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Potassium fraction and their availability in potato growing soils of Ballia District, U.P.

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Abstract

Potato growing surface soil samples were collected form three village of every three block *viz.* Bansdih, Reoti and Sohaon for analysis of soil fertility parameters and fraction of potassium. Potato growing surface soil samples of different village resulted soil pH was greater in Bansdih block followed by Sohaon and Reoti block with the range of 6.9-7.4, soil EC ranged from 1.02 – 1.04 had not much more varied in all village. Bulk density of soils of Bansdih block was lower than other block soils, water holding capacity of soil was greater in Reoti block as compared to Bansdih and Sohaon block's soil. The greater (0.34 – 0.86 %) amount organic carbon was observed in Bansdih block's followed by Sohaon and Reoti block. Exchangeable Ca ranged from 7.2-10.0, Mg ranged from 7.5 to 11.0 and $CaCO_3$ was ranged from 0.29 to 0.49 % in soil of Sohaon block. The available nitrogen value was ranged from 254.3 to 319.0 kg/ha in soils of all three blocks. Similarly available phosphorus (17.2-21.9 kg/ha) and available potassium (268-649.3 kg/ha) in surface soil were shows in considerable range in the different villages of all three blocks. Available sulphur (2.98-6.12 mg/kg soil) was also alarming in the soil of all blocks. Total potassium was ranged from 1784-2728 kg/ha, water soluble potassium was ranged from 151.2 – 362.4 kg/ha, reserve potassium content was ranged from 192.64 - 327.6 kg/ha, NaCl extractable K was 64.8 – 229.6 kg/ha, $CaCl_2$ extractable K was ranged from 128.8-358.7 kg/ha and ammonium acetate extractable K was ranged from 268-649.3 kg/ha, respectively in different villages of all three blocks.

Keywords- Available nutrients, soil physical properties and fractions of potassium

Introduction

Potassium is one the most essential plant nutrient elements which plays significant role in plant physiological processes, animal and microbial nutrition and in environmental sustainability (Yawson *et al.*, 2011). Soil potassium (K) exists in different forms as; solution, exchangeable, non-exchangeable or fixed and mineral or structural forms. Solution K is the most negligible fraction that is readily taken up by plants and microbes or lost via leaching (Sparks, 2000). The essentiality of K to plant growth has been known since the work of Liebig published in 1840 (Sparks, 2000). The concentration of the readily available K forms are relatively small at any time and do not provide a good indication long term ability of soils to supply K to plants (Jibrin, 2010). It has established that Plant requires potassium in large quantity. As a result of application of K in less quantity, most of the cropping systems are running with negative K balance. The highest water soluble potassium content was observed under NPK+FYM, which might be due the favourable influence of FYM on soil properties and its was lower in NP treatment. Continuous application of missing increasing level of potassic furtilizer maintained the content of non-exchangeable K at higher level at 150% of NPK when crops are grown successively without K application, the demand for the nutrient increase and the soil available pool remains constant under K stress (Ganeshamurthy and Biswas, 1985), the total K concentration revealed a declining trend with the progress in the number of crops, as a result of higher rates of K removed by the crops which for quantum of fertilizer input. The readily available or water soluble K has been reported to be dominant fraction in the initial stage while exchangeable and non-exchangeable K contribute more in the later stages of crop growth (Subba Rao *et al.,* 2003). Keeping in view on the above facts the present study initiated on different extractants of available K in soil.

Materials and methods

Experiment was conducted during July, 2016 to May, 2017 by collection of surface soil samples from potato gown area soils of Ballia distict.

Climatic condition-Ballia is lies between the parallels of 25^0 33' and $26^0$11' N Latitude and $83^0$39'and $84^0$39' E Longitude and 58-64 meter above the sea level and almost in Indo-Ganagetic belt in the semi-arid zone as per U.S.A. modern classification. The mean annual rainfall ranges from 950-1150 mm. This is normally confined during May-July. Normally the maximum temperature ranges from 30.2 ^{0}C to 45.3 ^{0}C to 28.1^{0}C, there is a gradual increase in temperature up to April and decrease from June to Janaury.

