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Effect of Integrated Phosphorus Management on Growth and Yield of Groundnut (*Arachis hypogaea* L.)

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A B S T R A C T

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif* season of 2017 on loamy sand soil. The experiment was laid down in randomized block design with 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 treatments of microbial inoculation (uninoculated and seed inoculation with PSB). Results revealed that among phosphorus management treatments, application of 50% P through inorganic + 50% through VC significantly increased the growth characters and yield of groundnut *viz*., crop dry matter accumulation at most of the stages, number and weight of root nodules/plant, CGR and chlorophyll content over rest of the treatments. It also recorded the significantly highest pod yield (2198 kg/ha), haulm yield (3009 kg/ha) and biological yield (5207 kg/ha) of groundnut. However, it showed statistical equivalence with 50% P through inorganic + 50% through PM in most of the growth and yield of the crop. Results further indicated that inoculation of groundnut seed with PSB significantly enhanced the growth characters and yield over uninoculated control. Seed inoculation with PSB also improved to pod, haulm and biological yield of groundnut to the extent of 20.3, 12.4 and 15.7 per cent over control, respectively.

Introduction

Groundnut (*Arachis hypogaea* L.) is a self-pollinated, annual, herbaceous, autotetrapliod legume with 2n = 40 chromosomes belonging to the family leguminoseae (Fabaceae). It is known by various names as “wondernut”, “Poor man’s Cashewnut”, “Peanut” “Monkey nut”, “Earth nut” or “*King of Oilseeds*”. It is the thirteenth most important food crop of the world; fourth most important source of edible oil and the third most important source of vegetable protein (Sorrensen *et al*., 2004; Taru *et al*., 2008). 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.

Nutrient management is one of the crucial factors deciding productivity of the crop. Phosphorus is an essential element in crop production. It plays an important role in root development, crop maturation, photosynthesis, nodulation, N_2-fixation and other vital processes. It is a key constituent of ATP and plays a significant role in transformation of energy in plants, as well as various roles in seed formation. Phosphorus application increases groundnut yield and its yield contributing characters (Hasan and Ismail, 2016). Most of soils of Rajasthan are poor in available phosphorus supply and low in organic matter.

Phosphate solubilizing bacteria (PSB) are a group of beneficial bacteria capable of hydrolysing organic and inorganic phosphorus from insoluble compounds. P-solubilization ability of the microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. 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). Keeping this in view the field experiment was conducted to study the effect of integrated phosphorus management on growth and yield of groundnut.

Materials and Methods

The field experiment was conducted during *kharif* season of 2017 on loamy sand soil at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan). The soil of experimental plot was 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}). The treatment were laid down in randomized block design and replicated thrice.

The experiment consisted eleven treatments of phosphorus 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.

Groundnut RG-425 was sown directly using seed rate of 100 Kg $ha-^{1}$ in 4.0 m x 3.15 m size plots with plant geometry of 45 cm x 10 cm. Nitrogen and phosphorus were applied through Urea and SSP as per treatments taking 20 kg/ha N and 40 kg P_2O_5/ha as 100% fertility levels. Whole amount of nitrogen and phosphorus was drilled 8 – 10 cm deep in soil at the time of sowing as per treatments. 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 per cent N; 0.23; 0.70 and 2.5 per cent P and 0.42; 1.03 and 1.8 per cent 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 100kg 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 sulphur per hectare was applied through SSP to all the treatments. Need based cultural and plant protection operations were taken up to harvest good crop.

Dry matter accumulation was also recorded at 35, 70 DAS and at harvest stages by removing plants from one meter row length from the outer sample rows in each plot. The root portion was removed and the samples were first dried in air and then in an electric oven at 70 ^{0}C till constant weight. Plant stand and dry matter accumulation were recorded by removing plants from one meter row length from the outer sample rows in each plot.

Five random plants were selected from each plot for taking observations on number and weight (fresh and dry) of nodules/plant. The CGR and mean relative growth rate (RGR) of the crop was calculated by the following formula (Radford, 1967). The chlorophyll content at 45 DAS was estimated using method advocated by Arnon (1949). 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 per cent level of significance.

Results and Discussion

Effect of phosphorous management

Phosphorous management significantly influenced the plant growth viz., dry matter accumulation, Crop growth rate, total number of nodules/plant, number of effective nodules/plant, fresh weight of nodules/plant dry weight of nodules/plant and chlorophyll content except for plant stand and mean relative growth rate.

