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Response of *Kharif* groundnut (*Arachis hypogaea* L.) to various levels and sources of potassium

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Abstract
An experiment entitled, "Effect of levels and sources of potassium on yield and quality of *kharif* groundnut (*Arachis hypogaea* L.) in Entisol" was conducted during *kharif*, 2016 at PG Research Farm, College of Agriculture, Kolhapur. The experiment was laid out in a Factorial Randomized Block Design with two replications comprising of five levels (0, 10, 20, 30, 40 kg K_2O ha^{-1}) and four sources (Muriate of potash, Sulphate of potash, Bagasse ash and Schoenite) of potassium. Results revealed that significantly highest dry pod and kernel yield (31.69 and 22.13 q ha^{-1}, respectively) were obtained with application of 40 kg K_2O ha^{-1}, while among sources, sulphate of potash (SOP) recorded highest yields (27.70 and 19.26 q ha^{-1}, respectively) which was significantly superior over S_3 (bagasse ash) but at par with rest of potassium sources. The nutrient uptake of groundnut was found to be increased significantly with increase in levels of potassium. Significantly highest total uptake of N, P, K, Ca and S (130.07, 19.81, 82.53, 56.92 and 18.40 kg ha^{-1}, respectively) were recorded by application of 40 kg K_2O ha^{-1} than rest of potassium levels. Amongst different sources S_2 -SOP recorded highest total N (114.32 kg ha^{-1}), Ca (53.24 kg ha^{-1}) and S (15.55 kg ha^{-1}) uptake, while highest total P (17.86 kg ha^{-1}), K (75.49 kg ha^{-1}) uptake were observed with S_1 (MOP).

Keywords: bagasse ash, groundnut, potassium, uptake, yield

Introduction
Groundnut (*Arachis hypogaea* L.) is a unique and important legume-oilseed crop of Indian agricultural system which contributes about 40 per cent of area and 30 per cent of the production of oilseed crops. It is the 4th most important source of vegetable oil and 3rd main source of vegetable protein in the world. As regards the nutritional value of groundnut, its seed contains about 40-50 per cent oil, 20-30 per cent protein and 10-20 per cent carbohydrates (Okello *et al.*, 2010) [6]. At present, India ranks 2nd after China with 33 per cent of world's total production, but the productivity is far below than the countries like China, Israel and USA because the crop is traditionally grown in dry land belt of India characterized by poor soil fertility, erratic rainfall and low input levels.

Potassium has been described as the "quality element" for crop production (Usherwood 1985; Pettigrew 2000) [7, 14]. It is the second most absorbed nutrient by the peanut crop (Tasso Júnior *et al*., 2004) which plays various metabolic functions in plants including photosynthesis, protein synthesis, activation of several enzymes and functioning of the stomata (Hawkesford *et al*., 2012) [3], and also have beneficial effect on nitrogen fixation and translocation of photosynthates from the leaves to the root nodules (Savani *et al*., 1995). The crop can remove 100 to 200 kg K_2O ha^{-1} during a growing season. This is usually far in excess of that released from slowly exchangeable sources in soils low in available K. Some studies have highlighted the importance of potassium fertilization on the peanut crop, emphasizing its effect on development, nutrition and production (Pradyut *et al*., 2006; Reddy *et al.*, 2011; Sharma *et al*., 2011; Lobo *et al*., 2012) [10, 12, 5, 8]; Groundnut is widely cultivated by farmers of the Sub-montane Zone of Maharashtra with the recommended dose 25:50:00 (N: P_2O_5:K_2O kg ha^{-1}). The soils of the sub-montane Zone region are widely reported to be low in potassium status. So the application of K along with existing recommendation of N and P is required to increase the groundnut production.

In view of the increasing awareness of the multitudes of crucially important roles played by K in plants, the present study was undertaken to assess yield and nutritional responses of groundnut plants when grown at variable levels and sources of K.

