Effect of Different Sources of Phosphorus on protein content, soil fertility and Yield of Greengram

ABSTRACT

To study the effect of different sources of phosphorus on quality, fertility status and yield of greengram, an experiment was conducted during the *kharif season of* 2014 at Crop Research Farm, Department of Agronomy, SHIATS, Allahabad, UP. The experiment was conducted in randomized block design with 9 treatments *viz*. Control (No Phosphorus, 100% P through SSP, 100% P through URP, 50% P through SSP + 50% P through URP, 75% P through SSP + 25% P through URP, 100% P through SSP + PSB inoculation, 100% P through URP + PSB inoculation, 50% P through SSP + 50% P through URP + PSB inoculation, 75% P through SSP + 25% P through URP + PSB inoculation. Greengram variety Samrat was sown at a spacing of 30cm x 10 cm and it was fertilized with Phosphorus, SSP, URP, PSB as per the requirement of the treatments. The experimental results revealed that application of 100% P through SSP + PSB seed inoculation produced significantly higher grain yield (1496.77 kg ha^{-1}), Stover yield (2920 kg ha^{-1}) and protein (24.06 %). There was a steady increase in the soil fertility status after harvesting of greengram. However, maximum available P_2O_5 (36.07 kg ha^{-1}), available N (329.03 kg ha^{-1}), available K_2O (220.80 kg ha^{-1}) was obtained with the application of 100% P through SSP + PSB seed inoculation. It also recorded higher net returns (Rs 47002.17 ha^{-1}) and Benefit Cost (1.89). Thus, application of 100% P through SSP + PSB seed inoculation) helps in improving the quality and enhancing the yield in Greengram for resource poor farmers of India.

KEYWORDS: Single super phosphate, Udaipur rock phosphate, Nutrient Uptake, Quality PSB, Green gram.

INTRODUCTION:

India holds the title of the world's largest producer and consumer of pulse crop, making it a vital legume crop in South and Southeast Asia. It contributes a significant 25% to the world's total pulse production, with one-third of the world's total acreage under pulses cultivated in India. The productivity of pulses mainly depends on proper nutrient management practices particularly phosphorus (P) However, the production of pulses in the country is far below the requirement to meet even the minimum level per capita consumption which is causing malnutrition among the population. To meet this malnutrition, there is need to increase pulse production in India.

Green gram belonging to the family leguminaceae is one of the important kharif pulse crops of India which can be grown as catch crop between rabi and kharif -seasons. India alone accounts for 65% of its world acreage and 54% of the total production. It is cultivated on an area of 34.50 lakh ha with a total production of 15.91 lakh tones (DPD, 2017). Greengram is mostly grown in Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Orissa and Bihar. A phenomenal increase in area, production and productivity has occurred since 1964-65. The area has increased from 1.99 million ha in 1964-65 to 3.54 million ha in 2018-2019. Pulses are commonly grown in soils with low fertility status or with application of low quantities of organic and inorganic sources of plant nutrients, which in turn resulted in deterioration of soil health and productivity (Kumpawat, 2010; Singh et al., 2022a, 2022b). The low productivity of mungbean may be due to nutritional deficiency in soil and imbalanced external fertilization (Awomi *et al.*, 2012). Greengram is one of the important short season grain legumes in the conventional farming system of tropical and temperate regions. It can be grown on a variety of soil and climatic conditions, as it is tolerant to drought. It is mostly grown under dry land farming system where erratic rains often fetch the crop under moisture stress (Malik *et al.*, 2006). Further, Indian soils are also poor to medium in available phosphorus whose deficiency can be meet by the application of phosphatic fertilizers. Phosphorus fertilization is important for pulse crops. Phosphorus plays an important role in virtually all major metabolic processes in plant including photosynthesis, energy transfer, signal transduction, macromolecular biosynthesis and respiration. Phosphorus, the master key element is known to be involved in a plethora of functions in the plant growth and metabolism. As the concentration of available P in the soil solution is normally insufficient to support the plant growth, continual replacement of soluble P from inorganic and organic sources is necessary to meet the P requirements of crop (Tisdale *et al.*, 2010). P is added extra dose in recommended dose of phosphorus which increase nitrogen fixation and finally improve productivity of green gram (Prasad *et al.*, 2014). The deficiency of can limit nodulation by legumes and to overcome the deficiency, P fertilizer application was done. The phosphorus fertilizers like Single Super Phosphate (SSP), Rock phosphate (RP) were used whose use efficiency was further enhanced by PSB inoculation due to its capability to solubilize phosphates and then after mobilize phosphorus in plants. It was reported that Phosphorus application mix with phosphate solubilizing bacteria (PSB) enhance the yield and nutrient use efficiency, it was due to fact that the PSB are capable to solubilize phosphates and then after mobilize phosphorus in plants. Similarly Rock phosphate (RP) is a common phosphatic fertilizers which is in use for pulses (Rao *et al.,* 2015). To increase the efficiency, different phosphate dissolving microorganisms (PDM) could be used as a means to improve the efficacy of rock phosphate and superphosphate (Hamdali, *et al.*, 2012). These microorganisms, which involves bacteria and fungi, are able to mobilize phosphorus from sparingly soluble rock phosphates, and they have an enormous potential in providing soil phosphates for plant growth. Phosphate solubilizing bacteria inoculation enhances the mineralization of organic forms of phosphorus and solubilization of inorganic phosphorus, improving the availability of native soil phosphorus to plants and thereby resulting to higher grain yield. Gull *et al.,* 2004). Thus, keeping the fact in view, an experiment was conducted to assess the effect of different sources of Phosphorus on protein content, fertility status and yield of Greengram**.**