Among different Phosphorus management used under present investigation, application of 50% P through inorganic + 50% through VC was recorded maximum dry matter accumulation of 22.48 (35 DAS), 232.25 (70 DAS) and 473.07 (At harvest) g/m row length which was significantly superior over rest of the treatments except 50 % P through inorganic + 50 % through PM and also attained CGR values of 1.43, 13.32 and 9.73 g/m^2/day during 0-35 DAS, 35-70 DAS and 70 DAS-harvest stages, respectively that were 34.9 and 48.9 per cent higher during 0-35 DAS; 22.4 and 38.4 per cent during 35–70 DAS and 32.7 and 45.8 per cent during 70 DAS-harvest stage over 25% P through inorganic + 75% through FYM and control, respectively.

Application of 50% P through inorganic + 50% through poultry manure also increased the CGR values by 39.6, 39.2 and 33.7 per cent over control during these stages. Application of 50% P through inorganic + 50% through vermicompost significantly increased the total number of nodules/plant (67.0) and number of effective nodules/plant (60.4) over rest of the treatments except 50% P through inorganic + 50% through PM, 75% P through inorganic + 25% through VC and 75% P through inorganic + 25% through PM. These four treatments increased the total nodules/plant by 48.6, 45.9, 45.2 and 45.2 per cent over control, respectively. The highest fresh weight (238 mg), dry weight of nodules/plant (106.0 mg) and chlorophyll content (3.84 mg/g) were recorded under 50% P through inorganic + 50% through VC treatment. 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). However, it showed statistical equivalence with 50% P through inorganic + 50% through PM.

Addition of phosphatic fertilizers and combined application of NPK to the groundnut increased the availability of major nutrients to plant as it might has enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth in terms of crop dry matter accumulation and CGR. These results are in close conformity with the findings Murthy *et al.,* (2009), Dhadge and Satpute (2014), Das *et al.,* (2015) and Choudhary *et al.,* (2017b) in groundnut (Fig. 1 and Table 1).

Effect of microbial inoculation

The data revealed that seed inoculation with PSB recorded significantly higher crop dry matter, CGR, number and weight of nodules and chlorophyll content than uninoculated control (Table 2 and 3). The highest dry matter, CGR number, fresh weight of nodules (233.7 mg/plant) and dry weight of nodules (102.9 mg/plant) and chlorophyll content (3.56 mg/g) were obtained when groundnut seed was inoculated with PSB. The per cent increase in dry matter incurred due to this treatment was 11.9, 13.0 and 11.8 per cent at 35 DAS, 70 DAS and at harvest over uninoculated control, respectively. The highest CGR values during 0-35 DAS; 35-70 DAS and 70 DAS- harvest stages were obtained when groundnut seed was inoculated with PSB (1.29, 13.03 and 8.61 g/m^2/day).

It thus increased the CGR to the extent of 12.1, 13.1 and 10.6 per cent over control at these three stages, respectively. Seed inoculation with PSB recorded the highest number of 64.6 nodules/plant and 57.4 effective nodules/plant that were 18.9 and 19.1 per cent, respectively more than noted under control. The highest pod, haulm, biological and kernel yields (2000, 2659, 4659 and 1420 kg/ha) were obtained under the treatment PSB. Seed inoculation with PSB increased the pod, haulm, biological and kernel yields to the extent of 20.3, 12.4,15.7 and 20.3 per cent, respectively over control. Seed inoculation with PSB recorded significantly higher crop dry matter, CGR number and weight of nodules and chlorophyll content over no inoculation. It is obvious because of the fact that PSB produces organic acids like gluconic, succinic, lactic, oxalic, citric and α-ketogluconic acids in micro environment around the roots (Table 4).

The role of these organic acids in solublizing mineral phosphates and phosphorylated minerals is attributed to the lowering pH which helps in release of phosphorus from the stable complexes with cations such as Ca^{++}, Mg^{++} which results in effective solublization of phosphates and also synthesizes growth promoting substances which augment plant growth. The results obtained in present investigation are in line with the findings of Zalate and Padmani (2009) and Patil *et al.,* (2014) in groundnut who recorded improvement in growth parameters and nodulation due to seed inoculation with PSB.