Material and Methods

Soil and climate

The study site is situated at the Post Graduate Research Farm, College of Agriculture, Kolhapur, Maharashtra ($16^0$42' N latitude, $74^0$14' E longitude and 548 m AMSL). The experimental site belongs to the class of sandy clay loam soil (56.70 % sand, 18.70 % silt and 24.60 % clay) containing low available N (150.25 kg $ha^{-1)}$, moderate P_2O_5 (21.37 kg ha^{-1}) K_2O (252.75 kg ha^{-1}) and available S (10.35 mg kg^{-1}). The status of organic carbon content (0.45 %) was moderate and moderately calcareous with 4.87 per cent $CaCO_3$ equivalent. The soil reaction was slightly alkaline (pH 7.6) and EC was normal (0.27 dS m^{-1}). The total rainfall received during the period of field experiment was 1056.50 mm in 63 rainy days. The relative humidity during the crop period was in the range of 70 to 91 per cent at morning and 48 to 90 per cent at evening. The minimum temperature varied from 10.6^0C to 21.5^0C, while maximum temperature was in the range of 25.3^0C to 31.9^0C. The evaporation during experimentation ranges between 1.4 mm to 5.7 mm per day.

Experimental details

As per recommendation, FYM @ 12t ha^{-1} was applied uniformly to all the plots well in advance (25 days) and recommended dose of N and P_2O_5 (25:50 kg ha^{-1}) was applied to all treatments through Urea and Single super phosphate. The experiment was laid out in the factorial randomized block design. The treatments consisted of five levels of potassium *viz*.0 (L_1), 10 (L_2), 20 (L_3), 30 (L_4) and 40 (L_5) kg ha^{-1} which were supplied through four different potassium sources *viz* muriate of potash (S_1), sulphate of potash(S_2), bagasse ash (S_3) and schoenite (S_4). Groundnut was sown with a spacing 30 cm x 15 cm. After experimental layout Bagasse ash was applied as per the treatments well in advance before dibbling of groundnut seeds and well mixed in surface soil. For uptake analysis, collected samples of haulm and kernels were dried at 60^0 C, powdered and preserved for analysis (Jackson, 1973). Total N, P, K, Ca and S uptake of plant samples was determined by adopting standard methods with the following formula:

Nutrient uptake (kg ha^{-1}) = Nutrient concentration (%) ×Dry matter yield ((kg ha^{-1})

Table 1: Effect of levels and sources of potassium on pod, kernel, haulm yield and shelling percentage of groundnut

Treatments	Dry pod yield (q ha^{-1})	Kernel yield (q ha^{-1})	Haulm yield (q ha^{-1})	Shelling %
Levels of potassium (kg ha^{-1})				
L_0 (0)	21.74	14.71	33.93	67.63
L_1(10)	23.68	16.28	35.05	68.73
L_2(20)	26.25	18.15	35.23	69.08
L_3(30)	29.26	20.27	37.67	69.26
L_4(40)	31.69	22.13	38.94	69.90
S.E.±	0.57	0.38	0.56	0.52
CD at 5%	1.69	1.14	1.67	NS
Sources of potassium				
S_1(MOP)	26.69	18.48	36.58	69.19
S_2(SOP)	27.70	19.26	36.64	69.46
S_3(BA)	25.07	17.06	35.49	67.89
S_4(SCH)	26.63	18.44	35.94	69.13
S.E.±	0.51	0.34	0.50	0.47
CD at 5%	1.51	1.02	NS	NS
Interaction (L x S)				
S.E.±	1.14	0.77	1.13	1.06
CD at 5%	NS	NS	NS	NS

Table 2: Effect of levels and sources of potassium on uptake of primary and secondary nutrients by haulm, kernel and shell of groundnut

