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Research Paper

Effect of sources and levels of phosphorus on productivity, economics, nutrient acquisition and phosphorus-use efficiency of groundnut (*Arachis hypogaea*) under hilly ecosystems of North-East India

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ABSTRACT

A field experiment was conducted at the ICAR Research Complex for North Eastern Hill Region, Tripura Centre during 2013 and 2014, to study the effect of Godawari phosgold (organic source) and single supperphosphate (inorganic source) at varying rates of application on yield, economics, nutrient uptake, and phosphorus (P) use efficiency of groundnut (*Arachis hypogaea* L.). Phosphorus supplied through Godawari phosgold (GPG) gave significantly more pods/plant (60.7), pod yield (1.89 t/ha) and haulm yield (3.22 t/ha) than single supperphosphate (SSP). This resulted in 10.5% and 9.9% increment in pod and haulm yields, respectively, over SSP. Among the P levels, application of 27 kg P/ha recorded significantly higher pods/plant (70.8), kernels/pod (2 kernels/pod), pod (2.09 t/ha) and haulm (3.58 t/ha) yields over rest of the P levels. With respect to nutrients acquisitions, groundnut plot treated with GPG resulted in higher NPK uptake (108.3, 15.8 and 64.0 kg/ha, respectively) over the SSP-treated plots. Among the rate of application, 27 kg P/ha recorded highest NPK uptake. The lowest cost of cultivation was recorded in SSP-treated plots. However, the net returns and benefit: cost ratio was higher under GPG-treated groundnut plots. Although the highest net returns (65.45×10^{3}₹/ha) and benefit: cost ratio (2.54) were noticed in groundnut plots, where 27 kg P/ha was applied. Application of P through GPG significantly increased the partial factor productivity (98.1 kg grain/kg P applied), agronomic efficiency (19.9 kg grain yield increase/kg P applied), recovery efficiency (20.4%) and utilization efficiency (2,185.5 kg biomass/kg P uptake) as compared to SSP. The maximum agronomic efficiency, recovery efficiency and utilization efficiency were recorded with application of 27 kg P/ha.

Key words *:* Godawari phosgold, Groundnut, Organic sources of phosphorus, Nutrient uptake

The soils of the Eastern Himalayas are much degraded due to cultivation on steep slopes, negligible nutrient supplementation and biomass burning under traditional practices (Saha *et al.*, 2012). Cultivation of exhaustive crops such as ginger, turmeric, maize, etc. on sloping land without proper soil and water-conservation measures exacerbates the degradation process, making the soil unfit for cultivation (Salahin *et al*., 2013). Hence there is a need for appropriate soil-management practices involving efficient cropping systems and nutrient-management practices for sustaining hill agriculture (Das *et al.*, 2013). Groundnut, one of the important oilseed crops of the world as well as in India, is largely grown as a small-holding crop in rainfed area of North-East (NE) India. The crop has the capacity to conserve the soil, check the soil erosion and improve the fertility of degraded sloping and *tilla* land. Therefore, crop is gaining popularity among the North-East farmers to grow on upland as well as on sloping land. But the productivity of the crop is low mainly due to low concentrations of native nutrients in soil, especially phosphorus (P), which is major constraint limiting crop productivity in highly leached acid soils of the subtropical Indian Himalayas. Therefore, groundnut crop suffers from deficiency of P, which is essential for plant growth and pod formation, besides nitrogen (N)-fixation activity (Vishwakarma *et al*., 2012). The crop response to varying doses and sources of inorganic phosphate fertilizer in NE India is very wide due to variation in soil *p*H, organic matter, iron and aluminum status in soil. Low soil *p*H in the region makes soil condition quite conducive for P fixation and precipitation. Added inorganic P as water-soluble

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phosphate fertilizers undergoes complex exchanges between various soil phosphorus pools (Shivay, 2010). Consequently, large amounts of inorganic P fertilizer is needed to attain reasonable crop yields. Hence, there is an urgent need for a P fertilizer, which may be an economical substitute to inorganic water-soluble P fertilizers and enhance the groundnut productivity and P-use efficiency. To address the above problem, the present investigation was undertaken to study the effect of Godawari phosgold (GPG), organic phosphorus fertilizer) and single supperphosphate (SSP, inorganic phosphorus fertilizer) at varying rate of application on yield, nutrient uptake, economics and P-use efficiency of groundnut.

