Original Research Article

Effect of long-term application of organic, inorganic and integrated nutrients on soil potassium fractions in a Vertisol of central India

ABSTRACT

Thepresentstudywas conductedat the experimental field of CollegeofAgriculture,Indoreduring2018-2019.Soybean (cv. JS-9305), was grown with 80 kg ha^{-1} seed rate with row to row and plant to plant spacing of 40 cm X 5 cm. Soybean crop was grown as per standard cultural practices. The experiment was conducted with nine treatments viz., T1- unfertilized control, T2-20 kg N + 13 kg P ha^{-1}, T3- 30 kg N + 20 kg P ha^{-1}, T4- 40 kg N + 26 kg P ha^{-1}, T5- 60 kg N + 35 kg P ha^{-1}, T6- 6 t ha^{-1} FYM + 20 kg N + 13 kg P, T7- 5 t ha^{-1} crop residues + 20 kg N + 13 kg P, T8- 6 t ha^{-1} FYM and T9- 5 t ha^{-1} crop residues (CR) laid out in a randomized block design (RBD) having three replications. Different K fractions in soil sample viz., water soluble-K, available-K, exchangeable-K, non-exchangeable-K, lattice-K and total-K were determined following standard methods. The mean values were grouped for comparisons and the least significant differences among them were calculated at $p<0.05$ confidence level using ANOVA statistics.The results of present study revealed that to sustain K status inVertisolthereisaneedofKapplicationalongwithorganic manure/crop residue.Theapplication of organics with and without N and P application can sustain theLattice-K availability in long run under soybean based cropping system ofVertisols. The rate of chemical fertilizer can be reduced up to 50% due to longterm application of 6tha^{-1} FYM or 5tha^{-1} crop residues are added to soil.

Keywords: potassium fractions, vertisol, available-K, water soluble-K, lattice-K, exchangeable-K, non exchangeable-K, total-K

INTRODUCTION

Potassium is the one of the three major nutrients (NPK) essential to plants. The consumption of potassium fertilizer in India increased from 0.24 million tonnes (mt) to 3.5 mt in last 50 years. However, it has dropped ratio from 5:2.4:1.0 to 8.36: 2.76:1.0. Currently we are importing 100% of the requirement of K due to widening the nutrient imbalance, resulting in a huge burden to the exchequer and a subsidy burden of thousands crores of rupees to the Government of India (Majumdar*et al.,* 2002). Long-term intensive cropping, in the absence of K inputs, adversely affected the K supply to crop plants and consequently crop yields (Subba Rao, 2016).Potassium is an essential element for plant growth which exists in soil in four forms, viz.,water soluble-K, which is taken up directly by plant; exchangeable-K, held by negative charges on clay particles and is available to plant; fixed-K which is trapped between layers of expanding lattice clays; and lattice-K and integral part of primary K bearing minerals (Pannu *et al.,* 2002). The knowledge about different forms and availability of potassium is must while, studying the response of crops to potassium application. As Potassium supply to crop plants is a complex phenomenon involving relationships among various K fractions in soils. Potassium availability to plants in general is governed by different forms of K viz., water soluble-K, exchangeable-K, fixed-K and mineral-K (Dotaniya *et al.*, 2022).

Plants utilize not only the readily available K but also the non- exchangeable and mineral K during the crop growth. The potassium availability to plants is determined by the rate of change in the dynamic equilibrium between different forms of K in the soil which in turn is controlled by the type of mineral, rate of weathering and exchange properties of the soil (Shirale *et al.,* 2023). Potassium is essential for various metabolic activities of living cell, transformation of carbohydrates, reduction of nitrates, synthesis of protein and normal meristematic activities where it acts as a catalyst or as a co-factor in enzymatic reaction of living cells. It has been suggested that potassium may also affect photosynthesis, maintenance of turgor in plant cells as well as formation of oil and imparting disease resistance. The black soils, through rich in available potassium have generally poor reserves of non exchangeable potassium (Misskire*et al.*2019). Although most of the Indian soils have been reported to be rich in Potassium (Aher *et al.,* 2015; Aher *et al.,* 2019) but due to cultivation of high yields varieties of crops with optimum applications of high rates of N and P tend to deplete the K reserve of soil at faster rate (Shirale *et al.,* 2023). To formulate sound fertilizersrecommendation, potassium supplying capacity of soil is essential (Das *et al.,* 2021). This will depend not only on the available K content of soil, but a sound knowledge of different forms of K and their relationship among themselves is also required. Long-term experiments provide a means of evaluating sustainable management systems in agriculture (Rasmussen *et al.*,1998).

