Biological Forum – An International Journal 15(4): 319-325(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Integrated Plant Nutrition System based Soil Test Crop Response Correlation Studies on the Potassium Fractions of Soil in a *Vertisol* of Chhattisgarh

Jyoti Bala*[*], L.K. Srivastava, Jagriti Patel, V.N. Mishra, R.K. Banwasi and Gourav Jatav
Department of Soil Science and Agricultural Chemistry,
Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), India.

(Corresponding author: Jyoti Bala[*]*)*
(Received: 15 February 2023; Revised: 15 April 2023; Accepted: 21 April 2023; Published: 20 May 2023)
(Published by Research Trend)

ABSTRACT: In an experiment conducted at the Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) with sweet corn as the main crop, various fractions of potassium in soil were analyzed, and their relationship with each other and with the potassium uptake and yield of sweet corn was studied. The experiment included 72 different treatment combinations as per the procedure for conducting a fertility gradient experiment under soil test crop response correlation approach, with four levels each of nitrogen, phosphorous and potassium fertilizers at varying levels of organic manure (farm yard manure). The results showed the order of dominance of the fractions in soil as: Lattice-K > Non-exchangeable K > Exchangeable K > Water soluble K. Exchangeable and non-exchangeable K showed the highest response due to the varying levels of fertilizer K in soil. It was observed that all the forms of K were positively and significantly correlated with each other, which supports well the dynamic equilibrium of K existing in soil. All the forms were significantly and positively correlated with the green cob yields and K uptake of sweet corn. However, non-exchangeable (r^2 value of 0.62) and exchangeable K (r^2 value of 0.63) showed highest correlations with the K uptake of sweet corn. This suggests that the non-exchangeable K and exchangeable K can be tested for fertilizer recommendation under soil test crop response correlation studies to determine the inherent supply of potassium by the soil.

Keywords: Exchangeable-K, non-exchangeable-K, lattice-K, soil test crop response correlation approach, farm yard manure.

INTRODUCTION

For balanced fertilizer use, the three main pillars are potassium (K), along with nitrogen (N) and phosphorous (P). K contributes only one-seventh of the total annual consumption of NPK fertilizers in India. India stands third in the use of NPK fertilizers in the world, with its current annual consumption at 18 million tonnes (Hassan, 2002). K is categorized as an essential, primary macronutrient with diverse functions. It activates 60 different enzymes, regulates stomata, controls water relations in the crop specifically in rainfed conditions; thus, affecting the water balance in plant systems and the sustainability and productivity of crops. The total K reserves in most of the soils are in general, large. However, only a driblet is slowly available or immediately available for uptake by the plants. In Indian agriculture, potassium has long been a neglected nutrient (Sanyal, 2014). Crops' potassium requirements are nearly comparable to their nitrogen requirements. Over extraction of K from soil as a result of a persistent imbalance between crop demand and external supply depletes the K reserve. For long-term crop yield and soil health, a well-balanced fertilizer application is required. Potassium exists in soil in several forms, including water soluble, exchangeable, non-exchangeable (fixed), and mineral K. In India, current K fertilizer recommendations based on neutral normal NH_4OAc extractable K are widely followed (Rao, 2014). Equilibrium exists among various forms, which affect the level of K in soil solution at a given time and the availability of K in plants. The distribution of these forms in soils is critical for understanding the conditions that influence their availability to the crops grown. Knowledge and understanding of K dynamics in soil has proven to be the most effective approach in recommending fertilizer for crops. Their distribution in soils and equilibrium between them determine the soil K status and supply potential of K to the plants (Rubio and Gil-Sotres 1997; Pavlov, 2007). Cropping and fertilization are the most significant factors of management that affect the equilibrium of K forms in soils (Singh *et al.*, 2002; Simonsson *et al.*, 2007). However, it is necessary to examine which fraction of K is dominantly contributing to the crop nutrition. The availability of each form of K in soil is highly influenced by soil characteristics, management practices, plant type, and environmental conditions. There are various climatic, biological, chemical and physical factors that affect the K forms and their equilibrium in soils, that are related to soil texture (Zubillaga and Conti 1994; Pal *et al.,* 2001), mineralogical composition of clays (Sharpley, 1989; Aide *et al.,* 1999; Srinivasa *et al.,* 2000; Barre *et al.,* 2008), moisture characteristics (Olk *et al.,* 1995; Zeng and Brown 2000), pH (Sahu and Gupta 1987; Uribe and Cox 1988), cation exchange capacity (Sharpley, 1990; Sardi and Csitari 1998), and concentration of other ions (Karmarkar *et al.,* 1991; Zawartka *et al.,* 1999) in the soil.