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})			Calcium (kg ha^{-1})			Sulphur (kg ha^{-1})		
	Haulm	Kernel	Shell	Haulm	Kernel	Shell	Haulm	Kernel	Shell	Haulm	Kernel	Shell	Haulm	Kernel	Shell
Levels of potassium (kg ha^{-1})															
L0	31.09	52.03	4.46	7.77	6.20	0.29	42.97	6.67	2.27	46.03	2.12	0.02	8.93	3.99	0.61
L1	33.36	57.13	4.89	8.26	6.64	0.29	52.67	7.47	2.40	48.09	2.18	0.02	9.73	4.35	0.82
L2	38.14	63.44	5.14	8.73	7.57	0.31	58.53	8.36	2.50	48.41	2.36	0.03	9.98	5.31	0.87
L3	44.11	70.53	6.04	9.60	8.40	0.33	62.65	9.34	2.89	52.08	2.43	0.03	10.17	5.76	1.03
L4	50.39	76.53	6.59	10.63	9.34	0.33	66.84	9.87	3.17	53.85	2.48	0.03	11.14	6.45	1.14
S.E. ±	0.93	1.20	0.12	0.16	0.17	0.007	1.33	0.185	0.042	0.08	0.07	0.016	0.23	0.18	0.03
CD at 5%	2.76	3.56	0.35	0.47	0.50	0.022	3.96	2.89	2.89	2.4	0.20	0.046	0.67	0.52	0.09
Sources of potassium															
S1(MOP)	40.99	64.80	5.59	9.91	7.81	0.31	63.12	8.82	2.86	51.42	2.28	0.02	9.88	5.04	0.93
S2(SOP)	40.61	67.14	5.53	9.87	7.91	0.32	56.07	8.78	2.80	51.50	2.44	0.03	10.34	5.62	1.03
S3(BA)	37.17	60.02	5.11	8.59	7.18	0.29	52.64	7.82	2.61	50.01	2.15	0.02	9.77	4.82	0.73
S4(SCH)	38.90	63.97	5.46	8.85	7.63	0.32	55.10	7.94	2.68	49.50	2.37	0.02	9.97	5.20	0.89
S.E. ±	0.83	1.07	0.10	0.14	0.15	0.007	1.19	0.165	0.037	0.73	0.06	0.014	0.20	0.16	0.03
CD at 5%	2.47	3.18	0.32	0.42	0.45	NS	3.54	3.12	3.12	NS	0.18	0.041	NS	0.47	0.08
Interaction (L x S)															
S.E. ±	1.86	2.40	0.23	0.32	0.34	0.015	2.67	0.269	.083	1.64	0.14	0.031	0.45	0.35	0.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	.093	NS	NS	NS

Table 3: Effect of levels and sources of potassium on total uptake of primary and secondary nutrients by groundnut

Treatments	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})	Total Ca uptake (kg ha^{-1})	Total S uptake (kg ha^{-1})
Levels of potassium (kg ha^{-1})					
L_0	90.39	14.55	53.21	48.59	13.57
L_1	96.89	15.61	63.82	50.66	14.77
L_2	106.59	16.64	71.09	51.27	16.01
L_3	119.76	18.05	77.17	55.07	16.73
L_4	130.07	19.81	82.53	56.92	18.40
S.E. ±	1.17	0.25	1.37	0.81	0.26
CD at 5%	3.47	0.74	4.06	2.39	0.76
Sources of potassium					
S_1(MOP)	109.33	17.86	75.49	52.88	15.55
S_2(SOP)	114.32	17.81	69.31	53.24	16.72
S_3(BA)	102.90	16.23	64.81	51.50	15.33
S_4(SCH)	108.40	16.72	67.87	52.40	15.89
S.E. ±	1.05	0.22	1.23	0.72	0.23
CD at 5%	3.10	0.66	3.64	NS	0.68
Interaction (L x S)					
S.E. ±	2.34	0.50	2.75	1.61	0.51
CD at 5%	NS	NS	NS	NS	NS

Results and Discussions

Effect on dry pod, kernel, haulm yield and shelling percentage of groundnut

It is evident that application of increasing levels of potassium significantly increased the dry pod, kernel and haulm yields of groundnut and highest yields (31.69, 22.13 and 38.94 q ha^{-1}, respectively) were recorded by application of 40 kg K_2O ha^{-1}. Amongst sources, highest dry pod, kernel and haulm yields (27.70, 19.26 and 36.64 q ha^{-1}, respectively) were recorded with S_2 –SOP which were at par with MOP and schoenite (Table 1). The highest yield obtained with SOP might be attributed to its sulphur content. Interaction effects of different levels and sources of potassium were found non significant in relation to dry pod yield. The shelling percentage ranged 67-70 % but the effect of various treatments on shelling percentage was non-significant. These results are in close conformity with the observations recorded by Hadwani and Gundalia (2005) [2] and Veramani and Subrahmaniyan (2011) [15] who also reported positive response of groundnut to the applied potassium.