MATERIALS AND METHODS

A field experiment was conducted during the crop-growing season (July–October) in 2013 and 2014 at Agronomy experimental plot, ICAR Research Complex for North Eastern Hills Region, Tripura Centre (23°54' 24.02" N, 91° 18' 58.35" E and 162 m above the mean sea–level) (Arabian Sea). The soil was sandy loam and its initial soil sample had 6.5 g/kg organic carbon (C), 292.0 mg/kg available N, 7.5 mg/kg available P and 295.5 mg/kg available potassium (K). The *p*H of soil was 5.3 (1:2.5, soil and water ratio). The experiment was laid out in split-plot design, assigning sources of phosphate fertilizers (GPG-containing 4.5% P and SSP-containing 7% P) in main plots and levels of P (control, 9 kg P/ha, 18 kg P/ha, 27 kg P/ha) in subplots. All the treatments replicated thrice during both the years. The main plot size was 8 m × 8 m and subplot size was 8 m × 2 m. Immediately with the onset of monsoon, field was ploughed with power tiller and leveled to reach the appropriate tilth condition for germination. The groundnut variety 'TG 37 A' was sown 30 cm × 10 cm spacing during the first week of July in both the years. A recommended dose of N (20 kg/ha) and K (40 kg/ha) was applied at the time of sowing. Phosphorus was applied as per treatment. Two hand-weedings were given at 20 and 45 days after sowing (DAS). The earthing-up was done along with the second weeding at 45 DAS. The crop was harvested in the last week of October in both the years. At harvesting, yield data of crop was recorded from the net plot area (7.4 m × 1.4 m). Economics of different treatments in this study was done by using cost of cultivation and prevailing market price during respective years. The plant samples were analysed for NPK content by Prasad *et al*. (2006) and uptake value was calculated by multiplying the content by kernels, shell and haulm yield of crop. The estimated values of partial factor productivity (PFP), agronomic efficiency (AE), recovery efficiency (RE), agro-physiological efficiency (APE), physiological efficiency (PE) and utilization efficiency (UE) of applied P were computed using the following expressions as suggested by Fageria and Filho (2007):

$PFP = Y_P/P_a$

$AE = (Y_P–Y_C)/P_a$

$RE = [(U_P–U_C)/P_a] \times 100$

$APE = (Y_P–Y_C)/(U_P–U_C)$

$PE = (B_P–B_C)/(U_P–U_C)$

$UE = PE \times RE$

where, Y_P and U_P refer to the grain yield (kg/ha) and total P uptake (kg/ha), respectively, of groundnut in P applied plots; Y_C and U_C refer to the grain yield (kg/ha) and total P uptake (kg/ha), respectively, of groundnut in control (no-P) plots; P_a refers to the P applied (kg/ha); and B_P and B_C refers to biomass yield of treated and control plots, respectively. Data were subjected to ANOVA, to test the significance of the overall differences among treatments by the 'F' test. When the 'F' value was found to be significant, the critical difference (CD) at P=0.05 was computed to compare the difference between the 2 treatment means (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield attributes and yield

Mean data of 2 years experiment showed that application of organic and inorganic sources of P with varying rate significantly increased the yield attributes (pods/plant, kernels/pod and 100-kernel weight) and pod and haulm yields (Table 1) of groundnut as compared to the control. The P supplied through Godawari phogold (GPG) resulted in significantly higher number of pods/plant, pods and haulm yields than SSP. However, sources of P had failed to affect the kernels/pod and 100-kernel weight statistically. The application of P through GPG increased the pod and haulm yield by 10.5% and 9.9%, respectively, over SSP. These results confirm the findings of Singh *et al*. (2014). In general, application of P caused significant improvement in growth and yield of groundnut. Increasing P application rate from 9 kg/ha to 27 kg/ha significantly increased the yield of groundnut. Among the P levels, application of 27 kg P/ha recorded significantly higher number pods/plant, pod and haulm yields over rest of the levels of P application (Rao and Shaktawat, 2005).

Protein content and yield

Protein content in kernel and protein yield of groundnut were significantly affected by P sources and rate of application. Groundnut grown with GPG recorded significantly higher protein content and yield compared to SSP plots (Fig. 1). Our results are confirm the findings of Singh *et al.* (2014). Among the levels of application, protein content as well as protein yield increased with level of application. Application P 27 kg/ha recorded significantly higher protein content and yield of groundnut over rest of P levels (Fig. 1).

Nutrient acquisition

The nutrient uptake was significantly affected by P sources and rate of application (Table 2). The groundnut plot treated with GPG recorded significantly higher values of N, P and K uptake than SSP treated plots (Table 2). Increase in pod and haulm yields of groundnut coupled with higher nutrients contents were responsible for increased uptake of nutrients by the crop. Another possible reason may be the higher availability of nutrients in GPG treated plot. These results support the findings of Sharma and Prasad (2009). Nutrients acquisition by groundnut progressively increases with the increase in the dose of P from 0 to 27 kg/ha. Among the P levels, application of 27 kg P/ha was recorded significantly highest N, P and K uptake, irrespective of P sources (Table 2).

