International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 983-989

Received: 19-01-2020
Accepted: 21-02-2020

Solanki KD
College of Agriculture, Department of Agricultural Chemistry & Soil Science Junagadh Agricultural University, Junagadh, Gujarat, India

Sakarvadia HL
College of Agriculture, Department of Agricultural Chemistry & Soil Science Junagadh Agricultural University, Junagadh, Gujarat, India

MP Purohit
College of Agriculture, Department of Agricultural Chemistry & Soil Science Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
Solanki KD
College of Agriculture, Department of Agricultural Chemistry & Soil Science Junagadh Agricultural University, Junagadh, Gujarat, India

Influence of nutrients accumulation by various levels of phosphorus and phosphorus solubilizing bacteria in summer groundnut

Solanki KD, Sakarvadia HL and MP Purohit

DOI: https://doi.org/10.22271/chemi.2020.v8.i2o.8895

Abstract
A field experiment was conducted on summer groundnut (var. GJG 31) at Junagadh Agricultural University, Junagadh during summer, 2018. The treatments comprising of different four levels of phosphorus viz., 0, 12.5, 25 and 50 kg ha^{-1} and four levels of phosphorus solubilizing bacteria (PSB) viz., 0, 1, 2 and 3 lit ha^{-1} in Factorial Randomized Block Design repeated thrice were tested in the experiment, in respect of content and uptake of nutrients like N, K, S, Fe, Mn, Zn and Cu at harvest and P at 30, 60 DAS and at harvest in pod & haulm and their total uptake by groundnut crop. Application of 50 kg P_2O_5 ha^{-1} significantly increased only the phosphorus content in pod and haulm at harvest and in plant at 30 and 60 DAS. Whereas, phosphorus application did not exert any significant effect on N, K, S, Fe, Mn, Zn and Cu content in pod and haulm. Application of 50 kg P_2O_5 ha^{-1} significantly increased the uptake of all the nutrients (N, P, K, S, Fe, Mn and Cu) by pod, haulm and its total uptake by the groundnut crop, except Zn uptake by pod and haulm. Application of PSB produced significantly favorable effect on phosphorus content in pod and haulm at harvest and in plant at 30 & 60 DAS of groundnut. While, PSB application did not exert any significant effect on N, K, S, Fe, Mn, Zn and Cu content in pod and haulm. Significantly higher values of all these parameters were observed with application of 3 lit PSB ha^{-1}. Application of 3 lit PSB ha^{-1} also significantly increased the uptake of all the nutrients (N, P, K, S, Fe, Mn and Cu) by pod, haulm and its total uptake by the groundnut crop, except Zn uptake by pod and haulm.

Keywords: Groundnut, phosphorus, PSB, nutrients content and uptake

Introduction
The groundnut (*Arachis hypogaea* L.) is one of the important food legume crop of tropical and subtropical parts of the world. China and India are the largest producers of groundnut sharing 42 and 20 per cent of the world groundnut production, respectively. India is one of the largest producers of oilseeds in the world and oilseeds occupy an important position in the Indian agricultural economy. In the recent years, the area under summer groundnut has increased due to assured and higher profit and productivity as it is grown in area where assured irrigation water is available and less incidence of a biotic and abiotic stresses on the crop as compared to rainy season (Rana *et al*., 2014) [1]. In Gujarat, It is grown on an area of 0.52 L ha with the production of 0.95 L tonnes and productivity of 1842 kg ha^{-1} during summer season (Anon., 2017) [2]. Phosphorus play beneficial role in the root development, nodulation and stimulation of the symbiotic nitrogen fixation. It enhances root development and nodulation, improves the supply of nutrients and water, increase in photosynthetic area resulting in more dry matter accumulation and yield (Rajanikanth *et al*., 2008) [3]. Phosphorus is an essential element for plant growth and development. Because of its sparingly soluble nature it is present in very less proportion in the soil for plant uptake. Major proportions of soil-P remain interlocked in various insoluble forms and not available for plant use. Some bacterial species have a natural potential to solublize the phosphorus. The use of phosphorus solubilizing bacteria (PSB) simultaneously enhances P availability to plants and crop yield. Present review emphasizes the role of phosphate solubilizing bacteria in sustainable management of soil by solubilization of fixed-phosphorus in relation to crop responses. This review exhaustively explores the potential of PSB to solublize phosphate by highlighting the current practices and future prospects of their utility in soil management.

