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Different levels of potassium effect on potassium fractions under soybean grown on farmer's field in vertisols

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Abstract

The field experiment was conducted to assess the effect of various levels of potassium on its forms under soybean grown on farmer's field in vertisols at Kanehri, Tq. Barshitakli, Dist. Akola during Kharif 2015-16.The experiment was conducted on farmer's field comprised four treatments and six replications (one farmer as one replicant) laid out in Randomized Block Design. The treatments comprised of 30:75:00 kg NPK ha^{-1} (T_1), 30:75:30 kg NPK ha^{-1} (T_2), 30:75:60 kg NPK ha^{-1} (T_3) and 30:75:90 kg NPK ha^{-1} (T_4). The results revealed that, increasing levls of K significantly increased all the K fractions. However, highest value of water soluble K (34 mg kg^{-1}), exchangeable K (152 mg kg^{-1}), non-echangeable K (586 mg kg^{-1}), lattice K (10535 mg kg^{-1}) and total K (11305 mg kg^{-1}) were recorded with the application of 30:75:90 kg NPK ha^{-1}. The sequential order of dominance of different fractions of K were lattice K>non-exchangeable K> exchangeable K and water soluble K. The per cent contribution of different fractions of K to total K were followed in the order of lattice K (93.29 %), non-exchangeabl K (5.14 %), exchangeable K (1.32 %), and water soluble K (0.26 %). There exists positive and significant correlation among various K fractions indicating dynamic equilibrium. The contribution of non-exchangeable K to total K uptake was increase with the decrease in the rate of potassium application. The higher contribution of non-exchangeable K to total K uptake (22.39 kg ha^{-1}) was noted with the application of 30:75:00 kg NPK ha^{-1} followed by application of 30:75:30 kg NPK ha^{-1}. The higher per cent contribution (84.87%) was noted with the lower level of K application. Potassium use efficiency increase with the decrease rate of potassium application. The higher potassium use efficiency (5.24%) was noted with the lower level of K application (30 kg K_2O ha^{-1}) followed by application of 30:75:60 kg NPK ha^{-1} (3.95%).

Keywords: exchangeable k, vertisols, lattice k, soybean, non-exchangeable potassium

Introduction

K exists in four forms in soil. The forms of potassium in soil in the order of their availability to plants and microbes are soil solution K, exchangeable K, non-exchangeable K and mineral K (Martin and Sparks, 1985; Sparks and Huang, 1985) [1, 16]. All these forms are in dynamic equilibrium with each other that affect the level of soil solution K for plants. Soil solution K is generally low in quantity and ranges between 2 to 5 µg ml^{-1}. Exchangeable K and non exchangeable K levels comprise a small portion of the total K. The bulk of the total K is in mineral fractions. The concentration of K in the soil solution is enigmatic. It fluctuates greatly and is very difficult to measure. Because the soil solution is poly-ionic and is often fairy concentrated the thermo-dynamic activity. Soil solution K is the form taken up directly by plants and microbes and is also subject to leaching (Sparks, 1980) [14].

Exchangeable K has been generally regarded as reliable index of K removal by crops. Exchangeable K is held by the negative charges of organic matter and clay minerals. It is easily exchanged with other cations and is readily available to plants. Plants absorb potassium as ion from solution which temporarily disrupts the equilibrium between solution and exchangeable forms and some of the exchangeable K moves to solution to maintain the equilibrium. Exchangeable K is generally more in black cotton and vertic type soils than in alluvial, red and lateritic soils. (Sekhon *et al*., 1992) [13].

The Non-exchangeable K is distinct from mineral K in that it is not bonded covalently within the crystal structures of soil mineral particles. Instead, it is held between adjacent tetrahedral layers of di-octahedral and tri-octahedral micas, vermiculites, and intergraded clay minerals (Rich, 1972; Sparks and Hunang, 1985; Sparks, 2000) [12, 16, 15]. Non-exchangeable K is moderately to sparingly available to plants, depending on various soil parameters.

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Release of non-exchangeable K to the exchangeable form occurs when levels of exchangeable and soil solution K are decreased by crop removal or leaching.

Exhaustive work has been carried out by many works on various forms K as a result of various nutrient management practices and levels of K (Gajbhiye, 1985, Shrinivas Rao *et al.* 2002 and Jadhao *et al.* 2015) [2, 17, 4]. However, limited work has been carried out to study the effect of levels of K along with common practices of N and P under soybean grown on farmer's field in vertisols. In view of the above, the present experiment was proposed.