Due to increased urbanisation and industrialisation, India is in a precarious scenario where the population is growing at an alarming rate but the amount of arable land is shrinking. As a result, intensive cropping is inevitable, and food production in the future will highly depend on inorganic or chemical fertilizers for supplementing the plant nutrients, which have now become crucial for ensuring adequate food production and impeding soil productivity decline. Therefore, the challenge is sustaining growth in production of food besides maintenance of soil fertility and optimal use of natural resources. Therefore, there is a necessity of balanced fertilization to the crops. However, farmers in our country mostly apply nitrogenous fertilizers due to their simultaneous visible effect on the plants or higher costs of potassic and phosphatic fertilizers, causing the ideal nutrient consumption ratio of 4:2:1 to change into 5.2:2.1:1.0 regarding nitrogen (N), phosphorous (P) and potassium (K) (Tiwari, 2006). This results in the depletion of nutrients, of which K is mostly depleted (Krishnakumari *et al.,* 1984; Pasricha, 2002). The continuation of negative K balance results in mining of K in soil and loss of fertility of soil and sustained productivity of the arable lands. Therefore, a judicial use of organic manures and inorganic fertilizers is needed for maintenance of higher crop yields and soil fertility and sustained productivity of the lands. Lakaria *et al.* (2012) studied the different forms of potassium and their contribution towards potassium uptake under long-term maize (*Zea mays* L.)–wheat (*Triticum aestivum* L.)–cowpea (*Vigna unguiculata* L.) rotation an *Inceptisol.* They found that various forms of K and their contribution towards K uptake were affected by the use of fertilizers and intensive cropping. All the forms of K were higher under the application of NPK + FYM and 150% NPK. The results revealed that within all the forms of K, water soluble fraction predominantly contributed to the uptake of K by maize and wheat; while, the non-exchangeable form of K significantly contributed to the uptake of K by cowpea. Therefore, focussing on the above concerns, this study was conducted to determine the effect of integrated plant nutrition system on the potassium fractions of soil in a *Vertisol* of Chhattisgarh.

MATERIALS AND METHODS

Experimental details and soil characteristics. The conduction of experiment was done at the instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, during 2020-2021 and 2021-2022 in *Rabi* season. The climate of the experimental area was characterized by 1400-1600 mm of average annual rainfall and sub-humid climate. The soil was clayey textured with dark brown to black color, typical fine montmorillonitic, hyperthermic, *Udic Chromustert* and it belong to the order *Vertisol*. The location of experiment was in the east of Raipur, at 21˚ 16" N latitude and 81˚ 36" E longitude with an altitude of 298.56 meter above the mean sea level. The initialphysico-chemical properties of the soil of study area were: pH 7.5, EC 0.21 dS m^{-1}, organic carbon 5.8 g kg^{-1}, available N 224 kg ha^{-1}, available P 18.9 kg ha^{-1} and available K 495 kg ha^{-1}.

The experiments were done following the field technique proposed by Ramamoorthy *et al.* (1967) of the All India Coordinated Research project for Investigation on Soil Test-Crop Response Correlation (STCR). The field was divided into three long fertility strips: L_0, L_1 and L_2, on which no general recommended dose of fertilizer (GRD), single GRD and double GRD was imposed. The exhaust crop taken was fodder maize. After the creation of fertility gradient under exhaust crop, the fertility strips were divided into three blocks on which three levels of FYM (0, 5, 10 t ha^{-1} FYM) were superimposed across the strips. On each block 7 treatments + 1 control was imposed, resulting in a total of 21 treatment combinations + 1 control in each fertility strip. The treatment combinations consisted of 4 levels each of N (0, 60, 120, 180 kg ha^{-1}), P_2O_5 (0,30,60,90 kg ha^{-1}) and K_2O (0,30, 60, 90 kg ha^{-1}) (treatment details given in Table 1). The fertilizers applied were Urea, Diammonium Phosphate (DAP) and Muriate of Potash (MOP). At the time of sowing, phosphate and potassium fertilizers were applied, and nitrogenous fertilizers were applied as basal and then at four-leaf, eight leaf and tasseling stage of the crop. The test crop taken was sweet corn, variety Sugar-75, sown at a spacing of 70×20 cm. in each of the potswith size 5m×4m = $20m^2$.

Soil Sampling and processing. Soil samples from 0-15 cm depth were taken with the help of spade after the harvest of sweet corn from each of 72 different treatment combinations during both the cropping years (2021 and 2022). The samples were air dried, processed and sieved through a 2mm sieve for analysing the different forms or fractions of K in soil.