Keeping all the above aspects in view and in order to test the combine effect of both factors with its various levels of application, investigation was carried out to study the "Influence of nutrients accumulation by various levels of phosphorus and phosphorus solubilizing bacteria in summer groundnut".

Materials and Methods

A field experiment was conducted on summer groundnut (var. GJG 31) at Instructional farm, Junagadh Agricultural University, Junagadh, during summer seasons of 2018. The experimental soil was medium black calcareous, clayey in nature which was slightly alkaline in reaction, $pH_{2.5}$ (7.8) and $EC_{2.5}$ (0.33 dS m^{-1}), low in available nitrogen (237.0 kg ha^{-1}), medium in available phosphorus (36.2 kg ha^{-1}), sulphur (17.5 ppm), iron (5.35 ppm) and zinc (0.78 ppm) and high in available potassium (284.0 kg ha^{-1}), manganese (14.8 ppm) and copper (2.06 ppm). The treatments comprising all possible combination of different four levels of each phosphorus viz., 0, 12.5, 25 and 50 kg ha^{-1} and phosphorus solubilizing bacteria (PSB) viz., 0, 1, 2 and 3 lit ha^{-1} in Factorial Randomized Block Design repeated thrice were tested in the experiment, in respect of content and uptake of nutrients like N, K, S, Fe, Mn, Zn and Cu at harvest and P at 30, 60 DAS in plant and at harvest in pod & haulm and their total uptake by groundnut. All the nutrients content and uptake in plant were determined by adopting standard processers.

Results and Discussion

Effect of phosphorus on nutrients content

An assessment of data indicated that different levels of phosphorus exerted their significant influence on only phosphorus content (Table-1) in summer groundnut. The concentration of phosphorus recorded significantly higher in pod and haulm with the values of 0.527% and 0.490% at harvest and at 30 and 60 DAS in groundnut plant with value 0.531% and 0.287% under application of 50 kg P_2O_5 ha^{-1}, respectively. The concentration of nitrogen, potassium, sulphur and micro-nutrient (Fe, Mn, Zn and Cu) in pod and haulm at harvest did not influenced by phosphorus application. Application of phosphorus significantly increased the P content in haulm at 30 and 60 DAS and in pod and haulm at harvest. This may be due to phosphorus increases root growth of the crop which ultimately helped in increasing the p absorption by groundnut and also may enhance the availability of the soil phosphorus for plant nutrition. The results of present investigation were in close agreements with the finding of Choudhary and Yadav (2017) [4], Vaghasia and Bhalu (2016) [5] and Agrawal (1997) [6].

Nutrients uptake

An assessment of data (Table-2) indicated that different levels of phosphorus exerted their significant influence on nutrients uptake by summer groundnut. The uptake of nitrogen, phosphorus, potassium, sulphur and micro-nutrient (Fe, Mn, and Cu) by pod and haulm were significantly increased with phosphorus application. The application of 50 kg P_2O_5 ha^{-1} showed significantly higher value of nitrogen (98.7 & 55.8 kg ha^{-1}), phosphorus (13.7 & 13.4 kg ha^{-1}), potassium (16.9 & 23.9 kg ha^{-1}), sulphur (8.13 & 9.75 kg ha^{-1}) and micro-nutrient like iron (1215 & 1881 g ha^{-1}), manganese (116 & 332 g ha^{-1}) and copper (81 & 107 g ha^{-1}) by pod and haulm, respectively. However, the zinc uptake by pod and haulm did not influenced significantly by phosphorus application. Similarly, the application of 50 kg P_2O_5 ha^{-1} showed significantly higher value of total uptake nitrogen (155 kg ha^{-1}), phosphorus (27.4 kg ha^{-1}), potassium (40.8 kg ha^{-1}), sulphur (17.88 kg ha^{-1}), iron (3122 g ha^{-1}), manganese (448 g ha^{-1}), zinc (312 g ha^{-1}) and copper (188 g ha^{-1}) by groundnut crop. The reason behind increases in uptake of nutrients may be due to phosphorus increases the root growth of the crop which ultimately helped in increasing the uptake of nutrients. This result is in accordance with Jana *et al.* (1990) [7]. The crop could better take up the said nutrients only when the suitable dose of phosphorus was applied (Deka *et al.*, 2001) [8]. The nutrient uptake is a function of yield and nutrient concentration in plant. Thus, improvement in uptake of N, P, K, S, Fe, Mn and Cu might be attributed to their respective higher concentration in pod and haulm and associated with higher pod and haulm yields. The results of present investigation are in close agreements with the findings of Hadwani and Gundalia (2005) [9], Thorave and Dhonde (2008) [10], Kumar *et al.* (2008) [11] and Vaghasia and Bhalu (2016) [5] in groundnut and Babaria *et al.* (2014) [12] in cotton.