Table.1 Effect of integrated phosphorus management on plant stand and crop dry matter accumulation in groundnut

Treatments	Plant stand/m		Dry matter (g/m row length)		
	20	At	35	70	At
Phosphorus management					
P_0- control	10.09	9.31	15.06	166.66	**331.70**
P_1- 100% RDF	10.28	9.50	18.87	211.14	**409.31**
P_2- 75% P through inorganic + 25% through FYM	10.26	9.48	19.06	211.39	**409.84**
P_3- 75% P through inorganic + 25% through vermicompost	9.89	9.11	21.25	231.84	**449.16**
P_4- 75% P through inorganic + 25% through poultry manure	9.94	9.16	21.04	231.80	**447.09**
P_5- 50% P through inorganic + 50% through FYM	10.45	9.67	19.39	211.49	**410.01**
P_6- 50% P through inorganic + 50% through vermicompost	9.95	9.17	22.48	232.25	**473.07**
P_7- 50% P through inorganic + 50% through poultry manure	9.83	9.05	21.12	232.06	**452.76**
P_8- 25% P through inorganic + 75% through FYM	10.11	9.33	16.67	188.08	**369.58**
P_9- 25% P through inorganic + 75% through vermicompost	10.17	9.39	18.50	210.82	**408.65**
P_{10}- 25% P through inorganic + 75% through poultry manure	10.06	9.28	18.26	210.41	**408.04**
SEm±	0.38	0.31	0.55	7.02	**12.71**
CD (P = 0.05)	NS	NS	1.58	20.02	**36.27**
Microbial inoculation					
I_0- Uninoculated	10.18	9.40	18.16	199.54	**392.15**
I_1- Seed inoculation with PSB	10.01	9.23	20.33	225.54	**438.61**
SEm±	0.16	0.13	0.24	2.99	**5.42**
CD (P = 0.05)	NS	NS	0.67	8.54	**15.46**
CV (%)	**9.13**	**8.15**	**7.05**	**8.09**	**7.49**

Table.2 Effect of integrated phosphorus management on mean crop growth rate (CGR) and RGR (mg/g/day) in groundnut

Treatments	CGR ($g/m^2/day$)			RGR (mg/g/day)	
	0 - 35 DAS	35 - 70 DAS	70 DAS - harvest	35 – 70 DAS	70 DAS - harvest
Phosphorus management					
P_0- control	0.96	9.62	6.67	68.67	**12.52**
P_1- 100% RDF	1.20	12.21	8.01	68.99	**12.04**
P_2- 75% P through inorganic + 25% through FYM	1.21	12.21	8.02	68.74	**12.04**
P_3- 75% P through inorganic + 25% through vermicompost	1.35	13.37	8.78	68.27	**12.03**
P_4- 75% P through inorganic + 25% through poultry manure	1.34	13.38	8.70	68.55	**11.95**
P_5- 50% P through inorganic + 50% through FYM	1.23	12.20	8.02	68.26	**12.04**
P_6- 50% P through inorganic + 50% through vermicompost	1.43	13.32	9.73	66.72	**12.94**
P_7- 50% P through inorganic + 50% through poultry manure	1.34	13.39	8.92	68.47	**12.16**
P_8- 25% P through inorganic + 75% through FYM	1.06	10.88	7.33	69.23	**12.29**
P_9- 25% P through inorganic + 75% through vermicompost	1.17	12.21	7.99	69.51	**12.04**
P_{10}- 25% P through inorganic + 75% through poultry manure	1.16	12.20	7.98	69.83	**12.05**
SEm±	0.03	0.35	0.23	2.64	**0.34**
CD (P = 0.05)	0.09	1.01	0.65	NS	**NS**
Microbial inoculation					
I_0- Uninoculated	1.15	11.52	7.78	68.52	**12.29**
I_1- Seed inoculation with PSB	1.29	13.03	8.61	68.80	**12.09**
SEm±	0.01	0.15	0.10	1.13	**0.14**
CD (P = 0.05)	0.04	0.43	0.28	NS	**NS**
CV (%)	**6.59**	**7.05**	**6.77**	**9.43**	**6.75**

Table.3 Effect of integrated phosphorus management on number and weight of nodules/plant and chlorophyll content in groundnut