Soil Analysis. Soil pH was determined in a soil water suspension of 1:2.5 (Piper, 1966). EC was determined on the same samples after allowing it to settle for a duration of 4 hours and conductivity of the supernatant liquid was determined with the help of a Conductivity TDS meter 308. Following the procedure of wet chromic acid oxidation method, given by Walkley and Black (1934), the soil organic carbon was determined. The available N was determined by the procedure of alkaline potassium permanganate method, by Subbiah and Asija (1956). Available P was determined by the procedure given by Olsen et al. (1954). Available K in the soil samples were determined with the help of the neutral normal ammonium acetate (NH_4OAc) extractant method (Hanway and Heidal 1952). Water soluble K was determined in a 1:5 soil water solution shaken for 1 hour (Black, 1965), which was then analyzed in a flame photometer. The exchangeable K in soil was determined by the procedure given by Black (1965). The non-exchangeable K in soil was determined by treating the soil with 1 normal nitric acid (HNO_3) in a 1:10 soil and nitic acid (HNO_3) ratio and then boiling them at 113 °C for 10 minutes (Wood and De Turk 1941). Lattice or mineral K is defined as the fraction of K which is present at the lattice sites of minerals present in the soil. It was determined by subtracting the non-exchangeable K from total K in soil (Grewal and Kanwar 1966). The total K in soil was determined by taking 1g air dried soil in a digestion flask along with one blank and treating it with 20 ml of HNO_3 and boiling the solution at 130 °C for 5 min to oxidize the organic matter present in the soil (Hesse, 1971). After that, the solution was treated with 15 ml 60% perchloric acid and placed in the digestion chamber for boiling the solution for 15 minutes. The temperature was increased slowly to 180-200°C and the samples were digested until white dense fumes of acid appear. This procedure of heating was continued for 15-20 minutes. The solution was then allowed to cool and then 25 ml of distilled water was added in the solution. The solution was then filtered through a Whatman no. 42 filter paper into a 100 ml volumetric flask and the volume was made up to 100 ml with distilled water. 1ml of the aliquot was taken from the digested extract in a 100 ml volumetric flask and the volume was made up to 100 ml with distilled water. The total K was then analysed under flame photometer in the diluted extract.

Statistical Analysis. The analysis was performed with the help of STCR software, which is made available from the All India Coordinated Research Project on Soil Test- Crop Response Correlation, Indian Institute of Soil Science, Bhopal. Linear regression analysis was performed to test the relationship between the different levels of potassium fertilizer and the various fractions of potassium.

RESULTS AND DISCUSSION

Effect of integrated plant nutrition system on the potassium fractions of soil. The values of WSK in L_0 strip varied from 12-22 kg ha^{-1} with a mean of 17 kg ha^{-1} during Rabi season, 2020-21, and 14-25 kg ha^{-1} with a mean of 19 kg ha^{-1} during Rabi season, 2021-22 (Table 2). In L_1 strip, the values ranged from 14-29 kg ha^{-1} with a mean of 21 kg ha^{-1} during 2020-21, and 15-32 kg ha^{-1} with a mean of 23 kg ha^{-1} during 2021-22. However, the values of WSK ranged from 15-26 kg ha^{-1} with a mean of 22 kg ha^{-1} during 2020-21, and 17-30 kg ha^{-1}. with a mean of 25 kg ha^{-1} during 2021-22 in L_2 strip. All the values were significant at 5% probability level. It indicated that the values of WSK increased along the strips i.e., with the fertility gradients. WSK is that fraction of K which is present in the soil solution and is prone to be lost through leaching and runoff. This might be the reason for its low availability in the soil. Similar results of the effect of combining organic with inorganic fertilizers under STCR based yield targeted treatments were reported by Upadhayay *et al.* (2021); Kurbah *et al*. (2019). Exch-K is that fraction of K in soil, which is present in the outer edges or surfaces of clay minerals and is able to exchange with the cations present in the soil solution. In our study, Exch-K varied from 729-885 kg ha^{-1} in L_0 strip with a mean of 805 kg ha^{-1} during Rabi season, 2020-21, and it varied from 723-877 kg ha^{-1} with a mean of 797 kg ha^{-1} during Rabi season, 2021-22 (Table 2). However, in L_1 strip, the values of Exch-K ranged from 734-894 kg ha^{-1} with a mean of 816 kg ha^{-1} during 2020-21, and 744-904 kg ha^{-1} with a mean of 827 kg ha^{-1} during 2021-22. The values ranged from 738-896 kg ha^{-1} with a mean of 818 kg ha^{-1} during 2020-21, and 752-899 kg ha^{-1} with a mean of 828 kg ha^{-1} during 2021-22 in L_2 strip. The values increased along the fertility strips, although there were not much marked differences in the variability of exchangeable potassium along the strips. Upadhayay *et al.* (2021); Kurbah *et al.* (2019) have also reported on the increments in Exch-K due to STCR target yield based treatments. The values of Non-exch-K in different strips varied from 1466-1610 kg ha^{-1} with a mean of 1529 kg ha^{-1}, and 1515-1664 kg ha^{-1} with a mean of 1582 kg ha^{-1} in L_0 strip during Rabi season, 2020-21 and 2021-22 after sweet corn (Table 2). It varied from 1481-1618 kg ha^{-1} with a mean of 1535 kg ha^{-1}, and 1548-1690 kg ha^{-1} with a mean of 1605 kg ha^{-1} in L_1 strip during 2020-21 and 2021-22. In L_2 strip, the non-exch-K varied from 1501-1642 kg ha^{-1} with a mean of 1566 kg ha^{-1}, and 1580-1724 kg ha^{-1} with a mean of 1650 kg ha^{-1} during 2020-21 and 2021-22. This showed that there were less marked differences in the values of non-exch-K along the fertility strips, although the mean values increased from L_0 to L_2. The significant effect of treatment combinations of organic with inorganic fertilizers on the non-exch-K fraction of soil have been reported by Jadhao *et al*. (2018); Kurbah *et al*. (2019); Upadhayay *et al.* (2021). Lattice-K in different strips varied from 11925-17891 kg ha^{-1} with a mean of 15082 kg ha^{-1} in L_0 strip during Rabi season, 2020-21, and 12234-18351 kg ha^{-1} with a mean of 15471 kg ha^{-1} in L_0 strip during Rabi season, 2021-22. In L_1 strip, the values ranged from 12358-18202 kg ha^{-1} with a mean of 15178 kg ha^{-1} during 2020- 21, and 12593-18556 kg ha^{-1} with a mean of 15471 kg ha^{-1} during 2021-22. The values ranged from 12994-17968 kg ha^{-1} with a mean of 15367 kg ha^{-1} during 2020- 21, and 13303-18410 kg ha^{-1} with a mean of 15740 kg ha^{-1} during 2021-22. Similar results were reported by Jadhao *et al.* (2018).