Effect on nutrient uptake by groundnut at harvest

Total Nitrogen uptake

The data presented in table 3 revealed that, the total uptake of nitrogen was significantly affected by different levels and sources of potassium. Significantly highest total N uptake was recorded by application of 40 kg ha^{-1} K_2O (L_4) and with SOP (S_2) (130.07 and 114.32 kg ha^{-1}, respectively) and it was superior over all other levels and sources of potassium. However, for total N uptake interaction effects were found non-significant. The added nutrients and synergetic effect N and S might have enhanced the microbial activities resulting in higher nitrogen fixation, profuse plant and root growth which ultimately increased total uptake of nitrogen. The results are in close agreement with the findings reported by Dutta *et al.* (2003) [1] and Rathore *et al.* (2014) [9].

Total Phosphorus uptake

The significantly highest total P uptake (19.81 kg ha^{-1}) was found with application of 40 kg K_2O ha^{-1} than the other levels of potassium. Among sources significantly highest total P uptake (17.86 kg ha^{-1}) was recorded with S_1-MOP which was at par with S_2-SOP (17.81 kg ha^{-1}) than the rest of potassium sources. Interaction effects of different levels and sources of potassium were found non- significant in relation to total P uptake.

The increased root and plant growth might have increased higher total uptake of P. Again, the presence of other nutrients in different potassium sources might have increased the availability of phosphate solubilizing bacteria which improved total P uptake. The results are in close conformity with the findings reported by Dutta *et al.* (2003) [1] and Hadwani and Gundalia (2005) [2].

Total potassium uptake

Among various levels and sources of potassium, 40 kg K_2O ha^{-1} (82.53 kg ha^{-1}) and MOP (75.49 kg ha^{-1}) respectively were found significantly superior over rest of levels and sources. Interaction effects were found non- significant in relation to total K uptake.

The increased uptake of potassium might be due to added potassium and profuse growth of root and plant as a result of added nutrients. Similar finding were reported by Dutta *et al.* (2003) [1] and Hadwani and Gundalia (2005.) [2].

Total calcium uptake

The data presented in table 3 shows that, total uptake of calcium by groundnut was found significantly highest (56.92 kg ha^{-1}) at L_4 -K 40 but it was at par with L_3-K 30 (55.07 kg ha^{-1}). The effect of sources and interaction effects of different levels and sources of potassium were found non- significant in relation to total Ca uptake.

The increased potassium levels associated with profuse growth of plant and roots and thus increased total Ca uptake by groundnut. The results are in close conformity with the findings reported by Rathore *et al.* (2014) [9].

Total sulphur uptake

The total uptake of sulphur was significantly highest (18.40 ha^{-1}) at L_4 (K 40) which was significantly superior over rest of potassium levels. Among sources highest total S uptake (16.72 kg ha^{-1}) was recorded with S_1 (MOP) which was significantly superior over rest of potassium sources. However, interactions were found non-significant in relation to total S uptake in all treatments.

The added sulphur by Sulphate of potash and schoenite might have increase the pool available sulphur in soil and improved activities of sulphur oxidizing microbs might have helped for oxidation of elemental sulphur to SO_4. Similar findings were reported by Rathore *et al*. (2014) [9].

Conclusions

From the present investigation it is observed that addition of potassium along with the recommended dose of NP influenced the yield and uptake by groundnut. Significant increase in yield and uptake were reported with higher dose potassium i.e. 40kg ha^{-1} and among different potassium sources SOP shows highly significant results. Therefore, potassium application along with recommended dose NP (25:50 kg ha^{-1}) can be recommended to achieve higher yield and improve quality of groundnut in sub-montane zones with low to moderate potassium status in soils.