Materials and Method

The experiment was carried out during *kharif* season year 2014 at Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad (U.P.). The experimental site is sub-tropical in nature, sandy loam in texture, low in organic carbon (4.0 g/kg) and medium in available nitrogen, phosphorus and low in potassium with electrical conductivity (0.19 dS /m) in the safer range. The experiment was laid out in randomized block design with 9 treatments which were replicated thrice. The treatments involves i,e. Control, 100% Phosphorus through SSP, 100% Phosphorus through URP, 50% Phosphorus through SSP + 50% Phosphorus through URP, 75% Phosphorus through SSP + 25% Phosphorus through URP, 100% Phosphorus through SSP + PSB seed inoculation, 100% Phosphorus through URP + PSB inoculation, 50% Phosphorus through SSP + 50% Phosphorus through URP + PSB inoculation, 75% Phosphorus through SSP + 25% Phosphorus through URP + PSB inoculation. The greengram crop i,e variety ‘Samrat’ was sown by taking 15 kg ha^{-1} seed rate. The fertilizer sources like urea, Single super phosphate (SSP), Udaipur rock phosphate (URP) and muriate of potash (MOP) were applied as side placement in furrows. The recommended dose was applied according to the treatment details as through Urea, SSP, URP and MOP while Whole of nitrogen, phosphorus and potash was applied as basal at the time of sowing. The crop was managed as per regional recommendations of SHITS Allahabad (U.P.).

Data pertaining to the yield was obtained at harvest. For grain and stover yield, from the individual plot, net plot was harvested and subsequently, the grain and stover yield thus obtained were weighed and expressed in kg ha^{-1}. For nutrient analysis, the plant samples were collected from each plot at the time of harvesting for estimation of N, P and K concentration and uptake in grains and stover. The samples were oven dried, grounded and analyzed for nitrogen, phosphorus and potassium concentration. N, P and K uptake in grains and stover were calculated by multiplying their per cent nutrient content in grains and stover with their respective dry matter accumulation i.e. grain yield and stover yield as per the formula given below:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (per cent) x Dry matter accumulation (kgha}^{-1}\text{)}}{100}$$

For protein content in seed can be calculated by the formula,

Protein (%) = N (%) x 6.25.

Among economic parameters, net return per ha was calculated by deducting cultivation cost from gross returns. Benefit cost (B:C) ratio was calculated by dividing net returns with total cost of cultivation to evaluate the economic viability of treatments. The analysis of variance was conducted using OP-Stat developed by CCSHAU, Hisar for all observations.

