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RESEARCH ARTICLE :

Effect of tillage and integrated nutrient management on potassium fractions in Vertisol under rainfed cotton

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SUMMARY : The experiment was carried out at Research Farm of Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2015 to study the effect of tillage and integrated nutrient management on potassium fractions in Vertisol under rainfed cotton. The experiment was laid out in randomized block design with sixteen treatment combinations with three replications. The treatments consisted of tillage (conservation and conventional),integratednutrient management comprised of eight treatments involving FYM, crop residues, *in situ* green manuring of sunhemp, glyricidia leaf manuring in combination with inorganic fertilizers and 100 per cent RDF (60:30:30 kg N, P_2O_5 and K_2O ha^{-1}). The results revealed that, the various treatments significantly increased the various forms of potassium.Significantly highest water soluble, exchangeable, lattice and total Kcontent of soil and highest potassium use efficiency was recorded with application of 50% N through FYM + remaining RD through chemical fertilizers.Significantly highest percentage contribution to total potassium uptake by cotton was observed in the treatment with application of 100% RDF (60:30:30 NPK kg ha^{-1}).

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BACKGROUND AND OBJECTIVES

Potassium (K)is the important essential element required for plant growth which exists in dynamic equilibrium in four forms viz., water soluble, exchangeable, non-exchangeable and lattice K, of which the first two are important for the growth of higher plants and microbes (Singh *et al.*, 2010). Water soluble K is taken up directly by plants. Exchangeable K has been generally regarded as reliable index of K removal by crops. This is followed by further release of exchangeable K from non-exchangeable form. Non-exchangeable K trapped between layers of expanding lattice clays and lattice-K, an integral part of primary K bearing minerals. The dynamics of K in soil depends on the magnitude of equilibrium among various forms which have relationship with physico-chemical properties (Sharma *et al*., 2009). The available K constitutes only 1-2% of total K and exists in soil in two forms *i.e.* water soluble and exchangeable K adsorbed on soil colloidal surface (Brady and Well, 2002). Soil solution K is the form of K that is directly taken up by plants and microbes and also is the form subject to most leaching in soil.Dynamic equilibrium affected when applied K is either taken up by plants or leached into the lower soil horizons or converted into unavailable form. Under this situation, non-exchangeable K playsan important role by releasing K to exchangeable and solution forms. The dynamics of K in soil depends on the rate of application and mining of K from the system (Sawarkar *et al*., 2013). In view of this, the present study was carried out to assess the effectof tillage and integrated nutrient management on potassium fractions in Vertisol under rainfed cotton.

RESOURCES AND METHODS

The experiment was conducted during *Kharif* 2015. The soil of the experimental site was clay in texture, deep to very deep and classified as Typic Haplusterts (Vertisol), moderately alkaline in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid outin Randomized Block Design with sixteen treatment combinations with three replications. The treatments consisted of tillage (conservation and conventional) and integrated nutrient management*viz.*,T_1:100% RDF (60:30:30 NPK kg ha^{-1}), T_2:50% RDF + *in situ* green manuring (sunhemp), T_3:50% N through FYM + remaining RD throughchemicalfertilizers,T_4:50% N through wheat straw +remaining RD through chemical fertilizers,T_5:50% Nthrough GLM (glyricidialeaf manuring) + remaining RD through chemical fertilizers, T_6: 25% N (FYM) + 25% N (wheat straw) + remaining RD through chemical fertilizers,T_7:25% N (FYM) + 25% N (GLM) + remaining RD through chemical fertilizers, andT_8:25% N (wheat straw) + 25% N (GLM) + remaining RD through chemical fertilizers.The conventional tillage included one ploughing, one harrowing, two hoeing + two hand weeding,while conservation tillage included one harrowing, two hand weeding.

The soil samples (0-20 cm depth) were collected by using soil auger after harvest of cotton. These samples were dried and grinded for analysis ofvarious parameters as per standard methods (Jackson, 1973).These samples were analyzed for water soluble, exchangeable,non-exchangeable, lattice and total K. The water soluble K was estimated in 1:5 (soil: water suspension) as described by Black (1965), exchangeable K was extracted by neutral ammonium acetate (1 N) extraction in 1:5 ratio. Non-exchangeable K was estimated by boiling soil with 1N HNO_3 extractable K in 1:10 (soil:acid suspension) for 10 min as described by Black (1965). For the total K determination, soil was digested with hydrofluoric (48%) and perchloric(70-72%) acid in platinum crucible by the method outlined by Black (1965) and estimated in solution after digestion. Lattice K was estimated by difference between total K and sum of water soluble, exchangeable and non-exchangeable K (Ranganathan and Satyanarayana, 1980).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Distribution of Potassium fractions :

