Vol. 42, No. 2, pp 204-208, 2014
Indian Journal of Soil Conservation
Online URL:http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home

Organic, inorganic sources of phosphorus and methods of application on performance of groundnut (*Arachis hypogaea*) under rainfed condition

Y.P. Singh[1], S. Singh[2], S.K. Dubey[3] and R. Tomar[2]

[1]ZARS, Krishi Vigyan Kendra, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Morena - 476 001, Madhya Pradesh; [2]Krishi Vigyan Kendra, Guna, Madhya Pradesh; [3]Central Soil and Water Conservation Research and Training Institute, Research Centre, Chhalesar, Agra-282 006, Uttar Pradesh.
[1]E-mail: ypsinghkvk@gmail.com

ARTICLE INFO

Article history :
Received : October, 2013
Revised : June, 2014
Accepted : July, 2014

Key words :
Application methods,
Groundnut,
P-sources,
Quality,
Recovery,
Yield

ABSTRACT

A field experiment for four consecutive rainy (*kharif*) seasons from 2006 to 2009 was conducted to study the response of P-enriched organic (compost and vermicompost) and inorganic (dia-ammonium phosphate) sources of phosphorus and methods of its application (broadcast and placement) to groundnut (*Arachis hypogaea* L.) crop grown on sandy soil under rainfed conditions. The results revealed that the recommended dose of phosphorus as a P-enriched vermicompost applied by placement method significantly improved the growth, yield, quality (oil and protein), uptake, recovery and use-efficiency of P by groundnut, followed by placement of P-enriched compost and broadcasted P-enriched vermicompost as compared to other treatments. The maximum pod (2535 kg ha^{-1}) and stover (3103 kg ha^{-1}) yield was obtained on placement of recommended dose of P through P-enriched vermicompost, resulted in maximum net return (Rs. 30,123 ha^{-1}) and benefit cost ratio (2.99). Second best increase in pod (2441kg ha^{-1}) and stover (2967 kg ha^{-1}) yield was with placement of recommended dose of P through P-enriched compost. Similarly, maximum recovery (23.28%) and use efficiency (15.63 kg pod kg^{-1} P_2O_5) of phosphorus was recorded under recommended dose of phosphorus through placement of P-enriched vermicompost followed by placement of P-enriched compost and broadcasting of P-enriched vermicompost.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), one of the major and important oil seed crops of the world, is largely grown as a small holding crop in rainfed area under arid and semi-arid conditions. Among the groundnut producing countries, India stands first in area (5.9 m ha) and as the second largest producer in the world. Though India is a leading producer of groundnut, the productivity is 913 kg ha^{-1}, whereas 1310 kg ha^{-1} of Rajasthan state of India as compared to other major producers *viz.* USA (3540 kg ha^{-1}) and China (2624 kg ha^{-1}) based on 2006-07 data (Mehrotra, 2011).

Groundnut crop suffers from deficiency of nutrients, especially immobile elements in soil like phosphorus, which is essential for plant growth and pod formation, besides N-fixation activity (Vishwakarma *et al.,* 2012). However, 'P' fixation and imbalanced use of chemical fertilizers has adversely affected the soil productivity. In India, the price of commonly used phosphatic fertilizer has increased considerably since the early seventies. Phosphate enriched organic manure - a value added product obtained by composting different organic wastes with rock phosphate has become a useful, eco-friendly and effective alternative to costly chemical fertilizers. Under current economic reforms subsidy on chemical fertilizers are being gradually withdrawn. It becomes very important, therefore to develop and popularize the use of low cost, environment friendly and appropriate technologies which empower the farmers (Singh and Sharma, 2011). Keeping the above points in view, a field study was undertaken to determine the effect of organic (P-enriched compost and vermicompost), and inorganic sources of phosphorus and methods of their application on growth, yield, quality, recovery and use-efficiency of phosphorus by groundnut crop grown on sandy soil under rainfed conditions.

