Article AR2086 DOI: HTTPS://DOI.ORG/10.23910/IJBSM/2020.11.2.2086

International Journal of Bio-resource and Stress Management

April 2020

Print ISSN 0976-3988
Online ISSN 0976-4038

IJBSM 2020, 11(2):195-200

Research Article | *Natural Resource Management*

Nutrient uptake, Quality traits and Yield of Groundnut as Influenced by Integrated Phosphorus Management

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Citation: Sharma et al., 2020. Nutrient uptake, Quality traits and Yield of Groundnut as Influenced by Integrated Phosphorus Management. International Journal of Bio-resource and Stress Management 2020, 11(2), 195-200. HTTPS://DOI.ORG/10.23910/IJBSM/2020.11.2.2086.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Abstract

An experiment was conducted to study the integrated phosphorus management in groundnut (*Arachis hypogaea* L.) at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan), having eleven phosphorus management treatments (Control, 100% RDF, 75% P through inorganic+25% through FYM, 75% P through inorganic+25% through VC, 75% P through inorganic+25% through PM, 50% P through inorganic+50% through FYM, 50% P through inorganic+50% through VC, 50% P through inorganic + 50% through PM, 25% P through inorganic+75% through FYM, 25% P through inorganic+75% through VC, 25% P through inorganic+75% through PM) and two microbial inoculation treatments (uninoculated and seed inoculation with PSB) during *kharif* season of 2017. Application of 50% P through inorganic+50% through VC significantly increased the nitrogen, phosphorus and potassium concentration in kernel and haulm, their uptake by crop and protein content (25.25%), oil content (43.55%), oil yield in kernel (681.01 kg ha^{-1}) and pod yield (2198 kg ha^{-1}), haulm yield (3009 kg ha^{-1}) and biological yield (5207 kg ha^{-1}) over rest of the treatments But it showed statistical equivalence with 50% P through inorganic+50% through PM. PSB inoculation registered significantly higher concentration of N, P and K in kernel and haulm and their total uptake as well as protein content (24.25%), oil content (42.35%) and oil yield (604.90 kg ha^{-1}) in kernel, pod (2000 kg ha^{-1}), haulm (2659 kg ha^{-1}) and biological yield (4659 kg ha^{-1}) over uninoculated control.

Keywords: Phosphorus management,nutrient uptake, quality, PSB, groundnut

1. Introduction

Groundnut is one of the important food and cash crops of our country. This crop has own importance due to high edible oil content and nutritional value of kernel as human food, and haulm as rich feed for animals. Peanut is very important source of oil (40-45%), protein (26%), carbohydrates (25%), minerals (Phosphorus, calcium and iron) and vitamins (vitamin B complex like thiamine, riboflavin, niacin and vitamin E) in addition to higher proportion of unsaturated fatty acids, including essential fatty acids like linolenic and linoleic acids. Groundnut cake obtained after extraction of oil is a valuable organic manure and animal feed which contains 7-8% N, 1.5% P_2O_5, and 1.3-1.5% K_2O. Continuousgrowing population and reduction in available land due

Article History
RECEIVED in 29th March 2020 RECEIVED in revised form 27th April 2020 ACCEPTED in final form 30th April 2020

to large scale urbanization and rapid setting of industries making severe pressure on available natural resources to meet the increasing food and oil demand (Bruinsma, 2009; Yadav et al*.,* 2018). Inorganic fertilizers are the major sources for meeting the phosphatic requirement of crops. However, continuous use of fertilizers adversely affects the soil fertility and fauna and flora activities in soil. Hence, judicious and combined use of organic manures with inorganic fertilizers and biofertilizer can be a better option for increasing the fertility and sustaining the productivity of soil and help to restore desired agro-ecosystem functions (Zhang et al*.,* 2012, Wu and Ma, 2015; Garai et al*.,* 2014). Application of FYM and vermi compost to groundnut significantly increased uptake of N, P and K (Mathukia et al., 2015). The inoculation of PSB secretes phosphate solubilizer that helps in conversion of unavailable to available form of phosphorus which increases yield of crops by 10-30% (Tilak and Annapurna, 1993). *Phosphobacterium*, a phosphate solubilizing bacteria is able to convert the unavailable phosphate present in the soil to an available form (Alori et al., 2017). The use ofPSBas inoculants simultaneously increases the P availability to plants (Shweta et al., 2008) and hence, increase symbiotic nitrogen fixation (Wani et al*.,* 2007).Combined application of PSB (*Bacillus polymixa* N_5), sulphur (30 kg S ha^{-1}) and phosphorus (50 kg P_2O_5 ha^{-1}) along with recommended dose of nitrogen and potash increased the nutrient availability, growth, yield & yield attributes of groundnut in *summer* season (Dileep kumar and Singh, 2019; Das et al., 2015). Therefore, keeping these facts into consideration, the present investigation was carried out to study the integrated phosphorus management in groundnut (*Arachis hypogaea* L.).

