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Effect of biofertilizers and phosphorus levels on economic performance of chickpea (*Cicer arietinum*)

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Chickpea (*Cicer arietinum* L.) is the world's third most important winter food legume crop. In our country, it covered about 9.18 mha area, with 8.22 mt production and 900 kg/ha productivity (Anonymous 2019). Chickpea has significant amounts of all the essential amino acids, protein, fat, minerals; vitamins that are important in the vegetarian diets of resource-poor consumers.It is not only supply the protein but also enhance the soil fertility and maintain the soil health. Bio-fertilizers contains living micro-organisms, it augments the biochemical processes in soil and pathogen control (Verma *et al*. 2019). Phosphorus (P) is one of the major essential primary nutrients after nitrogen for better crop growth and development. Pulses are heavy feeders of P because it is constituent of all living organism. Especially in the early stages of plant development, adequate supply of P is required for development of the reproductive parts and has a positive effect on root growth, early maturity and reduced disease incidence. To meet the rising demand, a quantum jump in chickpea production is required. But, majority of farmers usually grow pulses in marginal land with indiscriminate use of chemical fertilizers without biofertilizers and other faulty management practices that resulted in reduction of organic matter content and creates multi-nutrient deficiency in soil (Verma *et al*. 2019). Therefore, there is a need of present hour to find out eco-friendly, feasible and cheaper options to meet the nutrient need of crop grown in different cropping systems for maintaining soil fertility and crop productivity.

The field experiment was conducted during *rabi* 2015–16 at Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh is situated at 26°32'N latitude, 81°49'E longitude and at an altitude of 113.0 m from the mean sea level. The experimental soil having silty loam in texture with a *p*H of 8.24, EC 0.34 dS/m, low OC 0.31% and available nitrogen 180 kg/ha, medium in available phosphorus 18.2 kg/ha and potassium 226.3 kg/ha. The experiment comprised nine treatment combinations with three levels of phosphorus (0, 40 and 60 kg P_2O_5/ha) and three levels of biofertilizers (Uninoculated, PSB and VAM) were laid out in FRBD design and replicated thrice. The fertilizer nutrients were supplied through Urea, DAP and MOP used as the source of nitrogen, phosphorus and potassium, respectively. The nutrients were applied to the individual plots as per the treatment with different rates. The seed treatment was done by PSB @ 25 g/kg seeds. The treated seeds were kept in shade for two hours to get dry, thereafter the seeds were sown in plots as per respective treatments. VAM fungi were used as soil inoculants at the time of sowing. Chickpea variety PG-186 was sown at 40 × 10 cm crop geometry with a seed rate of 75 kg/ha apart during the first week of December and harvested at second week of April. The crop was raised with recommended package of practices. Fallow the standard procedures for calculation of protein content, nutrient uptake and economics by using following formula-

Protein content (%) = Total N concentration in seed (%) × 6.25

Nutrient uptake (kg/ha) in grain/stover = [% nutrient concentration in grain/stover × grain/stover yield (kg/ha)]

Total nutrient uptake (kg/ha) = Nutrient uptake by grain + Nutrient uptake by stover

Gross returns (₹/ha) = Value of the grain + Value of straw/stover

Net returns (₹/ha) = Gross returns – Total costs

Benefit: cost ratio = Net returns/Total cost

The data collected of different parameters were subjected to appropriate statistical analysis under FRBD by following the procedure of ANOVA analysis of variance (SAS Software packages, SAS EG 4.3). Significance of difference between means was tested through 'F' test and the least significant difference (LSD) was worked out where variance ratio was found significant for treatment effect. The treatment effects were tested at 5% probability level for their significance.