Collection of soil samples- Sampling sites were carefully chosen taking into consideration the ground cover, micro relief, degree of erosion, surface drainage, proximity to stress and all other factors likely to affect the soil in comparison with the normal type. Soil samples were collected from three block and nine village namely; Bansdih, Kharauni and Pitambra away from Bansdih block 2 km, 5.8 km, 6.5 km

respectively from Bansdih block. Sohaon, Daulatpur and Kathariya, Sohaon block 3.2 km, 11.6 km, 10.3 km respectively away from Sohaon block. Agnila, Kuapipara and Reoti respectively away from Reoti block 10.0 km, 2.2 km, 1 km respectively from Reoti block. Soil sample were collected by help of auger and *khurpi* from 0-15 cm depth from nine sampling points in each village of Reoti, Shohaon and Bansdih block. Collected soil samples from different village of potato grown were well processed and analyses for soil pH (glass electrode), EC (glass electrode), Bulk density, WHC (method described by Kanwar and Chopra, 2005), Organic carbon by wet digestion method (Walkley's and Black, 1934), available N (Subiah and Asija,1956), available P by 0.5N $NaHCO_3$ extractable (Olsen's *et al.* 1954), available K by NH_4OAc extractable (Muhr *et al.* 1965) and available S by 0.15 % $CaCl_2.H_20$ (Chesnin and Yein, 1959), exchangeable $Ca^{++}$and Mg^{++} by EDTA versinate method HCl extract A.E.A. (1931), $CaCO_3$% (Puri *et al.* 1993), water soluble potassium, total potassium, reserve potassium, calcium chloride, sodium chloride extractable K by using standard method described by different authors. Total Potassium- Wet digestion method- place 5 of surface soil sample in 100 ml digestion flask. Water Soluble Potassium- was estimated by Rouse and Bertramson, by shaking a 1:5 ratio of soil and extractant for a 24 hours period and uses the flame photometer. Reserve Potassium - the amount of non-exchangeable potassium was determined by the method proposed by Maclean 1954 which is a modification of Haylock's (1956) method by Nitric acid extractable potassium-In the context of times work, non-exchangeable K is defined as the K which is not accepted with 1M NH_4OAc. After Mortin and Sparks (1985). 1 M sodium chloride extractable K- by Scott *et al.* (1960) was used. 0.01 M Calcium Chloride extractable K- Calcium chloride method described by Woodruff and Mclntosh (1960) was used.

Results and discussion

Soil pH and Electrical Conductivity (dS/m) - Bansdih, Kharauni and Pitambra soil was 7.4, 7.0, and 7.3 in Bansdih block, 7.1 Sohaon, 7.03 Daulatpur and 7.26 Kathariya of Sohaon block and 6.9 Aghila, 7.4 Kuapipara and 6.96 (table.1) Reoti of Reoti block. The range of pH value towards saline for surface soil in all potato grown area, variation of different villages soils, which has attributed to the dominance of natural soluble salt (Abrolet *at al.* 1988). The higher biological activities might be responsible for decreased pH range on surface soil of different location. Electrical conductivity was 1.02, 1.00 and 1.00 dSm^{-1} (table-1) of Bansdih block. Sohaon, Daulatpur and Katharia were 1.01, 0.99 and 0.74 dSm^{-1} of Sohaon block and Aghaila, Kuapipara and Reoti was 1.02, 1.04 and 1.03 dSm^{-1} of Reoti block, but that have no marked variation from all different locations soils.

Bulk density (Mgm^{-3})- surface plow layer for all potato grown soil of Bansdih, Kharauni and Pitambra were 1.13**,** 1.33 and 1.43 Mg m^{-3} (table-1) of Bansdih block. Sohaon, Daulatpur, and Katharia were 1.39, 1.33 and 1.36 Mg m^{-3} of Sohaon block and Aghaila, Kuapipara and Reoti were 1.30, 1.41 and 1.31 Mg m^{-3} of Reoti block. Bulk density was varied among the village of different block were ranged from 1.13 to 1.43 Mg m^{-3} of different potato grown area respectively.

Water Holding Capacity (%) - Bansdih, Kharauni and Pitambra were 28.56%, 32.43% and 25.41% (table-1) of Bansdih Block. Sohaon, Daulatpur and Katharia were 31.4%, 34.0% and 29.2% of Sohaon Block and Aghaila, Kuapipara and Reoti were 35.33%, 37.19% and 31.80% of Reoti Block. So the greater value of WHC of Sohaon block's soil might be great clay.

