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Forms and Distribution of Potassium Fractions in different Production Systems of Kalyana Karnataka Region

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ABSTRACT: A study was conducted to evaluate the forms and distribution of potassium fractions in different production systems. Sixty representative soil samples were collected from different production systems *viz.*, Bajra-Groundnut and Pigeonpea crop under natural farming, Maize under organic farming, Paddy-Paddy under conventional and Pigeonpea under conventional farming and soils from currently uncultivated site at 0-15 cm and 15-30 cm soil depth. Results revealed that in all the production systems Water-soluble K and Exchangeable K were highest in surface soils and Non exchangeable K, Lattice K and Total K were highest in the subsurface soils. Among different production systems all potassium fraction were high in organic farming system and compare to all potassium fractions, Lattice K contributed more towards Total K and Water-soluble K contributed less in both surface and subsurface soils of all production systems.

Keywords: Production systems, Water-soluble K, Exchangeable K, Non exchangeable K, Lattice K and Total K.

INTRODUCTION

Potassium is an essential plant nutrient and plays several roles in plants such as enzyme activation, protein synthesis, ion absorption and transport, photosynthesis and respiration. Among the major plant nutrients in the soil potassium is also the abundant one, on an average, 2.6 per cent of the earth crust is made of K, making it the seventh most abundant element and fourth most abundant mineral nutrient in the lithosphere (Schroeder, 1978).

The potassium content of Indian soils generally varies from 0.5 to 2.5 per cent with an average value of 1.52 per cent. Potassium is known to occur in a number of forms in soils *viz.*, water soluble, exchangeable, non-exchangeable, lattice and total K. The forms of K in soils in the order of their availability to plants and microbes are in solution, exchangeable, non-exchangeable and mineral forms. The distribution of potassium differs from soil to soil and is a function of dominant clay minerals present.

The different forms are known to exist in dynamic equilibrium with each other indicating that any decrease in soil solution K would be made up by the exchangeable K, which is maintained by the release of non-exchangeable K forms (Rajesh, 2003).

The study conducted with the main objective to know the distribution pattern of various potassium fractions under different production systems and their contribution to the potassium uptake by the crops grown under the respective production systems.

MATERIAL AND METHODS

A total of 60 soil samples from two depths (0-15 cm and 15-30 cm depth) were collected from soils under different production systems. The different production systems are considered for the study are *viz*. a) Uncultivated site/reference site b) Bajra cropping system under natural farming system c) Pigeonpea cropping system under natural farming system d) Maize cropping system under organic farming system e) Paddy-paddy cropping system under conventional farming and f) Conventional Pigeonpea cropping system. The collected soil samples were analysed for the various physico-chemical properties and various potassium fractions *viz.*, water soluble K, exchangeable K, non-exchangeable K, lattice K and total K through the standard procedures given by Pratt (1982).

Table 1.

Sr. No.	Site name	Location	Latitude and longitude	Type of vegetation
01	Natural farming Zone -2 plot (NFS-1)	MARS, Raichur	16° 19' N and 77° 32' E	Bajra (3 years)
02	Farmers field (Natural farming) (NFS-2)	Gadavanthi, umnabad, Bidar	17° 77' N and 77° 10' E	Pigeonpea (22 years)
03	Organic Farming plot (OFRI, MARS) (OFS)	OFRI, MARS, Raichur	16° 20' N and 77° 32' E	Maize (7 years)
04	Farmers field (Conventional farming) (CFS-1)	Tekkalakote, Siraguppa, Bellary	15° 54' N and 76° 86' E	Paddy-Paddy (9 years)
05	Farmers field (Conventional farming) (CFS-2)	Chikkahesarur, Lingasugur, Raichur	16° 11' N and 76° 62' E	Pigeonpea (3 years)
06	Uncultivated soil(outskirts of Raichur city, Near reserve forest area) (UC)	Kolanki, Raichur	16° 18' N and 77° 35' E	Perennial grass cover

Forms of Potassium. The procedure outlined by Pratt (1982) was followed.