The effect of tillage on potassium fractions status of soil was significant. Significantly higher value of water soluble potassium (10.64 mg kg^{-1}), exchangeable potassium (152.39 mg kg^{-1}), non-exchangeable potassium (711.02 mg kg^{-1}), lattice potassium (11099.76 mg kg^{-1}) and total potassium (11973.81 mg kg^{-1}) was observed in conservation tillage as compared to conventional tillage (Table 1). The effect of integrated nutrient management on potassium fractions was significant. Significantly highest water soluble potassium (11.14 mg kg^{-1}), exchangeable potassium (163.61 mg kg^{-1}), lattice potassium (11378.58mg kg^{-1}) and total potassium (12325.58 mg kg^{-1}) was recorded with the application of 50% N through FYM + remaining RD through chemical fertilizers followed by treatment T_5 *i.e.* 50% N through GLM + remaining RD through chemical fertilizers was statistically at par. The increase in water soluble K under 50% N through FYM + remaining RD through chemical fertilizers over the 100% RDF might be due to addition of organic material.Yaduvanshi *et al*. (2013) reported that available K comprising water soluble K increased in treatments receiving GM or FYM. Such increase in status of available and solution forms of K with NPK + FYM may be due to stimulating effect of FYM in reducing K fixation, thereby bringing in more K into available form.FYM addition could increase the CEC of soil which was responsible for holding more amount of exchangeable K and helped in the release of exchangeable K from non-exchangeable pool (Yaduvanshi and Swarup, 2006). Sawarkar *et al.* (2013) while studying distribution of potassium fractions under soybean-wheat cropping system also reported that non-exchangeable potassium in the range of 736 to 885 mg kg^{-1} in Vertisols. The result on total potassium fraction (Table 1) studies showed that long-term addition of fertilization and manuring had depletion effect on total potassium level of soil after harvest of cotton. FYM, glyricidia and wheat straw in conjunction with NPK increase the total potassium may be attributed to the biochemical reactions which might have been helpful in converting the non-exchangeable potassium to exchangeable potassium and thereby total potassium. These results are in agreement with the findings of Sawarkar *et al.* (2013); Singh *et al.* (2014) and Jadhao *et al.* (2015).

Correlation among soil potassium fractions :

The correlations were worked out in order to assess relationship among various forms of potassium (Table 2).The correlation among all the forms of K was significant and positively correlated with each other. Thus, it indicates that all forms of K maintained a dynamic equilibrium (Sparks and Huang, 1985). Comparatively high degree of correlation of available K with exchangeable K (r=0.927**) showed that rapid establishment of equilibrium between these forms and soil exchangeable phase played more significant role in regulating the availability of K, followed by Total K and Lattice K (r=0.912**). Significant relationship among different K fractions has been reported by Srinivasrao *et al.* (2002). Significantly positive relationship between exchangeable K and labile K in smectite dominant soils (r=0.97) was reported by Singh *et al*. (2006). Similar type of correlation was reported by Jadhao *et al*. (2015).

Contribution of non-exchangeable potassium to total uptake by cotton :

The data pertaining to contribution of non-exchangeable potassium to total K uptake by cotton is presented in Table 3.The effect of tillage on contribution of non-exchangeable K to total potassium uptake by cotton was significant. Significantly higher contribution of non-exchangeable K was observed in conservation tillage (705.70 kg ha^{-1}) as compared to conventional tillage (694.52 kg ha^{-1}).

Table 1 : Effect of tillage and integrated nutrient management on potassium fractions after harvest of cotton

Treatments	Forms of potassium (mg kg^{-1})					
	WS K	EX K	AV K	NEK	Lattice K	Total K
Tillage						
Conservation tillage	10.64	152.39	163.03	711.02	11099.76	11973.81
Conventional tillage	10.48	149.02	159.50	700.19	11008.18	11867.86
S.E. ±	0.05	1.58	1.58	6.89	15.90	14.24
C.D. (P=0.05)	0.15	NS	NS	NS	45.89	41.11
Integrated nutrient management						
100% RDF (60:30:30 NPK kg ha^{-1})	9.62	134.71	144.33	647.54	10500.98	11292.85
50% RDF + *in situ* green manuring (sunhemp)	10.30	144.44	154.74	634.59	10627.35	11416.68
50% N (FYM) + Compensation RDF	11.14	163.61	174.75	772.25	11378.58	12325.58
50% N (wheat straw) + Compensation RDF	10.77	152.98	163.75	728.59	11304.67	12197.00
50% N (GLM) + Compensation RDF	10.86	159.34	170.19	740.74	11403.03	12313.97
25% N (FYM)+ 25% N (wheat straw) + Compensation RDF	10.61	150.40	161.01	701.52	11025.43	11887.97
25% N (FYM)+ 25% N (GLM) + Compensation RDF	10.57	150.58	161.15	711.65	11181.82	12054.62
25% N (wheat straw)+ 25% N (GLM) + Compensation RDF	10.61	149.57	160.18	707.95	11009.88	11878.02
S.E. ±	0.11	3.16	3.17	13.78	25.23	28.48
C.D. (P=0.05)	0.31	9.11	9.15	39.79	87.53	82.23
Interaction effect	NS	NS	NS	NS	NS	NS