The values of total K in different fertility strips varied from 13425-19495 kg ha^{-1} with a mean of 16612 kg ha^{-1}, and 13764-19988 kg ha^{-1} with a mean of 17031 kg ha^{-1} in L_0 strip during Rabi season, 2020-21 and 2021-22 (Table 2). However, in L_1 strip, the values varied from 13865-19820 kg ha^{-1} with a mean of 16713 kg ha^{-1}, and 14146-20222 kg ha^{-1} with a mean of 17052 kg ha^{-1} during 2020-21 and 2021-22. The values ranged from 14605-19525 kg ha^{-1} with a mean of 16932 kg ha^{-1}, and 14994-20046 kg ha^{-1} with a mean of 17384 kg ha^{-1} during 2020-21and 2021-22 in L_2 strip. The mean values in each strip during both the cropping years increased from L_0 to L_2 strip, although the variations were not much marked. These results were in corroboration with that reported by Jadhao *et al.* (2018). From the above data, it is clear that the dominance of different fractions of K in soil after sweet corn during both the cropping years followed: Lattice-K > Non-exchangeable K > Exchangeable K > Water soluble K. Similar kind of dominance of fractions of K have been reported by other workers like Sireesha *et al.* (2021); Majumdar *et al.* (2014).

Effect of different levels of potassium fertilizer application on various fractions of soil. The response of different levels of potassium fertilizer (0, 30, 60 and 90 kg ha^{-1}) was observed on the different fractions of K. The response was found non-significant on the water soluble, lattice and total K, as the variations due to different levels of K_2O on these fractions were found to be less than 50%. However, the effect of different levels of K_2O on the exchangeable K and non-exchangeable K was found satisfactory with 53.34% and 51.65% (R^2 = 0.53 and 0.52) variation on Exch-K during Rabi season, 2020-21 and 2021-22 (Fig. 1), and 59.18% and 51.37% (R^2 = 0.59 and 0.51) variation on Non-exch-K during 2020-21 and 2021-22 (Fig. 2) after sweet corn. WSK or soil solution K is that form of K which is taken up by the crops and soil microbes directly and is highly prone to leaching loss in soils. This might be the reason behind its lowest content among all the fractions and unsatisfactory effect of different K_2O levels. Exch-K is considered as a valid index for K removal by the crops as it is electro-statically bounded as outer-sphere complexes on the surface of clay minerals and humic compounds. Therefore, it is readily exchanged with the cations present in the soil solution and gets readily available to the plants. Figure 1 depicts the changes on Exch-K fraction due to different levels of K_2O. It indicated that there was an increment in the Exch-K with the levels of K_2O. Similar results of increase of Exch-K with the increase in levels of K application were reported by Bachkaiya (2005); Sireesha *et al*. (2021). Potassium held in the inter-lattice positions, not readily available to the plants and not exchangeable by NH_4OAc is Nex-K (Ramamoorthy and Velayutham 1976). Soil's inherent status is dependent on the rates and amount of Non-exch-K. Fig. 2 depicts the changes on Non-exch-K fraction due to different levels of K_2O. It showed that the Non-exch-K increased with increasing levels of K. This might be due to the alternate wetting and drying phenomena in *Vertisols* along with the higher concentration of Exch-K causing an increase in the transformation of Exch-K to Non-exch-K with time (Dhanorkar *et al*., 1994) or through weathering of soil minerals (montmorillonite). It might also be due to the N fertilizer addition which would have caused an increase in the concentration of NH^{4+} fertilizers in the soil solution, resulting in the displacement of K^+ ions from the site of exchange to the soil solution (Daliparthy *et al*., 1994). Similar results of increment of Non-exch-K with the increase in levels of K_2O were also reported by Bilkis *et al*. (2014); Sireesha *et al*. (2021).

