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Effects of godawariphosgold and single super phosphate on groundnut (*Arachis hypogaea*) productivity, phosphorus uptake, phosphorus use efficiency and economics

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ABSTRACT

The field experiment was conducted at Agronomy experimental plot of ICAR Research Complex for North East Region, Tripura Centre, Lembucherra, Tripura (W), India, to study the effects of different sources of phosphorus (P) at varying rates of application on yield, P uptake, economics and P use efficiency of groundnut. The experiments were laid out in a split-plot design with 3 replications. The treatments were consisted of 2 phosphate fertilizers [Godawariphosgold (GPG) and single super phosphate (SSP)] in main plots and 4 rates of application (control, 9, 18 and 27 kg P/ha) in sub-plots. Phosphorus applied through GPG produced significantly higher pod yield (1.86 to 1.93 tonnes/ha) and haulm yield (3.16 to 3.29 tonnes/ha) as compared to SSP. The application of P through GPG increased the pod and haulm yield 7.5 to 16.7% and 7.3 to 15.2%, respectively over SSP. Application of 27 kg P/ha through GPG produced highest pod and haulm yield. The groundnut plot treated with GPG recorded significantly more Puptake (15.6 to 15.9 kg/ha) as compared to SSP treated plots (13.3 to 13.9 kg/ha). P uptake was highest, when 27 kg P/ha was applied through GPG.Application of P through GPG significantly increased the agronomic efficiency (15.4 to 24.4 kg grain yield increase/kg P applied) and apparent recovery (15.4 to 25.4%) compared to SSP. The highest net return (₹ 71744/ha) was recorded with application of 27 kg P/ha through GPG, and highest B: C ratio (2.59) was noticed in groundnut plots, where 27 kg P/ha was applied through SSP. Therefore, we recommended that application of GPG at rate of 27 kg P/ha for increased productivity, P uptakes, P use efficiency and net returns in groundnut crop.

Key words: Agronomic efficiency, Apparent recovery, Godawariphosgold, Groundnut, Phosphorus uptake, Pod yield

Groundnut (*Arachis hypogaea* L.), one of the major and important oil seed crops of the world as well as in India, is largely grown as a small holding crop in rainfed area. The crop has the capacity to conserve the soil, check the soil erosion and improving the fertility of degraded sloping and *tilla* land (Yadav *et al*. 2015) Therefore, the crop is gaining popularity among the North East Farmers of India to grow in upland as well as in sloppy land. But the productivity of the crop is low mainly due to low concentrations of native nutrients in soil, especially phosphorus (P), which is limiting crop productivity in highly leached acid soils of the subtropical Indian Himalayas. Therefore, groundnut crop suffers from the deficiency of P, which is essential for plant growth and pod formation, besides N-fixation activity (Vishwakarma *et al*. 2012). The crop response to varying dose and sources of inorganic phosphate fertilizer in north east India is very wide, due to variation in soil pH, organic matter and iron aluminum status. The low soil pH of the region makes soil condition quite conducive for P fixation and precipitation. Added inorganic phosphorus as water soluble phosphate fertilizers undergoes complex exchanges between various soil phosphorus pools (Shivay 2010). Consequently, large amounts of inorganic fertilizer phosphorus are needed to attain reasonable crop yields. Thus, there is a necessity of appropriate soil management practices involving efficient cropping systems and nutrient management practices for sustainable hill agriculture (Das *et al.* 2013). To address the above problem the present investigation was undertaken to study the effect of godawariphosgold and single super

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phosphate on groundnut productivity, phosphorus uptake and phosphorus use efficiency.