Materials and Methods

Field experiment on soybean was conducted on farmer's field at Kanehri, Tq. Barshitakli, Dist. Akola during Kharif 2015-16 on effect of various levels of potassium on its forms under soybean grown on farmer's field in Vertisols. The experiment comprised four treatments and six replications as a siix farmer's laid out in Randomized Block Design. The treatments comprised of T_1 - 30:75:00 kg NPK ha^{-1}, T_2 - 30:75:30 kg NPK ha^{-1}, T_3 - 30:75:60 kg NPK ha^{-1} and T_4 - 30:75:90 kg NPK ha^{-1}.

The representative soil samples from the farmer`s field were collected by using soil auger. The soil samples were air dried in shade and ground to passe through 2 mm sieve. The processed samples were well mixed and stored in clean cloth bags with proper labels for subsequent analysis.

Various forms of potassium were determined by flame photometre. Water soluble K Extracted by shaking soil and water suspension (1:5) for 1 hour and K determined on Flame Photometer (Pratt, 1965) [10]. Exchangeable K extracted by using 1N neutral ammonium acetate, K on exchangeable complex determined with flame photometer (Knudsen *et al,* 1982) [7]. Non-exchangeable K determined 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 subtracting the sum of above three fractions from the total potassium content (Ranganathan and Satyanarayana, 1980) [11]. Total K extracted by HF digestion method (Jackson, 1967) [3].

Contribution of non-exchangeable K to total K uptake = {(Total K uptake + Available K) – Fertilizer K addition – Initial K status}.

$$\text{Percentage contribution (\%)} = \frac{\text{Contribution of non-exchangeable K}}{\text{Total K uptake}} \quad \text{X } 100$$

$$\text{Potassium use efficiency (KUE)} = \frac{\text{(Yield with K applied – Yield without K applied)}}{\text{Amount of K applied}} \quad \text{X } 100$$

Results and Discussion

Effect of different level of potassium 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 soybean crop is important for the appraisal of the available potassium. Therefore, it is necessary to study the transformation of applied K in different forms and their influence on the yield of soybean in vertisols.

Water soluble K

Water soluble K content at harvest ranged between 26 to 34 mg kg^{-1}**.** Water soluble K increased with the increase in the rate of potassium application. The higher content of water soluble K (34 mg kg^{-1}) was noted with the application of 30:75:90 kg NPK ha^{-1} followed by application of 30:75:60 kg NPK ha^{-1} which was to the extent of 30 mg kg^{-1}. The lowest value of water soluble K (26 mg kg^{-1}) was recorded with the treatment of 30:75:00 kg NPK ha^{-1}. Increase in water soluble K might be due to increase in concentration of K in solution due to increased rate of potassium application.

The contribution of water soluble K to total K ranged between 0.24% to 0.30% indicating almost least contribution in comparison with other K fractions.

Similar results were reported by Gajbhiye (1985) [2], Shrinivas Rao *et al.* (2002) [17] and Jadhao *et al.* (2015) [4] they reported that various fertilizer treatments comprising K levels significantly increased the various forms of potassium.

Exchangeable K

Exchangeable K content ranged between 139 to 152 mg kg^{-1}**.** Almost similar trend of exchangeable was followed on was water soluble K. The higher content of exchangeable K (152 mg kg^{-1}) was noted with the application of 30:75:90 kg NPK ha^{-1} followed by application of 30:75:60 kg NPK ha^{-1}. The lowest concentration of exchangeable K (139 mg kg^{-1}) was recorded with the treatment of 30:75:00 kg NPK ha^{-1}. The increasing levels of K application might have been the reason for the higher concentration of exchangeable K.

The contribution of exchangeable K to total K ranged between 1.29% to 1.35% which was slightly higher as compared to water soluble K.

Similar results were reported by Kadrekar (1976) [6], More and Gawali (1999) [9], Jawanjal (2002) [5] and Jadhao *et al.* (2015) [1] they reported that various fertilizer treatments significantly increased exchangeable K.

Non-exchangeable K

Non-exchangeable K content ranged between 549 to 586 mg kg^{-1}. Non-exchangeable K increased with the increased rate of potassium application. The higher content of non-exchangeable K (586 mg kg^{-1}) was with the application of 30:75:90 kg NPK ha^{-1} followed by application of 30:75:60 kg NPK ha^{-1}. The lowest concentration of non-exchangeable K (549 mg kg^{-1}) was recorded with the treatment of 30:75:00 kg NPK ha^{-1}.

The contribution of non-exchangeable K to total K indicate that, this form of K appreciably contributed to total pool indicating fixation of K in the interlayer, which suggest need of application of organics, which helps in release of K.

