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Hina A Raghorte
Soil Science and Agricultural Chemistry section, College of Agriculture, Nagpur, Amravati Road, Nagpur, Maharashtra, India

Ommala D Kuchanwar
Soil Science and Agricultural Chemistry section, College of Agriculture, Nagpur, Amravati Road, Nagpur, Maharashtra, India

AP Sawant
Soil Science and Agricultural Chemistry section, College of Agriculture, Nagpur, Amravati Road, Nagpur, Maharashtra, India

RM Ghodpage
Soil Science and Agricultural Chemistry section, College of Agriculture, Nagpur, Amravati Road, Nagpur, Maharashtra, India

Correspondence
Ommala D Kuchanwar
Soil Science and Agricultural Chemistry section, College of Agriculture, Nagpur, Amravati Road, Nagpur, Maharashtra, India

Effect of potassium and sulphur on forms of potassium, under pigeonpea grown in vertisols

Hina A Raghorte, Ommala D Kuchanwar, AP Sawant and RM Ghodpage

Abstract
The present investigation entitled "Effect of potassium and sulphur on forms of potassium, under pigeonpea grown in Vertisols." was conducted on EAD Farm, College of Agriculture, Nagpur during kharif season of 2017-2018. The field experiment was laid out in Factorial Randomized Block Design (FRBD) with four levels of potassium (0, 15, 30 and 45 kg ha^{-1}) and four levels of sulphur (0, 10, 20 and 30 kg ha^{-1}). Results indicated that grain and straw yield; content and uptake of N, P, K and S increased with increased in rate of application of K and S. The K fractions viz., water soluble K, exchangeable K, non-exchangeable K, lattice K and total K were increased significantly with the application of 45 kg K_2O ha^{-1} and 30 kg S ha^{-1} along with the recommended dose of N and P. The improvement in soil fertility status for major nutrients and micronutrients and also quality of grain in pigeonpea was influenced due to the application of potassium and sulphur along with RDF (25:50:00) NPK kg ha^{-1}.

Keywords: Potassium, sulphur, forms of potassium, pigeonpea

Introduction
Potassium is one of the major essential nutrient element required by plants. The potassium content in the soil varies from 0.1 per cent to 3.0 per cent or even more. It is present in soil in different forms viz. water soluble, exchangeable, non-exchangeable, total and lattice potassium. Water soluble and exchangeable potassium together forms available potassium. Chemically, all these forms are in dynamic equilibrium in the soils. Soil solution K is the form taken up directly by plants and microbes and is also subject to leaching (Spark, 1980) [11]. Exchangeable K has been generally regarded as reliable index of K removed by crops. Exchangeable K is held by negative charge of organic matter and clay minerals. It is easily exchange with other cations and is readily available to plants. The non-exchangeable K is distinct from mineral K in that it is not bonded covalently within the crystal structures of soil minerals particles. Instead, it is held between adjucent tetrahedral layers of di-octahedral and tri-octahedral micas, vermiculites, and integrated by clay minerals (Sparks and Huang, 1985) [12]. Lattice K is the fraction of K that gets fixed in lattice space of the 2:1 clay minerals. This form of K is distinct from mineral K (Sparks, 1980) [11]. Major portion of soil K exists as part of mineral structure and in a fixed or non-exchangeable form. In general more than 90 per cent of the total K in the soils is found in Mineral form as structural K (Pasricha, 2002) [8]. Increasing rates of added K (0, 25, 50, 100, 200 and 400 mg kg^{-1} soil) increased K fixation in all the soil (Padole and Mahajan, 2001). Water soluble, exchangeable, available, non - exchangeable, lattice and total K were affected significantly with the different addition of level of fertilizers. All the forms of K show highly significant correlation with yield (Ravankar *et al.*, 2004) [10].