Potassium deficiencies are now more widespread even on heavy textured soils such as alluvial illitic soils in India. Several studies have shown substantial contribution of non-exchangeable K towards K nutrition of crops grown on illite dominant alluvial soils (Srinivasa Rao *et al.*,2001). This is particularly so when cropping continues with N + P application without K addition. Potassium supply to crop plants is a complex phenomenon involving relationships among its various chemical forms. The dynamic equilibrium among the forms directs the release of K from non-exchangeable form to available forms under K stress environment. As the growing season is limited in case of short duration high yielding varieties, the rate of K supply during crop growth assumes significance (Patharia *et al.,* 2022). Therefore, current interest in K fertility soils has switched from simple measurement of the amounts of exchangeable K to determination of rate of K supply from soil during crop growth. Keeping these facts in view present study was under taken to study the effect of long term application of organic inorganic and integrated nutrient management on soil potassium fractions in vertisol of central India.

MATERIALSANDMETHODS

Experimental site and climate

Thepresentstudywas conductedat theexperimental field of CollegeofAgriculture,Indoreduring2018-2019. The area has almost uniform topography withlight to medium black soils. Indore is situated in Malwa Plateau in westernparts of Madhya Pradesh on 22.43°N latitude and 75.66°E longitudes with analtitude of 555.5 meters above the mean sea level. Thesoils of the area are medium deep, deep and shallow deep black soils, mostlyderived from Deccan trap. They are called black cotton soils and classified as*Vertisols.* The textural class was clay loam having high clay content (40-60%)mainlyofsmectite group.

The site is situated in semi-arid (Hot moist) climatic zone of Malwa Plateau in central Indian state Madhya Pradesh. The summers aredry with the rising temperature up to 44˚C or even higher during April-May.The winters are normal with temperature descending up to 10˚C or evenless during December and January. The average annual rainfall 750 mm to 1000mm and 90 percent of which is received during the last week of June, July,August, September and first week of October through South west monsoon.Themeanannualvalueofpotentialevaporation(PE)andrainfallare1781.52mm and

919.30 mm, respectively.

Experiment details

The on-going research project initiated in 1983 on "All India Coordinated Research Project on Dryland Agriculture" was used for this investigation. Soybean (cv. JS-9305), was grown with 80 kg ha^{-1} seed rate with row to row and plant to plant spacing of 40 cm×5 cm. Soybean crop was grown as per standard cultural practices. The experiment was conducted with nine treatments viz., T1- unfertilized control, T2- 20 kg N + 13 kg P ha^{-1}, T3- 30 kg N + 20 kg P ha^{-1}, T4- 40 kg N + 26 kg P ha^{-1}, T5- 60 kg N + 35 kg P ha^{-1}, T6- 6 t ha^{-1} FYM + 20 kg N + 13 kg P, T7- 5 t ha^{-1}crop residues + 20 kg N + 13 kg P, T8- 6 tha^{-1} FYM and T9- 5 tha^{-1} crop residues (CR) laid out in a randomized block design (RBD) having three replications. The application of nutrient was as per the designed treatments.

Experimental soil

The physico-chemical properties experimental soil was analyzed as per the method described in Singh *et al.*(2005). The soil of experimental site is classified as Vertisol (*Typic Haplusterts*) with smectite as the dominant clay mineral. Vertisols are churning heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks during summer season. The soil of the experimental site is clayey in texture with 9.28, 30.12 and 60.02 per cent of sand, silt and clay, respectively. The soil was low in soil organic carbon (0.28%), medium in available N (184.2kg ha^{-1}), medium in available P (8.18kg ha^{-1}) and high in available K (489.1kg ha^{-1}). The soil was normal in reaction (pH 7.65) and electrical conductivity (EC) was 0.54dS m^{-1}.

Soil sampling, processing and determination of soil K-fractions

Soil samples were collected from 0-10 cm and 10-20 cm depth after harvest of *kharif* season soybean crop from 26 years old ongoing experiments; and were homogenized. Visible litter and roots were picked out from collected soil samples. The soil samples were air-dried at room temperature, ground and sieved through 2 mm sieve. The processed soil was stored in air tight plastic containers for further analysis of different K fractions. Different K fractions in soil sample viz., water soluble-K, available-K, exchangeable-K, non exchangeable-K, lattice-K and total-K were determined following standard methods. The water-soluble K was determined in 1:2.5 soil : water extract by shaking soil-water suspension for half an hour

(USSLS, 1954). The soil available K was extracted from the soil using neutral normal ammonium acetate in 1:5 soil solution ratio and the K in extract was recorded using flame photometer (Hanway and Heidal, 1952). The soil Exchangeable-K fraction was calculated as the difference between available K and water soluble K. The total- K content was determined by digesting the soil samples with hydrofluoric acid (HF) in a closed vessel (Jackson, 1969). The lattice-K was also calculated from total K.

