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FRACTIONS OF SOIL POTASSIUM AND THEIR DEPTHWISE DISTRIBUTION UNDER LONG-TERM NUTRIENT MANAGEMENT PRACTICES IN SEMIARID ALFISOLS

ABSTRACT

A field experiment was conducted on a long-term experimental plot during for two consecutive *rabi* seasons of 2016-17 and 2017-18 at the college farm, College of Agriculture, Rajendranagar, Hyderabad, PJTSAU. The experimental soil was non-saline, neutral in reaction with sandy loam texture. Different forms of soil potassium were studied with six different nutrient management practices in randomized block design with four replications. The results of pooled data of two years study revealed that significantly higher contents of water soluble potassium (17.77 mg kg^{-1}), exchangeable potassium (568 mg kg^{-1}), nonexchangeable potassium (999 mg kg^{-1}) and Total potassium (1.80%) in surface layer (0-15 cm) at flowering were recorded with integrated application of 50% N through FYM and 50% N through chemical fertilizers and it was on par with treatment applied 100% RDF through chemical fertilisers and significantly superior over other organic nutrient management treatments. A similar trend was observed at all soil depths (15-30, 30-45, 45-60 cm) and all the contents were decreased from flowering to harvest. All potassium forms decreased with increasing the depth except non exchangeable K. All the fractions were found to be significant in surface layer (0-15 cm). The contribution of different forms of soil K to Total K was in the order of non-exchangeable K> exchangeable K> water soluble K and similar trend was observed in all soil layers.

Key words: Water soluble, Exchangeable, Non-exchangeable, Total Potassium fractions, Nutrient management *etc.*

Introduction:

Potassium (K) is one of the major essential nutrients for plant growth. In soil, Potassium is present in different forms, viz., water-soluble, exchangeable, non-exchangeable and lattice K forms and they exists in dynamic equilibrium of which water-soluble, exchangeable forms are important for the growth of higher plants and microbes (Singh *et al.* 2010). Based on the availability of these forms to the plants, water soluble and exchangeable potassium are considered as readily available K pool, which occupies only 1% to 2% of total soil while the non-exchangeable K serves as a reserve source of soil K. The dynamics of K in soil depends on the magnitude of equilibrium among various forms which have relationship with physico-chemical properties of the soil. Under intensive cultivation, readily available and exchangeable K is removed by crops.

This results in further release of exchangeable K from non-exchangeable forms. The level of soil solution K depends upon equilibrium and kinetic reactions that occur between different forms of soil K. The inter conversion of one form of potassium into other form determines the availability of potassium to the plants. Hence the distribution of different forms of K in soils is important to understand the conditions controlling their availability to growing crops. As Groundnut (*Arachis hypogaea* L.) is one of the most important oil seed and cash crops of India and particularly in *Alfisols*, potassium (K) is a deficient element (Subbarao and Srinivasarao 1996) and is limiting the growth of the crop the present investigation was carried out to study different forms of K as influenced by different nutrient management practices in different soil layers at different stages of crop growth.

Material and Methods:

The present field experiment was carried out at the college farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* seasons of 2016-17 and 2017-18. Prior to this experiment the field was under a long-term study which was aimed to evaluate the effect of organic, inorganic and integrated nutrient management practices on productivity of maize-onion cropping system from *kharif*, 2003-04 to 2014-15 under the ageis of AICRP-Integrated Farming Systems, Rajendranagar. During 2015-16 the field was kept fallow and undisturbed. At the initiation of the current study, the soil of the experimental field was neutral in reaction, non-saline, having medium organic carbon (0.81%), low nitrogen (255.2 kg ha^{-1}), high phosphorus (68.2 kg ha^{-1}) and potassium (489 kg ha^{-1}). The soil of the experimental site was sandy loam and classified taxonomically as Udic Ustochrept. This experiment was laid out in a simple randomized block design with six treatments and four replications. Six Treatments comprised of T1: 50% N through FYM + 50% N through chemical fertilizers, T2: 100% N basal through FYM + neem cake + vermicompost each on $1/3^{rd}$ basis), T3: $2/3^{rd}$ N basal through FYM + neem cake + $1/3^{rd}$ N top dress through vermicompost, T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB, T5: 100% N through FYM + neem cake + vermicompost each on $1/3^{rd}$ basis) + Biofertilizers for N and PSB, T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1}). Groundnut variety Kadiri 6 (K6) was used during both the years and sowing was done by dibbling method. The recommended dose of fertilizer of groundnut is 30-50-50 kg NPK ha^{-1} and urea, single super phosphate and muriate of potash were used as sources for nitrogen, phosphorus and potassium, respectively. The organic manures viz., vermicompost (1.23- 0.84 -1.13 and 1.41- 0.65 - 1.21), FYM (0.62 - 0.22- 0.72 and 0.55 - 0.17 - 0.58) and neem cake (3.2 - 0.58- 1.23 and 2.88 - 0.52 - 1.36) were analysed during 2016-17 and 2017-18 respectively for their NPK contents and were applied on nitrogen equivalence. All the manures were applied two weeks prior to sowing of crop while in treatment T3, FYM and neem cake were applied basally and vermicompost was top dressed at 30 DAS. In the T4 treatment rock phosphate was mixed with FYM and applied to soil as basal. Seed inoculation with *Rhizobium* strain was done before sowing and rock phosphate was mixed thoroughly with PSB before their application.