Effect of phosphorus solubilizing bacteria nutrients content

An assessment of data (Table-1) indicated that different levels of phosphorus solubilizing bacteria exerted their significant influence only on phosphorus content in summer groundnut. The concentration of phosphorus recorded significantly higher in pod and haulm with the values of 0.530% and 0.530% at harvest and at 30 and 60 DAS in groundnut plant with value 0.522% and 0.275% under treatment of 3 lit PSB ha^{-1} (PSB_3), respectively. The concentration of nitrogen, potassium, sulphur and micro-nutrient (Fe, Mn, Zn and Cu) in haulm at harvest did not influenced by PSB application. Application of PSB significantly increased the P content in pod and haulm at 30 and 60 DAS and at harvest, which might be due to releasing P from native as well as protecting fixation of applied phosphorus which rendered more available P for the plant leading to increased nutrient content. Sharma *et al.* (2014) [13] showed that application of PSB significantly increase P content in pod and haulm of groundnut.

Nutrients uptake

An examination of data (Table-2) showed that different levels of phosphorus solubilizing bacteria executed their significant influence on nutrients uptake by summer groundnut. The uptake of nitrogen, phosphorus, potassium, sulphur and micro-nutrient (Fe, Mn, and Cu) by pod and haulm were significantly increased with PSB application. The application of 3 lit PSB ha^{-1} showed significantly higher value of nitrogen (98.4 & 55.9 kg ha^{-1}), phosphorus (13.6 & 13.3 kg ha^{-1}), potassium (17.2 & 23.7 kg ha^{-1}), sulphur (7.93 & 9.78 kg ha^{-1}) and micro-nutrient like iron (1196 & 1873 g ha^{-1}), manganese (114 & 331g ha^{-1}) and copper (78 & 106 g ha^{-1}) by pod and haulm, respectively. However, zinc uptake by pod and haulm did not influenced by PSB application. The application of 3 lit PSB ha^{-1} showed significantly higher value of total uptake of nitrogen (168 kg ha^{-1}), phosphorus (27.2 kg ha^{-1}), potassium (40.8 kg ha^{-1}), sulphur (17.71 kg ha^{-1}), iron (3102 g ha^{-1}), manganese (445 g ha^{-1}), zinc (312 g ha^{-1}) and copper (185 g ha^{-1}) by groundnut crop. Phosphate solubilizing bacteria had shown positive response with respect to uptake of all the nutrients under study (N, P, K, S, Fe, Mn, Zn and Cu) by pod and haulm and its total uptake by groundnut crop at harvest, except Zn uptake by pod and haulm. Phosphate solubilizing bacteria (PSB) solubilize unavailable phosphorus by secretion

of organic acids and phosphatase enzyme. These all might have contributed towards increased available phosphorus status of the soil (Kachot *et al.*, 2001) [14]. Thus, increased yield of pod and haulm ultimately, improvement in uptake of N, P, K, S, Fe, Mn, Zn and Cu by groundnut. The observations recorded were found similar with Manisha *et al.* (2006) [15], Zalate and Padmani (2010) [16], Choudhary *et al.* (2011) [17] and Singh *et al.* (2013) [18].