MATERIALS AND METHODS

The field experiment was conducted at Agronomy experimental plot of ICAR Research Complex for North East Region, Tripura Centre, Lembucherra, Tripura (W), India ($23^0$54'24.02" N and $91^0$18'58.35"E and altitude of 162 m above mean sea level) during the crop-growing season (July-October) in 2013 and 2014. The annual rainfall of the area is 2200 mm. The soil of the experimental field is sandy loam and its initial soil sample had 6.5 g/kg organic C, 292.0 mg/kg available nitrogen (N), 7.5 mg/kg available phosphorus (P) and 295.5 mg/kg available potassium (K). The pH of soil was 5.3 (1: 2.5, soil and water ratio). The experiment was laid out in a split-plot design with 3 replications. The treatments were consisted of 2 phosphate fertilizers (Godawariphosgold and single super phosphate) in main plots and 4 rates of application (control, 9, 18 and 27 kg P/ha) in sub-plots. The treatments were continued for 2 years in the same plots. The main plot size was 8 × 8 m and sub plot size was 8 × 2 m. Organic P fertilizer godawariphosgold (GPG) containing 4.4% phosphorus and single super phosphate (SSP) containing 7 % phosphorus were used. Immediately with the onset of monsoon, field was ploughed with power tiller and levelled to reach the appropriate tilth condition for germination. The groundnut variety TG-37 A was sown in 30 × 10 cm spacing during first week of July in both the years. A recommended dose of N 20 kg/ha and K_2O 40 kg/ha was applied at the time of sowing. Phosphorus was applied as per treatment. Two hand weeding were performed at 20 and 45 days after sowing (DAS). The earthing up was done along with second weeding at 45 DAS. The crop was harvested in last week of October in both the years. At harvest yield data of crop was recorded from the net plot area (7.4 m × 1.4 m). The pod yield was adjusted at 14% moisture. A plant sample was drawn from each plot for moisture determination and haulm yield was adjusted at oven dry basis. The kernel, shell and haulm samples were analyzed for P content by Prasad *et al*. (2006) and uptake value was calculated by multiplying the content by kernels, shell and haulm yield of crop. The agronomic efficiency (AE) of P sources was calculated by using following expression:

$$AE = (Y_t - Y_c)/ P_a$$

where, AE is the agronomic efficiency in kg seed/kg P applied, Y_t is the pod yield in applied plot in kg/ha, Y_c is the pod yield in control plot in kg/ha and Pa is the P applied in kg/ha.

The apparent recovery (AR) of P was computed using following expression:

$$AR(\%) = [(P_t - P_c)/ P_a] \times 100$$

where, AR is the apparent recovery in percentage, P_t is the amount of P taken up from P applied plot in kg/ha, P_c is the amount of P taken up from control plot in kg/ha and P_a is the amount of P applied in kg/ha.

Gross income of different treatments was calculated using following expression:

$$GI = Yi \times Pc$$

where, GI is the gross income in ₹/ha, Yi is the pod yield of the treatment I and Pc is the procurement price of groundnut pod. Cost of cultivation of groundnut was calculated on the basis of prevailing rates of inputs in the market during the study and then the cost of cultivation was averaged over 2 years. The net income of treatment I was obtained by subtracting the cost of cultivation of treatment I from gross income of treatment I.

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 test the significance of the difference between the two treatment means (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Pod and haulm yields

Pod yield of groundnut ranged from 1.56 to 2.19 tonnes/ha and 1.51 to 2.30 tonnes/ha in GPG treated plots and

Table 1 Effects of sources and rates of phosphorus applicationon pod and haulm yields (tonnes/ha) of groundnut

Treatment	2013			2014		
	GPG	SSP	Mean	GPG	SSP	Mean
Pod yield						
0 kg P/ha	1.56	1.52	1.54	1.51	1.46	1.48
9 kg P/ha	1.71	1.59	1.65	1.83	1.64	1.73
18 kg P/ha	1.96	1.75	1.86	2.09	1.80	1.95
27 kg P/ha	2.19	1.91	2.05	2.30	1.97	2.13
Mean	1.86	1.69		1.93	1.72	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	0.02	0.13		0.03	0.17	
Rate (R)	0.02	0.05		0.02	0.05	
S × R	0.02	0.07		0.02	0.07	
Haulm yield						
0 kg P/ha	2.66	2.59	2.62	2.54	2.49	2.52
9 kg P/ha	2.91	2.71	2.81	3.12	2.85	2.98
18 kg P/ha	3.33	2.98	3.16	3.57	3.14	3.35
27 kg P/ha	3.72	3.24	3.48	3.93	3.41	3.67
Mean	3.16	2.88		3.29	2.97	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	0.04	0.23		0.02	0.11	
Rate (R)	0.04	0.11		0.04	0.11	
S × R	0.05	0.16		0.05	0.15	