Total Potassium. Total potassium was determined by digesting the samples with hydrofluoric acid (HF) in closed polypropylene bottles. 100 mg of soil sample was transferred into a 250 ml polypropylene bottle without sticking on to its sides. 2 ml of Aqua regia was added by means of a plastic pipette to disperse the sample. Then exactly 10 ml of hydrofluoric acid was added and shaken to dissolve the sample for a period of 2-8 hours. The white residue, present after the treatment, was dissolve in 50 ml of 6 *N* HC1 and the final volume was made up to 100 ml and subsequently used for analysis of total potassium by flame photometry.

Water Soluble Potassium (WS - K). Five grams of soil sample was taken in a 50 ml centrifuge tube and 25 ml of distilled water was added. The contents were shaken in an end-to-end shaker for one hour, centrifuged and filtered. The filtrate was used to estimate water soluble K by flame photometry.

Available Potassium (Avail. -K). Five gram of soil was taken in a 50 ml centrifuge tube and was shaken with 25 ml neutral *N* NH_4OAC for 10 minutes and filtered. The potassium in the filtrate was estimated flame photometrically.

Exchangeable Potassium (Exch. -K). It was calculated by the difference between available potassium and water soluble potassium.

Non-Exchangeable Potassium (Non-Exch - K). Two and a half gram soil sample was taken in a 100 ml beaker, to which 25 ml of 1 *N* HNO_3 was added. The contents were boiled on a hot plate for 10 minutes. After boiling, the contents were filtered and the filtrate was received in a 100 ml volumetric flask. The residue on the filter paper was washed with four portions of 20 ml of 0.1 *N* HNO_3. After dilution, the K content was determined with a flame photometer using appropriate K standards prepared in 0.1 *N* HNO_3. The content of non-exchangeable form was obtained by subtracting the quantity of K in the NH_4OAc form than in the HNO_3 extract.

Lattice Potassium. It was calculated by finding the difference between the total potassium and the sum of water soluble, exchangeable and non-exchangeable K fractions.

Plant analysis. The plants samples of the respective crops from the respective production systems were collected and analysed for the nutrient content and potassium uptake.

Potassium uptake. The uptake of potassium by grain and straw at harvest were calculated by using the following formula:

$$\text{Potassium uptake by grain (kg/ha}^{-1}\text{)} = \frac{\text{Potassium concentration (\%)} \times \text{ grain yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Potassium uptake by straw (kg/ha}^{-1}\text{)} = \frac{\text{Potassium concentration (\%)} \times \text{ straw yield (kg ha}^{-1}\text{)}}{100}$$

Total potassium uptake by the crop was computed by summing up the uptake by both grain and stover/straw.

RESULTS AND DISCUSSION

A. Water soluble potassium (WS-K)

Data pertaining to water soluble potassium in surface (0-15 cm depth) and subsurface (15-30 cm depth) soils of different production systems are given in Table 2.

Water soluble potassium was generally variable in between the production systems in both the soil depths and it varied from 9.48 to 13.49 mg kg^{-1} in 0-15 cm soil depth and from 8.87 to 12.11 mg kg^{-1} in 15-30 cm soil depth. In 0-15 cm soil depth, the highest value of mean water soluble potassium was seen in conventional farming with paddy-paddy (CFS-1) cropping pattern (13.49 mg kg^{-1}), this was followed by organic farming system following maize cropping pattern (12.72 mg kg^{-1}) and the lowest mean value of water soluble potassium was observed in natural farming system practicing pigeonpea (NFS-2) cropping pattern (9.48 mg kg^{-1}).

In 15-30 cm soil depth, the highest mean value of water soluble potassium was observed in conventional farming with paddy-paddy (CFS-1) cropping pattern (12.11 mg kg^{-1}), this was preceded by organic farming system following maize cropping pattern (11.94 mg kg^{-1}) and the lowest mean value of water soluble potassium was seen in natural farming system practicing pigeonpea (NFS-2) cropping pattern (8.87 mg kg^{-1}).

Contribution of water soluble potassium towards the total potassium was less compared to remaining forms of potassium, *i.e.* Exchangeable, non-exchangeable and lattice potassium. It was ranged from 0.08 to 0.19 per cent and 0.06 to 0.13 per cent in surface and subsurface soils respectively. The lower contribution of water soluble potassium might be due to the fact that potassium in soil solution is present in lower quantities, when compared to that on the colloids and those which are constituent of minerals (Bansal *et al.*, 2002).