Soil samples were collected from 0-15, 15-30 and 30- 45, 45-60 cm depths at the time of flowering and after harvest of groundnut during *rabi*, 2016-17 and 2017-18. Collected soil samples ware air-dried, processed and analyzed for water soluble-K, Exchangeable K, Non Exchangeable K and Total K. Water soluble K was extracted by shaking the soil water suspension in the ratio of 1:5 for one hour then filtered and K was determined (Grewal and Kanwar, 1966). Exchangeable-K was estimated by neutral ammonium acetate (1 N) extraction in 1:5 ratio. The amount of exchangeable K was calculated by subtracting water soluble K from K extracted with neutral ammonium acetate. Non exchangeable-K was determined by boiling soil with 1N HNO3 extractable K in 1:10 (soil: acid) for 10 min. The non-exchangeable K was calculated by subtracting K extracted with neutral ammonium acetate from K extracted in hot 1N HNO_3.(Wood and De Turk 1941). Total K was extracted by Hydrofluoric acid digestion method (Jackson,1973). The K concentration in various extracts was estimated using flame photometer.

The data generated from field and laboratory analysis were subjected to statistical analysis using the technique of analysis of variance for randomized block design with factorial concept as suggested by Panse and Sukhame (1978).

Results and Discussion:

The nutrient management practices evaluated in the current study showed statistically significant impact on different forms of potassium (K) in soil *viz.* water soluble, exchangeable K, non- exchangeable K and Total K different fractions of potassium both in surface and sub-surface soil layers at flowering and at harvest stages of the crop during both the years.

Water soluble potassium:

The water soluble K or soil solution K is the readily available form and is directly taken up by the plants and is also susceptible to leaching. The changes in contents of this form are influenced by cropping or external K supply either through inorganic K fertilizers or through organics. The content of water soluble potassium in different soil layers (0-15, 15-30, 30-45, 45-60 cm) at flowering stage (table 1) ranged from 13.07 to 17.62 mg kg^{-1} during 2016-17 and from 13.86 to 17.93 mg kg^{-1} during 2017-18. Pooled analysis of data indicated a non-significant interaction effect of treatments and years. On perusal of pooled data of two years, maximum water soluble potassium was recorded with combined application of 50% N through FYM and 50% N through chemical fertilizers (17.77 mg kg^{-1}) and was on par with treatment applied with 100 %NPK through chemical fertilizers (17.62 mg kg^{-1}) and significantly superior over other treatments *viz.*, T_2, T_3,T_4 and T_5 wherein only organic manures were applied. Topdressing of vermicompost (T_3) did not show any effect. Lowest water soluble potassium was observed under T_4 (13.34 mg kg^{-1}).

The water soluble potassium content decreased with depth from 0-15 cm to 45-60 cm. However the effect of treatments was confined only to 30-45 cm and at 45-60 cm depth the effect of treatments was not observed. The trend of water soluble potassium in different soil depths (15-30 and 30-45 cm) in relation to treatments was similar to that of 0-15 cm.