Organic carbon (%) - The content of organic carbon was 0.86%, 0.34% and 0.84% of Bansdih, Kharuni and Pitambara village of Bansdih Block (table-1), Sohaon, Daulatpur and Katharia soils were 0.53 %, 0.45 % and 0.55 % of Sohaon block and Aghaila, Kuapipara and Reoti soils were showed 0.47%, 0.50% and 0.46% organic carbon of Reoti block. The similar finding was given by Sahu and Bala (1995). Differences in organic carbon content of the soil and high rate of possible CO_2 evolution leads to low organic carbon content (Sharma *et al.* 1998, Singh, 1991). Therefore, Organic carbon content were ranged from 0.33 to 0.84% of targeted village migh be due to different land use system.

Exchangeable Ca and Mg (cmol (p^+) kg^{-1}) – The value in surface soil of Bansdih, Kharauni and Pitambra village were 7.4, 9.0 and 8.4 cmol (p^+) kg^{-1} of Bansdih Block, Sohaon, Daulatpur and Katharia village were 10.4, 10.3 and 11.0 cmol (p^+) kg^{-1} of Sohaon Block and Aghaila, Kuapipara and Reoti village were 8.0, 7.4 and 10.0 cmol (p^+) kg^{-1} of Reoti Block. The content of exchangeable Mg in Bansdih, Kharauni and Pitambra were 9.5, 10.2 and 8.3 cmol (p^+) kg^{-1} of Bansdih Block, Sohaon, Daulatpur and Katharia were 10.4, 10.3 and 11.0 (cmol (p^+) kg^{-1}) (table-1) of Sohaon block and Reoti block was 7.5, 9.3 and 8.4 cmol (p^+) kg^{-1}. A very small variation was observed in exchangeable Mg^{++} in surface soil of all village but Sohaon block village soils were showed greater value than other block's might be due clay humus complexes.

Calcium carbonate- Value in surface soil was in Bansdih, Kharauni and Pitambra viallage 0.46, 0.49 and 0.39% of Bansdih block. Sohaon, Daulatpur and Katharia were showed 0.29, 0.32 and 0.41 of Sohaon block and Reoti, Aghaila and Kuapipara village were 0.44, 0.33 and 0.22(table-1) of Reoti block. It might be due to cultural practices the carbonation process slow and short duration.

Available nitrogen (kg/ha)- Content in soil of all potato growing area of Bansdih, Kharauni and Pitambra were showed 282.9 kg/ha, 260.2 kg/ha and 275.2 kg/ha (table.1) of Bansdih block. Sohaon, Daulatpur and Katharia were showed 354.3 kg/ha, 288.5 kg/ha and 319 kg/ha of Sohaon block and Aghail, Kuapipara and Reoti village were showed 235.2 kg/ha, 260 kg/ha, and 285.8 kg/ha of Reoti block. However available nitrogen

content in surface soil of potato grown area of Sohaon block's showed greater value due to the accumulation of natural vegetation residues and organic material, it might be there where more microbial transformation due to partial water logged body (Prasuna Rani *et. al* 1992). The continue application of imbalance chemical fertilizers and cultural practices, extent of available nitrogen status at soil due to partial decomposition of crop residues (Hedge and Dwivedi, 1992; Devi, 1993). The surface soil were showed low extent of available nitrogen might be due to its higher removal by crops than annual addition. Moreover, surface soil have greater extent of available nitrogen in Sohaon block soil respectively as per elevation of cultivated accumulation organic material and pedogenic process.

Available Phosphorus (kg/ha) **-** The content in soils of Bansdih, Kharauni and Pitambra village were 18.2, 18.0 and 19.6 kg/ha (table.1) of Bansdih block. Similarly, Sohaon, daulatpur and Katharia were showed 21.9, 20.2 and 20.7 kg/ha of Sohaon block and Aghaila, Kuapipara and Reoti were found that 17.20, 20.3 and 19.4 kg/ha of Reoti Block. The greater amount of available phosphorus was found in potato growing area of Sohaon block due to its different land use system, eventually, lower dose application of phosphorus might have increased the phosphorus fixation capacity of soil under mixed alleviate of cultivated land current follows land use system (Das *et al.;* 1993) with the respect of phosphorus fixation capacity. The variation trend in all surface soil showed similar and not much more variation due similarly of parent materials and crop management practices.