GPG-Godawariphosgold, SSP-Single super phosphate

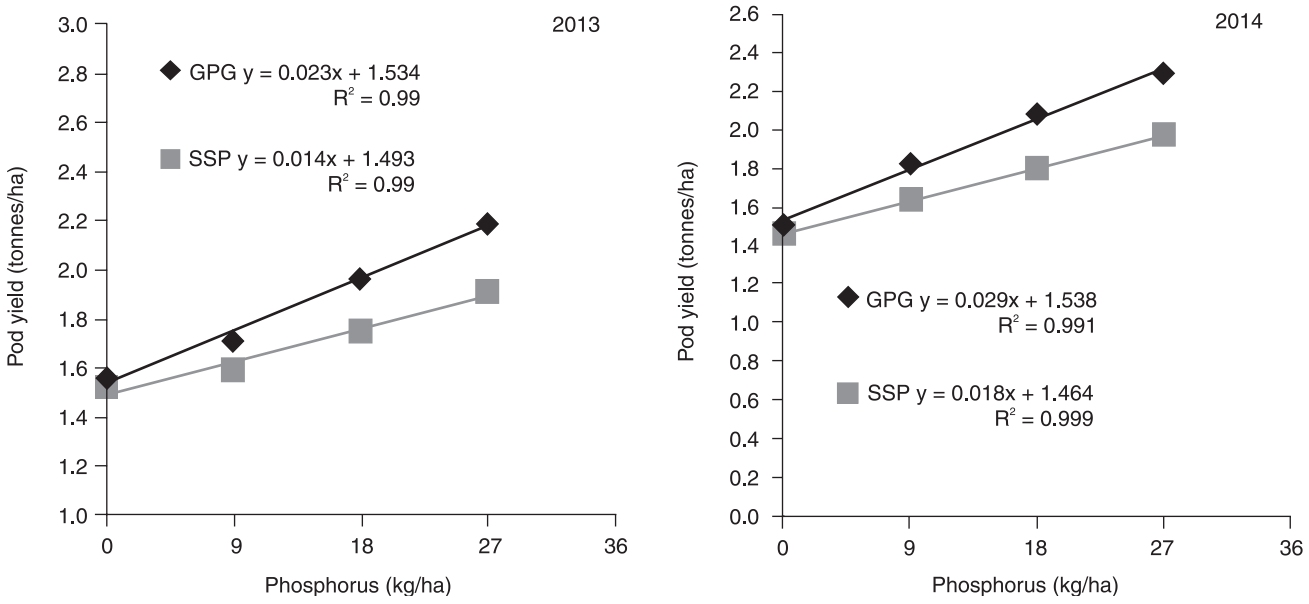
from 1.52 to 1.69 tonnes/ha and 1.46 to 1.97 tonnes/ha in SSP treated plots in 2013 and 2014, respectively (Table 1). GPG treated plots produced significantly higher groundnut pod yield as compared to SSP treated plots (Singh *et al*. 2014). GPG treated plots produced 10.1% and 12.2% higher pod yield over SSP treated plots in 2013 and 2014, respectively. Pod yield of groundnut increased significantly when rate of P application was increased from 0 to 27 kg P/ha irrespective of source of application, whereas increase in pod yield was higher in 2014 as compared to 2013. The marginal increase in pod yield per unit increase in P levels was higher under GPG treated plots as compared to SSP treated plots. Application of 27 kg P/ha through GPG produced significantly higher pod yield as compared to other levels of application (Table 1). Similar result was also reported by Yadav *et al*. (2015). The responses of groundnut pod yield to GPG and SSP were linear during both years (Fig 1). Haulm yield of groundnut ranged from 2.66 to 3.72 tonnes/ha and 2.54 to 3.93 tonnes/ha in GPG treated plots and from 2.59 to 3.24 tonnes/ha and 2.49 to 3.41 tonnes/ha in SSP treated plots in 2013 and 2014, respectively (Table 1). Application of P through GPG produced more haulm yield as compared to SSP. GPG produced 9.7% and 10.7% more haulm yield over SSP treated plots in 2013 and 2014, respectively (Yadav *et al*. 2015). Application of 27 kg P/ha through GPG was also produced significantly higher haulm yield (3.72 to 3.93 tonnes/ha) as compared to rest of the levels of P application irrespective of sources (Singh *et al*. 2014).