At harvest stage (table 2) the water soluble potassium content in soil followed a similar trend as that of at flowering stage. The interaction effect of years and treatments was non-significant. Pooled data of the two years indicated that the water soluble K in 0-15 cm soil depth ranged from 11.64 to 16.12 mg kg^{-1} under various nutrient management practices. The content of this form of potassium followed a similar trend as that of flowering stage with maximum content under 50% N though FYM + 50% N through chemical fertilizer (16.12 mg kg^{-1}) followed by 100% NPK though chemical fertilizers (16.00 mg kg^{-1}). All other treatments registered significantly lower water soluble potassium with lowest under T_4 treatment (11.64 mg kg^{-1}). The content was higher in surface layers and decreased with increase in depth. The treatments effect was observed up to 30-45 cm only. The treatment wise trends in sub-surface layers of 15-30 cm and 30-45 cm were almost similar as was observed in surface layer. Water soluble potassium decreased with increase in depth. The increase in water soluble K with the addition of FYM along with chemical fertilisers may be due to stimulating effect of FYM in reducing K fixation, thereby bringing in more K into vailable form. (Jadhao*et al*.2018). Similar results have also been reported by Sharma*et al*. (2018a).

Exchangeable potassium:

The form of potassium that is adsorbed and held by negative charges of organic matter and clay minerals on the soil surface is represented by exchangeable fraction and is estimated by deducting water soluble k content from ammonium acetate extractable potassium. At flowering stage the content of exchangeable potassium in different soil layers (0-15, 15-30, 30-45, 45-60 cm) (table 3) ranged from 339 to 550 mg kg^{-1} during 2016-17 and from 361 to 587 mg kg^{-1} during 2017-18. A non-significant interaction effect of treatments and years was observed on pooled analysis of data. Examination of pooled data indicated that significantly higher content of exchangeable potassium was recorded in the treatment of integrated application of 50% N through FYM and 50% N through chemical fertilizers (568 mg kg^{-1}) and it was at par with T_6 which received 100% NPK through chemical fertilizers (554 mg kg^{-1}) and significantly superior over other organic nutrient management treatments T_2 (437 mg kg^{-1}), T_3 (449 mg kg^{-1}), T_4 (350 mg kg^{-1}) and T_5 (463 mg kg^{-1}). All the nutrient management treatments supplying 100% N through organics viz., $T_{2,}$ T_3 and T_4 were at par with each other and significantly superior over T_5 wherein only 50% of N through farm yard manures was applied (489 mg kg^{-1}) along with bio-fertilizers. Topdressing of vermicompost (T_3) at 30 DAS did not show any effect. The exchangeable potassium content decreased with depth from 0-15 cm to 45-60 cm. The effect of treatments was confined only up to 30-45 cm and at 45-60 cm depth, effect of treatments was not observed. The trend of exchangeable potassium in different soil depths (15-30 and 30-45 cm) was similar to that of 0-15 cm.

At harvest stage (table 4) the exchangeable potassium content in soil followed a similar trend as that of at flowering stage. The interaction effect of years and treatments in pooled analysis was non-significant. Pooled data indicated that the exchangeable K in 0-15 cm soil depth ranged from 270 to 445 mg kg^{-1} under various nutrient management practices. The content of this form of potassium followed a similar trend as that of at flowering stage. The content was maximum in surface layers and decreased with increase in depth. The treatments effect was observed up to 30-45 cm only. The treatment wise trends in sub-surface layer were almost similar as was observed under surface layer. However, the content of exchangeable potassium decreased with increase in depth.

The higher amount water soluble and exchangeable fractions of K in the surface layer could be attributed to more exposure of K bearing minerals to weathering and/or upward translocation of K from sub-surface layer by capillary rise or due to addition of K through manures and fertilizers (Rao *et al*., 2013). Sawarkar *et al. (*2013) also reported decreased contents of various soil K fractions with increasing depth after 36 years of soybean-wheat cropping sequence under continuous application of inorganic fertilizers with and without organic manures.

The increase in content of water soluble K in integrated and organic nutrient management could be attributed to the direct contribution of K through the decomposing FYM, vermicompost and other manures. The increase in exchangeable potassium with the application of organics could be due to the increase in CEC (Cation Exchange Capacity) of soil, and as a result, soil can hold more amount of exchangeable K and can release it from non-exchangeable K to exchangeable K due to mass action effect (Black,1968).