Statistical analysis

The experiment comprised with nine treatments laid out in a randomized block design (RBD) with three replications under soybean crop. All the measurements are the mean value of three separate replicates. Data was subjected to an analysis of variance. The mean values were grouped for comparisons and the least significant differences among them were calculated at $p < 0.05$ confidence level using ANNOVA statistics as outlined by Gomez and Gomez (1983).

RESULTS

Available-K

The available-Kasinfluencedby various treatments hasbeen determined at two depths i.e. 0-10 cm and 10-20 cm soil depth and dataarepresented inTable1.The available-Katsurfacelayer(0-10cm)rangedfrom381.01-593.78kgha^{-1} (Fig. 1) amongvarioustreatmentsanditrangedfrom312.5-474.3 kg ha^{-1}in the lower depth i.e. 10-20 cm (Fig. 2). The available-K content was affectedsignificantly due to different treatments. The lowest available-K at 0-10 cmdepth of soil was obtained in T1 (control). The highest value 593.78 kg ha^{-1}was noticed in the treatment T6 (Fig.1). However, the available-K content declinedwith the depth but the trend of available-K was also maintained at 10-20 cmdepthas itwasinsurfacelayeri.e.0-10cmdepth. Theoverallresults suggested that available-K content was in medium category in case of controltreatmentwhile,itwashighinrestofthetreatmentunderstudy.Theresultsrevealed that, the available-Khaschangedfromhightomediumcategoryincaseofthetreatment T1wherenochemical fertilizer was applied while in other treatments it was in high category. In the surface layer, the available-K content was 28.53-55.84percent higher in case of the treatment where organics were applied with andwithout chemical fertilizer as compared to control. The result suggests that byadditionoforganics,useofchemicalfertilizermaybereducedwithoutaffectingthe status ofavailable- K inlongterm invertisols.

Table 1. Effect of various treatments on soil available-K and water soluble-K

TREATMENT	Available K (kg ha^{-1})		Water soluble K (kg ha^{-1})	
	0-10 cm	10-20 cm	0-10 cm	10-20 cm
T1: Control	381.01	312.52	4.94	1.22
T2: 20 kg N + 13 kg P ha^{-1}	447.69	410.51	5.91	3.83
T3: 30 kg N + 20 kg P ha^{-1}	455.99	420.53	6.45	4.22
T4: 40 kg N + 26 kg P ha^{-1}	462.08	433.23	7.23	4.81
T5: 60 kg N + 35 kg P ha^{-1}	475.91	448.54	7.32	4.96
T6: 6 t ha^{-1}FYM + 20 kg N + 13 kg P	593.78	474.32	9.61	6.88
T7: 5 t ha^{-1}crop residues + 20 kg N + 13 kgP	554.22	459.61	8.76	6.52
T8: 6 t ha^{-1} FYM	534.85	430.11	8.72	6.56
T9: 5 t ha^{-1}crop residues	489.75	460.22	8.66	6.64
SEm(±)	54.13	11.78	1.07	0.88
CD (p=0.05)	114.7	24.98	2.28	1.86