2. Materials and Methods

The field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan), India during *kharif* season of 2017 on loamy sand soil. The experiment was laid down in randomized block design and replicated thrice. The experiment consisted eleven treatments of phosphrous management through organic and inorganic sources (Control, 100% RDF, 75% P through inorganic+25% through FYM, 75% P through inorganic + 25% through VC, 75% P through inorganic+25% through PM, 50% P through inorganic+50% through FYM, 50% P through inorganic + 50% through VC, 50% P through inorganic + 50% through PM, 25% P through inorganic + 75% through FYM, 25% P through inorganic + 75% through VC, 25% P through inorganic+75% through PM) and two treatments of microbial inoculation (PSB) (uninoculated and seed inoculation with PSB) thereby making twenty two treatment combinations. The soil of experimental plot was loamy sand in texture, alkaline in reaction (PH-8.2), poor in organic carbon (0.24%), low in available nitrogen (125.7 kg ha^{-1}) and phosphorus (7.04 kg ha^{-1}) and potassium (125.52 kg ha^{-1}). Groundnut RG-425 was sown directly using seed rate of 100 Kg ha^{-1} in 4.0×3.15 m^2 size plots with plant geometry of 45x10 cm^2. FYM, vermicompost and poultry manure were applied prior to cross ploughing and incorporated thoroughly in soil with the help of cultivator as per treatments. The nutrient composition of FYM, vermicompost and poultry manure was 0.48; 1.22 and 3.5% N; 0.23; 0.70 and 2.5% P and 0.42; 1.03 and 1.8% K, respectively. The amount of these manures was calculated on the basis of their P content. Groundnut seed were inoculated with PSB cultures as per treatment by using three packets (200 g each) for 100 kg seed of groundnut needed for sowing one hectare area. First of all, about 0.5 kg jaggery was mixed in 2 liters of water and boiled. After cooling it, PSB cultures were mixed in the solution as treatments and stirred well for proper mixing. The seeds were spread on a jute mat, sprinkled with culture solution and mixed with hands for proper coating. After drying in shade, the seeds were used for sowing. A uniform dose of 40 kg S ha^{-1} was applied through SSP to all the treatments. Need based cultural and plant protection operations were taken up to harvest good crop. Nitrogen was estimated, by colorimetric method (Snell and Snell, 1949). Phosphorus and Potassiumconcentration in haulm, and kernel were determined by "Vanado molybdo phosphate" yellow colour method and flame photometer method, respectively. Based on potassium content in the plant, the total uptake of potassium at harvest was computed and expressed in kg ha^{-1} (Jackson, 1967). The total uptake of nitrogen, phosphorus and potassium was computed from N, P and K concentration in kernel and haulm at harvest using following relationship:

Total uptake (kg ha^{-1}) =((Nutrient conc. in kernel (%)xKernel yield (kg ha^{-1}))+(Nutrient conc. in haulm (%)×Haulm yield (kg ha^{-1}))

Protein content in grain was calculated from the%nitrogen in the kernel multiplied by the factor 6.25 (AOAC, 1960) and expressed as % protein content. Oil content in the kernel was determined by Soxhlet's apparatus using petroleum ether (60-80 °C) as an extractant (AOAC, 1960). The experimental data recorded for Plant growth, yield and other characters were statistically analysed by Fisher's 'Analysis of Variance' technique (Fisher, 1950). Critical difference (CD) was worked out wherever the difference was found significant at 5.0 or 1.0% level of significance