In all the production systems, water soluble potassium decreased with increase in soil depth. The high content of water soluble potassium in the surface layers was mainly due to upward translocation of potassium from subsurface layers by capillary rise or due to addition of potassium through plant residues, manures and fertilizers. The low concentration of water soluble potassium is possible due to the fact that, the potassium in soil solution is utilized by crops more easily and subjected to erosion losses. Similar results were reported by research workers (Rao *et al.*, 2013 and Hebsur, 1997).

Among the different production systems, the highest water soluble potassium content was seen in CFS-1 and the lowest was seen in NFS-2 in both the surface and subsurface soil. The high content of water soluble potassium in the CFS-1 was mainly due to release of labile K from organic residues, application of K containing fertilizers and upward translocation of K from lower soil depths with capillary rise of groundwater . The low concentration of water soluble potassium in NFS-2 was due to no application of potassium fertilizers and also due to the fact that, the potassium in soil solution is utilized by crops more easily and subjected to erosion losses. Similar results were reported by Mazumdar *et al.* (2014).

B. Exchangeable potassium (Exch-K)

Data regarding to the exchangeable potassium in surface (0-15 cm depth) and subsurface (15-30 cm depth) soils of different production systems are presented in Table 2. Exchangeable potassium was generally variable in between the production systems in both the soil depths and it varied from 139.72 to 291.34 mg kg^{-1} in 0-15 cm soil depth and from 97.39 to 286.14 mg kg^{-1} in 15-30 cm soil depth. In 0-15 cm soil depth, the highest value of mean exchangeable potassium was seen in organic farming with maize cropping pattern (291.34 mg kg^{-1}).

Table 2: Distribution of potassium fractions in soils under different production systems.

Sample	WS-K (mg kg^{-1})		Exch-K (mg kg^{-1})		Non Exch-K (mg kg^{-1})		Lattice-K (g kg^{-1})		Total-K (g kg^{-1})	
	0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
NFS-1	11.35 (0.15)	9.89 (0.13)	148.13 (2.02)	112.46 (1.37)	199.41 (2.72)	255.12 (3.10)	6.97 (95.09)	7.84 (95.38)	7.33	8.22
NFS-2	9.48 (0.14)	8.87 (0.12)	139.72 (2.14)	97.39 (1.33)	187.12 (2.87)	239.31 (3.29)	6.18 (94.79)	6.93 (95.20)	6.52	7.28
OFS	12.72 (0.08)	11.94 (0.06)	291.34 (1.76)	286.14 (1.41)	1066.23 (6.43)	1232.35 (6.06)	15.21 (91.80)	18.78 (92.42)	16.57	20.32
CFS-1	13.49 (0.19)	12.11 (0.13)	192.88 (2.70)	178.49 (1.87)	670.93 (9.38)	812.55 (8.51)	6.29 (87.97)	8.53 (89.32)	7.15	9.55
CFS-2	10.47 (0.12)	9.38 (0.10)	188.96 (2.20)	186.09 (1.92)	502.01 (5.86)	542.04 (5.60)	7.83 (91.37)	8.98 (92.77)	8.57	9.68
CUS	11.86 (0.19)	10.73 (0.11)	175.85 (2.90)	188.35 (1.94)	660.73 (10.90)	502.43 (5.17)	5.21 (85.97)	9.01 (92.79)	6.06	9.71

Note: The values within the parentheses indicates the per cent contribution of different fractions of potassium to the total potassium.

This was followed by conventional farming system following paddy-paddy (CFS-1) cropping pattern (192.88 mg kg^{-1}) and the lowest mean value of exchangeable potassium was observed in natural farming system practicing pigeonpea (NFS-2) cropping pattern (139.72 mg kg^{-1}).

In 15-30 cm soil depth, the highest mean value of exchangeable potassium was observed in organic farming with maize cropping pattern (286.14 mg kg^{-1}), this was preceded by uncultivated soil (188.35 mg kg^{-1}) and the lowest mean value of exchangeable potassium was seen in natural farming system practicing pigeonpea (NFS-2) cropping pattern (97.39 mg kg^{-1}).