Non-exchangeable potassium:

Non-exchangeable fraction of K releases slowly into soil when the plants are under potassium stress. The non-exchangeable K contents at flowering stage in different soil depths (0-15, 15-30, 30-45, 45-60 cm) varied from 643 to 991 mg kg^{-1} during 2016-17 and 706 to 1007 mg kg^{-1}

during 2017-18 (table 5). As treatments and interaction was not significant the influence of treatments on non-exchangeable K fraction was interpreted based on the pooled mean. Non-exchangeable K was significantly higher in the soil under 50% N through FYM and 50% N through chemical fertilizers treatment (999 mg kg^{-1}) and was closely followed by T_6 which received 100% NPK through chemical fertilizers (970 mg kg^{-1}). All the nutrient management treatments supplying 100% N through organics through various sources and along with bio-fertilizers *viz.*, T_2 (819 mg kg^{-1}), T_3 (831 mg kg^{-1}) and T_4 (848 mg kg^{-1}) were at par with each other and significantly superior over T_5 (675mg kg^{-1}) wherein only 50% of N through farm yard manure was applied along with bio-fertilizers.

The non-exchangeable potassium content in soil at harvest stage (table 6) followed a similar trend as that of at flowering stage. The interaction effect of years and treatments was non-significant. Pooled data indicated that the non-exchangeable K in 0-15 cm soil depth ranged from 611 to 907 mg kg^{-1} under various nutrient management practices. The content of this form of potassium followed a similar trend as that of at flowering stage with maximum content under 50% N though FYM + 50% N through chemical fertilizer (907 mg kg^{-1}) followed by 100% NPK though chemical fertilizers (885 mg kg^{-1}). All other treatments registered significantly lower non-exchangeable potassium with lowest under T_4 treatment (611 mg kg^{-1}). The greater depletion of non-exchangeable K at flowering and harvest stages in presence of organic matter in T_2, T_3, T_4 and T_5 might be due to accumulation of organic matter and a probable a shift in CEC sites towards divalent selectivity (Salmon, 1964), which would decrease percentage K saturation of CEC, resulting in the shift of equilibrium of non-exchangeable K to exchangeable K in favour of the latter, thereby releasing more non-exchangeable K. Similar results were reported by Majumdar *et al.* (2014) in an alluvial soil under Jute-Rice-Wheat cropping system under long-term application of inorganic fertilizers and organic manures for 42 years.

Unlike water soluble and exchangeable potassium the content of non-exchangeable fraction both at flowering and harvest stages was high in subsurface soil and increased with increase in the depth of soil, indicating its higher reserve in the subsurface than surface soil. The low reserve of this form in the surface soil could be due to its release in the exchangeable form as a result of its depletion by crop uptake and leaching loss (Kundu *et al*., 2014). Similar results were reported by Das *et al.* (2000). The treatments effect was observed up to 15-30 cm only and the treatment wise trends in sub-surface layers of 15-30 cm were almost similar as was observed under surface layer.

Total potassium:

The impact of nutrient management practices on total K at flowering stage is presented in table 7. Pooled data was used to understand the results in view of non-significant effect year and interaction effect of treatments and years. The total potassium decreased with increasing depth of soil. The total K under various treatments varied from 1.22 to 1.80% in the surface soil layer of 0-15 cm and 1.20 to1.73% in the 15-30 cm soil layer respectively. Effect of treatments was recorded up to 15-30 cm depth only, thereafter the total potassium under various treatments was found to be unaffected. Significantly higher content of total potassium in 0-15 cm soil layer was recorded with integrated application of 50% N through FYM and 50% N through chemical fertilizers (1.80%) and it was at par with T_6 which received 100% NPK through chemical fertilizers (1.77 %) and significantly superior over other organic nutrient management treatments T_2 (1.47%), T_3 (1.51%)T_4 (1.22%) and T_5 (1.53%). All the treatments which supplied 100% N through organics (T_2, T_3 and T_5) were at par with each other and superior over T_5 treatment in which 50% of N was applied through farm yard manures along with bio-fertilizers. Higher total potassium might be due to the supply of K through organic residues in the form of FYM coupled with minimizing the losses from leaching by retaining K+ ion on exchange sites, Kumar and Narwal, 2016). The results of study corroborate with findings of Sharma *et al.* (2018a) and Sharma and Paliyal (2015). The treatments followed a similar trend as that of 0-15 cm in 15-30 cm soil layer also.