Available Potassium (kg/ha**)-** Potato growing area of Bansdih, Kharauni and Pitambra village were showed 168, 246.4 and 257 kg/ha (table.1) of Bansdih block. Sohaon, Daulatpur and Katharia village were showed 448, 649.6 and 672 kg/ha of Sohaon block and Aghaila, Kuapipara and Reoti were observed 480.08, 268.8 and 302.4 kg/ha of Reoti block. Available potassium was found in greater amount in potato growing soil of Sohoan blocks might be due to potassic minerals.

Available sulphar (mg/kg**) -** Content in surface soil of Bansdih, Kharauni and Pitambra were observed 4.12, 5.20 and 2.98 mg/kg (table.1) of Bansdih block. Sohaon, Daulatpur and Katharia were showed 4.25, 6.12 and 4.27 mg/kg of Sohaon block and Aghaila, Kuapipara and Reoti were found 3.37, 3.12 and 4.15 mg/kg of Reoti block. Greater amount of available sulphar was found in surface soil of Sohaon block than other block's in resulted from its recycling over the years by plants and subsequent organic matter accumulation. (Trivedi *et al.;*. 1998). Negligible amount of use of organic manure and sulphur containing fertilizer has led to low sulphur content in observed area soils.

Total potassium (kg/ha) - different potato grown soils of Bansdih, Kharauni and Pitambra were showed 2217.6, 2750 and 2112 kg/ha (table.2), respectively of Bansdih block. Sohaon, Daulatpur and Katharia were showed 2304, 2784 and 2592 (kg/ha) respectively of Sohaon block and Aghaila, Kuapipara and Reoti were found 1728, 1824

and 1680 kg/ha respectively. Total potassium is large portion of the potassium mineals in soil occurs as structural component of soil farming minerals and is unavailable to plants, smectitic, vertic vertisols, intergrades, kaolinitic, latrite soil, kaolinitic acid of alluvial soil. Similarlys Ahmed and walia (1999) observed higher amount of total K in sub-surface soil than surface soil which has provide the balance of availability to crops (sharma *et al.* 2009).

Water soluble K (kg/ha) - Value in different potato grown area of Bansdih, Kharauni and Pitambra were 151.2, 218.4 and 218.12 kg/ha (table.2) of Bansdih block. Sohaon, Daulatpr and Katharia were 246.4, 281.2 and 362.4 kg/ha of Sohaon block and Aghaila, Kuapipara and Reoti were 202.75, 218.4 and 202.75 kg/ha respectively, Reoti block. Water soluble K constituent 0.12 percent total K in surface soil indication and almost negligible constribution to the total potassium of soil. Generally surface soil had relatively high water soluble K than the sub surface soil due to moisture content. The possible reason for availability to upward translocation of K by capillaries rise (Sharma *et al.*; 2009).

Reserve potassium (kg/ha) - Value (table-2) in different potato growing soils of Banasdih, Kharauni and Pitambra were showed 192.64, 215.6 and 264.6 kg/ha of Bansdih block. Sohaon, Daulatpur and Kharauni were 266, 324.8 and 313.6 kg/ha of Sohaon block and Aghaila, Kuapipara and Reoti were 327.6, 316 and 282.8 kg/ha respectively, in Reoti block. The contribution of reserve potassium to crop was relatively more in untreated plot than those receiving fertilizer K and there was close relation between K in crops and reserve K released from the soil (Ganeshamurthy and Biswas, 1988). Substantial contribution of reserve K in plant nutrient and soil K fertility management especially under continuous cropping in the absence of K inputs (Srinivas Rao *et al.;* 1999, 2001) for potassium transformation and recycling in soil.

Sodium chloride (kg/ha)- Value of NaCl extractable K (table-2) different potato growing soils of Banasdih, Kharauni and Pitambra were 78.4, 95.2 and 78.4 kg/ha of Bansdih block. Sohaon, Daulatpur and Kharauni were 151.2, 229.6 and 224.8 kg/ha of Sohaon block and Aghaila, Kuapipara and Reoti were 151.2, 95.2 and 48.4 kg/ha respectively, in Reoti block. The solubility of potassium might be depending on exchangeable amount of sodium in soil comoperatively black soil showed greater value.