2. MATERIALS AND METHODS

Soil and Experimentation

A field experiment was conducted on instructional farm, Banasthali University, Banasthali, Rajasthan during *kharif* seasons for four years (2006 to 2009) under rainfed conditions. The experimental soil was sandy in texture and had pH 7.8, electrical conductivity 0.32 dS m^{-1}, organic carbon content 2.05 g kg^{-1}, available N 141 kg ha^{-1}, P 8.14 kg ha^{-1}, K 281 kg ha^{-1} and S 9.8 kg ha^{-1}. The experiment was laid out in a randomized block design with seven treatments *viz.,* T_1- control, T_2- recommended dose of P as DAP through broadcasting, T_3- recommended dose of P as DAP through placement, T_4- recommended dose of P as P-enriched compost through broadcasting, T_5- recommended dose of P as P-enriched compost through placement, T_6- recommended dose of P as P-enriched vermicompost through broadcasting, T_7- recommended dose of P as P-enriched vermicompost through placement. The recommended doses of nutrients for groundnut crop were 20 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and the same were applied as per treatment through 1.27 tons ha^{-1} P-enriched vermicompost and 1.39 tons ha^{-1} P-enriched compost and remaining N was applied through urea at sowing time. The recommended dose 40 kg S ha^{-1} was applied through gypsum at the time of sowing. The groundnut variety 'RSB-87' was sown with monsoon rain during first week of July every year. The packages of practices were adopted as per ARS, Durgapura, Jaipur (RAU, Bikaner). The rainfall during cropping season was 506, 614, 415 and 635 mm during first, second, third and fourth year of experimentation, respectively. The crop was harvested in last week of October every year.

Preparation of Enriched Compost/Vermicompost

For preparation of P-enriched vermicompost and compost from raw material (mustard straw) and fresh dung in the ratio of 1:1 on dry weight basis was mixed with 2.5% P_2O_5 through rockphosphate (34% P_2O_5, 74 micron size particles). Total 1.8 tons raw material and 0.118 ton rockphosphate were used for preparing P-enriched compost and the same amount of material was used for P-enriched vermicompost. For composting, the material was saturated with water and decomposed in pit 3.0 m x 1.8 m x 0.9 m and for vermicomposting two pits 3.0 m x 0.9 m x 0.5 m each were used. The temperature increased from 28 to 32^{0}C after 35 days when 1000 earthworms (*Eisenia foetida*) m^{-3} were applied for vermicomposting. Also, two turnings after 30 days each were given, and 35 to 40% moisture content was maintained by adding water on alternate days. The decomposition periods for P-enriched vermicompost and compost were 90 and 150 days, respectively.

Analytical Methods

Nitrogen content in compost/vermicompost was determined by Kjeltec-II autoanalyzer (Jackson, 1973). Phosphorus, potassium and micronutrients (Cu, Fe, Zn and Mn) were estimated by taking one g dry sample in a digestion flask with 10 ml tri-acid mixture (9:3:1 HNO_3:$HClO_4$: H_2SO_4) and digestion was carried out on a hot plate at 180-200^{0}C until dense white fumes of H_2SO_4 and $HClO_4$ were evolved. The digested material was used for estimation of phosphorus as given by Jackson (1973). The determination of potassium was done using flame photometer and Cu, Fe, Zn and Mn using atomic absorption spectrophotometer (Lindsay and Norvell, 1978). The nutrient content of P-enriched compost was 0.76% N, 2.87% P_2O_5, 0.80 % K_2O, 47 mg kg^{-1} Cu, 9640 mg kg^{-1} Fe, 87 mg kg^{-1} Zn and 306 mg kg^{-1} Mg, while P-enriched vermicompost contained 1.15% N, 3.16% P_2O_5, 0.85% K_2O, 49 mg kg^{-1} Cu, 10285 mg kg^{-1} Fe, 98 mg kg^{-1} Zn and 325 mg kg^{-1} Mg. At harvest, growth and yield data of crop were recorded from the net plot area (5 m x 5 m). Economics of different treatments in this study was done by using cost of cultivation and support price prevailing during respective years. The plant samples were analyzed for P content (Piper, 1966) and uptake value was calculated by multiplying the content by kernels and stover yield of crop. Protein in kernels was calculated by multiplying the percent of N in kernels by 6.25, and oil content was determined by Soxhlet method (AOAC, 1960). Initial and after harvest of crop soil samples (0-15cm) were drawn and analyzed for Olsen P (Jackson, 1973). Per cent recovery and phosphorus-use efficiency was calculated by the formula suggested by Carsesill and Godwin (1984).