Results and discussion

Yield

The data presented in Table 1 revealed that significantly higher seed yield (1496.67 kg ha^{-1}) and stover yield (2920 kg ha^{-1}) was recorded with the application of 100% P through SSP + PSB seed inoculation which might be due to overall increment in seed yield by phosphorus application which increases yield attributes and finally contributes in seed yield. Further, the increase in P availability through solubilization of phosphate rich compound resulted in increase in seed yield. The PSB secrete a number of organic acids which may form chalets resulting in effective solubilization of phosphate, favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of P and other plant nutrients and ultimately positive resultant effect on growth and finely yield attributes and yield. Similar results were also reported by Chesti and Ali (2007) and Rathour *et al.* (2015). The better performance of SSP+PSP compared to other sources might be attributed to readily available phosphorus resulting in better absorption and utilization of phosphorus by plant and presence of other important plant nutrients i.e. sulphur. Sulphur, besides increasing phosphorus availability (Sacchidanand *et al.*, 1980) also increases its assimilation rate and crop yield (Chen *et al.*, 2006)

Table 1. Effect of different sources of phosphorus on yield and protein percent of greegram

Treatments	**Seed yield (kg ha^{-1})**	**Stover Yield (kg ha^{-1})**	**Grain protein** (%)
Control (No Phosphorus)	1130.00	2280.00	21.87
100% P through SSP	1380.00	2700.00	22.53
100% P through URP	1348.67	2500.00	22.31
50% P through SSP + 50% P through URP	1384.33	2600.00	22.66
75% P through SSP + 25% P through URP	1376.67	2566.67	22.75
100% P through SSP + PSB inoculation	1496.67	2920.00	24.06
100% P through URP + PSB inoculation	1433.33	2793.33	23.18
50% P through SSP + 50% P through URP + PSB inoculation	1403.33	2740.00	23.62
75% P through SSP + 25% P through URP + PSB inoculation	1401.00	2753.33	23.84
SEd (±)	28.47	91.99	0.63
CD (P=0.05)	60.36	193.34	1.34

Protein content

Data presented in Table 1 revealed that highest protein content of 24.06% was recorded with the application of 100% P through SSP + PSB seed inoculation which was found to be at statistically par with 100% P through URP + PSB seed inoculation, 50% P through SSP + 50% P through URP + PSB seed inoculation, 75% P through SSP + 25% P through URP + PSB seed inoculation and 75% P through SSP + 25% P through URP. The probable reason for increasing protein content was due to application of 100% P through SSP and seed inoculation by PSB which plays significant role in root enlargement, better microbial activities resulted in more availability and uptake of nitrogen and thereby increased protein content in seed. The results are in agreement with those of Patel *et al.* (2013), Jat *et al.* (2012) and Shukla and Dixit (1996). Further, Phosphate solubilizing bacteria are also capable of transforming soil phosphorus to the forms available to plant. Similar finding was reported by Devi *et al.* (2012) and Rathour *et al.* (2015).

Soil fertility Status

The data presented in Table 2 related to effect of different sources of phosphorus on soil fertility status after harvest of greengram revealed that that there was a steady increase in the soil fertility status after harvesting of greengram. It was reported that maximum available P_2O_5 (36.07 kg ha^{-1}) was obtained by the application of 100% P through SSP + PSB seed inoculation, which was statistically at par with 100% P through URP+ PSB seed inoculation. The maximum available N (329.03 kg ha^{-1}), Maximum pH (8.3) and maximum Organic carbon (0.68%) was obtained by the application of100% P through SSP + PSB seed inoculation. Further, maximum available K_2O (220.80 kg ha^{-1}) was obtained by the application of 100% P through SSP + PSB seed inoculation, which was 15.69% higher than control. The probable reason for increasing soil fertility status after harvest was due to the application of nutrients through SSP + PSB seed inoculation which improved soil nutritional status, soil physico-chemical properties and soil microbial population which resulted in increased availability of these elements which resulted into their higher uptake by the crop. Uptake of N, P and K is a function of the content of these elements in seed and straw and their respective yields. These nutrients improved the soil physical conditions which in turn improved the nutrient uptake and hence content increased. Similar results were also reposted by Basak and Subodh (2002), Hemalatha *et al.* (2002) and Kumar *et al.* (2006). Improved efficiency of the phosphorus fertilizers by the activity of phosphate solubilizing bacteria. Effectiveness of inorganic phosphorus was increased and phosphorus recovery was improved with the addition of organic manure (Whalen and Chang, 2001). Cassman *et al.* (2002) also reported that nutrient efficiency was greatly affected by the amount of nutrient used and by the synchronization between demand and supply of the nutrients.

