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Effect of biofertilizer and phosphorus on growth and yield of kabuli chickpea (*Cicer arietinum kabulium* L.)

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Abstract
A field experiment was conducted during *Rabi* 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The experiment was laid out in Randomized block design with ten treatments replicated thrice. The treatment combinations are mentioned as T_1 - Rhizobium + Phosphorus 40 kg/ha, T_2 - Rhizobium + Phosphorus 60 kg/ha, T_3 - Rhizobium + Phosphorus 80 kg/ha, T_4 - PSB + Phosphorus 40 kg/ha, T_5 - PSB + Phosphorus 60 kg/ha, T_6 - PSB + Phosphorus 80 kg/ha, T_7 - VAM + Phosphorus 40 kg/ha, T_8 - VAM + Phosphorus 60 kg/ha, T_9 - VAM + Phosphorus 80 kg/ha, T_{10} – control (RDF) - 20:60:20 NPK kg/ha The important findings of the experiment have been summarized and concluded here under the objectives taken. The application of Rhizobium+ Phosphorous 80 kg/ha recorded significantly higher Plant height (51.3 cm), Plant dry weight (38.7 g/plant), number of nodules per plant (26.5). Significantly maximum number of pods per plant (23), number of seeds per pod (1.60).

Keywords: Kabuli chickpea, rhizobium, PSB, VAM, phosphorus

Introduction
Kabuli Chickpea (*Cicer arietinum kabulium* L.) belongs to the family Fabaceae, within the tribe Cicerae. It is a self-pollinated, diploid, annual grain legume crop. The global production of chickpea is nearly 11 million tonnes and India is the major producer accounting for 64% of the total chickpea production (FAOSTAT, 2012) [4]. It is a major source of high-quality protein in human diet and also provides high quality crop residues for animal feed. Chickpea is classified into two broad types, desi and kabuli. Most of the desi types are small in size, angular in shape with dark seed color and rough seed coat, while kabuli have large beaked seeds with white or beige seed coat colour and larger in size with smoother seed coat. Kabuli type chickpea is mostly grown in the temperate regions, while the Desi type of chickpea is grown in the semi-arid tropics (Muehlbauer and Singh, 1987) [8].

Chick-pea has one of the highest nutritional composition of any dry edible legume and does not contain any specific major anti-nutritional factors, and contains proteins, carbohydrates, fat, crude fibre, soluble sugar and ash, chick-pea protein digestibility in highest among the dry edible legumes. Legumes are heavy feeders of phosphorus and less responsive to nitrogen and potash because of there capacity to meet their own nitrogen requirement through symbiotic fixation (114 kg N/year), and reduce fertilizer cost to the farmer and improves the texture and structure of soil. Biofertlizers could play a crucial role by fixing the atmospheric nitrogen for the crops or by increasing the availability of phosphorus and other nutrients to the crops. Nitrogen phosphorus and are the major nutrients required for increasing yield potential. They are renewable source of fertilizers and a promising source of essential plant nutrients and growth promoting substances. Rhizobium inoculation on plant growth: Nitrogen fixers benefit the plant by providing them atmospheric nitrogen, which contributes to the development of plant growth and biomass production. The effect of inoculation with Rhizobium on growth attributes and observed that chickpea gave higher plant height (3.3%), number of branches per plant (23.3%) and biomass per plant (144%) as compared to uninoculated control. In similar findings, Elkoca *et al.* (2008) [3] revealed that Rhizobium inoculation increased plant height, shoot dry

weight and chlorophyll content in chickpea. These findings agree with that of Giri and Joshi (2010) [14] in chickpea. The increment in the root length was also observed in the inoculated treatments which in return resulted in increased root surface area. The increase in root surface area enhances the nutrient acquisition by plant from the soil.

Arbasculer Micorrhiza is fungi which help to solubilize phosphorus and make available for the plants. Arbascular Micorrhiza is root formation of intracellular structure arbuscles during various phases of plant development. The Arabascular Mycorrhiza found in root system of most flower plants. The Arbascular Mycorrahizal Fungi increases uptake of phosphorus by plants in three ways (i) increase the absorption of phosphorus from soil by hyphae, (ii) translocation of phosphorus along with hyphae, and (iii) the transfer of phosphorus to cortical root cells, which is readily used by plant. The AM fungi also increased availability of micronutrients like zinc (Zn), copper (Cu), iron (Fe) and also macronutrients like K and N. The combination of Arbascular Mycorrhiza fungi and phosphorus greatly effect on the nodule population and nitrogen fixation in addition to phosphorus uptake and growth. Ali *et al.* (2006) [1]

Phosphorus Solubilizing Bacteria (PSB) play important role in soil biochemical cycle. It have the cheapest source to increase availability of phosphorus. There are many bacteria's having the ability to bring insoluble inorganic or organic phosphates into soluble form by secreting organic acids. It increase the availability organic acid chelates like Ca, Al, Fe and phosphorus, also increase higher utilization by plants. Phosphorus solubilizing bacteria mostly available in soils have rich in organic matter and low in available phosphorus Pramanik *et al.* (2003) [9]. It increases phosphorus availability is an important trait in sustainable farming for increasing plant yields. Phosphorus solubilizing bacteria is capable to increase availability of phosphorus by solubilization of inorganic phosphorus or by mineralization of organic phosphorus. It is considered to increase plant growth and yield.