Phosphorus uptake

Phosphorus uptake was significantly affected by P sources and rate of application (Sharma and Prasad 2009). Groundnut removed 11.2–19.5 kg P/ha from GPG treated plots and 10.9–15.9 kg P/ha from SSP applied plots (Table 2). The P concentration ranged from 0.49 to 0.51% in kernel, 0.17 to 0.19% in shell and 0.22 to 0.26 in haulm. Phosphorus application significantly increased P uptake of groundnut in both the years of study. P uptake of groundnut increased more when the rate of P application was increased from 0 to 27 kg P/ha as GPG as compared to SSP. In general P uptake was higher under GPG treated plots as compared to SSP treated plots. Among the levels, application of P 27 kg/ha recorded higher P uptake than other levels (Yadav *et al*. 2015). These results show that effects of P application on P uptake were higher than on pod and haulm yields because of a positive effect of P application on P concentrations in kernel, shell and haulm of groundnut (Sharma and Prasad 2009).

Phosphorus use efficiency

Agronomic efficiency (AE) and apparent recovery (AR) of applied P were affected by P sources and rate of application (Fageria and Barbosa Filho 2007). Application of P through GPG was significantly increased the AE (15.4 and 24.4 kg grain yield increase/kg P applied) and AR (15.4 and 25.4%) as compared to SSP in 2013 and 2014, respectively (Table 3). The AE and AR of both GPG and SSP increased with the increase of rate of P application during the first year, whereas during the second year the AE and AR of GPG and SSP increased with the increase of rate of P application up to 18 kg P/ha (Yadav *et al*. 2015). The rate of application of P had also significant effect on AE and AR irrespective of P sources. AE was ranged from 12.4 to 18.7 and 24.0 to 27.7 kg grain yield increase/kg P applied and AR from 11.6 to 19.2% and 24.6 to 27.4% under different rates of P application, 2013 and 2014, respectively (Table 3). Both mean AE and AR of P application increased as levels of P application increased from 9 to 27 kg/ha during first year. In second year of study, AE and AR decreased as the rate of P application increased from 9 to 27 kg/ha (Sharma and Prasad 2009).



GPG-Godawariphosgold, SSP-Single super phosphate

Fig 1 Response of pod yield of groundnut to rates and sources of phosphorus

Table 2 Effects of sources and rates of phosphorus application on phosphorus uptake in groundnut

Treatment	2013			2014		
	GPG	SSP	Mean	GPG	SSP	Mean
P uptake (kg/ha)						
0 kg P/ha	12.9	12.2	12.6	11.2	10.9	11.1
9 kg P/ha	14.3	12.9	13.6	14.6	12.5	13.5
18 kg P/ha	16.9	14.5	15.7	17.2	14.0	15.6
27 kg P/ha	19.4	16.0	17.7	19.5	15.9	17.7
Mean	15.9	13.9		15.6	13.3	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	0.15	0.93		0.09	0.52	
Rate (R)	0.12	0.38		0.17	0.53	
S × R	0.17	0.54		0.24	0.75	

GPG-Godawariphosgold, SSP-Single super phosphate

Economics

The net returns of groundnut ranged from ₹ 42815 to 71744/ha in GPG treated plots and ₹ 40615 to 62526/ha in SSP applied plots (Table 4). Application of P increased net returns and benefit: cost ratios (B: C ratios) of groundnut in all the 2 years of study. Effect of P application on net returns and B: C ratios were more under GPG treated plots.