Economics

Cost of cultivation, net returns and benefit: cost ratio were also varied among the P sources and rates of application. The lowest cost of cultivation was recorded in SSP treated plots. However, the net returns and benefit: cost ratio was higher under GPG treated groundnut plots, this was mainly owing to more pod and haulm yield in this respective plots. The cost of cultivation, net returns and benefit: cost ratio showed increasing trends with the rate of application; although highest net returns and benefit: cost ratio were noticed with 27 kg P/ha.

Table 1. Effect of sources and levels of phosphorus on yield attributes and yields of groundnut (mean data of 2 years)

Treatment	Pods/plant	Kernels/pod	100-kernel weight (g)	Pod yield (t/ha)	Haulm yield (t/ha)
Source of phosphorus					
GPG	60.7	1.9	38.6	1.89	3.22
SSP	53.8	1.9	36.9	1.71	2.93
SEm±	0.9	0.01	0.8	0.02	0.03
CD (P=0.05)	5.2	NS	NS	0.15	0.17
Level of phosphorus (kg/ha)					
0	44.0	1.7	33.3	1.51	2.57
9	50.7	1.9	37.3	1.69	2.90
18	63.4	2.0	40.3	1.90	3.25
27	70.8	2.0	40.2	2.09	3.58
SEm±	1.4	0.1	1.2	0.02	0.04
CD (P=0.05)	4.2	0.2	NS	0.05	0.11

GPG, Godawary phosgold; SSP, single supperphosphate

Table 2. Effect of sources and levels of phosphorus on nutrient uptake and economics in groundnut (mean data of 2 years)

Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Cost of cultivation (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Source of phosphorus						
GPG	108.3	15.8	64.0	40.52	57.35	2.41
SSP	96.2	13.6	57.5	36.63	51.59	2.40
SEm±	1.10	0.10	0.6	–	0.68	0.04
CD (P=0.05)	7.00	0.70	3.8	–	4.14	NS
Level of phosphorus (kg/ha)						
0	84.2	11.9	50.1	34.52	43.71	2.27
9	95.8	13.6	57.0	37.23	50.35	2.35
18	108.6	15.7	64.4	39.93	58.37	2.46
27	120.5	17.7	71.5	42.63	65.45	2.54
SEm±	0.80	0.10	0.5	–	1.08	0.02
CD (P=0.05)	2.50	0.50	1.6	–	3.34	0.07

GPG, Godawary phosgold; SSP; single supperphosphate
Nutrients uptake (uptake in kernel + shell + haulm)

Table 3. Effect of sources and levels of phosphorus on phosphorus-use efficiencies of groundnut (mean data of 2 years)

Treatment	Partial factor productivity (kg kernel/kg P applied)	Agronomic efficiency (kg kernel yield increase/kg P applied)	Crop recovery efficiency (%)	Agro physiological efficiency (kg kernel increase/kg P uptake)	Physiological efficiency (kg biomass increase/kg P uptake)	Utilization efficiency (kg biomass/kg P uptake)
Source of phosphorus						
GPG	98.1	19.9	20.4	77.3	111.5	2185.5
SSP	87.6	11.6	10.9	82.7	106.9	1313.0
SEm±	1.30	0.70	0.60	1.60	7.40	97.5
CD (P=0.05)	7.70	4.10	3.70	NS	NS	593.1
Level of phosphorus (kg/ha)						
0	0.0	0.0	0.0	0.0	0.0	0.0
9	188.2	20.1	19.5	118.2	168.0	1820.1
18	105.6	21.6	21.3	102.5	134.6	2508.3
27	77.4	21.4	21.9	99.1	134.1	2668.4
SEm±	2.40	1.10	1.00	3.70	8.90	139.4
CD (P=0.05)	7.40	3.40	2.90	11.40	27.20	429.5

GPG, Godawary phosgold; SSP, single supperphosphate

Phosphorus-use efficiency

Critical appraisal of data presented in Table 3 showed that PFP, AE, RE, APE, PE and UE of applied P were affected significantly by P sources and rate of application (Fageria and Filho, 2007). Application of P through GPG was significantly increased the PFP, AE, RE and UE as compared SSP (Table 3). However, no significant effect of P sources was observed on APE and PE. The rate of application of P had also significant effect on P-use efficiencies irrespective of their sources. The PFP decreased with the increase in P application rate from 9 to 27 kg/ha. AE, RE and UE increased as the rate P application increased from 9 to 27 kg/ha, and their maximum value were recorded with application of 27 kg P/ha. However, APE and PE had showed similar trends as shown by PFP (Table 3).