Contribution of exchangeable potassium towards the total potassium was less compared to non-exchangeable and lattice potassium. It was ranged from 1.76 to 2.90 per cent and 1.33 to 1.94 per cent in surface and subsurface soils respectively. This variation in contribution of exchangeable potassium might be attributed to variation in the clay and organic matter content of soils and differential release of labile K from other organic residues.

In all the production systems, exchangeable potassium decreased with increase in soil depth. This might be due to the intensive weathering of minerals, release of potassium from organic matter, application of potassic fertilizers, upward movement of ground water by capillary action and also due to higher crop residues yielding higher humus content. Similar results were reported by Singh *et al.,* 2001 and Devi *et al.,* 1990.

Among the different production systems, the highest exchangeable potassium content was seen in organic farming with maize cropping pattern and the lowest was seen in NFS-2 in both the surface and subsurface soil. The high content of exchangeable potassium in the organic farming system which might be due to comparatively more weathering, addition of potassium from organic sources and presence of high cation exchange capacity. The low concentration of exchangeable potassium in NFS-2 was due to no application of potassium fertlizers and also due to less CEC compare to all other production systems. The findings are in corroborate with the findings of Yadav *et al.,* 2019.

C. Non exchangeable potassium (Non Exch-K)

Data related to the non-exchangeable potassium in surface (0-15 cm depth) and subsurface (15-30 cm depth) soils of different production systems are presented in Table 2.

Non-exchangeable potassium was generally variable in between the production systems in both the soil depths and it varied from 187.12 to 1066.23 mg kg^{-1} in 0-15 cm soil depth and from 239.31 to 1232.35 mg kg^{-1} in 15-30 cm soil depth. In 0-15 cm soil depth, the highest value of mean non-exchangeable potassium was observed in organic farming with maize cropping pattern (1066.23 mg kg^{-1}), this was followed by conventional farming system following paddy-paddy (CFS-1) cropping pattern (670.93 mg kg^{-1}) and the lowest mean value of non-exchangeable potassium was observed in natural farming system practicing pigeonpea (NFS-2) cropping pattern (187.12 mg kg^{-1}).

In 15-30 cm soil depth, the highest mean value of non-exchangeable potassium was observed in organic farming with maize cropping pattern (1232.35 mg kg^{-1}), this was preceded by conventional farming system following paddy-paddy (CFS-1) cropping pattern (812.55 mg kg^{-1}) and the lowest mean value of non-exchangeable potassium was seen in natural farming system practicing pigeonpea (NFS-2) cropping pattern (239.31 mg kg^{-1}).

Contribution of non-exchangeable potassium towards the total potassium was ranged from 2.72 to 10.90 per cent and 3.10 to 8.51 per cent in surface and subsurface soils respectively. This variation in contribution of non-exchangeable potassium might be attributed to variation in the clay and organic matter content of soils.

In all the production systems, non-exchangeable potassium increased with increase in soil depth. Lower concentration of non-exchangeable K in surface soil than the sub-surface soil might be due to release of non-exchangeable K to compensate the water soluble and exchangeable forms as it was removed by plants and leaching losses (Dhillon *et al.,* 1985).

Among the different production systems, the highest non-exchangeable potassium content was seen in organic farming with maize cropping pattern and the lowest was seen in NFS-2 in both the surface and subsurface soil. The high content of non-exchangeable potassium in the organic farming system which might be due to the accumulation of organic matter, there could be a shift in cation exchange sites towards divalent selectivity (Salmon, 1964), which decreases percentage potassium saturation of CEC, resulting in the shift in equilibrium of non-exchangeable potassium towards exchangeable potassium, there by releasing more non-exchangeable potassium. The low concentration of non-exchangeable potassium in NFS-2 was due to less CEC compare to all other production systems. The results are in accordance with the findings of Yadav *et al.,* 2019.

D. Lattice potassium (Lattice-K)

Data pertaining to the lattice potassium in surface (0-15 cm depth) and subsurface (15-30 cm depth) soils of different production systems are shown in Table 2.