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Table 1 Effect of phosphorus levels and biofertilizers on performance of chickpea

Treatment	Plant height (cm)	No. of pods/ plant	No. of seeds/ pod	Test weight (gram)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest Index (%)
Phosphorus levels (kg/ha)							
0	31.1	38.1	1.24	16.4	16.1	25.9	38.3
40	34.2	39.7	1.54	17.3	18.1	28.3	38.9
60	36.9	41.4	1.72	18.1	18.9	29.6	38.9
SEm±	0.64	0.75	0.05	0.41	0.36	0.69	1.5
LSD (P=0.05)	1.93	2.27	0.16	NS	1.09	2.07	NS
Biofertilizers							
Un-inoculated	31.6	38.31	1.41	16.6	16.7	26.7	38.4
PSB	34.0	39.74	1.49	17.0	17.9	28.1	38.9
VAM	36.4	40.33	1.61	18.1	18.5	29.0	38.9
SEm±	0.64	1.3	0.05	0.41	0.36	0.69	-
LSD (P=0.05)	1.93	NS	0.16	NS	1.09	2.07	-

The result showed that application of phosphorus @ 60 kg/ha was recorded significantly maximum plant height (36.9 cm) and number of seeds/pod (1.72) compared to other treatments. Significant higher number of pods/plant (41.4), seed yield (18.9 q/ha) and stover yield (29.6 q/ha) was noticed with the application of phosphorous @ 60 kg/ha compared to control plot. Maximum test weight (18.1 g) and harvest index (38.9) was registered with the application of phosphorous @ 60 kg/ha whereas, minimum was recorded under control treatment. This might be due to phosphorus levels had favourable effect on plant growth over control treatment that results better nutrient availability and number of metabolic processes taking place in the plant body, which in turn are affected by a variety of inherent and environmental factors to which plant is exposed that results more growth and yield attributes which ultimately resulted more yield (Verma *et al.* 2019). The inoculation of VAM biofertilizer was found significant tallest plant (46.4 cm) as compared to remaining treatments. Maximum number of seeds/pod (1.61), seed yield (18.5 q/ha) and stover yield (29.0 q/ha) was noticed by inoculation of VAM which was statistically at par with inoculation of PSB and significantly higher than uninoculated plot. However, higher number of pods/plant (40.3), test weight (18.1 g) and harvest index (38.9) was recorded under VAM treated plot followed by PSB treated plot but lowest values were recorded under un-inoculated plot. This might be because of more solubility of phosphorus and other nutrients which increased the nutrient availability resulted in sufficient formation of photosynthates which promotes the metabolic activities, accelerates cell division and formation of meristem which results better crop growth, development and yield (Singh *et al*. 2018).

Significant maximum nutrients uptake by seeds and stover, viz. nitrogen in seed (63.8 kg/ha) and stover (44.5 kg/ha), phosphorus in seed (7.49 kg/ha) and stover (5.31 kg/ha) and potassium in seed (26.5 kg/ha) and stover (81.6 kg/ha) was recorded with the application of phosphorus @ 60 kg/ha compared to remaining treatments. Whenever, maximum protein content (20.7%) was noticed under application of phosphorus @ 60 kg/ha followed by application of phosphorus @ 40 kg/ha but lowest protein content was found under control plot. The improved uptake of nutrients at increasing phosphorus doses might be due to the combined effect of variation in nutrient concentration in produce (seed and stover) obtained under these treatments (Sasode and Patil 2014). The significantly maximum uptake of nitrogen and potassium in seed (60.2 and 25.6 kg/ha) and stover (42.1 and 79.3 kg/ha) was recorded with the inoculation of VAM compared to uninoculated plot but it was statistically at par with PSB. Whenever, significantly highest uptake of phosphorus by seed (6.75 kg/ha) and stover (5.20 kg/ha) was recorded with the inoculation of VAM compared to remaining treatments. The highest uptake of nutrients might be attributed to the relatively accelerated nutrients availability and its absorption by the roots in soil through reducing precipitation and preventing its fixation which results comparatively more uptake which ultimately increased the concentration in seed and stover (Egamberdieva *et al.* 2015). Application of phosphorus @ 60 kg/ha was noticed highest protein content (20.7%) whereas, control plot resulted lowest protein content (19.1%). This might be due to the fact that the adequate supply of phosphorus accelerated the synthesis of various nitrogenous compounds such as nucleic acid, nucleoprotein and nucleotides that results more protein content (Verma *et al.* 2019). Inoculation of VAM was resulted maximum protein content (20.3%) in seed and minimum (19.3%) was noticed under uninoculated plot. It is due to VAM enhances the nutrients availability for longer time during the crop period that results more nitrogen concentration and uptake by the seeds which ultimately results increase the protein content (Das *et al.* 2016).