Table 1: Effect of phosphorus and phosphorus solubilizing bacteria on N, P, K and S content in groundnut

Treatments	Phosphorus content (%)				N (%)		K (%)		S (%)	
	At 30 DAS	At 60 DAS	At harvest		Pod	Haulm	Pod	Haulm	Pod	Haulm
			Pod	Haulm						
P levels (kg P_2O_5 ha^{-1})										
P_0 – 0	0.467	0.237	0.487	0.404	3.62	1.81	0.650	0.743	0.294	0.296
P_1- 12.5	0.496	0.251	0.499	0.413	3.75	1.81	0.657	0.756	0.300	0.312
P_2 – 25	0.513	0.270	0.511	0.431	3.78	1.82	0.659	0.774	0.310	0.317
P_3 – 50	0.531	0.287	0.527	0.490	3.80	1.83	0.651	0.785	0.313	0.320
S.Em.±	0.009	0.006	0.010	0.009	0.10	0.05	0.014	0.014	0.006	0.007
C.D. at 5%	0.027	0.017	0.028	0.026	NS	NS	NS	NS	NS	NS
PSB levels (lit PSB ha^{-1})										
PSB_0 – 0	0.481	0.250	0.481	0.401	3.59	1.80	0.635	0.736	0.298	0.297
PSB_1 – 1	0.496	0.257	0.502	0.420	3.71	1.80	0.646	0.759	0.301	0.307
PSB_2 – 2	0.509	0.264	0.512	0.510	3.79	1.83	0.663	0.779	0.306	0.316
PSB_3 – 3	0.522	0.275	0.530	0.530	3.86	1.86	0.673	0.784	0.311	0.324
S.Em.±	0.009	0.006	0.010	0.009	0.10	0.05	0.014	0.014	0.006	0.007
C.D. at 5%	0.027	0.017	0.028	0.026	NS	NS	NS	NS	NS	NS
P x PSB										
S.Em.±	0.019	0.012	0.019	0.018	0.20	0.10	0.028	0.028	0.012	0.014
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	6.55	7.82	6.5	7.4	9.4	9.1	7.3	6.3	6.8	7.7

Table 1.1: Effect of phosphorus and phosphorus solubilizing bacteria on micronutrients (Fe, Mn, Zn and Cu) content in groundnut

Treatments	Fe (ppm)		Mn (ppm)		Zn (ppm)		Cu (ppm)	
	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm
P levels (kg P_2O_5 ha^{-1})								
P_0 – 0	457	598	43.6	102	64.1	54.0	29.7	34.6
P_1- 12.5	462	606	44.1	106	63.5	53.7	30.1	34.8
P_2 – 25	468	621	44.3	108	62.8	52.3	30.5	35.0
P_3 – 50	469	618	44.9	109	61.1	50.7	31.0	35.3
S.Em.±	9	13	1.0	2	1.7	1.1	0.6	0.8
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
PSB levels (lit PSB ha^{-1})								
PSB_0 – 0	458	598	43.6	102	63.9	53.8	29.8	34.7
PSB_1 – 1	462	607	44.0	105	63.2	53.1	30.1	34.9
PSB_2 – 2	466	616	44.4	108	62.6	52.3	30.4	35.0
PSB_3 – 3	469	622	44.8	110	61.7	51.5	30.8	35.2
S.Em.±	9	13	1.0	2	1.7	1.1	0.6	0.8
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
P x PSB								
S.Em.±	19	26	2.0	5	3.4	2.16	1.3	1.6
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	7.1	7.3	7.9	8.1	9.3	7.1	7.4	7.8

Table 2: Effect of phosphorus and phosphorus solubilizing bacteria on nutrients uptake by summer groundnut

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Pod	Haulm	Total	Pod	Haulm	Total	Pod	Haulm	Total
P levels (kg P_2O_5 ha^{-1})									
P_0 – 0	79.7	48.7	128	10.7	10.8	21.7	14.3	19.9	34.2
P_1- 12.5	83.5	48.8	132	11.1	11.1	22.4	14.7	20.4	35.0
P_2 – 25	90.5	52.2	143	12.3	12.4	25.0	15.8	22.3	38.2
P_3 – 50	98.7	55.8	155	13.7	13.4	27.4	16.9	23.9	40.8
S.Em.±	2.7	1.7	3	0.4	0.3	0.5	0.5	0.7	0.8
C.D. at 5%	7.9	5.0	11	1.1	1.0	1.5	1.5	1.9	2.3
PSB levels (lit PSB ha^{-1})									
PSB_0 – 0	79.4	47.0	135	10.6	10.5	21.2	14.0	19.3	33.4
PSB_1 – 1	83.6	49.0	143	11.3	11.4	22.9	14.6	20.7	35.3
PSB_2 – 2	91.0	53.5	158	12.3	12.5	25.2	15.9	22.8	38.7
PSB_3 – 3	98.4	55.9	168	13.6	13.3	27.2	17.2	23.7	40.8
S.Em.±	2.7	1.7	4	0.4	0.3	0.5	0.5	0.7	0.8
C.D. at 5%	7.9	5.0	11	1.1	1.0	1.5	1.5	1.9	2.3

