Original Research Article

Response of Bio-fertilizer and Phosphorus on Growth and Yield of *Kabuli* Chickpea (*Cicer arietinum* L. var. *kabulium*)

ABSTRACT

A field experiment entitled "Response of Bio-fertilizer and Phosphorus on growth and yield of *Kabuli* Chickpea (*Cicer arietinum* L. var. *kabulium*)" was conducted during *rabi* season, 2022 at Crop Research Farm in the Department of agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh. The soil texture of the experimental plot was sandy loam, with a pH of 7.1, low organic carbon (0.28 percent), available N (225 kg/ha), available P (19.50 kg/ha), and available K (213.7 kg/ha). The treatment consisted of three levels of Bio-fertilizer *Rhizobium sp*, PSB, *Rhizobium sp* and PSB in combination with Phosphorus (50, 60 and 70 kg/ha) and control. The experiment was layout in Randomized Block Design (RBD) with 10 treatments and replicated thrice. Application of (*Rhizobium sp* + PSB + Phosphorus 70 kg/ha) produces maximum plant height (57.67 cm), number of nodules/plant (47.80), dry weight (10.32 g), number of pods/plant (30.17), number of grains/pod (1.65) and seed yield (2975.44 kg/ha).

Keywords: *Kabuli* Chickpea, Bio-fertilizer, Phosphorus, Growth and Yield.

1. Introduction

Chickpea, (Cicer arietinum), also called garbanzo bean or Bengal gram, periodic plant of the pea family (Fabaceae), extensively grown for its nutritional seeds. Legumes are a nutritional chief of diets around the world. They're an affordable source of protein, vitamins, complex carbohydrates, and fiber. Although used interchangeably, the terms "legumes", "pulses", and "beans" have distinct meanings. A legume refers to any plant from the Fabaceae family that would include its leaves, stems, and capsules. A pulse is the comestible seed from a legume plant. Pulses include beans, lentils, and peas. For illustration, a pea cover is a legume, but the pea inside the cover is the pulse. The entire legume plant is frequently used in agrarian operations (as cover crops or in beast feed or fertilizers), while the seeds or pulses are what generally end up on our dinner plates. Beans in their colorful forms (kidney, black, pinto, navy, chickpeas, etc.) are just one type of pulse. Legumes are emphasized by the U.S. Dietary Guidelines (about 3 mugs a week) and the DASH Eating Plan of the National Heart, Lung, and Blood Institute (4- 5 half-mug servings a week). The Food and Agriculture Organization (FAO) of the United Nations declared the International Year of Pulses in 2016, focusing on the donation of pulses in food product and nutritive diversity to help eradicate hunger and malnutrition. Over the last several times, India has been the top patron of chickpeas, also known as garbanzo beans, worldwide. In 2021, the product volume of chickpeas in India amounted to nearly 12 million metric tons. Australia came in alternate at an estimated876.5 thousand metric tons of chickpeas. In that time around15.97 million metric tons of chickpeas were produced worldwide.

Protein (18–22%), carbohydrate (52–70%), fat (4–10%), minerals (calcium, phosphorus, iron etc.), and vitamins are all abundant in chickpeas. It makes a superior source of animal feed, and the straw has good forage value **(Prasad 2012)**.

Bio-fertilizers are required to restore the fertility of the soil. Prolonged use of chemical fertilizers degrades the soil and affects crop yield. Bio-fertilizers, on the other hand, enhance the water holding capacity of the soil and add essential nutrients such as nitrogen, vitamins and proteins to the soil. They are the natural form of fertilizers and hence, widely used in agriculture. Bio-fertilizers utilise certain microorganisms. These microorganisms trap atmospheric nitrogen and reduce it to ammonia and make it available to the plants. They also convert insoluble phosphates into the forms required by the plants. *Rhizobium* is an important nitrogen-fixing bacteria. *Rhizobium* lives in symbiotic association with the leguminous plants, specifically in their root nodules. It traps the atmospheric nitrogen and converts it into ammonia that enhances the growth of the plants.

The first thing you should know is that phosphorus is one of the main agents that make photosynthesis possible. Besides helping plants convert and process solar energy, it also promotes the transport and absorption of other essential nutrients such as nitrogen. Thus, when a phosphorus deficiency is present, the crop will be less vigorous and the leaves may be weak and purple in colour due to the lack of sufficient photosynthesis. Phosphorus has diverse physiological and biochemical function in plants. There are several basic compounds in cellular systems which require P for their structure and biological functions including DNA, RNA, ATP, NADPH and phospholipids. Phosphorus is required in energy transfer and storage through ATP (adenosine triphosphate) in biological systems and contributes to synthesis and stability of DNA and RNA. Similarly, as a basic component of membrane phospholipids, an adequate P nutrition is also essential for the structural and functional integrity of cell membranes. Phospholipids are the major component of cell membranes, required for structural stability and function and affect the membrane transport systems. Under P deficiency, structural impairments in cell membranes can be expected with adverse effects on nutrient transport across the root cell membranes NADPH serves as a major provider of reducing equivalents in cellular systems and plays diverse critical roles including regeneration antioxidant defence systems .