3. RESULTS AND DISCUSSION

Growth and Yield Attributes

Application of organic and inorganic sources of phosphorus through broadcast and placement methods significantly increased the growth (plant height, branching, nodulation, tap root length, root weight, number of pod $plant^{-1}$ and 100 kernel weight) of groundnut as compared to control (Table 1). Among the treatments, maximum increases in height (66.5 cm $plant^{-1}$), primary branching (9.2 $plant^{-1}$), secondary branching (21.5 $plant^{-1}$), number of nodule (174 $plant^{-1}$), nodule dry weight (549 mg $plant^{-1}$), tap root (14.1 cm $plant^{-1}$), root weight (6.68 g $plant^{-1}$), number of pod (27.7 $plant^{-1}$) and 100 kernel weight (133.7g) were

Table: 1
Effect of organic, inorganic sources of P and its method of application on growth and yield attributes of groundnut (pooled data of 4 years)

Treatments	Plant height (cms)	Number of branches plant^{-1}		Nodules		Tap root length (cm)	Root weight plant^{-1} (g)	No. of pods plant^{-1}	100 kernel weight (g)
		Primary	Secondary	No. plant^{-1}	Dry weight (mg plant^{-1})				
T_1	49.6	6.9	15.9	121	381	8.1	4.33	20.7	99.8
T_2	57.5	8.0	18.2	158	480	10.8	5.72	24.1	115.8
T_3	59.4	8.3	19.0	167	496	11.5	5.93	24.9	119.8
T_4	60.6	8.4	19.5	161	504	11.9	6.04	25.3	121.6
T_5	63.9	8.9	20.4	169	531	14.2	6.41	26.7	128.7
T_6	63.5	8.8	20.3	168	527	14.0	6.36	26.5	127.6
T_7	66.5	9.2	21.5	174	549	14.1	6.68	27.7	133.7
SEm±	0.52	0.30	0.16	5.0	19.1	0.45	0.13	0.94	1.94
CD at 5%	1.29	0.65	0.34	10.9	41.6	0.98	0.38	2.06	4.23

T_1- Control, T_2- Recommended dose (RD) of P through broadcasting DAP, T_3- RD of P through placement DAP, T_4- RD of P as broadcasting through P-enriched compost, T_5- RD of P as placement through P-enriched compost, T_6- RD of P as broadcasting through P-enriched vermicompost, T_7- RD of P as placement through P-enriched vermicompost

obtained by application of recommended dose of P through placement of P-enriched vermicompost followed by placement of P-enriched compost and broadcasting of P-enriched vermicompost. Thus, placement of P-enriched vermicompost was found more efficient than its broadcasting in improving growth as well as yield attributes. Narolia *et al.* (2009) reported that drilling of vermicompost gave better nutritional environment in the crop root zone and plant system as vermicompost was known to improve the physical and biological properties of soil as well as supply all the essential nutrients for growth and development of the plant. Singh and Ganguli (2005) also reported that P-enriched vermicompost was superior in terms of all quality parameters and nutrient status than the P-enriched compost.

Yield and Economics

Placement method of recommended dose of P through P-enriched vermicompost recorded significant higher pod and stover yield of groundnut compared to other treatments (Table 2). The extent of increase in pod and stover yield with placement method of recommended dose of P through P-enriched vermicompost was 48.25 and 33.98% followed by 42.75 and 28.11% with recommended dose of P through placement of P-enriched compost and 38.42 and 27.07% with recommended dose of P through broadcasting of P-

Table: 2
Effect of organic, inorganic sources of P and its method of application on yield and economics of groundnut (pooled data of 4 years)

Treatments	Pod yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Cost of cultivation (₹ha^{-1})	Gross Return (₹ha^{-1})	Net Return (₹ha^{-1})	B:C ratio
T_1	1710	2316	11,590	28,904	17,314	2.49
T_2	2001	2686	12,790	35,827	23,037	2.80
T_3	2182	2779	13,250	38,992	27,086	2.94
T_4	2260	2826	14,115	40,360	26,245	2.86
T_5	2441	2967	14,615	43,550	28,935	2.98
T_6	2367	2943	14,715	42,262	27,547	2.87
T_7	2535	3103	15,115	45,238	30,123	2.99
SEm±	64	71	-	-	-	-
CD at 5%	141	156	-	-	-	-