3. Results and Discussion

3.1. Nitrogen, phosphorus and potassium concentration and their total uptake

Different phosphorus management treatments significantly influenced the N concentration in kernel, haulm and total N uptake of groundnut in Table 1. Application of 50% P through inorganic+50% through VC witnessed the highest nutrient concentration of 4.04 % in kernel, 2.29 % in haulm and highest uptake of 158.42 kg N ha^{-1} which were at par with 50% P through inorganic + 50% through PM (3.87 and 2.14%). The maximum P concentration in kernel and haulm

Table 1: Effect of integrated phosphorus management on N, P and K concentration in kernel and haulm of groundnut and total uptake by crop

Treatments	N concentration (%)		Total N uptake (kg ha^{-1})	P concentration (%)		Total P uptake (kg ha^{-1})	K concentration (%)		Total K uptake (kg ha^{-1})
	Kernel	Haulm		Kernel	Haulm		Kernel	Haulm	
Phosphorus management									
P_0- control	2.99	1.58	64.20	0.704	0.368	15.04	0.610	1.195	28.26
P_1- 100% RDF	3.54	1.85	113.65	0.814	0.430	26.20	0.669	1.259	44.69
P_2- 75% P through inorganic+25% through FYM	3.55	1.86	114.77	0.816	0.431	26.38	0.673	1.261	44.97
P_3- 75% P through inorganic+25% through vermicompost	3.85	2.08	137.37	0.881	0.484	31.61	0.758	1.305	52.07
P_4- 75% P through inorganic+25% through poultry manure	3.83	2.05	135.70	0.879	0.477	31.27	0.746	1.301	51.56
P_5- 50% P through inorganic+50% through FYM	3.56	1.89	116.15	0.819	0.434	26.61	0.684	1.263	45.40
P_6- 50% P through inorganic+50% through vermicompost	4.04	2.29	158.42	0.931	0.497	35.37	0.771	1.309	56.45
P_7- 50% P through inorganic+50% through poultry manure	3.87	2.14	141.74	0.887	0.491	32.63	0.778	1.328	53.91
P_8- 25% P through inorganic+75% through FYM	3.45	1.70	89.90	0.758	0.410	20.46	0.628	1.229	35.68
P_9- 25% P through inorganic+75% through vermicompost	3.53	1.84	104.15	0.811	0.429	24.02	0.663	1.255	40.82
P_{10}- 25% P through inorganic+75% through poultry manure	3.52	1.83	103.41	0.809	0.427	23.87	0.634	1.251	40.12
SEm±	0.09	0.06	3.56	0.021	0.012	0.99	0.021	0.040	1.75
CD (*p*= 0.05)	0.26	0.18	10.16	0.059	0.033	2.83	0.061	NS	5.00
Microbial inoculation									
I_0- Uninoculated	3.34	1.79	99.00	0.791	0.422	23.38	0.680	1.215	40.27
I_1- Seed inoculation with PSB	3.88	2.05	133.63	0.865	0.465	29.98	0.705	1.322	49.54
SEm±	0.04	0.03	1.52	0.009	0.005	0.42	0.009	0.017	0.75
CD (*p*= 0.05)	0.11	0.08	4.33	0.025	0.014	1.21	0.026	0.049	2.13

(0.931 and 0.497%) was recorded under 50% P through inorganic+50% through VC, which was 32.2 and 35.1% higher over control. All the treatments except P_1, P_9, P_{10} and P_8 significantly enhanced the K concentration in kernel of groundnut. The maximum concentration (0.778%) was recorded under 50% P through inorganic + 50% through PM and was very closely accompanied by 50% P through inorganic+50% through VC (0.771%), 75% P through inorganic +25% through VC (0.758) and 75% P through inorganic+25% through PM (0.746%). Remaining at par among themselves, these four treatments increased the K concentration in kernel to the extent of 27.5, 26.4, 24.3 and 22.3% over control, respectively. Concentration of K in haulm was not influenced significantly due to P management treatments. Among microbial inoculation, inoculation of groundnut seed with PSB recorded significantly higher N concentration of 3.88 in kernel, 2.05% in haulm and total uptake of 133.63 kg N ha^{-1} than control. Phosphorus concentration due to inoculation of seed with PSB was 9.4% in kernel,10.2% in haulm and total uptake of 29.98 kg P ha^{-1} and thus increased it to the extent of 28.2% over uninoculated control. Seed with PSB recorded 7.8 and 8.8% higher concentration of K in kernel (0.691%) and haulm (1.322%). The increased availability of nutrients in the root zone coupled with accelerated metabolic activities at the cellular level probably might have increased the nutrient uptake and their accumulation in the vegetative parts of plant.