The maximum gross returns (81.6×10^3 ₹/ha), net returns (53.7×10^3 ₹/ha) and B: C ratio (1.94) was recorded with the application of phosphorus @ 60 kg/ha which was statistically at par with application of phosphorus @ 40 kg/ha

Table 2 Nutrient uptake, protein content and economics of chickpea influenced by phosphorus levels and biofertilizers

Treatment	Nutrient uptake (kg/ha)						Protein content (%)	Gross returns (10^3 × ₹/ha)	Cost of cultivation (10^3 × ₹ /ha)	Net returns (10^3 × ₹ /ha)	B: C ratio
	Nitrogen		Phosphorus		Potassium						
	Seed	Stover	Seed	Stover	Seed	Stover					
Phosphorus levels (kg/ha)											
0	51.7	35.2	4.37	3.96	21.6	70.4	19.1	69.6	25.9	43.7	1.68
40	58.3	38.8	6.31	4.92	24.7	74.6	19.6	78.0	26.9	51.0	1.89
60	63.8	44.5	7.49	5.31	26.5	81.6	20.7	81.6	27.8	53.8	1.94
SEm±	1.32	1.33	0.16	0.13	0.63	0.95	0.80	2.42	-	1.98	0.05
LSD (P=0.05)	3.96	3.98	0.50	0.39	1.91	2.84	NS	6.84	-	4.70	0.15
Biofertilizers											
Un-inoculated	54.3	36.1	5.33	3.97	22.7	70.4	19.3	72.2	25.8	46.3	1.79
PSB	59.3	40.2	6.09	4.73	24.6	76.9	19.8	77.3	26.5	50.7	1.91
VAM	60.2	42.1	6.75	5.20	25.6	79.3	20.3	79.8	27.2	52.5	1.93
SEm±	1.35	0.65	0.14	0.13	0.63	0.95	0.7	2.61	-	1.86	0.04
LSD (P=0.05)	4.10	1.90	0.43	0.42	1.91	2.84	NS	7.37	-	5.24	0.12

but significantly higher than control treatment. Inoculation of VAM was registerd highest gross returns (81.6 × 10^3 ₹/ha), net returns (53.7 × 10^3 ₹/ha) and B: C ratio (1.94) which was statistically at par with PSB but significantly higher than un-inoculated treatment. This might be due to variation in cost of cultivation and gross return. Increased net income with increasing doses of phosphorus might be explained on the basis of variation in yield of chickpea and total cost of cultivation (Kumar *et al*. 2017).

SUMMARY

The maximum seed and stover yield (18.9 and 29.6 q/ha) was noticed under 60 kg P_2O_5/ha as compared to control plot. Also similar result was noticed under inoculation of VAM as compared to untreated plot. Maximum NPK uptake by seed (63.8, 7.49 and 26.5 kg/ha) and stover (44.5, 5.31 and 81.6 kg/ha) was recorded under 60 kg P_2O_5/ha as compared to control plot. Highest uptake of NPK in seed (60.2, 6.75 and 25.6 kg/ha) and stover (42.1, 5.20 and 79.3 kg/ha) was recorded under inoculation of VAM compared to control plot. Maximum protein content was noticed under 60 kg P_2O_5/ha but lowest was found under control plot. Inoculation of VAM was resulted maximum protein content in seed. Maximum gross returns (81.6 × 10^3 ₹/ha), net returns (53.7 × 10^3 ₹/ha) and B: C ratio (1.94) was recorded under 60 kg P_2O_5/ha as compared to control treatment. Inoculation of VAM was registerd highest gross returns (81.6 × 10^3 ₹/ha), net returns (53.7 × 10^3 ₹/ha) and B: C ratio (1.94) compared to control plot. Application of 60 kg P_2O_5/ha and inoculation of seeds with VAM may be recommended for the farmers of Eastern Uttar Pradesh for profitable cultivation of chickpea crop under saline condition.

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