T_1- Control, T_2- Recommended dose (RD) of P through broadcasting DAP, T_3- RD of P through placement DAP, T_4- RD of P as broadcasting through P-enriched compost, T_5- RD of P as placement through P-enriched compost, T_6- RD of P as broadcasting through P-enriched vermicompost, T_7- RD of P as placement through P-enriched vermicompost, Minimum support price for pods of groundnut in 2006, 2007, 2008 and 2009 were ₹1520, 1550, 2100 and 2100 q^{-1}, and for stover, ₹ 50, 60, 70 and 80 q^{-1}, respectively during the period of experimentation. Total cost of production of P-enriched vermicompost was ₹ 2925 and P-enriched compost ₹ 2325 for one ha of groundnut crop.

enriched vermicompost over control, respectively. Kumari *et al*. (2002) reported that the increased P availability in P-enriched vermicompost compared to other treatments promoted root growth raised root shoot ratio thereby increased the yield of cowpea. Similarly, Narolia *et al.* (2009) reported that drilling of vermicompost @ 1 ton ha^{-1} was at par with broadcasting of 2 tons ha^{-1} in pearlmillet crop. The application of recommended dose of P by placement of P-enriched vermicompost was the best treatment for obtaining net return (₹ 30,123 ha^{-1}) and B:C ratio (2.99), which was superior over rest of the treatments (Table 2). Also, the recommended dose of P through placement of P-enriched compost gave the next best net return (₹ 28,935 ha^{-1}) and B:C ratio (2.98). However, minimum net return (₹ 17,314 ha^{-1}) and B:C ratio (2.49) was recorded under control plot due to low productivity of groundnut. The benefit cost ratio was at par of placing of P through P-enriched vermicompost and P-enriched compost due to higher cost of production of vermicompost as compared to P-enriched compost. Ghosh *et. al.* (2011) also reported the enhanced net return through INM technologies.

Quality Parameters

Addition of P-enriched organic (compost and vermicompost), inorganic sources and method of its application significantly improved the oil and protein content in kernels of groundnut as compared to control (Table 3). Maximum and significantly higher values of oil (47.8%) and protein (27.04%) content in kernels of groundnut were observed with the application of recommended dose of P through placement of P-enriched vermicompost followed by recommended dose of P through placement of P-enriched compost. Minimum oil (46.0%) and protein (24.17%) content in kernels was recorded under control plots.

Uptake and Use-efficiency of Phosphorus

Significantly higher amount of P uptake by kernels (9.23 kg ha^{-1}) and stover (8.62 kg ha^{-1}) recorded in groundnut crop was due to placement of recommended dose of P through P-enriched vermicompost, whereas placement of recommended dose of P through P-enriched compost remained at par with broadcasting of P through P-enriched vermicompost (Table 3). The minimum uptake of P by kernel and stover of groundnut was recorded as 4.61 kg ha^{-1} and 3.93 kg ha^{-1}, respectively, under control plot. Increase in pod and stover yield of groundnut coupled with higher P contents were responsible for increased uptake of P by the crop. Singh and Sharma (2011) reported that the application of recommended dose of P through P-enriched vermicompost recorded highest uptake of P followed by P-enriched compost and chemical fertilizer in Chickpea crop grown in sandy loam soil.

Available P in soil after harvest of groundnut crop was significantly higher in all the treatments as compared to control (Table 3). Maximum availability of P (15.91 kg ha^{-1}) was recorded with the application of P through broadcasting of P-enriched vermicompost. Available P status of soil after harvest of crop was at par irrespective of source P and its method of application. Maximum recovery (23.28%) and use-efficiency of P (15.63 kg pod kg^{-1} P_2O_5) was recorded under placement of P-enriched vermicompost followed by placement of P-enriched compost and broadcasting of P-enriched vermicompost.