The increase in non-exchangeable K with the application of 30:75:90 kg NPK ha^{-1} was 6.5% higher over 30:75:00 kg NPK ha^{-1}, whereas 4.64% over 30:75:30 kg NPK ha^{-1} indicating increasing levels of K also found beneficial in improving non-exchangeable K pool of soil.

Similar results were also observed by Bhalerao and Pharande (2003) [1], Talashikar *et al.* (2006) [18] and Jadhao *et al.* (2015) [4] they reported that various fertilizer treatments significantly increased non-exchangeable K.

Lattice K

Lattice K content at harvest ranged between 10047 to 10535 mg kg^{-1}. Lattice K increased with the increase in the rate of potassium application. However, higher concentration of lattice K (10535 mg kg^{-1}) was noted with the application of 30:75:90 kg NPK ha^{-1} followed by application of 30:75:60 kg NPK ha^{-1} i.e. 10351 mg kg^{-1}. The lowest content of lattice K (10047 mg kg^{-1}) was recorded with the treatment of 30:75:00 kg NPK ha^{-1}. The contribution of lattice K to total K was found to be 93.19% to 93.36% indicating lattice or mineral K is the dominant K fractions, which contributed substantially to total K.

Similar results were also observed by Bhalerao and Pharande (2003) [1], Talashikar *et al.* (2006) [18] and Jadhao *et al.* (2015) [4] who reported that various fertilizer treatments significantly increased lattice K.

Total K

Total K content ranged between 10762 to 11305 mg kg^{-1}**.** Total K increased with the increase in the rate of potassium application. The higher content of total K (11305 mg kg^{-1}) was noted with the application of 30:75:90 kg NPK ha^{-1} followed by application of 30:75:60 kg NPK ha^{-1}. The lowest content of total K (10762 mg kg^{-1}) was recorded with the treatment of 30:75:00 kg NPK ha^{-1}.

Similar results were also observed by Bhalerao and Pharande (2003) [1], Talashikar *et al.* (2006) [18] and Jadhao *et al.* (2015) [4] who reported that various fertilizer 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 (Spark and Huange, 1985) [16]. Higher degree of correlation of was noted among lattice-K and total K (r=0.999**) followed by non-exchangeable K and total K (r=0.964**) indicating lattice K and non-exchangeable K is that pool, which is closely associated with total K

Contribution of non-exchangeable K to total K uptake

The contribution of non-exchangeable K to total K uptake ranged between 22.39 to 2.60 kg ha^{-1}. The higher contribution of non-exchangeable K to total K uptake (22.39 kg ha^{-1}) was noted with the application of 30:75:00 kg NPK ha^{-1} followed by application of 30:75:30 kg NPK ha^{-1}. The lowest contribution of non-exchangeable K to total K uptake (2.60 kg ha^{-1}) was recorded with the treatment of 30:75:90 kg NPK ha^{-1} which indicate that contribution of non-exchangeable K to total K uptake increase with the decrease in the rate of potassium application.

The per cent contribution ranged between 84.87% to 9.87%. The higher per cent contribution (84.87%) was noted with the lower level of K application followed by application of 30:75:30 kg NPK ha^{-1} (29.29%). The least contribution (9.87 % kg ha^{-1}) of non-exchangeable K to total K uptake was recorded with the application of 30:75:90 kg NPK ha^{-1} indicating negligible replenishment of water soluble and exchangeable K from non-exchangeable post of K due to higher K status under such treatment.

Potassium use efficiency

Potassium use efficiency ranged between 3.36 to 5.24 %.The higher potassium use efficiency (5.24%) was noted with the lower level of K application (30 kg K_2O ha^{-1}) followed by application of 30:75:60 kg NPK ha^{-1}. The lowest potassium use efficiency (3.36%) was recorded with the treatment of 30:75:90 kg NPK ha^{-1} indicate that potassium use efficiency increase with the decrease in the rate of potassium application. The higher use efficiency is always observed at lower levels of fertilizer application indicating response to particular applied nutrient.