Correlation studies between different fractions of K in soil, green cob yields and K uptake of sweet corn. The correlation between different fractions of K in soil with each other and with the green cob yield and K uptake of sweet corn have been determined with the help of correlation matrix (Table 3). It was observed that all the forms of K were significantly and positively correlated with each other, and with the green cob yields and K uptake of sweet corn. Similar results of positive and significant correlations among different forms of K, grain yield and K uptake of sweet corn were reported by Lakaria *et al*. (2012); Majumdar *et al.* (2014); Sharma and Paliyal (2015). The significant and positive correlations between each form of K indicates that there was a dynamic equilibrium existing between different fractions of K, which shows that each of the form affects another in a direct or indirect way. Therefore, it can be said that all the fractions of K are important for availability of K in soil in one way or the other (Girija and Badrinath 1996). Non-exch-K and exch-K were highly correlated with each other (Table 3; r value of 0.75), which indicates a constant replenishment of exch-K by non-exch-K as soon as the exch-K is removed by the crop from soil. Non-exch-K was also highly correlated with the WSK (Table 3; r value of 0.54), which shows constant fulfilment of the soil solution K by non-exch-K as soon as water soluble K is removed by sweet corn. Significant and positive correlations of different forms of K with the K uptake indicates that K uptake in sweet corn may be a function of WSK, Exc-K, Nex-K, Lattice-K and total K (Sutar *et al*., 1992; Singh and Singh 1999). This suggests that sweet corn possess a good ability to absorb the less-available fractions of K in soil. The higher response of Nex-K (r value of 0.62) and Exch-K (r value of 0.63) to K uptake indicates that the requirement of K for sweet corn is not only met through available K, but also through soil reserves K, and it can be suggested that Nex-K and Exch-K can be considered for soil test-based calibrations for fertilizer recommendations of crops (Srinivasa Rao *et al*., 2001).

Table 1: Combination of treatments in each fertility strip: 21 + 3 Control.

A	B	C
T_1: 120:90:90	T_9: 0:0:0	T_{17}: 120:60:90
T_2: 180:90:90	T_{10}: 120:90:60	T_{18}: 120:0:60
T_3: 0:0:0	T_{11}: 180:30:30	T_{19}: 180:60:30
T_4: 0:60:60	T_{12}: 180:60:60	T_{20}: 0:0:0
T_5: 180:90:30	T_{13}: 120:30:60	T_{21}: 60:60:30
T_6: 180:90:60	T_{14}: 60:60:60	T_{22}: 60:30:30
T_7: 60:30:60	T_{15}: 120:60:0	T_{23}: 120:30:30
T_8: 180:60:90	T_{16}: 120:60:60	T_{24}: 120:60:30

Table 2: Effect of IPNS on potassium fractions of soil during *Rabi* season, 2020-21 and 2021-22 after sweet. corn.

Sweet corn	Fertility Strips	WSK (kg ha^{-1})	Exch-K (kg ha^{-1})	Nex-K (kg ha^{-1})	Lattice K (kg ha^{-1})	Total K (kg ha^{-1})
2020-21	L_0 (Mean)	12-22 (17)	729-885 (805)	1466-1610 (1529)	11925-17891 (15082)	13425-19495 (16612)
	L_1 (Mean)	14-29 (21)	734-894 (816)	1481-1618 (1535)	12358-18202 (15178)	13865-19820 (16713)
	L_2 (Mean)	15-26 (22)	738-896 (818)	1501-1642 (1566)	12994-17968 (15367)	14605-19525 (16932)
	Mean	**20**	**813**	**1543**	**15209**	**16752**
2021-22	L_0 (Mean)	14-25 (19)	723-877 (797)	1515-1664 (1582)	12234-18351 (15471)	13764-19988 (17031)
	L_1 (Mean)	15-32 (23)	744-904 (827)	1548-1690 (1605)	12593-18556 (15471)	14146-20222 (17052)
	L_2 (Mean)	17-30 (25)	752-899 (828)	1580-1724 (1650)	13303-18410 (15740)	14994-20046 (17384)
	Mean	**22**	**817**	**1612**	**15561**	**17056**

Table 3: Estimates of correlation (r) between water soluble K, exchangeable K, non-exchangeable K, lattice K, total K, green cob yield and K uptake of sweet corn.