At harvest, the changes in total potassium under various treatments were similar to that of at flowering stage (Table 8).Changes in contents of the total potassium with treatments was recorded up to 15-30 cm depth only, thereafter all the treatments were found to be comparable.

Conclusion: Integrated application of 50% N through FYM and 50% N through chemical fertilizers resulted in significantly higher contents of water soluble K, exchangeable K, non-exchangeable K and Total K and it was on par with treatment applied 100% RDF through chemical fertilisers and significantly superior over other organic nutrient management treatments. The lowest contents were observed in the treatment which received 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB. All the fractions exhibited significant influence in 0-15 cm layer and higher contents were observed at flowering stage and they decreased after harvest of the crop. The water soluble K, exchangeable K and Total K contents were maximum in surface layers and decreased with increase in depth whereas non exchangeable K increased with depth. Among the K fractions, water soluble K was the smallest fraction and the magnitude of different fractions at various soil depths studied was in order of non-exchangeable K> exchangeable K> water soluble K.

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Treatment	0-15 cm	15-30 cm	30-45cm	45-60cm

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	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T1: 50% N through FYM + 50% N through Chemical fertilizers	17.62	17.93	17.77	13.09	13.29	13.19	7.93	8.10	8.01	5.20	4.88	5.04
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	15.09	16.39	15.36	11.10	11.58	11.34	6.79	6.89	6.84	5.10	5.08	5.09
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	15.13	16.72	15.42	11.13	11.64	11.38	6.81	6.91	6.86	5.10	4.98	5.04
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	13.07	13.86	13.34	9.43	10.05	9.74	5.78	5.88	5.83	4.90	5.10	5.00
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Biofertilizers for N and PSB	15.31	16.78	15.61	11.19	11.67	11.43	6.93	6.95	6.94	5.30	5.05	5.18
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	17.37	17.13	17.62	12.85	13.23	13.04	7.90	7.96	7.93	5.20	4.95	5.08
SE ± for Treatments	0.65	0.70	0.45	0.54	0.50	0.37	0.31	0.32	0.23	0.34	0.25	0.21
SE ± for Years			0.26			0.21			0.13			0.12
SE ± for Years × Treatments			0.63			0.52			0.32			0.30
CD (P=0.05) for Treatments	1.97	2.12	1.29	1.64	1.50	1.07	0.95	0.98	0.65	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	8.39	8.56	7.96	9.51	8.38	8.94	8.97	9.13	9.05	13.31	9.94	11.79

Table 1 Water soluble K (ppm) content in different depths at flowering stage of *rabi* groundnut under different nutrient management practices

Table 2 **Water soluble K content(ppm) in different depths after harvest of *rabi* groundnut under different nutrient management practices**

Treatment	**0-15 cm**			**15-30 cm**			**30-45cm**			**45-60cm**		
	2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
T1: 50% N through FYM + 50% N through Chemical fertilizers	15.74	16.50	16.12	12.07	13.19	12.63	7.07	7.24	7.15	5.75	5.10	5.43
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	13.34	14.02	13.68	10.00	10.33	10.16	5.97	6.20	6.08	5.20	5.80	5.50
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	13.58	14.27	13.92	10.26	10.39	10.32	6.01	6.16	6.09	5.80	4.83	5.31
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	11.55	11.73	11.64	8.41	8.56	8.48	4.88	5.16	5.02	4.93	5.66	5.29
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Biofertilizers for N and PSB	13.77	14.33	14.05	10.30	10.58	10.44	6.06	6.36	6.21	5.95	5.14	5.54
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	15.59	16.41	16.00	11.87	12.39	12.13	6.93	7.20	7.06	5.12	5.40	5.26
SE ± for Treatments	0.58	0.68	0.45	0.51	0.57	0.38	0.27	0.27	0.19	0.41	0.42	0.30
SE ± for Years			0.26			0.22			0.11			0.17
SE ± for Years × Treatments			0.63			0.54			0.27			0.42
CD (P=0.05) for Treatments	1.74	2.06	1.29	1.53	1.73	1.11	0.80	0.80	0.54	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS

CV (%)	8.30	9.38	8.88	9.69	10.55	10.14	8.62	8.32	8.47	15.05	15.94	15.49

Table 3 Exchangeable K(ppm) content in different depths at flowering stage of *rabi* groundnut under different nutrient management practices