Lattice potassium was generally variable in between the production systems in both the soil depths and it varied from 5.21 to 15.21 g kg^{-1} in 0-15 cm soil depth and from 6.93 to 18.78 g kg^{-1} in 15-30 cm soil depth. In 0-15 cm soil depth, the highest value of mean lattice potassium was observed in organic farming with maize cropping pattern (15.21 g kg^{-1}), this was followed by conventional farming system following pigeonpea (CFS-2) cropping pattern (7.83 g kg^{-1}) and the lowest mean value of lattice potassium was observed in uncultivated soil (5.21 g kg^{-1}).

In 15-30 cm soil depth, the highest mean value of lattice potassium was observed in organic farming with maize cropping pattern (18.78 g kg^{-1}), this was preceded by uncultivated soil (9.01 g kg^{-1}) and the lowest mean value of lattice potassium was seen in natural farming system practicing pigeonpea (NFS-2) cropping pattern (6.93 g kg^{-1}).

Contribution of lattice potassium towards the total potassium was ranged from 85.97 to 95.09 per cent and 89.32 to 95.38 per cent in surface and subsurface soils respectively. According to Ranganathan and Sathyanarayana (1980) the lattice potassium constituted on an average of 91 per cent of total potassium in some soils of Karnataka.

In all the production systems, lattice potassium increased with increase in soil depth. Fairly high content of lattice potassium in subsurface soil layer indicates that these soils have been developed from mica-rich parent material and much of potassium is present in the mica-lattice. Similar results were reported by Kundu *et al.*, 2014.

Among the different production systems, the highest lattice potassium content was seen in organic farming with maize cropping pattern in both surface and subsurface soil and the lowest was seen in uncultivated soil in surface layer and in NFS-2 in subsurface layer. The high content of lattice potassium in the organic farming system which might be due to increase in CEC with conjoint application of organic sources (Kher and Minhas, 1991 and Yadav *et al.*, 2019). The low concentration of lattice potassium in uncultivated soil and NFS-2 was due to the variation in particle size fraction and nature of the parent material in the soils of these production systems. The results are in accordance with the findings of Ajiboye and Ogunwale, 2011.

E. Total potassium (Total-K)

Data related to the total potassium in surface (0-15 cm depth) and subsurface (15-30 cm depth) soils of different production systems are depicted in Table 2.

Total potassium was generally variable in between the production systems in both the soil depths and it varied from 6.06 to 16.57 g kg^{-1} in 0-15 cm soil depth and from 7.28 to 20.32 g kg^{-1} in 15-30 cm soil depth. In 0-15 cm soil depth, the highest value of mean total potassium was observed in organic farming with maize cropping pattern (16.57 g kg^{-1}), this was followed by conventional farming system following pigeonpea (CFS-2) cropping pattern (8.57 g kg^{-1}) and the lowest mean value of total potassium was observed in uncultivated soil (6.06 g kg^{-1}).

In 15-30 cm soil depth, the highest mean value of total potassium was observed in organic farming with maize cropping pattern (20.32 g kg^{-1}), this was preceded by uncultivated soil (9.71 g kg^{-1}) and the lowest mean value of total potassium was seen in natural farming system practicing pigeonpea (NFS-2) cropping pattern (7.28 g kg^{-1}).

In all the production systems, total potassium increased with increase in soil depth. indicating an edge over surface soil, which might be due to more organic matter and clay content. The lower value in the surface soil was due to removal of K by crop and its leaching loss paving to subsurface soil. The high content of total potassium in these soils could be due to the dominance of potassium bearing primary minerals such as mica in clay fraction. The results are in accordance with the findings of Singh *et al.* (2001).

Among the different production systems, the highest total potassium content was seen in organic farming with maize cropping pattern in both surface and subsurface soil and the lowest was seen in uncultivated soil in surface layer and in NFS-2 in subsurface layer. The high content of total potassium in the organic farming system which might be due to the addition of potassium through organic sources. Addition of organic matter also provides exchange sites for potassium. Nitrogen rates influenced total potassium content significantly probably because of higher production of root biomass, which on decomposition supply potassium to plants and result in relatively less mining of soil potassium. (Singh and Wanjari, 2012 and Yadav *et al.*, 2019). The low concentration of total potassium in uncultivated soil and NFS-2 was due to more mining of soil potassium as there is no application of potassic fertilizers. The results are in accordance with the findings of Meena *et al.* (2006).