	WSK (kg ha^{-1})	Exc-K (kg ha^{-1})	Nex-K (kg ha^{-1})	Lattice-K (kg ha^{-1})	Total-K (kg ha^{-1})	Green cob yield (q ha^{-1})	K uptake (kg ha^{-1})
WSK (kg ha^{-1})	1						
Exc-K (kg ha^{-1})	0.49**	1					
Nex-K (kg ha^{-1})	0.54**	0.75**	1				
Lattice-K (kg ha^{-1})	0.48**	0.46**	0.47**	1			
Total-K (kg ha^{-1})	0.49**	0.47**	0.49**	0.99**	1		
Green cob yield (q ha^{-1})	0.62**	0.62**	0.63**	0.61**	0.62**	1	
K uptake (kg ha^{-1})	0.57**	0.63**	0.62**	0.56**	0.57**	0.95**	1

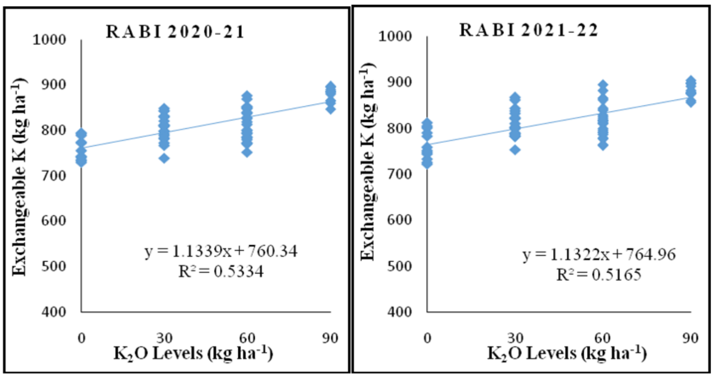

Fig. 1. Response of different levels of K_2O (kg ha^{-1}) on exchangeable-K fraction of soil after sweet corn.

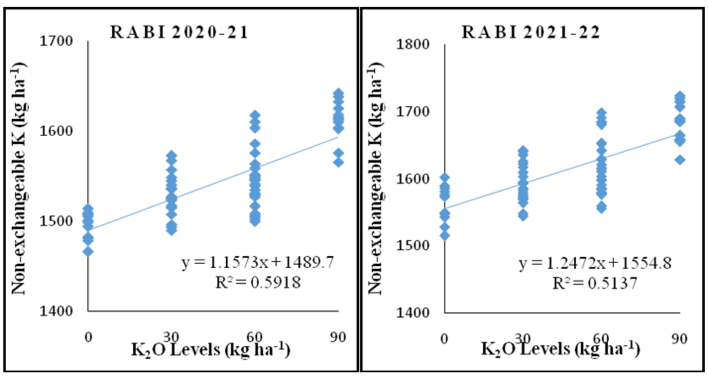

Fig. 2. Response of different levels of K_2O (kg ha^{-1}) on non-exchangeable-K fraction of soil after sweet corn.

CONCLUSIONS

The order of dominance of the fractions of K in soil was: Lattice-K > Non-exchangeable K > Exchangeable K > Water soluble K. High correlation among all the forms of K indicates the existence of dynamic equilibrium in soil. Exchangeable and non-exchangeable K fractions of soil were significantly affected by different levels of soil K as compared to the other fractions. Further, they contributed highest towards the K uptake of sweet corn. This suggests that the requirement of K for sweet corn is not only met through available K, but also through soil reserves K. Therefore, non-exchangeable and exchangeable K can be used for soil test calibration methods to determine the soil inherent K status and thus, for fertilizer recommendations.

Acknowledgement. Department of Soil Science, Indira Gandhi Krishi Vishwavidyalaya, for providing lab facilities, necessary chemicals and instruments for conduction of this research.

Conflict of Interest. None.

REFERENCES

Aide, M. T., Cwick, G. C. and Cummings, M. F. (1999). Clay mineralogy and potassium status of selected soils in the Glacial Lake Agassiz Region of Central Manitoba. *Can. J. Soil Sci., 79,* 141–148.

Bachkaiya, V. (2005). Depletion and Buildup of potassium in a *Vertisol* after third crop cycle under rice-wheat cropping system. M.Sc. (Ag.) Thesis. Indira Gandhi Agricultural University. Raipur, 58.

Barre, P., Velde, B., Fontaine, C., Catel, N. and Abbadie, L. (2008). Which 2:1 clay minerals are involved in the soil potassium reservoir? Insights from potassium addition or removal experiments on three temperate grassland soil clay assemblages. *Geoderma, 146*(1–2), 216–223.

Bilkis, S., Abedin, M. Md. J., Rafikul, I. Md. and Md, M. A. Z. (2014). Fractionation of potassium in soil amended with organic and inorganic fertilizers. *Bangladesh Journal of Progressive Science and Technology, 12*(1), 71-74.