Materials and Methods
An experiment was conduct at experimental field at Exta Assistant Director (EAD) Farm of Agronomy section, College of Agriculture, Nagpur. The field experiment was laid out in Factorial Randomized Block Design (FRBD) with four levels of potassium (0, 15, 30 and 45 kg ha^{-1}) and four levels of sulphur (0, 10, 20 and 30 kg ha^{-1}). In order to study the chemical characteristics, a composite soil sample was prepared for the whole field by collecting soil samples up to 0-15 cm depth from randomly selected spots over the experimental field. This composite soil sample was analyzed for various chemical properties in order to assess the fertility status of soil. Various forms of potassium were determined by flame photometer.

Water soluble K extracted by shaking soil and water suspension (1:5) for 1 hour and K determined on flame photometer. Exchangeable K extracted by using 1 N neutral ammonium acetate, K on exchangeable complex determined with the help of flame photometer. Non-exchangeable K determining by treating with 1 N HNO_3 in (1:10) ratio and boiling for 10 minutes and K estimated with the help of flame photometer as described by Wood and Deturk, 1941. Lattice K was calculated by substracting the sum of above three fractions from the total potassium content (Ranganathan and Satyanarayana, 1980) [9]. Total K extracted by HF digestion method (Jackson, 1967) [4].

Results and Discussion

Effects of different levels of potassium and Sulphur on potassium fractions in soil

The availability of potassium to plant depends on relative mobility of the different forms of K in soil. A knowledge regarding the various form of K in soil and the condition controlling its availability to pigeonpea crop is important for the appraisal of available potassium. Therefore, it is necessary to study the transformation of applied K in different forms and their influence on the yield of pigeonpea in Vertisols. The result presented in table 1 indicate that, various potassium fractions viz., water soluble (WS K), exchangeable (EX K), non-exchangeable (NEK), lattice K (LK) and total K (TK) were significantly influenced with the various levels of potassium and sulphur.

Table 1: Effect of different levels of potassium and sulphur on potassium fractions in soil

Treatments	Water soluble K mg kg^{-1}	Exchangeable K mg kg^{-1}	Non-exchangeable K mg kg^{-1}	Lattice K mg kg^{-1}	Total K mg kg^{-1}
Levels of potassium(kg ha^{-1})					
K_0	20.7	160.7	347.7	8450.9	9041.6
K_{15}	21.5	162.4	342.2	8825.4	9249.1
K_{30}	22.3	176.0	374.7	8735.2	8924.7
K_{45}	22.4	179.8	390.5	8912.4	9539.1
SE (m)$^{\pm}$	0.45	5.61	9.24	111.5	110.0
CD at 5 %	1.30	16.2	26.6	333.8	317.8
Levels of sulphur (kg ha^{-1})					
S_0	19.8	133.8	348.5	8023.1	9308.3
S_{10}	20.6	167.8	353.7	8783.8	9309.1
S_{20}	22.4	178.8	383.4	8963.6	8998.9
S_{30}	24.1	198.8	369.5	8353.2	9358.3
SE (m)$^{\pm}$	0.45	5.61	9.24	111.5	110.0
CD at 5 %	1.30	16.2	26.6	333.8	317.8
Interaction (potassium x sulphur)					
SE (m)$^{\pm}$	1.10	13.7	22.64	283.1	269.6
CD at 5 %	3.20	39.7	65.30	817.6	778.6

Water soluble K

Water soluble K content at harvest ranged between 19.8 to 24.1 mg kg^{-1}. The higher content of water soluble K (22.4 mg kg^{-1}) was noted with the application of 45 kg K_2O ha^{-1} which foun d at par with 30 kg K_2O ha^{-1}. Increased in water soluble K might be due to increased in concentration of K in solution due to increased rate of potassium application. The highest content of water soluble K (24.1 mg kg^{-1}) was noted with the application of 30 kg S ha^{-1} which found at par with 20 kg S K_2O ha^{-1}.

Similar result were reported by Gajbhiye (1985 [3], Shrinivasrao et al. (2002). They reported that, various fertilizer treatments comprising K levels and sulphur levels along with RDF 25:50:00 NP kg ha^{-1} significantly increased the various forms of potassium.