P x PSB									
S.Em.±	5.5	3.5	7	0.7	0.7	1.1	1.0	1.3	1.6
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	10.8	11.7	8.6	10.6	10.0	7.7	11.5	10.6	7.5

Table 2.1: Effect of phosphorus and phosphorus solubilizing bacteria on nutrients uptake by summer groundnut

Treatments	S uptake (kg ha^{-1})			Fe uptake (g ha^{-1})			Mn uptake (g ha^{-1})		
	Pod	Haulm	Total	Pod	Haulm	Total	Pod	Haulm	Total
P levels (kg P_2O_5 ha^{-1})									
P_0 – 0	6.46	7.95	14.41	1007	1596	2621	96	274	370
P_1- 12.5	6.70	8.38	15.07	1030	1630	2670	98	285	383
P_2 – 25	7.43	9.13	16.56	1120	1791	2937	106	312	418
P_3 – 50	8.13	9.75	17.88	1215	1881	3122	116	332	448
S.Em.±	0.22	0.31	0.33	30	48	60	3	10	10
C.D. at 5%	0.63	0.91	0.97	88	139	175	8	29	30
PSB levels (lit PSB ha^{-1})									
PSB_0 – 0	6.60	7.80	14.41	1012	1572	2583	97	267	364
PSB_1 – 1	6.80	8.38	15.18	1044	1655	2709	99	287	386
PSB_2 – 2	7.38	9.25	16.63	1120	1798	2956	107	316	423
PSB_3 – 3	7.93	9.78	17.71	1196	1873	3102	114	331	445
S.Em.±	0.22	0.31	0.33	30	48	60	3	10	10
C.D. at 5%	0.63	0.91	0.97	88	139	175	8	29	30
P x PSB									
S.Em.±	0.43	0.63	0.67	61	96	121	5	20	21
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	10.5	12.4	7.2	10.2	9.7	7.4	9.3	11.4	8.8

Table 2.2: Effect of phosphorus and phosphorus solubilizing bacteria on nutrients uptake by summer groundnut

Treatments	Zn uptake (g ha^{-1})			Cu uptake (g ha^{-1})		
	Pod	Haulm	Total	Pod	Haulm	Total
P levels (kg P_2O_5 ha^{-1})						
P_0 – 0	141	144	285	65	93	158
P_1- 12.5	142	144	286	67	94	161
P_2 – 25	150	150	301	73	101	174
P_3 – 50	158	154	312	81	107	188
S.Em.±	5	5	6	2	3	4
C.D. at 5%	NS	NS	18	7	9	11
PSB levels (lit PSB ha^{-1})						
PSB_0 – 0	141	141	283	66	91	157
PSB_1 – 1	143	145	287	68	95	163
PSB_2 – 2	150	152	303	73	102	176
PSB_3 – 3	157	155	312	78	106	185
S.Em.±	5	5	6	2	3	4
C.D. at 5%	NS	NS	18	7	9	11
P x PSB						
S.Em.±	10	10	12	5	7	8
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. %	12.2	11.3	7.3	12.4	11.5	7.8