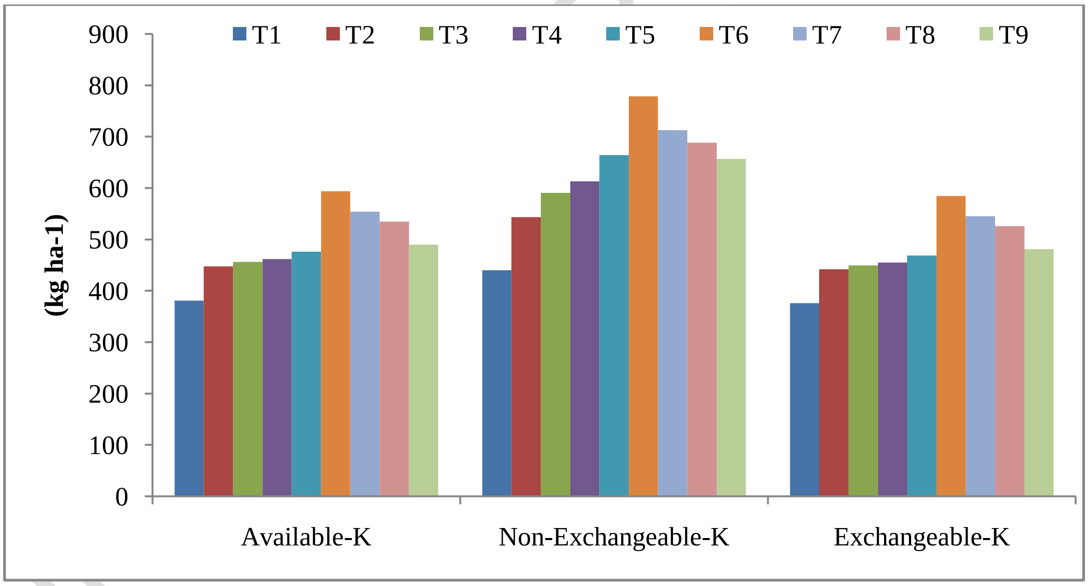

Fig. 1. Effect of different nutrient management on soil available K, Non-exchangeable K and exchangeable K (0-10 cm)

Watersoluble-K

The watersoluble-Kasinfluencedby different treatments at two depths i.e. 0-10 cm and 10-20 cm arepresented inTable1.Thewatersoluble-Katsurfacelayer (0-10cm) rangedfrom4.94-9.60 kg ha^{-1}among various treatments and it ranged from 1.22-6.88 kg ha^{-1}in the lower depth i.e.

10-20 cm (Fig. 3). The water soluble-K content was influenced significantlydue to different treatments. Thehighestvalue9.60kgha^{-1}wasnoticedinthetreatmentT6,whilethelowestvalueobservedincontrol(4.94kgha^{-1})followedbyT2(5.90kgha^{-1}). However, the water soluble-K content declined with the depth but thetrend of water soluble-K was also maintained at 10-20 cm depth as it was insurfacelayeri.e.0-10cmdepth.Theoverallresultssuggestthatwatersoluble K lower in the treatment where no fertilizer was applied or sub-optimaldoses of N and P were applied as compared to the treatment where superoptimal doses of fertilizer were applied or organics applied with or withoutchemicalfertilizer.

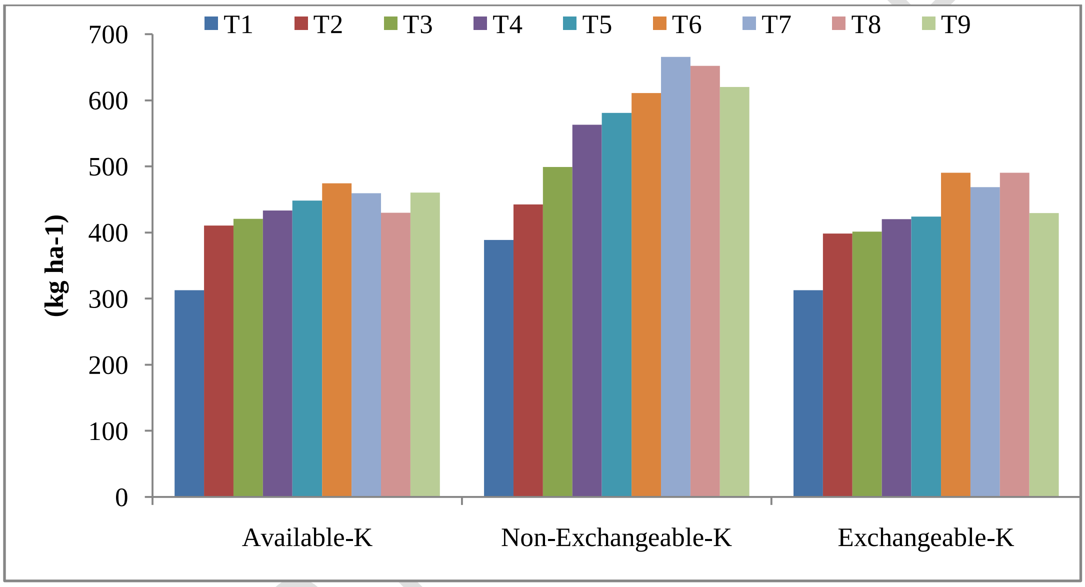

Fig. 2. Effect of different nutrient management on soil available K, Non-exchangeable K and exchangeable K (10-20 cm)