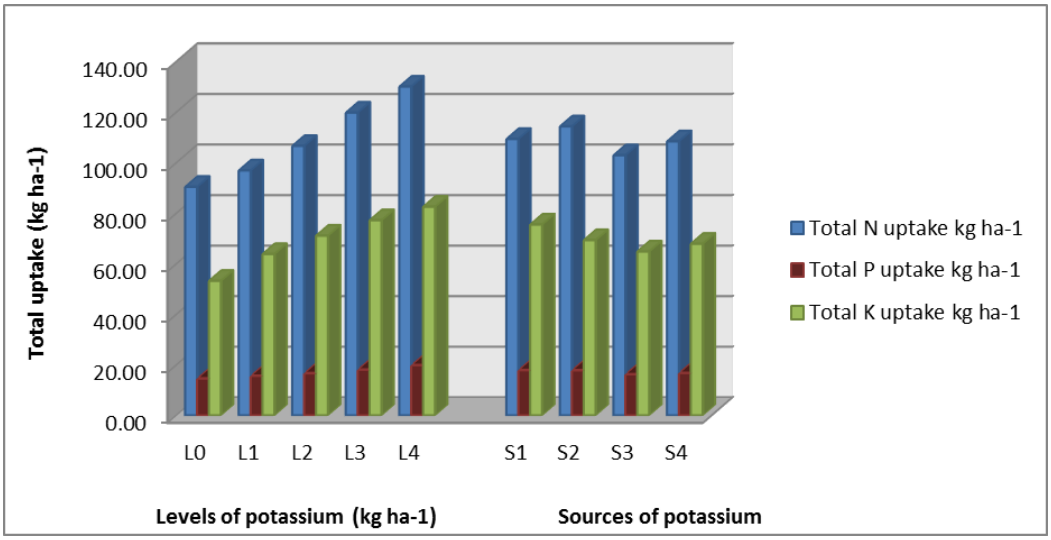

Fig 1: Effect of levels and sources of potassium on total uptake of primary nutrients by groundnut

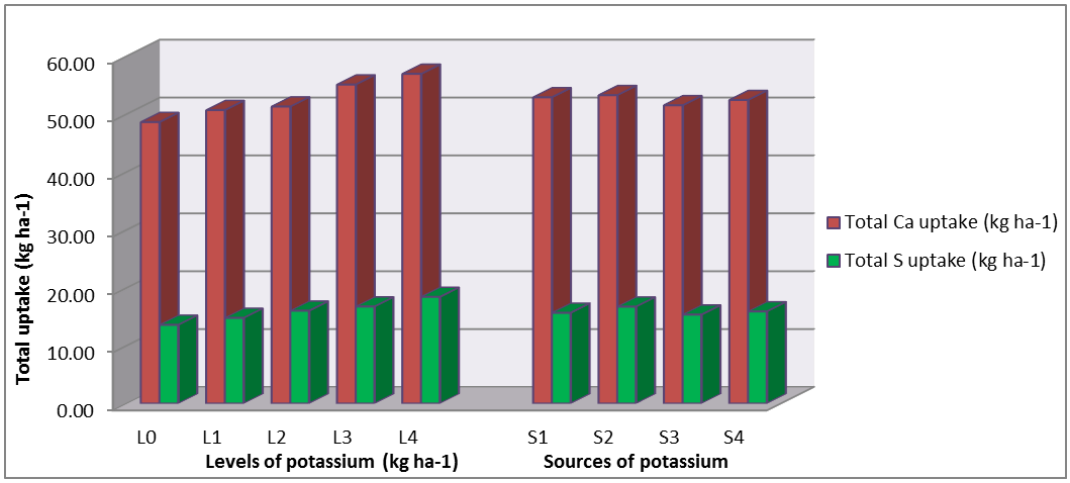

Table 2: Effect of levels and sources of potassium on total uptake of secondary nutrients by groundnut

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