Correlation studies between the selective soil properties and potassium fractions under organic farming system with maize cropping pattern.

Correlation matrix for selective soil properties and potassium fractions under organic farming system with maize cropping pattern in both surface (0-15 cm depth) and subsurface soil (15-30 cm depth) are shown in Table 3 and Fig. 1.

In 0-15 cm soil depth, all the potassium fractions showed negative non-significant correlation with the sand fraction. Water soluble potassium showed positive and strong significant correlation with clay (r = 0.977**), exchangeable potassium (r = 0.985**), non-exchangeable potassium (r = 0.988**), lattice potassium (r = 0.981**) and total potassium (r = 0.999**). Exchangeable potassium showed positive and highly significant correlation with the clay (r = 0.992**), non-exchangeable potassium (r = 0.998**), lattice potassium (r = 0.995**) and total potassium (r = 0.982**). Non-exchangeable potassium showed positive strong significant correlation with clay (r = 0.997**), lattice potassium (r = 0.998**) and total potassium (r = 0.984**). Lattice potassium showed positive and highly significant correlation with clay (r = 0.999**) and total potassium (r = 0.977**). Total potassium showed positive and highly significant correlation with clay (r = 0.972**). Das *et al.* (2000) and Chand and Swami, (2000) also had similar observations in their studies.

In 15-30 cm soil depth, all the potassium fractions showed negative non-significant correlation with the sand fraction. Water soluble potassium showed positive strong significant correlation with clay (r = 0.996**) and positive non-significant correlation with other potassium fractions. Exchangeable potassium showed positive and highly significant correlation with the CEC (r = 0.923*) but positive non-significant correlation with other forms of potassium. Non-exchangeable potassium showed positive and highly significant correlation with silt (r = 0.960**), lattice potassium (r = 0.982**) and total potassium (r = 0.988**). Lattice potassium showed significant and strong positive correlation with silt (r = 0.989**) and total potassium (r = 0.995**). Total potassium also showed significant and strong positive correlation with silt (r = 0.978**). The findings are in accordance with Kundu *et al.*, 2014.

The correlation studies between the potassium fractions indicated the presence of dynamic equilibrium among the potassium fractions as they are positively and highly significantly correlated with each other and the correlation analysis between the potassium fractions and selective soil properties that to with silt and clay fraction showed highly significant and positive correlation indicated their influence on the forms of potassium fractions in soil.

Potassium uptake by the plant samples grown under different production systems.

Data pertaining to the potassium uptake by the plant samples under different production systems are presented in Table 4.

Potassium uptake by the grain and straw of the bajra plant sample under natural farming system (NFS-1) is 8.93 and 68.92 kg ha^{-1} respectively and a total potassium uptake by the whole bajra plant is 77.85 kg ha^{-1}.

Potassium uptake by the pigeonpea grain and straw sample under natural farming system (NFS-2) is 1.77 and 23.91 kg ha^{-1} respectively with a total potassium uptake by the whole pigeonpea plant is 18.82 kg ha^{-1}.

Potassium uptake by the maize grain and straw sample under organic farming system is 20.20 and 122.51 kg ha^{-1} respectively with a total uptake of potassium by the whole maize plant is 178.43 kg ha^{-1}.

Uptake of potassium by the grain and straw of paddy plant sample under conventional farming system (CFS-1) is 26.85 and 110.34 kg ha^{-1} respectively with the total potassium uptake by the whole paddy plant is 137.19 kg ha^{-1}.

Uptake of potassium by the pigeonpea grain and straw sample under conventional farming system (CFS-2) is 3.88 and 43.46 kg ha^{-1} respectively with a total uptake of potassium by the pigeonpea plant is 47.34 kg ha^{-1}.

Among the different plant samples in different production systems the highest potassium uptake by the whole plant was seen in maize crop under organic farming system. This might be due to the presence of more amount of available potassium in the soil under organic farming system make its easy availability to plants and compare to other crops maize has more potassium uptake, this might be due to difference in root characteristics, growth pattern and dry matter accumulation compare to other crops in the study. The findings are similar with findings observed by Sharma *et al.* (2018).