Treatment	0-15 cm			15-30 cm			30-45cm			45-60cm		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T1: 50% N through FYM + 50% N through Chemical fertilizers	550	587	568	481	498	489	363	370	366	213	218	216
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	435	439	437	393	400	396	288	287	288	206	214	210
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	442	449	445	397	406	401	295	293	294	206	213	210
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	339	361	350	297	299	298	227	232	230	215	216	215
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Biofertilizers for N and PSB	450	475	463	403	412	408	299	306	303	201	206	204
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	535	574	554	465	492	479	352	363	357	206	213	209
SE ± for Treatments	28	24	18	20	25	16	16	15	11	9	12	8
SE ± for Years			10.60			9.21			6.48			4.38
SE ± for Years × Treatments			25.96			22.57			15.86			10.72
CD (P=0.05) for Treatments	83.29	72.89	53.03	60.72	74.64	46.10	49.18	46.42	32.40	NS	NS	NS

CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	12.06	10.06	11.06	9.93	11.85	10.96	10.73	9.98	10.36	8.40	11.63	10.18

Table 4 Exchangeable K content(ppm) in different depths after harvest of *rabi* groundnut under different nutrient management practices

Treatment	0-15 cm			15-30 cm			30-45cm			45-60cm		
	2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
T1: 50% N through FYM + 50% N through Chemical fertilizers	437	452	445	392	411	401	303	316	309	188	187	187
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	336	340	338	309	324	316	227	234	231	186	188	187
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	344	353	348	323	327	325	235	248	242	180	187	183
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	267	273	270	242	256	249	160	185	173	191	186	188
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Bio-fertilizers for N and PSB	356	382	369	329	344	336	243	256	250	184	176	180
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	429	446	437	386	407	396	304	307	306	185	183	184
SE ± for Treatments	22	21	15	17	20	13	16	15	11	10	12	8
SE ± for Years			8.65			7.57			6.42			4.60
SE ± for Years × Treatments			21.19			18.54			15.74			11.27

CD (P=0.05) for Treatments	64.98	62.78	43.29	51.28	60.16	37.87	48.42	46.44	32.14	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	11.93	11.13	11.52	10.31	11.57	10.99	13.08	11.96	12.51	10.83	13.44	12.19

Table 5 Non ExchangeableK (ppm) content in different depths at flowering stage of *rabi* groundnut under different nutrient management practices

Treatment	**0-15 cm**			**15-30 cm**			**30-45cm**			**45-60cm**		
	2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
T1: 50% N through FYM + 50% N through Chemical fertilizers	991	1007	999	1196	1216	1206	1321	1246	1284	1493	1445	1469
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	803	836	819	1009	1017	1013	1391	1366	1378	1482	1502	1492
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	822	839	831	1022	1022	1022	1316	1391	1353	1463	1481	1472
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	643	706	675	871	856	864	1281	1324	1302	1446	1414	1430
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Biofertilizers for N and PSB	839	856	848	1032	1038	1035	1266	1266	1266	1420	1432	1426
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	949	990	970	1172	1206	1189	1316	1291	1303	1409	1440	1425
SE ± for Treatments	32	37	24	45	52	34	80	74	54	57	69	45
SE ± for Years			14.14			19.74			31.41			25.77

SE ± for Years × Treatments			34.64			48.36			76.95			63.12
CD (P=0.05) for Treatments	96.73	111.56	70.74	135.45	155.39	98.76	NS	NS	NS	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	7.63	8.48	8.08	8.56	9.73	9.17	12.19	11.20	11.71	7.80	9.50	8.69

Table 6 Non ExchangeableK (ppm) content in different depths at flowering stage of *rabi* groundnut under different nutrient management practices

Treatment	**0-15 cm**			**15-30 cm**			**30-45cm**			**45-60cm**		
	2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
T1: 50% N through FYM + 50% N through Chemical fertilizers	886	929	907	1055	1071	1063	1148	1298	1223	1350	1310	1330
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	735	725	730	868	839	854	1271	1296	1283	1357	1309	1333
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	751	744	748	881	848	864	1238	1233	1235	1356	1399	1378
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	606	617	611	733	720	727	1150	1205	1178	1318	1339	1329
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Bio-fertilizers for N and PSB	768	775	771	893	883	888	1150	1245	1198	1385	1306	1345
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	873	897	885	1045	1048	1047	1173	1266	1219	1309	1330	1320
SE ± for Treatments	31.66	31.17	22.21	37.79	38.48	26.97	70.43	87.20	56.05	51.57	65.08	41.52