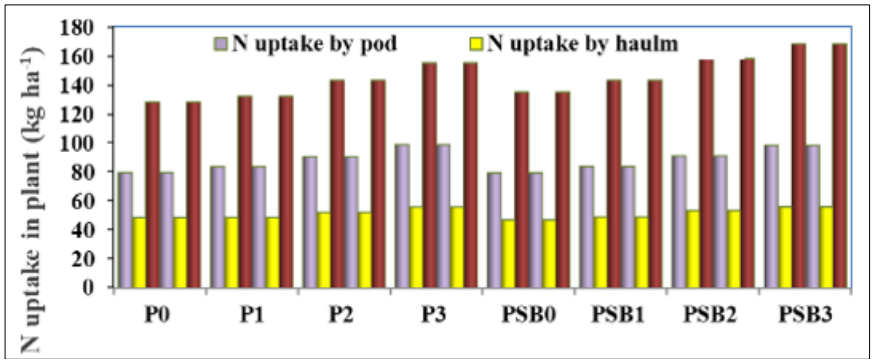

Fig 1: Effect of P and PSB on N uptake by pod, haulm its total uptake

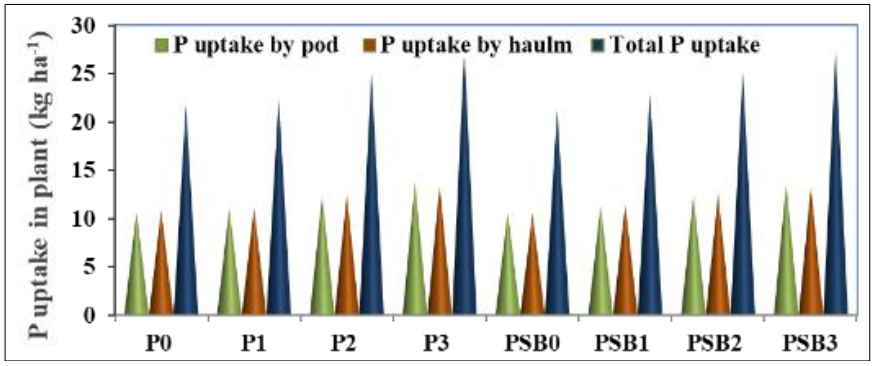

Fig 2: Effect of P and PSB on P uptake by pod, haulm and its total uptake

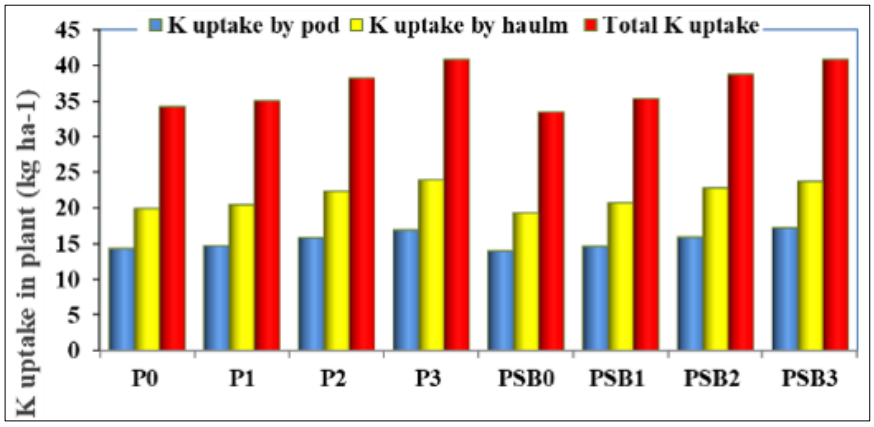

Fig 3: Effect of P and PSB on K uptake by pod, haulm and its total uptake

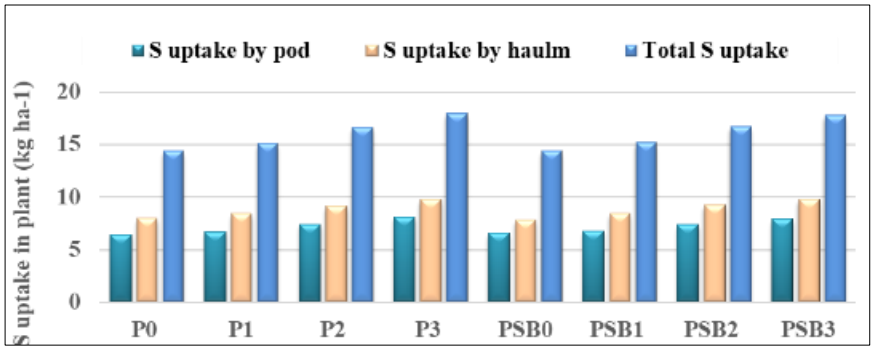