Treatments	**Number of nodules/plant**		**Weight of nodules/plant (mg)**		**Chlorophyll content (mg/g of fresh weight)**
	Total	**Effective**	**Fresh**	**Dry**	
Phosphorus management					
P_0- control	45.1	40.4	171.0	74.3	**2.76**
P_1- 100% RDF	58.4	51.5	215.4	92.8	**3.37**
P_2- 75% P through inorganic + 25% through FYM	58.6	52.4	218.8	94.5	**3.38**
P_3- 75% P through inorganic + 25% through vermicompost	65.5	59.6	230.7	102.5	**3.80**
P_4- 75% P through inorganic + 25% through poultry manure	65.5	58.5	229.3	98.9	**3.75**
P_5- 50% P through inorganic + 50% through FYM	58.9	50.5	223.1	95.1	**3.43**
P_6- 50% P through inorganic + 50% through vermicompost	67.0	60.4	238.0	106.0	**3.84**
P_7- 50% P through inorganic + 50% through poultry manure	65.8	57.6	234.6	104.2	**3.82**
P_8- 25% P through inorganic + 75% through FYM	52.5	45.8	193.1	83.5	**3.05**
P_9- 25% P through inorganic + 75% through vermicompost	58.2	51.7	214.0	91.3	**3.35**
P_{10}- 25% P through inorganic + 75% through poultry manure	58.2	52.5	211.6	88.0	**3.33**
SEm±	1.9	1.5	6.3	2.7	**0.10**
CD (P = 0.05)	5.3	4.4	18.0	7.7	**0.28**
Microbial inoculation					
I_0- Uninoculated	54.3	48.2	198.9	84.6	**3.33**
I_1- Seed inoculation with PSB	64.6	57.4	233.7	102.9	**3.56**
SEm±	0.8	0.7	2.7	1.1	**0.04**
CD (P = 0.05)	2.3	1.9	7.7	3.3	**0.12**
CV (%)	**7.74**	**7.1**	**7.26**	**7.01**	**7.08**

Table.4 Effect of integrated phosphorus management on pod, haulm, biological and kernel yields in groundnut

Treatments	Yield (kg/ha)			
	Pod	Haulm	Biological	Kernel
Phosphorus management				
P_0- control	1222	1735	2957	**868**
P_1- 100% RDF	1859	2554	4413	**1320**
P_2- 75% P through inorganic + 25% through FYM	1869	2561	4430	**1327**
P_3- 75% P through inorganic + 25% through vermicompost	2036	2799	4835	**1446**
P_4- 75% P through inorganic + 25% through poultry manure	2029	2791	4820	**1441**
P_5- 50% P through inorganic + 50% through FYM	1876	2571	4447	**1332**
P_6- 50% P through inorganic + 50% through vermicompost	2198	3009	5207	**1560**
P_7- 50% P through inorganic + 50% through poultry manure	2075	2835	4910	**1473**
P_8- 25% P through inorganic + 75% through FYM	1555	2102	3657	**1104**
P_9- 25% P through inorganic + 75% through vermicompost	1715	2339	4054	**1218**
P_{10}- 25% P through inorganic + 75% through poultry manure	1708	2334	4042	**1213**
SEm±	53	76	147	**53**
CD (P = 0.05)	152	217	419	**151**
Microbial inoculation				
I_0- Uninoculated	1662	2365	4027	**1180**
I_1- Seed inoculation with PSB	2000	2659	4659	**1420**
SEm±	23	32	63	**23**
CD (P = 0.05)	65	92	179	**64**
CV (%)	**7.14**	**7.41**	**8.28**	**9.97**

Table.5 Correlation coefficients and linear regression equations showing relationship between pod yield (kg/ha) and independent variables (X)

S. No.	Independent variables (X)	Correlation coefficients (r)	Regression equations ($Y = a + b_{yx}.X$)
1.	Crop dry matter at harvest (kg/ha)	0.981**	$Y = -1016.199 + 6.854\ X_1$
2.	Total number of nodules per plant	0.972**	$Y = -407.622 + 37.669\ X_5$
3.	Effective number of nodules per plant	0.986**	$Y = -376.932 + 39.214\ X_6$
4.	Fresh weight of nodules (mg)	0.956**	$Y = -747.904 + 11.922\ X_7$
5.	Dry weight of nodules (mg)	0.959**	$Y = -377.025 + 23.557\ X_8$