Increased accumulation of nutrients especially N, P and K in vegetative plant parts concomitant with improved metabolism led to greater translocation of these nutrients in reproductive structures. It led to higher concentration and uptake. The higher concentration of N, P and K in grain and haulm together with significantly higher grain and haulm yields resulted in significantly higher uptake of these nutrients by crop. These results are close in conformity with the findings of Reddy (2005), Pooniaet al. (2013) in groundnut and Murthy et al. (2009) in groundnut, Gonçalves et al. (2017) in common bean.

3.2. Protein and oil content in kernel

All the treatments except 25% P through inorganic+75% through FYM significantly increased the protein and oil content in groundnut kernel than control in Table 2. The highest protein (25.25%) and oil content (43.55%) were obtained under application of 50% P through inorganic 50% through VC and was followed by 50% P through inorganic+50% through PM. Being at par with each other, these two treatments enhanced the protein content to the extent of 73.9 and 77.2% over control. Treatment P_6 indicating an increase oil content of 16.1% over control. Protein content of grain is essentially the manifestation of N content, higher concentration of N in grain due to organic and inorganic fertilization might have increased protein content. Seed crude protein concentrations were found maximum with application higher levels of P in both the low-phytate line and normal-phytate soybean cultivar (Taliman et al., 2019). Ola et al. (2013) observed that integrated application of FYM @ 8 t/ ha + 50% RDF produced significantly increase oil content, oil yield and protein content as well as N, P content and uptake by groundnut but remained at part with VC @ 3 t ha^{-1}+50% RDF. These results are close in conformity with the findings of Reddy (2005) and Murthy et al. (2009) in groundnut. Among microbial inoculation, seed inoculation with PSB represented 86.0 and 42.35% higher protein and oil content kernel over no inoculation. Oil content, protein content and oil yield were also significantly enhanced due to inoculation of groundnut seed with PSB over no inoculation (Table 3). These findings corroborate the results of Basu et al. (2006) and Prasad et al. (2016) in groundnut, Khan et al. (2015).

Table 2: Effect of integrated phosphorus management on protein, oil content and oil yield in groundnut kernel

Treatments	No. of pods $plant^{-1}$	No. of kernels pod^{-1}	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein content (%)	Oil yield (kg ha^{-1})	Oil content (%)
P_0	2.99	1.58	64.20	0.704	0.368	15.04	0.610	1.195	28.26
P_1	3.54	1.85	113.65	0.814	0.430	26.20	0.669	1.259	44.69
P_2	3.55	1.86	114.77	0.816	0.431	26.38	0.673	1.261	44.97
P_3	3.85	2.08	137.37	0.881	0.484	31.61	0.758	1.305	52.07
P_4	3.83	2.05	135.70	0.879	0.477	31.27	0.746	1.301	51.56
P_5	3.56	1.89	116.15	0.819	0.434	26.61	0.684	1.263	45.40
P_6	4.04	2.29	158.42	0.931	0.497	35.37	0.771	1.309	56.45
P_7	3.87	2.14	141.74	0.887	0.491	32.63	0.778	1.328	53.91
P_8	3.45	1.70	89.90	0.758	0.410	20.46	0.628	1.229	35.68
P_9	3.53	1.84	104.15	0.811	0.429	24.02	0.663	1.255	40.82
P_{10}	3.52	1.83	103.41	0.809	0.427	23.87	0.634	1.251	40.12
SEm±	0.09	0.06	3.56	0.021	0.012	0.99	0.021	0.040	1.75
CD (*p*=0.05)	0.26	0.18	10.16	0.059	0.033	2.83	0.061	NS	5.00
I_0	3.34	1.79	99.00	0.791	0.422	23.38	0.680	1.215	40.27
I_1	3.88	2.05	133.63	0.865	0.465	29.98	0.705	1.322	49.54
SEm±	0.04	0.03	1.52	0.009	0.005	0.42	0.009	0.017	0.75
CD (*p*=0.05)	0.11	0.08	4.33	0.025	0.014	1.21	0.026	0.049	2.13