Non-Exchangeable-K

The non-exchangeable-K as influenced by different treatments hasbeendeterminedattwodepthsi.e.0-10cmand10-20cmsoildepthanddataarepresentedinTable 2.The non-exchangeable-K at surface layer (0-10 cm) rangedfrom 439.89-778.9 kg ha^{-1}(Fig 1) among various treatments and it ranged from388.6-610.7 kg ha^{-1}in the lower depth i.e. 10-20 cm (Fig 2). The non exchangeable-K content was influenced significantlyduetodifferenttreatments.The highest value 778.9 kg ha^{-1}wasnoticedinthetreatmentT6while, thelowestvalueobservedincontrol (439.89 kg ha^{-1}). However, the Non-exchangeable-K content declined withthe depth but the trend of non-exchangeable-K was also maintained at 10-20 cm depth as it was in surface layer i.e. 0-10 cm depth. The overall resultssuggest that non-exchangeable-K content was in lowest in case of controltreatment and it increased as the level of N and P application was increasedup to 150% of RDF. The application of organics with and without fertilizerapplicationcanalsosustainthe non-exchangeable-Kinlongrunundersoybeanbased croppingsystemofVertisols.

Table 2.Effect of various treatments on soil non exchangeable-K and exchangeable-K

TREATMENT	Non-Exchangeable K (kg ha^{-1})		Exchangeable-K (kg ha^{-1})	
	0-10 cm	10-20 cm	0-10 cm	10-20 cm
T1: Control	439.89	388.62	376.07	312.54
T2: 20 kg N + 13 kg P ha^{-1}	543.21	442.54	441.79	398.42
T3: 30 kg N + 20 kg P ha^{-1}	590.51	498.93	449.54	401.53
T4: 40 kg N + 26 kg P ha^{-1}	612.89	562.82	454.85	420.31
T5: 60 kg N + 35 kg P ha^{-1}	664.23	580.71	468.61	423.91
T6: 6 t ha^{-1}FYM + 20 kg N + 13 kg P	778.92	610.72	584.18	490.52
T7: 5 t ha^{-1}crop residues + 20 kg N + 13 kgP	712.63	665.84	545.46	468.54
T8: 6 t ha^{-1} FYM	688.36	652.23	526.15	490.23
T9: 5 t ha^{-1}crop residues	656.34	620.21	481.09	429.52
SEm(±)	54.61	15.22	54.98	30.94
CD (p=0.05)	115.78	32.91	116.57	65.64

Exchangeable-K

The data pertaining to the soil exchangeable-Kas influenced by different treatments has been determined at two depths i.e. 0-10 cm and 10-20 cm soil depthanddata arepresented inTable 2. The exchangeable-K at surface layer (0-10 cm) ranged from376.07-584.18kgha^{-1}(Fig. 1) amongvarioustreatmentsanditrangedfrom312.5-490.5 kg ha^{-1}(Fig. 2) in the lower depth i.e. 10-20 cm. The exchangeable-K contentwasaffectedsignificantly due todifferent treatments.Thehighest value 584.18 kg ha^{-1}was noticed in the treatment T6, while thelowest value observed in control (376.07 kg ha^{-1}) followed. However, theexchangeable-Kcontentdeclinedwiththedepthbutthetrendofexchangeable-Kwas also maintained at 10-20 cm depth as it was insurfacelayeri.e.0-10cmdepth.Theoverallresultssuggestthat exchangeable-Kcontent was lowest in caseofcontrol treatmentandincreased as the level of N and P application increased upto 150% RDF.The results clearly emphasized that by the application of organics with andwithout K application can sustain the Exchangeable-Kin long run undersoybean based cropping system of Vertisols, while reducing the use ofchemicalfertilizer.