Calcium chloride extractable K (kg/ha)- Content of calcium chloride extractable K in different potato growing soils of Banasdih, Kharauni and Pitambra were 156.8, 123.2 and 190.4 kg/ha of Bansdih block. Sohaon, Daulatpur and Kharauni were 224, 358.4 and 336 kg/ha of Sohaon block and Aghaila, Kuapipara and Reoti were showed 190, 128.8 and 128.8 kg/ha respectively of Reoti block. Exchangeable cations might be due to increase the availability of potassium in black soil such as Sohaon block.

Table1. General soil fertility status of potato grown soil of Ballia district, U.P.

Block/Village	Exchangeable Ca^{++}	Exchangeable Mg^{++}	$CaCO_3$ (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	O.C. (%)	pH	EC (dS/m	B.d. (Mg/m3)	WHC (%)
Bansdih Block Bansdih	7.4	9.5	0.46	282.9	18.2	168	4.12	0.86	7.4	1.02	1.13	28.56
Kharouni	9.0	10.2	0.49	260.2	18.0	246.4	5.20	0.34	7.0	1.00	1.33	32.43
Pitambra	8.4	8.3	0.39	275.2	19.6	257.6	2.98	0.84	7.3	1.00	1.43	25.41
Sohaon Block Sohaon	9.6	10.4	0.29	354.3	21.9	448	4.25	0.53	7.1	1.01	1.39	31.4
Daulatpur	10.5	10.3	0.32	288.5	20.2	649.6	6.12	0.45	7.03	0.99	1.33	34.0
Katharia	9.2	11.0	0.41	319.0	20.7	672	4.27	0.55	7.26	0.74	1.36	29.2
Reoti Block Aghila	8.0	7.5	0.44	235.2	17.20	480.4	3.37	0.47	6.9	1.02	1.30	35.33
Kuapipara	7.4	9.3	0.33	260.0	20.3	268.8	3.12	0.50	7.4	1.04	1.41	37.19
Reoti	10.0	8.4	0.27	285.8	19.4	302.4	4.15	0.46	6.96	1.03	1.31	31.80

Table-2. Potassium fraction (kg/ha) of surface soil of three block of Ballia District

Block	Village	Total K	Water Soluble K	Reserve K	NaCl Extractable K	$CaCl_2$ Extractable K
Bansdih	Bansdih	2217.6	151.2	192.64	78.4	156.8
	Kharouni	2750	218.4	215.6	95.2	123.2
	Pitambra	2112	218.12	264.6	78.4	190.4
Sohaon	Sohaon	2304	246.4	266	151.2	224
	Daulatpur	2784	281.2	324.8	229.6	358.4
	Katharia	2592	362.4	313.6	64.8	336
Reoti	Aghila	1728	202.75	327.6	151.2	190
	Kuapipara	1824	218.4	316	95.2	128.8
	Reoti	1680	202.75	282.8	78.4	128.8

Conclusion

Soil pH was greater in Bansdih block followed by Sohaon and Reoti block with in the alkaline range, soil EC had not much more varied in all village. Bulk density of soils of Bansdih block was lower than other block soils, water holding capacity of soil was greater in Reoti block as compared to Bansdih and Sohaon block's soil. The greater (0.34 – 0.86 %) amount of organic carbon was observed in Bansdih block's followed by Sohaon and Reoti block. Exchangeable Ca, Mg and $CaCO_3$ concentation in higher in soil of Sohaon among the block. Concentration of available nitrogen, available phosphorus and available potassium in surface soil were showed in considerable range in the different villages of all three blocks but available sulphur was seen in alarming levels of all blocks. Total potassium was ranged from 1784-2728 kg/ha, water soluble potassium was ranged from 151.2 – 362.4 kg/ha, reserve potassium content was ranged from 192.64 - 327.6 kg/ha, NaCl extractable K was 64.8 – 229.6 kg/ha, $CaCl_2$ extractable K was ranged from 128.8-358.7 kg/ha and ammonium acetate extractable K was ranged from 268-649.3 kg/ha, respectively in different villages of all three blocks.

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