3.3. Yield attributes and yield

Application of 50% P through inorganic+50% through VC and 50% P through inorganic+50% through PM recorded significantly highernumber of pods/plant and number of kernels pod^{-1} andoil yield (681.01 630.40 kg ha^{-1}) in groundnut than most of the treatments except P_3 and P_4 treatments. Application of 50% P through inorganic+50% through vermicompost recorded the significantly highest number of pods plant (20.58) and number of kernels pod^{-1} (2.16) among all the phosphorus management treatments except

Table 3: Correlation coefficients and linear regression equations showing relationship between pod yield (kg ha^{-1}) and independent variables (X)

Sl. No.	Independent variables (X)	Correlation coefficients (r)	Regression equations (Y = a + byx.X)
1.	N uptake by crop (kg ha^{-1})	0.953**	Y = 661.837+ 10.052 X9
2.	P uptake by crop (kg ha^{-1})	0.981**	Y=567.418 +47.365 X10
3.	K uptake by crop (kg ha^{-1})	0.981**	Y=343.953+ 33.504X11

**Significant at (p=0.01) level of significance

50% P through inorganic+50% through PM (19.31 and 2.01), respectively. These treatments were significantly increased number of pods plant^{-1} by 62.2, and 51.3% over control, respectively. The extent of increase in kernels pod^{-1} due to these two phosphorus management treatments was 37.5 and 28.0% over 25% P through inorganic+75% through FYM and 53.1 and 42.5% over control, respectively. The increased yield attributes and yield might be due the increased supply of almost all essential plant nutrients by translocation of the photosynthates accumulated under the influence of the sources of organic nutrients. Further, the translocation and accumulation of photosynthates in the economic sinks resulted in increased pod, haulm and biological yields of groundnut. Inoculation with PSB provided the maximum oil yield of 604.90 kg ha^{-1}, registering an increase of 26.6% over uninoculated control. The results are closely related to findings of Bharose et al. (2011) and Chouksey et al. (2017). Application of 50% P through inorganic+50% through VC produced the significantly highest pod, haulm, biological and kernel yields of groundnut (2198, 3009, 5207and 1560 kg ha^{-1}). However, it showed statistical equivalnce with 50% P through inorganic+50% through PM. Yadav et al. (2019)recorded the maximum pod, kernel and haulm yield were recorded with application of 5 t FYM+50% chemical P+DGRC^{-1}.The highest pod, haulm, biological and kernel yields (2000, 2659, 4659 and 1420 kg ha^{-1}) were obtained under the treatment PSB. Seed inoculation with PSB increased the pods plant^{-1} (18.19), number of kernels pod^{-1} (2.05), pod, haulm, biological and kernel yields to the extent of 20.3, 12.4,15.7 and 20.3%, respectively over control. PSB helped in higher uptake of other nutrients especially micro and secondary nutrients and enhanced photosynthesis. Thus, greater assimilation of photosynthates and their subsequent partitioning between vegetative and reproductive structures might have helped in improving the yield attributes (number of pods plant^{-1}, number of kernels pod^{-1}) and finally, the pod as well as haulm yield. These findings corroborate the results of Basu et al. (2006), Patil et al. (2014) and Prasad et al. (2016) in groundnut.

4. Conclusion

The highest concentration of N and P in kernel and haulm, protein content (25.25%), oil content in kernel (43.55%), oil yield (681.01 kg ha^{-1}), kernel and haulm yield of groundnut was recorded under application of 50% P through inorganic +50% through VC. Whereas, maximum K concentration in kernel was obtained under 50% P through inorganic+50% through PM. However, it was found statistically similar with 50% P through inorganic+50% through PM.

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