Table 2. Effect of different sources of phosphorus on soil fertility status after harvest of greengram

Treatments	**Soil parameters**				
	pH	**OC (%)**	**Nitrogen (kg ha^{-1})**	**Phosphorus (kg ha^{-1})**	**Potassium (kg ha^{-1})**
Control (No Phosphorus)	8.1	0.58	318.55	23.73	190.86
100% P through SSP	8.3	0.64	319.60	28.29	224.54
100% P through URP	8.2	0.63	322.74	27.09	209.57
50% P through SSP + 50% P through URP	8.1	0.62	317.50	27.99	217.06
75% P through SSP + 25% P through URP	8.2	0.61	326.93	29.49	213.31
100% P through SSP + PSB inoculation	8.3	0.68	329.03	36.07	220.80
100% P through URP + PSB inoculation	8.3	0.67	327.98	34.58	213.32
50% P through SSP + 50%	8.2	0.65	326.93	31.88	224.54

P through URP + PSB inoculation					
75% P through SSP + 25% P through URP + PSB inoculation	8.3	0.66	327.98	30.08	213.31
S Ed (±)	0.06	0.03	4.59	1.12	13.74
CD (P=0.05)	N.S	N.S	N.S	2.38	N.S

Relative economics

Relative economics of greengram calculated on grain and stover basis presented in Table 3 revealed that the application of 100% P through SSP + PSB seed inoculation resulted in higher cost of cultivation, gross return (Rs 71766.82 ha^{-1}), net returns (Rs 47002.17 ha^{-1}) and Benefit Cost (1.89) which might have happened due to that due to superiority of PSB over the control in respect of higher pod yield and net return obtained by the application of SSP + PSB seed inoculation in greengram. Similar results were also reported by Devi *et al.* (2012) and Rathour *et al.* (2015).

Table 3. Effect of different sources of phosphorus on Economics of greengram

Treatments	Cost of Cultivation (Rsha^{-1})	Gross Return (Rs/ha^{-1})	Net return (Rs/ha^{-1})	B:C ratio
Control (No Phosphorus)	22734.65	54260.00	31525.35	1.38
100% P through SSP	24734.65	66180.00	41445.35	1.67
100% P through URP	23793.41	64538.82	40745.41	1.71
50% P through SSP + 50% P through URP	24264.03	66279.18	42015.15	1.73
75% P through SSP + 25% P through URP	24499.34	65893.49	41394.15	1.68
100% P through SSP + PSB inoculation	24764.65	71766.82	47002.17	1.89
100% P through URP + PSB inoculation	23823.41	68726.51	44903.10	1.88
50% P through SSP + 50% P through URP + PSB inoculation	24294.33	67293.18	42998.85	1.76
75% P through SSP + 25% P through URP + PSB inoculation	24529.34	67199.33	42669.99	1.73

CONCLUSION

It can be concluded that the application of 100% P through SSP + PSB seed inoculation recorded significantly higher grain yield and Stover yield and protein content. Further, it was revealed that application of 100% P through SSP + PSB recorded maximum N, P_2O_5 and K_2O, higher net returns and Benefit Cost. Thus, application of 100% P through SSP + PSB seed inoculation) was found to be most promising treatment in enhancing the yield in Greengram.

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