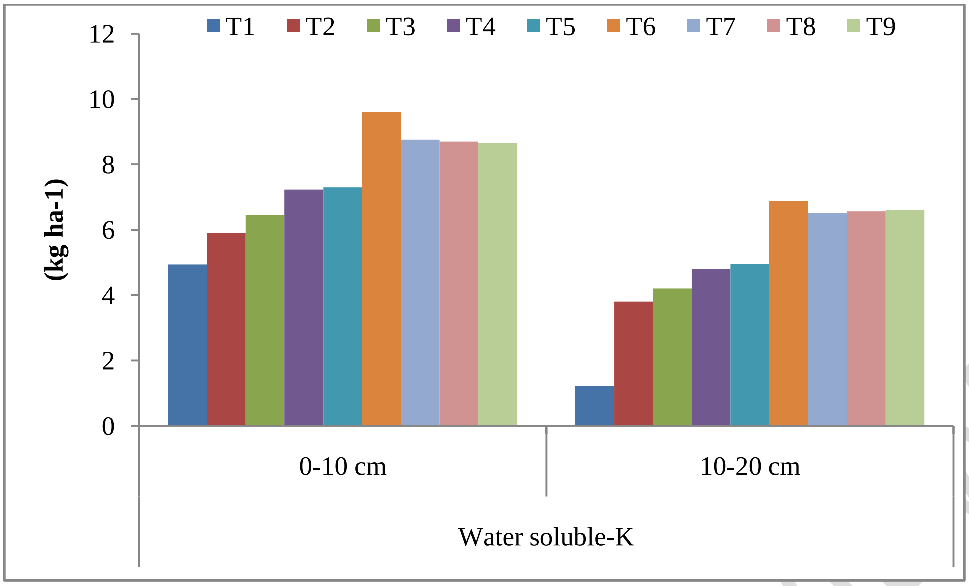

Fig. 3. Effect of different nutrient management on soil water soluble K

Lattice-K

Thelattice-K data at two depths i.e. 0-10 cm and 10-20 cm soil depth arepresentedinTable 3.The lattice-K at surface layer (0-10 cm) ranged from 7177.1-13154.3 kg ha^{-1}(Fig. 4) among various treatments and it ranged from 7144.5-12994.4 kg ha^{-1}(Fig. 5) in the lower depth i.e. 10-20 cm.

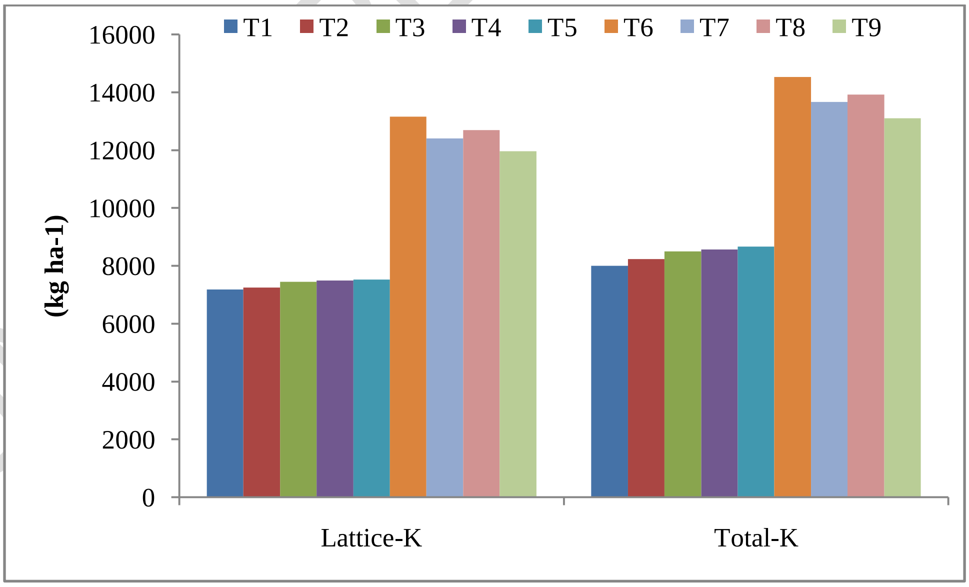

Fig. 4. Effect of different nutrient management on soil lattice K and total K (0-10 cm)

The lattice-K content wasaffected significantly due to different treatments. Thehighestvalue13154.3 kg ha^{-1}was noticed in the treatment T6, while the lowest valueobserved in control (7177.1kg ha^{-1}). However, the lattice-Kcontentdeclined with the depth but the trend of lattice-K was also maintained at 10-20cm depth as it was in surface layer i.e. 0-10 cm depth. The overall resultssuggest that lattice-Kcontent was in lowest in case of control treatment andincreased in other treatments having higher dose of N and P fertilizer and dueto addition of organics high in all the other treatments. The results clearlyemphasized that by the application of organics with and without K applicationcansustainthe lattice-Kavailabilityinlongrunundersoybeanbasedcroppingsystemof Vertisols.