Black, C. A. (1965). Methods of Soil Analysis. Amer. Soc. of Agro. Inc. Publ. Madison, Wisconsin, USA.

Daliparthy, J. and Barker, A. V. (1994). Potassium fractions with other nutrients in crops: A review focusing on the tropics. *J. Plant Nutr., 17,* 1859–1886.

Dhanorkar, B. A., Borkar, D. K., Puranik, R. B. and Joshi, R. P. (1994). Forms of soil potassium as influenced by long-term application of FYM and NPK in *Vertisol. Journal of Potassium Research, 10,* 42–48.

Girija, G. K. and Badrinath, M. S. (1996). Forms of potassium in surface soils under different agricultural situations in Dakshina Kannada district of Karnataka. *Agropedology, 6,* 65–74.

Grewal, J. S. and Kanwar, J. S. (1966). Forms of potassium in Punjab Soils. *Journal of the Indian Society of Soil Science 14*(1), 63–67.

Hanway, J. J. and Heidel, H. (1952). Soil analysis methods as used in Iowa State College Soil Testing Laboratory. *Iowa State College of Agriculture Bulletin 57,* 1–31.

Hassan, R. (2002). Potassium status of soils of India. *Better Crop International, 16,* 3-5.

Hesse, P. R. (1971). A textbook of soil chemical analysis. London: John Murray.

Jadhao, S. D., Arjun, D., Mali, D. V., Singh, M., Kharche, V. K., Wanjari, R. H., Kadu, P. R., Sonune, B. A. and Magare, P. N. (2018). Effect of long-term manuring and fertilization on depth wise distribution of potassium fractions under sorghum-wheat cropping sequence in *Vertisol. Journal of the Indian Society of Soil Science, 66*(2), 172-181.

Karmarkar, S. V., Dudley, L. M., Jurinak, J. J. and James, D. W. (1991). Chloride and perchlorate influence on calcium potassium and magnesium-potassium exchange. *Soil Sci. Soc. Am. J., 55,* 1268–1274.

Krishnakumari, M., Khera, M. S., & Ghosh, A. B. (1984). Studies on potassium release in an Inceptisol soil (Holambi Series) at the minimum level of exchangeable potassium. *Plant and soil, 79*, 3-10.

Kurbah, I. and Dixit, S. P. (2019). Soil potassium fractions as influenced by integrated fertilizer application based on soil test crop response under maize-wheat cropping systems in acid *Alfisol*. *International Journal of Economic Plants, 6*(1), 025-029.

Lakaria, B.L., Behera, S.K. and Singh, D. (2012). Different forms of potassium and their contributions toward potassium uptake under long-term maize (*Zea mays* L.) – wheat (*Triticum aestivum* L.) – cowpea (*Vigna unguiculata* L.) rotation on an *Inceptisol*. *Communications in Soil Science and Plant Analysis, 43*, 936–947.

Mazumdar, S. P., Kundu, D. K., Ghosh, D., Saha, A. R., Majumdar, B. and Ghorai, A. K. (2014). Effect of Long-Term Application of Inorganic Fertilizers and Organic Manure on Yield, Potassium Uptake and Distribution of Potassium Fractions in the New Gangetic Alluvial Soil under Jute-Rice-Wheat Cropping System. International Journal of Agriculture and Food Science Technology, *5*(4), 297-306.

Olk, D. C., Cassman, K. G. and Carlson, R. M. (1995). Kinetics of potassium fixation in vermiculitic soils under different moisture regimes. *Soil Sci. Soc. Am. J., 59,* 423–429.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA Circular*, *939*, 1–19.

Pal, Y., Gilkes, R. J. and Wong, M. T. F. (2001). Mineralogy and potassium release from some Western Australian soils and their size fractions. *Aust. J. Soil Res., 39,* 813–822.

Pasricha, N.S. (2002) Potassium dynamics in soils in relation to crop nutrition. *Journal of the Indian Society of Soil Science, 50,* 333-344.

Pavlov, K. V. (2007). The assessment of the potassium status of soil by the proportion between different forms of potassium. *Eurasian Soil Sci., 40*(7), 792–794.

Piper, C. S. (1966). Soil and Plant Analysis. Hans Publisher, Bombay. pp. 85-102.

Ramamoorthy, B. and Velayutham M. (1976). N, P & K in soil - chemistry, Form & availability in soil fertility – Theory & practice compiled & edited by J.S. Kanwar, I.C.A.R., New Delhi.

Ramamoorthy, B., R.L. Narasimham, and Dinesh, R. S. (1967). Fertilizer Application for Specific Yield Targets of Sonora 64 (wheat). *Indian Fmg,* 5, *17,* 43-45.

Rao, Ch. S. (2014). Potassium recommendations in Indian agriculture: Emerging concepts. *Journal of the Indian Society of Soil Science, 62,* 131–142.