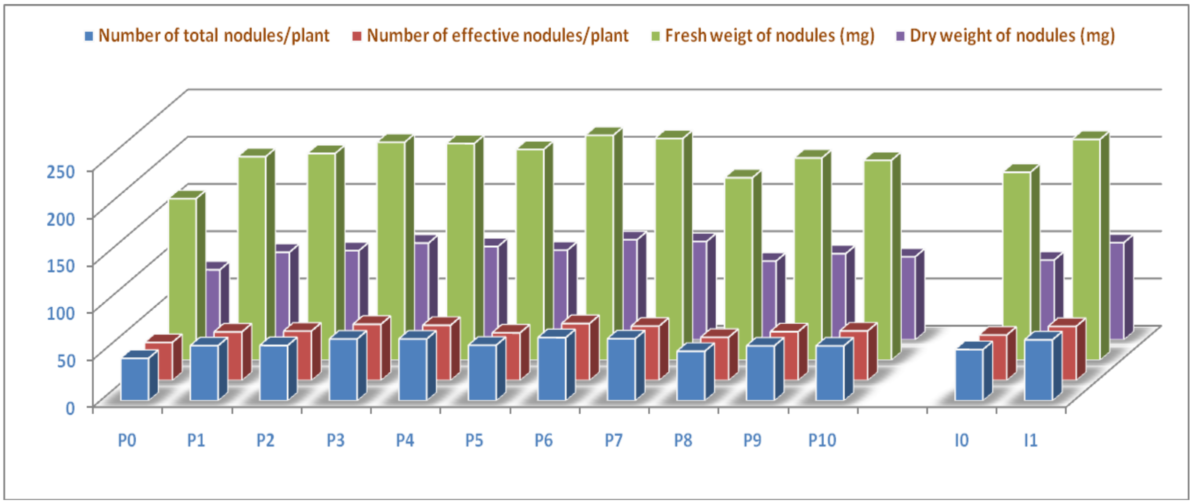

Fig.1 Effect of integrated phosphorus management on number and weight of nodules/plant in groundnut

Correlation and regression studies

Correlation coefficients and regression equations were worked out to study the relationship of pod yield with crop dry matter accumulation at harvest, total and effective nodules/plant, fresh and dry weight of nodules/plant of crop. The values calculated are presented in Table 5. The results of correlation coefficients indicated that pod yield of groundnut was significantly and positively correlated with crop dry matter accumulation at harvest (r = 0.981), number of total nodules/plant (r = 0.972), effective nodules/plant (r = 0.986), fresh weight of nodules (r = 0.956), dry weight of nodules (r = 0.959), number of pods/plant (r = 0.968). The regression equations (Table 5) showed that unit increase in crop dry matter at harvest, number of total nodules, effective number of nodules, fresh weight of nodules, dry weight of nodules increased the pod yield of groundnut by 6.85, 37.66, 39.21, 11.92 and 23.55kg/ha, respectively.

References

Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts polyphenol oxidase in *Beta vulgaris.* Plant Physiology 24: 1-5.

Choudhary, R.R. and Yadav, H.L. 2017. Effect of Conjunctive use of phosphorus and Bio–Organics on phosphorus content and uptake in summer groundnut (*Arachis hypogaea* L.). International Journal of Current

Microbiology and Applied Sciences 6(8): 1618–1621.
Das, T., Debnath, P., Satpute, S.B. and Bandyopadhyay. 2015. Effect of phosphorus enriched vermicompost on growth and yield of groundnut (*Arachis hypogaea* L.) as influenced by soil phosphorus use efficiency. Indian Journal of Science and Technology 8(11): 0974-6846.
Dhadge, S.M. and Satpute, N.R. 2014.Effect of integrated nutrient management on growth, yield and quality of summer groundnut (*Aarchis hypogaea* L.). International Journal of Agricultural Sciences 10(1): 314-316.
Fisher, R.A. 1950. Statistical Methods for Research Workers. Oliver and Boyd, Edinburg, Landon.
Hasan, M. and Ismail, B.S. 2016.Effect of phosphorus fertilizers on growth and yield of groundnut. Journal of Environmental Biology 30(2): 275-281.
Murhty, R.K., Vasudev, H.S., Devagiri, G.M., Umashankar, N. and Raveendra, H.R. 2009. Effect of Integrated nutrient management of growth and yield parameters and nutrient uptake of groundnut *(Arachis hypogaea* L.). Mysore Journal Agricultural Science 43(4): 696–699.
Patil, S.R., Kadam, S.R., Kalegore, N.K. and Dadgale, P.R. 2014. Effect of inorganic and bio-fertilizers on growth and yield of summer groundnut. Advance Research Journal of Crop Improvement 5(1): 23-25.
Radford, P.J. 1967. Growth analysis formulae–their use and abuse. Crop Science 7: 171-175.
Sorrensen, R., Butts, C., Lamb, M. and Rowland, D. 2004. Five Years of Subsurface Drip Irrigation on Peanut. Research and Extension Bulletin No. 2004.
Taru, V.B., Khagya, I.Z., Mshelia, S.I. and Adebayo, E.F. 2008.Economic efficiency of resource use in groundnut production in Adamawa State of Nigeria. World Journal of Agricultural Science 56: 4896- 9000.
Tilak, K.V.B.R. and Annapurna, K. 1993. Effect of PSB in different crops. National Academy Science Letters– India 59: 315–317.
Zalate, P.Y. and Padmani, D.R. 2009. Effect of organic manure and biofertilizers on growth and yield attributing characters of *kharif* groundnut (*Arachis hypogaea* L.).*International Journal of Agricultural Sciences* 5(2): 343-345.

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