Table 3: Correlation between the selective soil properties and the potassium fractions in surface and subsurface soils of organic farming system (OFS).

	Sand	Silt	Clay	SOC	$CaCO_3$	CEC	WSK	Exch. K	Non-Exch. K	Lattice K	Total K
WSK	-0.319	0.302	0.977**	0.451	0.073	0.226	1				
Exch. K	-0.315	0.33	0.992**	0.479	0.207	0.328	0.985**	1			
Non-Exch. K	-0.373	0.358	0.997**	0.502	0.178	0.35	0.988**	0.998**	1		
Lattice K	-0.396	0.412	0.999**	0.552	0.168	0.367	0.981**	0.995**	0.998**	1	
Total K	-0.289	0.298	0.972**	0.449	0.053	0.191	0.999**	0.982**	0.984**	0.977**	1

**. Correlation is significant at the 0.01 level (2-tailed).

	Sand	Silt	Clay	SOC	$CaCO_3$	CEC	WSK	Exch. K	Non-Exch. K	Lattice K	Total K
WSK	-0.309	0.33	0.996**	0.557	0.114	0.197	1				
Exch. K	-0.476	0.313	0.565	0.286	0.771	0.923*	0.506	1			
Non-Exch. K	-0.64	0.960**	0.249	0.852	-0.083	0.502	0.203	0.461	1		
Lattice K	-0.558	0.989**	0.247	0.903*	-0.238	0.331	0.209	0.317	0.982**	1	
Total K	-0.613	0.978**	0.199	0.877	-0.231	0.372	0.162	0.324	0.988**	0.995**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