SE ± for Years			12.83			15.57			32.36			23.97
SE ± for Years × Treatments			31.42			38.14			79.26			58.72
CD (P=0.05) for Treatments	95.45	93.94	64.16	113.90	115.99	77.88	NS	NS	NS	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	8.23	7.98	8.10	8.28	8.54	8.41	11.85	13.87	12.96	7.67	9.77	8.77

Table 7 Total K (%) content in different depths at flowering stage of *rabi* groundnut under different nutrient management practices

Treatment	0-15 cm			15-30 cm			30-45cm			45-60cm		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T1: 50% N through FYM + 50% N through Chemical fertilizers	1.76	1.85	1.80	1.72	1.75	1.73	1.59	1.60	1.60	1.25	1.30	1.27
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	1.46	1.48	1.47	1.39	1.43	1.41	1.57	1.57	1.57	1.32	1.39	1.36
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	1.51	1.50	1.51	1.40	1.46	1.43	1.57	1.59	1.58	1.34	1.43	1.39
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	1.22	1.22	1.22	1.18	1.22	1.20	1.47	1.56	1.51	1.33	1.31	1.32
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Biofertilizers for N and PSB	1.53	1.54	1.53	1.46	1.49	1.48	1.61	1.61	1.61	1.37	1.26	1.32
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	1.74	1.79	1.77	1.67	1.71	1.69	1.51	1.58	1.54	1.25	1.31	1.28

SE ± for Treatments	0.06	0.06	0.05	0.07	0.05	0.04	0.07	0.06	0.05	0.07	0.08	0.05
SE ± for Years			0.03			0.02			0.03			0.03
SE ± for Years × Treatments			0.06			0.06			0.07			0.07
CD (P=0.05) for Treatments	0.20	0.19	0.13	0.20	0.16	0.12	NS	NS	NS	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	8.46	8.01	8.23	8.98	7.16	8.10	9.44	7.69	8.59	10.21	12.04	11.17

Table 8 Total K (%) content in different depths after harvest of *rabi* groundnut under different nutrient management practices

Treatment	**0-15 cm**			**15-30 cm**			**30-45cm**			**45-60cm**		
	2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
T1: 50% N through FYM + 50% N through Chemical fertilizers	1.74	1.80	1.77	1.63	1.68	1.66	1.54	1.55	1.54	1.23	1.24	1.23
T2: 100% N basal through FYM + Neem cake + Vermicompost each on 1/3rd basis)	1.41	1.46	1.44	1.29	1.31	1.30	1.54	1.54	1.54	1.28	1.25	1.27
T3: 2/3rd N basal through FYM + Neem cake + 1/3rd N top dress through Vermicompost	1.44	1.49	1.47	1.32	1.36	1.34	1.53	1.56	1.54	1.26	1.21	1.24
T4: 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB	1.20	1.24	1.22	1.07	1.12	1.10	1.48	1.55	1.51	1.19	1.25	1.22
T5: 100% N through FYM + Neem cake + Vermicompost each on 1/3rd basis) + Biofertilizers for N and PSB	1.48	1.51	1.49	1.40	1.41	1.41	1.58	1.58	1.58	1.29	1.25	1.27
T_6: 100% NPK through chemical fertilizers (30:50:50 kg NPK ha^{-1})	1.72	1.77	1.74	1.61	1.65	1.63	1.48	1.57	1.52	1.22	1.27	1.25
SE ± for Treatments	0.06	0.06	0.04	0.07	0.06	0.05	0.07	0.06	0.05	0.05	0.05	0.04

SE ± for Years			0.03			0.03			0.03			0.02
SE ± for Years × Treatments			0.06			0.06			0.07			0.05
CD (P=0.05) for Treatments	0.19	0.18	0.13	0.20	0.19	0.13	NS	NS	NS	NS	NS	NS
CD (P=0.05) for Years			NS			NS			NS			NS
CD (P=0.05) for Years × Treatments			NS			NS			NS			NS
CV (%)	8.27	7.89	8.08	9.46	8.69	9.07	9.69	7.98	8.86	7.72	8.56	8.15