Fig 4: Effect of P and PSB on S uptake by pod, haulm and its total uptake

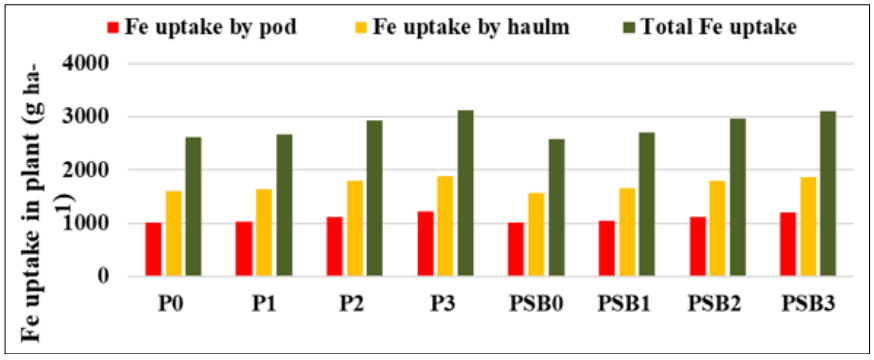

Fig 5: Effect of P and PSB on Fe uptake by pod, haulm and its total uptake

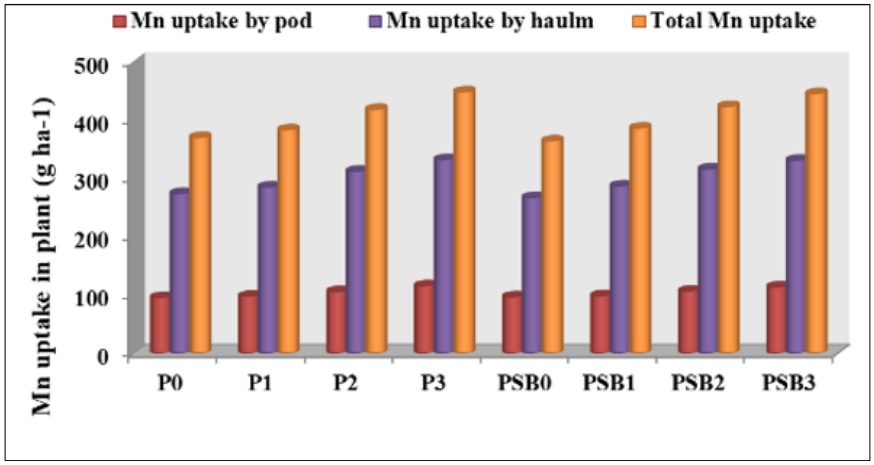

Fig 6: Effect of P and PSB on Mn uptake by pod, haulm and its total uptake

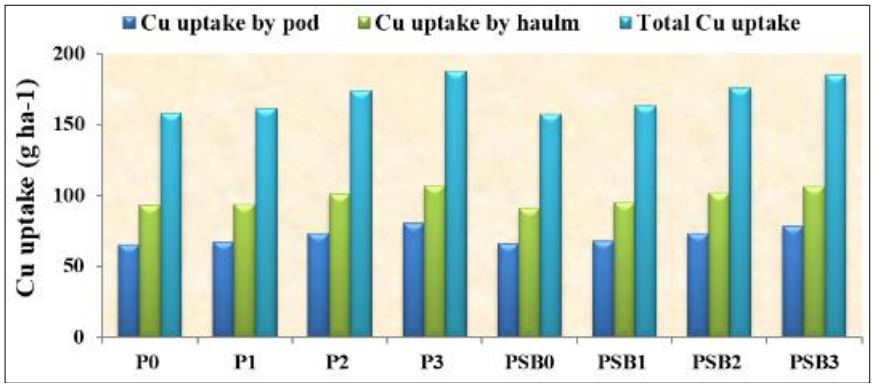

Fig 7: Effect of phosphorus and PSB on Cu uptake by pod, haulm and its total uptake