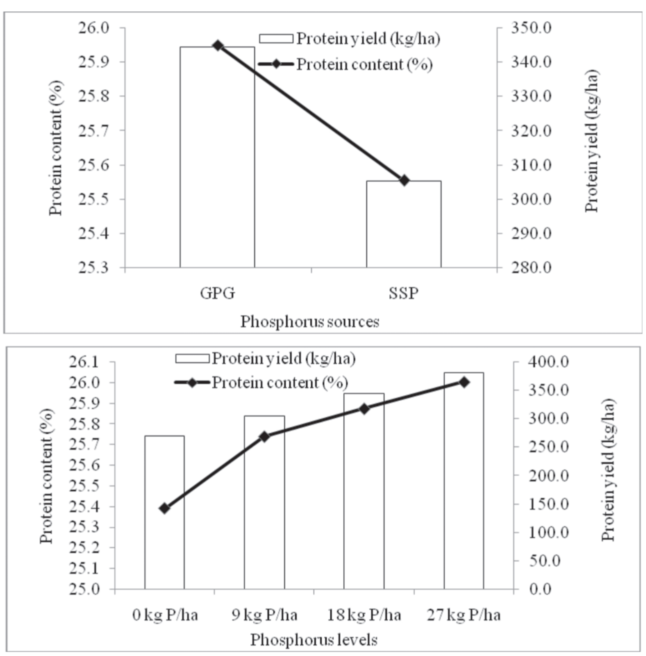

Fig. 1. Effect of sources and levels of phosphorus on protein content and protein yield of groundnut (mean data of 2 year).

Thus, it can be concluded that the supply of P through GPG enhanced the groundnut yield, nutrient uptake, net returns, benefit: cost ratio and P-use efficiency, and groundnut responds well up to 27 kg P/ha in sandy soil of NE India. Therefore, supply of 27 kg P/ha through GPG may be recommended for enhancing the productivity, profitability and P-use efficiency of groundnut in hilly ecosystem of NE India.

REFERENCES

Das, A., Patel, D.P., Ramkrushna, G.I., Munda, G.C., Ngachan, S.V., Kumar, M. and Naropongla, J. 2013. Crop diversification, crop and energy productivity under raised and sunken beds: results from a seven-year study in a high rainfall organic production system. *Biological Agriculture and Horticulture* **30**: 73–87.

Fageria, N.K. and Barbosa Filho, M.P. 2007. Drymatter and grain yield, nutrient uptake, and phosphorus useefficiency of lowland rice as influenced by phosphorus fertilization. *Communications in Soil Science and Plant Analysis* **38**: 9–10.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedure for Agricultural Research,* edn 2, pp. 680. John Wiley & Sons, New York.

Prasad, R., Shivay, Y.S., Kumar, D. and Sharma, S.N. 2006. *Learning by Doing Exercises in Soil Fertility – A Practical Manual for Soil Fertility,* pp. 1–68, Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Rao, S.S. and Shaktawat, M.S. 2005. Effect of organic manure, phosphorus and gypsum on nutrient uptake in groundnut. *Agropedology* **15**(2): 100–106.

Saha, R., Chaudhary, R.S. and Somasundaram, J. 2012. Soil health management under hill agro-ecosystem of North East India. *Applied and Environmental Soil Science* Vol. 2012.

Salahin, N., Begum, R.A., Hossain, S., Ullah, M.M. and Alam, M.K. 2013. Degradation of soil properties under ginger, turmeric, aroid, and *jhum* rice cultivation in hilly areas of Bangladesh. *Bangladesh Journal of Agricultural Research* **38**: 363–71.

Sharma, S.N. and Prasad, R. 2009. Effect of different sources of phosphorus on summer mungbean (*Vigna radiata*) in alkaline soil of Delhi. *Indian Journal of Agricultural Sciences* **79**(10): 782–89.

Shivay, Y.S. 2010. Effect of diammonium phosphate and mussoorie rock phosphate on productivity and economics of potato (*Solanum tuberosum*). *Indian Journal of Agricultural Sciences* **80**(4): 329–32.

Singh, Y.P., Singh, S., Dubey, S.K. and Tomar, R. 2014. Organic, inorganic sources of phosphorus and methods of application on performance of groundnut (*Arachis hypogaea*) under rainfed condition. *Indian Journal of Soil Conservation* **42**(2): 204–08.

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. *Indian Journal of Soil Conservation* **40**(2): 152–157.