NS=Non-significant

The effect of integrated nutrient management on contribution of non-exchangeable K tototal K uptake by cotton was significant. Significantly higher contribution of non-exchangeable K (739.57 kg ha^{-1}) was observed in the treatment with application of 50% N through FYM + remaining RD through chemical fertilizer (T_3) followed by 725.94 kg ha^{-1} with application of 50% N through GLM remaining RD through chemical fertilizers (T_5) which were statistically at par. The lowest per cent contribution of non-exchangeable K to total potassium uptake by cotton (655.40 kg ha^{-1}) was recorded in treatment T_1 *i.e.* 100% RDF through chemical fertilizers.Contribution of non-exchangeable K towards K uptake by crop was above 90% in the absence of applied K, which decreases with use of applied K. The per cent contribution of non-exchangeable K found to be increased with decrease in soil available K in treatments. The per cent contribution was higher under 100% RDF and wheat straw compensation treatments because of less availability of available K. The per cent contribution was lower under FYM and GLM treated plots because of high availability of available K. Similar observations were made by Subba Rao *et al.*(1993), Rupa *et al.* (2003), and Jadhao *et al.* (2015).

Potassium use efficiency :

The effect of tillage on potassium use efficiency was non-significant(Table 3). Numerically higher value of potassium use efficiency was observed in conventional tillage (8.29 kg per kg K) as compared to conservation

Table 2 : Correlation co-efficient (r) among soil potassium fractions

	WS K	Ex. K	Av. K	N.E. K	Lat. K	Total K
WS K	1.000					
Ex. K	0.696**	1.000				
Av. K	0.719**	0.927**	1.000			
N.E. K	0.687**	0.494**	0.509**	1.000		
Lat. K	0.776**	0.737**	0.749**	0.707**	1.000	
Total K	0.796**	0.743**	0.755**	0.773**	0.912**	1.000

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Effect of tillage and integrated nutrient management on potassium use efficiency and contribution of non-exchangeable K to total K uptake

	Treatments	Potassium use efficiency (kg yield per kg fertilizer)	Contribution of non-exchangeable K to Total uptake (kg ha^{-1})	Percent contribution of non-exchangeable K
Tillage				
I	Conservation tillage	7.51	705.70	19.91
II	Conventional tillage	8.29	694.52	21.59
	S.E. ±	0.54	3.64	0.44
	C.D. (P=0.05)	NS	10.50	1.28
Integrated nutrient management				
T_1	100% RDF (60:30:30 NPK kg ha-1)	-	655.40	24.91
T_2	50% RDF + *insitu* green manuring (sunhemp)	8.52	687.78	22.39
T_3	50% N (FYM) + Compensation RDF	11.10	739.57	17.02
T_4	50% N (wheat straw) + Compensation RDF	8.08	702.11	20.89
T_5	50% N (GLM) + Compensation RDF	11.32	725.94	18.66
T_6	25% N (FYM)+ 25% N (wheat straw) + Compensation RDF	6.09	696.87	21.12
T_7	25% N (FYM)+ 25% N (GLM) + Compensation RDF	6.14	701.29	19.99
T_8	25% N (wheat straw) + 25% N (GLM) + Compensation RDF	4.03	691.97	23.54
	S.E. ±	1.09	7.27	0.89
	C.D. (P=0.05)	3.13	21.00	2.57
	Interaction effect	NS	NS	NS

NS=Non-significant

tillage (7.51 kg per kg K). The effect of integrated nutrient management on potassium use efficiency was significant. Significantly the highest potassium use efficiency (11.32 kg per kg K) was observed in the treatment with application of 50% N through GLM + remaining RD through chemical fertilizers (T_5)followed by treatment 50% N through FYM + remaining RD through chemical fertilizers (11.10 kg per kg K) which were statistically at par.The lowest potassium use efficiency was recorded in treatment T_1 *i.e.* 100% RD through chemical fertilizers.

Conclusion :

From the present study, It can be concluded that, application of 50% N through FYM + remaining RD through chemical fertilizers under conservation tillage resulted inimprovement in potassium fractions and potassium use efficiency of cotton grown inVertisols under rainfed condition.

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