Right Bank command for sustainable land use planning. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad (India). 2004.