Table 3 Effect of sources and rates of phosphorus application on agronomic efficiency and apparent recovery of phosphorus in groundnut

Treatment	2013			2014		
	GPG	SSP	Mean	GPG	SSP	Mean
Agronomic efficiency (kg grain yield increase/kg P applied)						
9 kg P/ha	16.6	8.2	12.4	35.9	19.5	27.7
18 kg P/ha	22.1	12.8	17.5	32.3	19.0	25.6
27 kg P/ha	23.1	14.3	18.7	29.3	18.7	24.0
Mean	15.4	8.8		24.4	14.3	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	0.71	4.31		0.63	3.83	
Rate (R)	1.01	3.10		1.19	3.65	
S × R	1.42	4.38		1.68	5.17	
Apparent recovery (%)						
9 kg P/ha	15.3	7.8	11.6	37.3	17.4	27.4
18 kg P/ha	22.0	12.7	17.4	33.5	16.8	25.2
27 kg P/ha	24.0	14.3	19.2	30.8	18.3	24.6
Mean	15.4	8.7		25.4	13.1	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	0.57	3.45		0.63	3.81	
Rate (R)	0.51	1.58		1.35	4.17	
S × R	0.73	2.24		1.91	5.89	

GPG-Godawariphosgold, SSP-Single super phosphate

Table 4 Effect of sources and rates of phosphorus application on net return and benefit: cost ratios of groundnut

Treatment	2013			2014		
	GPG	SSP	Mean	GPG	SSP	Mean
Net return (₹/ha)						
0 kg P/ha	46811	44588	45700	42815	40615	41715
9 kg P/ha	50518	46987	48753	55536	48344	51940
18 kg P/ha	59365	53721	56543	64884	55528	60206
27 kg P/ha	67124	60408	63766	71744	62526	67135
Mean	55954	51426		58745	51753	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	630	3834		731	4449	
Rate (R)	1025	3158		1140	3514	
S × R	1449	NS		1613	NS	
B: C ratio						
0 kg P/ha	2.38	2.31	2.34	2.22	2.16	2.19
9 kg P/ha	2.33	2.33	2.33	2.42	2.33	2.38
18 kg P/ha	2.41	2.46	2.43	2.51	2.47	2.49
27 kg P/ha	2.46	2.58	2.52	2.53	2.59	2.56
Mean	2.39	2.42		2.42	2.39	
	SEm±	*LSD (P=0.05)*		*SEm*±	*LSD (P=0.05)*	
Source (S)	0.03	NS		0.04	NS	
Rate (R)	0.02	0.07		0.02	0.07	
S × R	0.03	NS		0.03	NS	

GPG-Godawaryphosgold, SSP-Single super phosphate

Lowest cost of cultivation was recorded SSP treated plots. However, the net return and B: C ratio was higher under GPG treated groundnut plots, this was mainly due to more pod and haulm yield in this respective plots (Yadav *et al*. 2015). Net returns and B: C ratios showed increased trends as the rate of application increased. Although highest net return and B: C ratios were noticed in groundnut plots, where 27 kg P/ha was applied (Yadav *et al*. 2015).

Thus, it could be concluded that the application of P through GPG enhances the groundnut yield, P uptake, agronomic efficiency, apparent recovery and net return, B: C ratio. An amount of 27 kg P/ha is more beneficial than lower dose of P application. Therefore, we recommend that application of 27 kg P/ha through GPG in groundnut crop for higher productivity, agronomic efficiency, apparent recovery and net return.

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