References

1. Rana DS, Kumar D, Sepat S. Groundnut. In: Prasad, R. (ed.), Textbook of Field Crops Production-Commercial Crops. ICAR, New Delhi, 2014, 73p.
2. Anonymous. Groundnut area, production and productivity, USDA Foreign Agriculture Service, 2017. https://www.fas.usda.gov/Accessed on Dt. 14/11/2017.
3. Rajanikanth E, Subrahmanyam MVR, Rao JV. Effect of integrated nutrient management practices on growth and yield of rainfed groundnut (*Arachis hypogaea* L.) intercropped with guava (*Psidium guajava*). Oilseeds Research. 2008; 25(2):157-160.
4. Choudhary RR, Yadav HL. Effect of conjunctive use of phosphorus and bio-organics on Phosphorus content and uptake in summer groundnut (*Arachis hypogaea* L.). Int. J. Curr. Microbial. App. Sci. 2017; 6(8):1618-1621.
5. Vaghasia PM, Bhalu VB. Nutrient requirement for bold seeded confectionery groundnut (*Arachis hypogaea* L.) under irrigated condition. International Journal of Agricultural Sciences. 2016; 12(1):81-84.
6. Agrawal HR. Effect of irrigation phosphorus and sulphur on fenugreek [*Trigonella foenum-graecum* (L.)]. Ph.D Thesis, Rajasthan Agriculture University, Bikaner, 1997.
7. Jana PK, Ghatak S, Barik A, Biswas BC, Sounda G, Mukherjee AK. Response of summer groundnut to phosphorus and potassium. Indian Journal of Agronomy. 1990; 35(1-2):137-143.
8. Deka NC, Gogoi PK, Pinku B, Dutta R. Effect of levels of lime and phosphorus on nutrient content and uptake of groundnut. Annals of Agricultural Research. 2001; 22(4):503-507.
9. Hadwani GJ, Gundalia JD. Effect of N, P and K Levels on Yield, nutrient content, uptake and quality of summer groundnut Grown on Typic Haplustepts. Journal of the Indian Society of Soil Science. 2005; 53(1):125-128.
10. Thorave DS, Dhonde MB. Effect of integrated nutrient management on yield and nutrient uptake in summer groundnut. Journal of Maharashtra Agricultural University. 2008; 33(2):284-285.
11. Kumar A, Mahendra S, Mahera RK. Effect of phosphorus and sulphur on yield and nutrient uptake by groundnut in Inceptisols. An Asian Journal of Soil Science. 2008; 3(1):139-141.
12. Babaria NB, Shalini Kumari, Rajani AV, Sakarvadia HL. Effect of balanced fertilization on yield, nutrient content and uptake in the *Bt* Cotton (*Gossypium hirsutam* L.) of South Saurashtra region. Agriculture: Towards a New Paradigm of Sustainability, Publishing by Excellent Publishing House, New Delhi, 2014, 238-244.
13. Sharma S, Jat NL, Shivran AC, Choudhary S. Fertility levels and biofertilizers on nutrient concentration, uptake and quality of groundnut. Annals of Agricultural Research New Series. 2014; 35(1):71-74.
14. Kachot NA, Malvia DO, Solanki RM, Sagarka BK. Integrated nutrient management in *kharif* season groundnut (*Arachis hypogaea* L.). Indian Journal of Agronomy. 2001; 46(3):516-522.
15. Manisha B, Bhadoria PBS, Mahapatra SC. Influence of microbial culture in combination with micronutrient in improving the groundnut productivity under alluvial soil of India. Acta Agricultural Slovenica. 2006; 87(2):435-444.
16. Zalate PY, Padmani DR. Quality and nutrient uptake pattern of groundnut (*Arachis hypogaea* L.) as influenced by integrated nutrient management. GAU Research Journal. 2010; 35(2):94-96.

17. Choudhary SK, Jat MK, Sharma SR, Singh P. Effect of INM on soil nutrient and yield in groundnut field of semi-arid area of Rajasthan. Legume Research. 2011; 34(4):283-287.
18. Singh GP, Singh PL, Panwar AS. Seed yield, quality and nutrient uptake of groundnut (*Arachis hypogaea* L.) as affected by integrated nutrient management in mid hill altitude of Meghalaya. Legume Research. 2013; 36(2):147-152.