Table 1: Effect of different levels of potassium on potassium fractions at harvest of soybean

Treatments	Potassium fractions (mg kg^{-1})				
	WS. K	**Ex. K**	**Non-Ex. K**	**Lattice K**	**Total K**
T_1 - 30:75:00 kg NPK ha^{-1}	26	139	549	10047	10762
T_2 - 30:75:30 kg NPK ha^{-1}	27	143	560	10195	10925
T_3 - 30:75:60 kg NPK ha^{-1}	30	146	572	10351	11098
T_4 - 30:75:90 kg NPK ha^{-1}	34	152	586	10535	11305
SE(m)±	0.43	4.03	1.76	29.68	27.96
CD at 5%	1.31	12.07	5.32	89.45	84.28

Table 2: Effect of different levels of potassium on contribution of different forms of K to total K

Treatments	Potassium fractions (mg kg^{-1})			
	WS. K	**Ex. K**	**Non-Ex. K**	**Lattice K**
T_1 - 30:75:00 kg NPK ha^{-1}	0.24	1.29	5.10	93.36
T_2 - 30:75:30 kg NPK ha^{-1}	0.25	1.31	5.13	93.31
T_3 - 30:75:60 kg NPK ha^{-1}	0.27	1.31	5.15	93.27
T_4 - 30:75:90 kg NPK ha^{-1}	0.30	1.35	5.18	93.19

Table 3: Relationship among soil K fractions

	WS-K	Ex.-K	Av.-K	NEK	LK	TK
WS-K	1.000					
Ex.-K	0.600**	1.000				
Av.-K	0.786**	0.964**	1.000			
NEK	0.630**	0.555**	0.640**	1.000		
LK	0.545**	0.514*	0.585**	0.866**	1.000	
TK	0.572**	0.546**	0.618**	0.964**	0.999**	1.000

* Significant at 5% level ** Significant at 1% level

Table 4: Contribution of non-exchangeable K to total K uptake

Treatments	Contribution of non-exchangeable K to total K uptake				
	Yield (q ha^{-1})		**Contribution of non-exchangeable K to total K uptake (Kg/ha)**	**Percent contribution (%)**	**KUE (%)**
	Grain	**straw**			
T_1 - 30:75:00 kg NPK ha^{-1}	14.19	21.02	22.39	84.87	-
T_2 - 30:75:30 kg NPK ha^{-1}	15.76	25.06	11.53	29.29	5.24
T_3 - 30:75:60 kg NPK ha^{-1}	16.56	26.37	5.06	10.24	3.95
T_4 - 30:75:90 kg NPK ha^{-1}	17.21	27.04	2.60	9.87	3.36

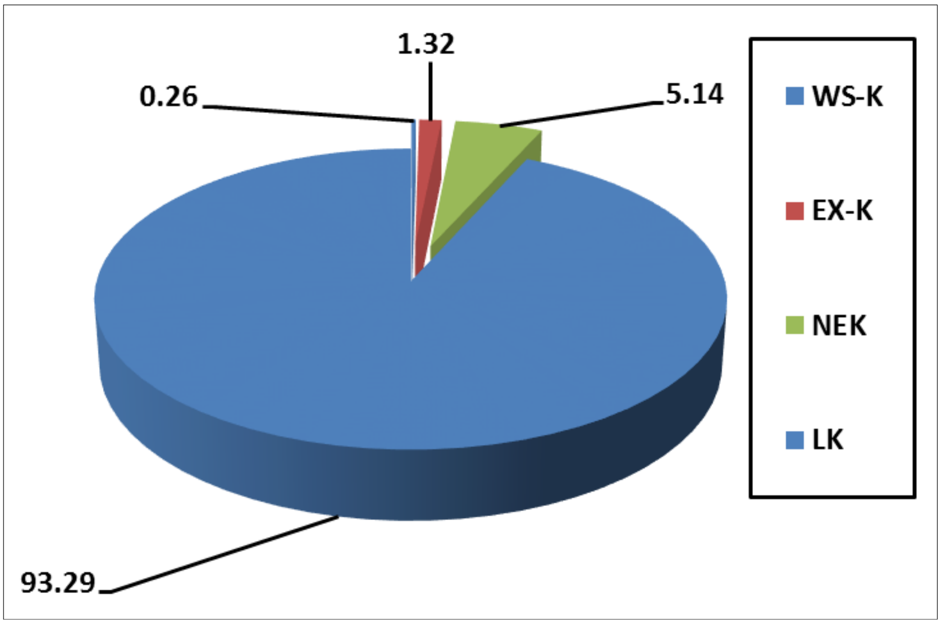

Fig 1: Contribution of different potassium fractions to total K

Conclusion

From the present study, it can be concluded that, application of 30:75:90 kg N, P_2O_5 AND K_2O ha^{-1} significantly increase all the K fractions, over rest of the treatments. Thus, the sequential order of dominance of different fractions of K were lattice K (LK) > non-exchangeable K (NEK) > exchangeable K (Ex. K) > water soluble K (WS K). There exists a significant and positive correlation among different forms of K. The K use efficiency and contribution of non-exchangeable to total K uptake was observed at lower levels of K application.

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