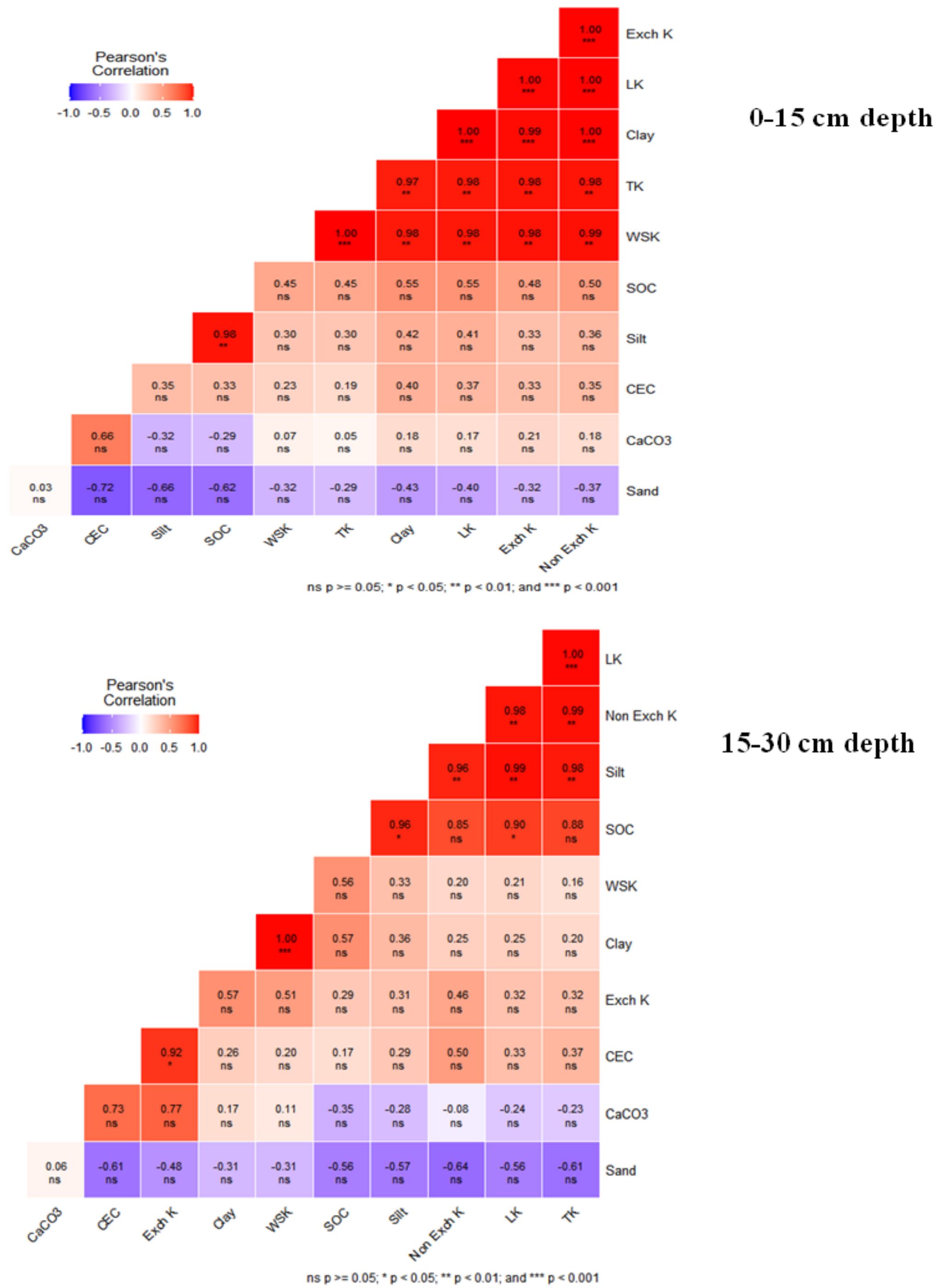

Fig. 1. Heat map illustrating the relationship between selective soil properties and potassium fractions in organic farming with maize cropping pattern.

Table 4: Potassium uptake by respective plant samples from different production systems.

Plant samples	Potassium uptake (kg ha^{-1})		
	Grain	Straw	Total K uptake
Bajra-(NFS-1)	8.93	68.92	77.85
Pigeonpea-(NFS-2)	1.77	23.91	18.82
Maize-(OFS)	20.20	122.51	178.43
Paddy-(CFS-1)	26.85	110.34	137.19
Pigeonpea-(CFS-2)	3.88	43.46	47.34

Correlation between potassium fractions in surface soil with grain and straw yield of maize crop from organic farming system (OFS)

Data pertaining to the correlation study between the potassium fractions with grain and straw yield of maize is presented in Table 5.

The grain yield is positively and significantly correlated with water soluble potassium fraction (r = 0.972**) and exchangeable potassium (r = 0.917*) in the soil. Whereas, potassium uptake by the grain showed positive correlation with all the potassium fractions in soil.

The straw yield also followed the similar trend as grain yield, it showed positive and strong significant correlation with water soluble (r = 0.984**) and exchangeable potassium fraction (r = 0.926*) in soil and potassium uptake by straw showed positive correlation with all the potassium fractions.

The grain and straw yield of maize crop from organic framing system was mainly influenced by the water soluble and exchangeable potassium fraction in soil.

Table 5: Correlation between potassium fractions in surface soil with grain and straw yield of maize crop from organic farming system (OFS).

	Grain yield	Grain K uptake	Straw yield	Straw K uptake	WSK	Exch. K	Non Exch. K	Lattice K	Total K
Grain yield	1	0.693	0.885*	0.673	0.972**	0.917*	0.860	0.848	0.658
Grain K uptake		1	0.687	0.871*	0.793	0.782	0.711	0.702	0.474
Straw yield			1	0.745	0.984**	0.926*	0.874	0.863	0.639
Straw K uptake				1	0.801	0.791	0.722	0.717	0.451

CONCLUSION

In general, the concentration of potassium in soil followed its sequence of total K > lattice K > non-exchangeable K > exchangeable K > water soluble K irrespective of production systems. Among different production systems, organic farming system with maize cropping pattern was found to be high in all the potassium fractions and natural farming system with pigeonpea cropping pattern was found to be less in all potassium fractions. Among the various potassium fractions, plants uptake mainly the water soluble potassium fraction and the crop yield was found to be more influenced by water soluble potassium fraction which was followed by exchangeable potassium fraction.

Conflict of Interest. None.

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