Exchangeable K

Exchangeable K content ranged between 133.8 to 198.6 mg kg^{-1}. Almost similar trend of exchangeable K was followed as on water soluble K. The higher content of exchangeable K (179.8 mg kg^{-1}) was noted with the application of 45 kg K_2O ha^{-1} followed by application of 30 kg K_2O ha^{-1}. The lowest concentration of exchangeable K (160.7 mg kg^{-1}) was recorded with no use of K_2O.

Similar result were reported by Kadrekar (1976), More and Gawali (1999). They reported that, different levels of potassium and sulphur significantly increased exchangeable K.

Non-exchangeable K

Non-exchangeable K content ranged between 342.2 to 390.5 mg kg^{-1}. Non-exchangeable K increased with the increased rate of potassium and sulphur. The higher content of non-exchangeable K (390.5 mg kg^{-1}) was noted with the application of 45 kg K_2O ha^{-1}. The highest content of non-exchangeable K (383.4 mg kg^{-1}) was found with the application of 20 kg S ha^{-1}.

Similar result were also observed by Bhalerao and Pharande (2003). They reported that, various fertilizers treatments significantly increased non-exchangeable K.

Lattice K

Lattice K content at harvest ranged between 8023.1 to 8353.2 mg kg^{-1}. Lattice K increased with the increase in the rate of potassium and sulphur application. However, higher content of lattice (8912.4 mg kg^{-1}) was noted with the application of 45 kg K_2O ha^{-1}. The lowest content of lattice K (8450.9 mg kg^{-1}). The highest content of lattice K (8963.6 mg kg^{-1}) was found with the application of 20 kg S ha^{-1}.

Similar result were also observed by Talashikar *et al*. (2006) that, various fertilizers treatments along with RDF significantly increased lattice K.

Total K

Total K content ranged between 9041.6 to 9539.1 mg kg^{-1}. Total K increased with the increase in the rate of potassium and sulphur application. The higher content of total K (9539.1 mg kg^{-1}) was noted with the application of 45 kg K_2O ha^{1}.

The highest content of total K (9358.3 mg kg^{-1}) was found with the application of 30 kg S $ha^{-1.}$

Similar result were also observed by Bhalerao and Pharande (2003) that, various fertilizers treatments significantly increased total K. However, the sequential order of dominance of different fractions of K were lattice K >non-exchangeable K > exchangeable K and water soluble K.

Relationship among soil K fractions

Different K fractions were positively and significantly correlated with each other indicating dynamic equilibrium among various fractions of K which is shown in table 2. In case of different forms of potassium exchangeable K showed positive significant correlation with non-exchangeable K (r=0.344*) and negatively correlated with total K (r=0.307*) at 5% level. Lattice K also showed positive and significant coefficient of correlation with total K (r=0.323*) at 5% level. Similar result were also observed by Sparks and Huang (1985) [12]. They reported that, positive and significant correlation among various K fraction indicating dynamic equilibrium.

Akolkar and Sonar (1994) observed that, the application of increasing level of potash increased the grain and fodder yields. The highest response of sorghum was observed at 100 kg K_2O $ha^{-1.}$ Among the various extract used, NH_4OAC showed the highest correlation of 0.941** and 0.831** with per cent yield, fodder yield and K uptake by sorghum grains.

Table 2: Correlation between different forms of potassium

	WS-K	Ex-K	NEK	LK	TK
WS-K	1				
Exc-K	0.127	1			
Nonex-K	0.119	0.344*	1		
Lattice K	0.228	-0.205	0.024	1	
Total K	0.247	-0.307*	-0.201	0.323*	1

Conclusion

From the result it can be concluded that, the increase levels of K application also influence significantly the various fraction of K. However, the sequent order of dominant of different fractions K were lattice K> Non-exchangeable K> exchangeable K> water soluble K. Individual increasing application of either potassium or sulphur improve their own fertility status in soil.

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