Table 3.Effect of various treatments on soil lattice-K and total-K

TREATMENT	**Lattice K (kg ha^{-1})**		**Total K (kg ha^{-1})**	
	0-10 cm	**10-20 cm**	**0-10 cm**	**10-20 cm**
T1: Control	7177.1	7144.5	7998.3	8102.4
T2: 20 kg N + 13 kg P ha^{-1}	7246.1	7200.1	8237.2	8443.2
T3: 30 kg N + 20 kg P ha^{-1}	7446.5	7222.9	8493.4	8540.3
T4: 40 kg N + 26 kg P ha^{-1}	7492.0	7435.1	8567.1	8640.7
T5: 60 kg N + 35 kg P ha^{-1}	7520.9	7329.8	8661.2	8751.4
T6: 6 t ha^{-1}FYM + 20 kg N + 13 kg P	13154.3	12994.4	14527.3	14888.4
T7: 5 t ha^{-1}crop residues + 20 kg N + 13 kgP	12402.2	12101.5	13669.2	13770.3
T8: 6 t ha^{-1} FYM	12694.8	11620.5	13918.1	14290.4
T9: 5 t ha^{-1}crop residues	11959.9	11840.9	13106.4	13442.1
SEm(±)	2610.1	2613.2	2720.4	2847.6
CD (p=0.05)	5533.5	5539.9	5767.2	6036.9

Total-K

The total-K as influenced different treatments has been determined attwo depths i.e. 0-10 cm and 10-20 cm and data are presented inTable3. The total-K at surface layer (0-10 cm) ranged from 7998.3-14527.3 kgha^{-1}among various treatments and it ranged from 8102.4-14888.4 kg ha^{-1}inthe lower depth i.e. 10-20 cm. The total -K content was affected significantlyduetodifferenttreatments.The highest value 14527.3 and 14888 kg ha^{-1}was noticed in thetreatment T5, whilethelowestvalueobservedincontrol.However, the total-K content increased with the depth but the trend of total-K was also maintained at 10-20 cm depth as it was in surface layer i.e.0-10cmdepth.Theoverallresultssuggestthat total-Kcontentwasinfluenced by the sub-optimal, optimal, super-optimal and the addition oforganics with or without application of fertilizer those treatments recordedhigher total-K in both the depth as compared to control treatment. It may beconcluded by the results obtained that by the use of organics (FYM / CropResidues) one can reduce the application of N and P upto 50% of RDFwithoutaffectingthestatusoftotal-Kunderthefertilityexperimentsof Vertisols.

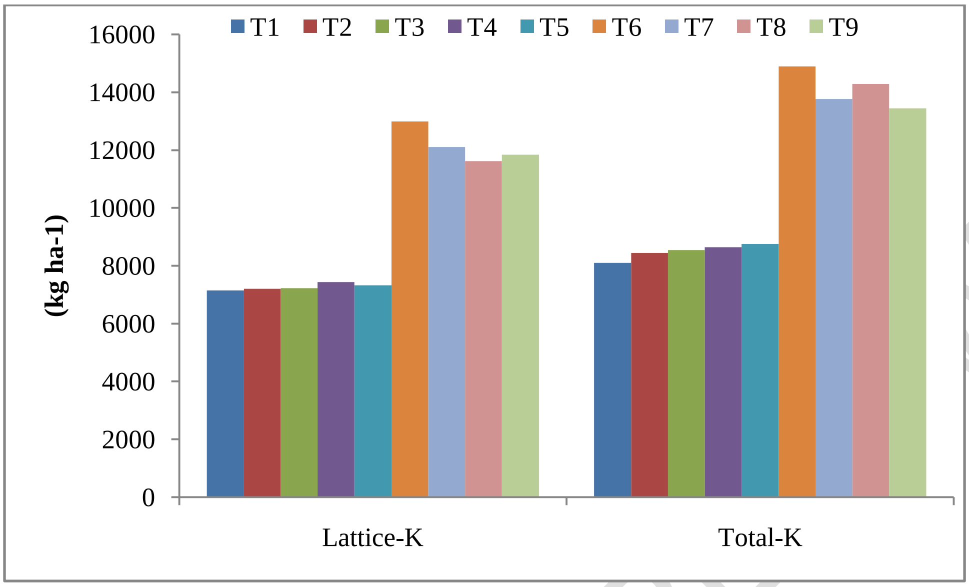

Fig. 5. Effect of different nutrient management on soil lattice K and total K (10-20 cm)