Materials and Methods

The experiments on the effect of biofertilizer and phosphours on growth and yield attributes enhancement of kabuli chickpea were conducted at *Rabi* season of 2023-2024 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj which is located at 250 24 42 N latitude, 810 50 56 E longitude and 98 m altitude above the mean sea level. This region is located approximately 5 kilometers from Prayagraj city on the right bank of the Yamuna River beside Prayagraj Rewa Road. A composite soil sample was taken between 0 and 30 cm down. It was crushed, let to air dry, and its chemical and physical qualities examined. The soil reaction of the sandy clay loam was 7.6, the organic matter content was 0.69 (0.72%), the available nitrogen was 152.7 kg/ha, the phosphorus was 10.4 kg/ha, the potassium was 174.0 sulfur content was 7.2 mg/kg, the zinc was 0.72 mg/kg, and the available B was 0.56 mg/kg. the Kabuli Chickpea (*cicer arietium kabulium* L.) variety PUSA1003 were selected for sowing. Seeds were sown in line manually on 2023. Seeds were covered with the soil immediately after sowing. The spacing adopted was plant to plant 10 cm and row to row 30 cm according to the treatment details and the seeds were drilled at 3-4 cm depth.

Results and Discussion

Plant height: highest plant height (51.3 cm) was recorded with the application of rhizobium + phosphorus 80 kg/ha (40,60,80 DAS), whereas treatment rhizobium + phosphorus 60 kg/ha (49.1 cm) was found to be statistically at par with T_3, and minimum was reported in control (41.1 cm).Phosphate fertilization of chick-pea promotes growth, nodulation and enhance yield and improves grain quality, regulate the photosynthesis, govern physio-bio-chemical process, enlargement root and nodules production and thereby increase nitrogen fixation. Rhizobium which are responsible for symbiotic nitrogen fixation.

Plant dry weight: Significant difference among the treatments. However, highest dry weight (38.7 g) was recorded with the application of rhizobium + phosphorus 80 kg/ha (40,60,80 DAS), whereas treatment rhizobium + phosphorus 60 kg/ha (37.9 g) was found to be statistically at par with T_3, and minimum was reported in control (31.1 g).

This might be due to the fact that phosphorus being an energy bond compound and its major role is transformation of energy essential for almost all metabolic processes *viz*., photosynthesis, respiration, cell elongation and cell division, activation of amino acids for synthesis of protein and carbohydrate metabolism which ultimately increase all the growth attributes and dry weight of plants. Similar results have also been reported by Singh *et al.* (2010) [10].

Number of nodules per plant: At harvest there was significant difference among the treatments. However, highest number of nodules (26.5) was recorded with the application of rhizobium+ Phosphorus 80 kg/ha, whereas treatment rhizobium+ Phosphorus 60 kg/ha (25.1) was found to be statistically at par with T_3, and minimum was reported in control (20.00).

The application of biofertilizer like Rhizobium, PSB also increased the number of nodules considerably in comparison to control. The inoculation of rhizobium and PSB enhance the microbial population in legume crop and form higher number of nodules per plant. The activity of microorganism increased in legumes crop due to rhizobium and PSB and this inoculation of Rhizobium and PSB increased the number of nodules per plant. The increase in nodulation was highest with the T_8 (Rhizobium, PSB and RDF 100%). Similar results are also reported by Tagore *et al.* (2014) [11].

Number of pods per plant: Significantly Maximum number of pods per plant (23.00) was recorded with the treatment in application of rhizobium + phosphorus 80 kg/ha and minimum was recorded in control (20:60:20) (20.13), whereas rhizobium + phosphorus 60 kg/ha (22.60) was statistically at par with T_3.

The inoculation of Rhizobium and PSB enhance the phosphorus availability and this available phosphorus enhances the number of seed yield straw yield and harvest index. The increases in harvest index were highest with the biofertilizer along with RDF 100%. The crop having the more harvest index which has more seed yield. Similar results are also reported by Gupta *et al*., 2006 [5].

Number of seed per pod: Significantly Maximum number of seeds per pod (1.60) was recorded with the treatment in application of rhizobium + phosphorus 80 kg/ha and minimum was recorded in control (20:60:20) (1.07), whereas rhizobium + phosphorus 60 kg/ha (1.47) was statistically at par with T_3.

Table 1: Effect of Biofertilizer and Phosphorus on Growth and Yield of Kabuli Chickpea

S No	Treatments	Plant height	Plant dry weight	Number of nodules per plant	Number of pods per plant	Number of seeds per pod
1.	Rhizobium + Phosphorus 40 kg/ha	43.9	32.1	21.1	20.40	1.33
2.	Rhizobium + Phosphorus 60 kg/ha	49.1	37.9	25.1	22.60	1.47
3.	Rhizobium + Phosphorus 80 kg/ha	51.3	38.7	26.5	23.00	1.60
4.	PSB + Phosphorus 40 kg/ha	44.5	32.0	22.6	20.20	1.27
5.	PSB + Phosphorus 60 kg/ha	48.1	34.1	23.3	21.13	1.33
6.	PSB + Phosphorus 80 kg/ha	48.7	35.2	24.0	22.53	1.40
7.	VAM+ Phosphorus 40 kg/ha	43.1	31.6	20.4	20.27	1.20
8.	VAM + Phosphorus 60 kg/ha	44.1	33.6	23.1	20.80	1.20
9.	VAM + Phosphorus 80 kg/ha	45.9	34.0	22.7	21.47	1.33
10.	Control (20:60:20)	41.9	31.1	20.0	20.13	1.07
	F – Test	S	S	S	S	S
	SEm±	0.75	0.34	0.36	0.16	0.09
	CD (p=0.05)	2.21	1.02	1.07	0.46	0.27

Conclusion

It was concluded that for obtaining higher yield components with better quality of Chickpea application of Rhizobium along with Phosphorus 80 kg/ha was recorded significantly highest plant height (51.3 cm), highest dry weight (38.7 g), highest number of nodules (26.5) higher number of pods per plant (23), Maximum number of seeds per pod (1.60) as compared to other treatments. Since, the finding based on the research done in one season.

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