4. CONCLUSIONS

It is concluded that application of recommended doses of phosphorus through P-enriched vermicompost with placement method maximized the pod and stover yield, contents of oil and protein, uptake, recovery and use-

Table: 3
Effect of organic and inorganic sources of phosphorus and method of its application on quality parameters, availability, recovery and use-efficiency of phosphorus by groundnut crop (pooled of 4 years)

Treatments	Oil Content (%)	Protein content (%)	P uptake (kg ha^{-1})		Available P after harvest (kg ha^{-1})	Recovery of P_2O_5 (%)	Phosphorus use efficiency (kg pod kg^{-1} P_2O_5)
			Kernel	Stover			
T_1	46.0	24.17	4.61	3.93	10.96	-	-
T_2	46.7	26.10	6.98	6.25	14.51	11.73	7.28
T_3	46.8	26.27	7.73	7.06	13.18	15.63	9.30
T_4	47.1	26.31	7.61	6.91	15.25	14.95	10.00
T_5	47.3	26.79	8.59	7.90	14.87	19.88	13.28
T_6	47.2	26.60	8.50	7.83	15.91	19.48	12.68
T_7	47.8	27.04	9.23	8.62	15.13	23.28	15.63
SEm±	0.19	0.12	0.42	0.31	0.75	-	-
CD at 5%	0.42	0.26	0.93	0.79	1.67	-	-

T_1- Control, T_2- Recommended dose (RD) of P through broadcasting DAP, T_3- RD of P through placement DAP, T_4- RD of P as broadcasting through P-enriched compost, T_5- RD of P as placement through P-enriched compost, T_6- RD of P as broadcasting through P-enriched vermicompost, T_7- RD of P as placement through P-enriched vermicompost

efficiency of phosphorus, net return and B:C ratio of groundnut crop followed by placement of P-enriched compost and broadcasting of P-enriched vermicompost.

ACKNOWLEDGEMENTS

Authors acknowledge the financial assistance to the project received from the Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.

REFERENCES

AOAC. 1960. Official methods of analysis, 18th edition. *Association of Official Agricultural Chemist*, Washington DC., 70 p.

Carsesill, E. T. and Godwin, D. C. 1984. The efficiency of nitrogen fertilizers applied to cereals in different climates. *Adv. in Plant Nutri.,* 1: 1-55.

Ghosh, B.N., Sharma, N.K. and Dadhwal, K.S. 2011. Integrated nutrient management and cropping systems impact on yield, water productivity and net return in valley soils of north-west Himalayas. *Ind. J.Soil Cons.,* 39(3): 236-242.

Jackson, M.L. 1973. *Soil Chemical Analysis*, Prentice Hall of India, Pvt. Ltd, New Delhi. pp. 54-59.

Kumari, M.S., Sailaja and Kumari, Usha. 2002. Effect of vermicompost enriched with rock phosphate on growth and yield of cowpea (*Vigna unguiculata* L.). *J. Ind. Soc. Soil Sci.,* 50(2): 234-238.

Lindsay, W.L. and Norvell, W.A. 1978.Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.,* 52: 421-428.

Mehrotra, Nirupam. 2011. Commodity specific study on Groundnut. Department of Economics for Agricultural and Rural Development.*Pulished by NABARD*, 4th floor Bandra-Kurla Complex, Bandra (East), Mumbai-400 051, 8 p.

Narolia, R.S., Poonia, B.L. and Yadav, R.S. 2009. Effect of vermicompost and inorganic fertilizers on productivity of pearlmillet (*Pennisetum glaucum*). *Indian J. Agric. Sci.*, 79(7): 506-509.

Piper, C.S. 1966. *Soil and Plant analysis*. University of Adelaide, Adelaide, Australia. pp. 368-401.

Singh, A.B. and Ganguly, T.K. 2005. Quality comparison of conventional compost and chemically enriched compost. *J. Ind. Soc. Soil Sci.,* 53(3): 352-355.

Singh, Y.P. and Sharma, Anubhuti. 2011. Effect of sources of phosphorus and microbial inoculation on productivity, nutrients availability in soil and uptake of nutrients by chickpea (*Cicer arietinum*) grown on sandy loam soil. *Indian J. Agric. Sci.*, 81(9): 834-837.

Vishwakarma, A.K., Brajendra, Pathak, K.A. and Ramakrishna, Y. 2012. Effect of different sources of nutrient application on productivity, nutrient uptake and economics of groundnut *(Arachis hypogaea.)* in Kolasib district of Mizoram. *Ind. J. Soil Cons.,* 40(2): 152-157.