DISCUSSION

The available-K comprises of exchangeable and water soluble. Insome instances, K may be available from fixed state to a substantial degree(Jadhao*et al.*, 2018).The available-K was more in surface layer than subsurfacelayer.Yaduvanshi*et al.*(2013) reported that available-K increased in treatmentsreceiving green manure or FYM with 120:26:42 kgha^{-1}NPK. Das*et al.*(2020) also reported that addition of inorganic fertilizer along with organicsshowed an improvement in the build-up of K whereas omission of fertilizer Kand organics did not exhibit profound influence on status of K. The applicationof K in balanced dose to the sequence resulted in highest content of soilavailable-K.The water soluble-K or soil solution-K is the form of potassium that is directly taken by the plants andmicrobes and also is the form subject to most leaching in soil. The water soluble-K was lower in the treatmentwhere no fertilizer was applied or sub-optimal doses of N and P were appliedas compared to the treatment where super optimal doses of fertilizer wereapplied or organics applied with or without chemical fertilizer. This was might be duetogreater release of K from these treatments. These findings are in accordancewith Yaduwanshi and Swaroop (2006).Such increased status of available and water soluble-K with the application of organics (FYM / crop residue) may be due tostimulating effect ofFYM in reducing K fixation, thereby, bringing more potassium inthesolution.Thepresentfindingsarecorroboratedwiththefindingsof Singh*et al.*(2002), Singh *et* *al.*(2006), Das *et al.* (2021) and Dotaniya *et al.* (2022).

The exchangeable-KhasbeenregardedasreliableindexofK-removal by crops. It is held by the negative charges of organic matter and clayminerals.Theexchangeable-K content declinedwiththedepth but the trendofexchangeable-Kwasalsomaintainedat10-20cmdepthasitwasinsurfacelayeri.e.0-10cmdepth.Thehigherexchangeable-Kcontentinorganicsaddedtreatmentsmaybeduetoincreasedcationexchangecapacityofsoilduetocontinuousapplicationoforganicsinthesetreatments.Increasedorganicsurfaceshelpsinionexchange,resultinginanincrease in exchangeable and plant available-K. Similarly, Bhattacharya*et al.*(2006) reported that higher amount of K is attributed to the process ofstructuralKreleasedthroughincreasingtheareaofexchangeablesurfaceand due to the accelerated weathering of the interlayer K by application ofFYM. The higher concentration of Exchangeable-K under N and P fertilized plots ascompared to control treatment could be attributed to the addition of Kthroughplant residues(Sharma*et al.*,2009).Similarly, thenonexchangeable-Kwas also found declinedwiththedepthbutthetrendofnon exchangeable-Kwasalsomaintained at 10-20 cm depth as it was in surface layer i.e. 0-10 cm depth.SimilarresultswerealsoreportedbySrinivas Rao*et al.*(2014) and Jadhao *et al.* (2018).

The lattice-K contentwas found declined with the depth butthe trend was maintained at 10-20 cm depth as it was insurfacelayer i.e.0-10cmdepth.However, the total-K content increased with the depth but the trend of total-K was also maintained at 10-20 cm depth as it was in surface layer i.e. 0-10cm depth. Bhattacharya *et al.*(2008) reported depletion of total-K in the topsoil after 30 years of cropping, with the highest depletion of K recorded in o-15cmsoillayerwasundercontroltreatmentfollowedbyN+FYMandminimumin case of 100% NPK + FYM. Similar results were also reported by Srinivas Rao*et al.*(2000), Kori *et al.* (2018), Balik *et al.*(2019), Das *et al.* (2020), Das *et al.* (2021), Dotaniya *et al.* (2022) and Shirale *et al.* (2023).

CONCLUSION

Although most of the Indian soils have been reported to berich in Potassium but due to cultivation of high yields varieties of crops withoptimum applications of high rates of N and P tend to deplete the K reserveofsoilatfasterrate.The potassium supplying capacity of soil is not onlydepends on the available K content of soil, but a sound knowledge of different formsof K is also required. Theoptimum applications or high rates of N and P tend to deplete the K reserve ofsoil at faster rate. This is study clearly concludes that to sustain K status inVertisolsthereisaneedofKapplicationalongwithorganic manure/crop residue.Theapplication of organics with and without N and P application can sustain theLattice-K availability in long run under soybean based cropping system ofVertisols. The rate of chemical fertilizer can be reduced up to 50% due to longterm application of 6tha^{-1}FYM or 5tha^{-1} crop residues are added to soil.

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