Rubio, B. and Gil-Sotres, F. (1997). Distribution of four major forms of potassium in soils of Galicia (N. W. Spain). *Commun. Soil Sci. Plant Anal. 28,*1805–1816.

Sahu, S and Gupta, S. K. (1987). Fixation and release of potassium in some alluvial soils. *J. Indian Soc. Soil Sci., 35,* 35–40.

Sanyal, S. K. (2014). Potassium- The neglected major plant nutrients in soil- crop management practices. *Journal of the Indian Society of Soil Science, 62,* 117–130.

Sardi, K. and Csitari, G. (1998). Potassium fixation of different soil types and nutrient levels. *Commun. Soil Sci. Plant Anal. 29,* 1843–1850.

Sharma, U. and Paliyal, S. S. (2015). Forms of soil potassium as influenced by long term application of chemical fertilizers and organics in rainfed maize-wheat cropping system. *J. Krishi Vigyan, 3*(2), 48-53.

Sharpley, A. N. (1989). Relationship between soil potassium forms and mineralogy. *Soil Sci. Soc. Am. J., 52,*1023–1028.

Sharpley, A. N. (1990. Reaction of fertilizer potassium in soils of differing mineralogy. *Soil Sci., 149,* 44–51.

Simonsson, M., Andersson, S., Andrist-Rangel, Y., Hillier, S., Mattsson, L. and Oborn, I. (2007). Potassium release and fixation as a function of fertilizer application rate and soil parent material. *Geoderma, 140*(1–2), 188–198.

Singh, H. R. and Singh, T. A. (1999). Potassium forms and release in *Mollisols* from northern India. Advances in Plant Science Research in India *10,* 33–52.

Singh, M., Tripathi, A. K. and Reddy, D. D. (2002). Potassium balance and release kinetics of non-exchangeable K in a Typic Haplustert as influenced by cattle manure application under a soybean-wheat system. *Aust. J. Soil Res., 40,* 533–541.

Sireesha, A., Ramalakshmi, Ch. S. and Sreelatha, T. (2021). Effect of Different Levels of Potassium on Soil Potassium Fractions and on Sugarcane Yield and Quality. *Journal of Experimental Agriculture International.*

Srinivasa, R. C., Subba, R. A. and Rupa, T. R. (2000). Plant mobilization of soil reserve potassium from fifteen smectitic soils in relation to soil test potassium and mineralogy. *Soil Sci., 165,* 578–586.

Srinivasa, Rao, C., Subba Rao, A. and Rupa, T. R. (2001). Need for inclusion of non-exchangeable potassium as a measure in soil test calibration and potassium recommendations. *Fertilizer News, 46,* 31-38.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci. 25,* 259-260.

Sutar, V. S., J. H. Dongale, and A. S. Chavan (1992). Forms of potassium and evaluation of soil K test methods along with critical limits of K in laterite soils. *Journal of Potassium Research, 8,* 187–199.

Upadhayay, R., Banwasi, R., Srivastava, L. K., Khalkho, D., Jatav, G. and Patel, V. (2021). Studies on potassium fraction as influenced by nutrients management practices under rice-wheat cropping system. *International Journal of Ecology and Environmental Sciences, 3*(1), 110-113.

Uribe, E. and Cox, F. R. (1988). Soil properties affecting the availability of potassium in highly weathered soils. *Soil Sci. Soc. Am. J., 52,* 148–152.

Walkley, A. and Black, C.A. (1934). Estimation of soil organic carbon by chromic acid titration method. *Soil Sci., 47,* 29-38.

Wood, L. K. and K. K. DeTurk (1941). The adsorption of K in soil in nonexchangeable form. *Soil Science Society of America Proceedings, 5,* 152–161.

Zawartka, L., Huszcza-Ciolkowska, G. and Szumska, E. (1999). Effects of poly- and orthophosphates on the dynamics of some macro- and micro-nutrient elements in soil material of varied pH: III. Potassium. *Commun. Soil Sci. Plant Anal. 30,* 655–661.

Zeng, Q. and Brown, P. H. (2000). Soil potassium mobility and uptake by corn under differential soil moisture regimes. Plant *Soil, 221,* 121–134.

Zubillaga, M. M. and Conti, M. (1994). Importance of the textural fraction and its mineralogic characteristics in the potassium contents of different Argentine soils. *Commun. Soil Sci. Plant Anal., 25,* 479–487.

How to cite this article: Jyoti Bala, L.K. Srivastava, Jagriti Patel, V.N. Mishra, R.K. Banwasi and Gourav Jatav (2023). Effect of Integrated Plant Nutrition System based Soil Test Crop Response Correlation Studies on the Potassium Fractions of Soil in a *Vertisol* of Chhattisgarh. *Biological Forum – An International Journal, 15*(5): 319-325.