2. MATERIALS AND METHODS

During the Rabi season of 2022, the experiment was carried out. The experiment was set upin a Randomized Block Design with ten treatment combinations and three replications, with the different treatments being assigned to each replication at random. The experimental field's soil was sandy loam in texture, with a slightly alkaline response (pH 7.1), low organic carbon (0.28 percent), accessible N (225 kg/ha), P (19.50 kg/ha), and a greater quantity of K (92.00 kg/ha). T_1- Control, T_2- *Rhizobium spp* + Phosphorus 50 kg/ha, T_3- *Rhizobium spp* + Phosphorus 60 kg/ha, T_4- *Rhizobium spp* + Phosphorus 70 kg/ha, T_5- PSB + Phosphorus 50 kg/ha, T_6- PSB + Phosphorus 60 kg/ha, T_7- PSB + Phosphorus 70 kg/ha, T_8- *Rhizobium spp* + PSB + Phosphorus 50 kg/ha, T_9- *Rhizobium spp* + PSB + Phosphorus 60 kg/ha, T_{10}- *Rhizobium spp* + PSB + Phosphorus 70 kg/ha. Plant height (cm), number of nodules per plant, plant dry weight, number of pods per plant, number of seeds per pod, seed yield, and stover yield were all recorded as growth metrics at harvest. Data recorded on different aspects of crop, *viz.*, growth, yield attributes were subjected to statistically analysis by analysis of variance method. (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

3. RESULTS AND DISCUSSION

Growth Parameters

Plant Height (cm)

At 80 days after sowing, significantly higher plant was recorded in treatment 10 with the application of [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)]. However, the treatment 3 [*Rhizobium spp* + Phosphorus (40 kg/ha)] (53.98 cm), treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50 kg/ha)] (53.54 cm), treatment 2 [*Rhizobium spp* + Phosphorus (50 kg/ha)] (52.25 cm), treatment 7 [PSB+ Phosphorus (70 kg/ha)] (51.59 cm) were found to be statistically at par with treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)] in (Table 1).

The application of Phosphorus and iron performs positively and improves the growth parameters and yield attributes of chickpea. The maximum plant height (69.10 cm) was recorded in 40kg/ha phosphorus and 5kg/ha iron. **(Susan *et al*., 2022)**.

The combined inoculation of *Rhizobium sp*. and PSB significantly amplify the growth, yield attributes, yield, nutrient content and their uptake in seed and straw of chickpea **(Das *et al*., 2013)**

Number of Nodules/plant

At 80 days after sowing, there was significant difference between the treatments and maximum number of nodules per plant (47.80) was observed with the application of [*Rhizobium spp* + PSB+ Phosphorus (70kg/ha)] in treatment 10. However, treatment 9 [*Rhizobium spp* + PSB + Phosphorus (60 kg/ha)] (46.97), treatment 6 [PSB + Phosphorus (60 kg/ha)] (45.87), treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50 kg/ha)] (45.33) and treatment 7 [PSB+ Phosphorus (70 kg/ha)] (45.27) were found to be statistically at par with treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)] in (Table 1).

The application of 60 kg P/ha significantly boost the number of nodules per plant, fresh and dry weight of nodules per plant of chickpea act in accordance with by 40 kg P/ha and over control.**(Singh *et al*., 2014)**

The *Rhizobium sp*. and PSB was found most productive in terms of nodule number (27.66

nodules/plant), nodule fresh weight (144.90) mg/plant), nodule dry weight (74.30 mg/plant), shoot dry weight (11.76 g/plant) and also showed its positive effect in strengthening all the yield attributing parameters grain and straw yields.**(Tagore *et al*., 2013)**

Dry Matter Accumulation (g)

At 80 days after sowing, the significantly higher plant dry weight (10.32g) was observed in treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)]. However, treatment 9 [*Rhizobium spp* + PSB + Phosphorus (60 kg/ha)], was found to be statistically at par with treatment 10 [*Rhizobium spp* + PSB + Phosphorus (60 kg/ha)] in (Table 1).

The application of phosphorus at 60 kg/ha and seed inoculation with PSB+ Rhizobium sp. Significantly enlarged the growth, dry weight, number Of nodules per plant and yields (grain & straw yield) of chickpea over the control. (**Singh *et al*., 2018)**

The *Rhizobium sp* inoculation of seed of chickpea significantly boost the number of nodules and dry weight of nodules per plant as compared to un- inoculated treatment. **(Singh *et al*., 2011)**

Yield Parameters

Number of Pods/Plant

At harvest, Significant and higher number of pods (30.17) was observed in treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)]. However, the treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50 kg/ha)], treatment 9 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)], treatment 7 [PSB + Phosphorus (70 kg/ha)], treatment 6 [PSB + Phosphorus (60kg/ha)], treatment 5 [PSB + phosphorus (50 kg/ha)], treatment 4 [*Rhizobium spp* + phosphorus 70 kg/ha], was found to be statistically at par with the treatment 10 [*Rhizobium sp*. + PSB + Phosphorus (70 kg/ha)] in (Table 2).

The application of micronutrients up to second level along with *Rhizobium sp*. inoculation was more effective for growth and yield of Chickpea micronutrients and bio-fertilizer application also influenced significantly the yield attributes i.e, pods per plant, plant height except seed per pod and test weight. **(Nirmala *et al*., 2019)**

The application of 65 kg P2O5/ha has taking 75.50 days to flowering, 44.50 pods per plant, 49.33 seeds plant, 1.38 cm pod per length and 1691.21 kg/ha seed yield. **(Badini *et al*., 2015)**

Number of Seeds/Pods

At harvest, Significant and higher number of seeds (1.65) was observed in treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)]. However, the treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50 kg/ha)], treatment 9 [*Rhizobium spp* + PSB + Phosphorus (60 kg/ha)], treatment 7 [PSB + Phosphorus (70 kg/ha)], treatment 6 [PSB + Phosphorus (60kg/ha)], was found to be statistically at par with the treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70kg/ha)] in (Table 2).

The phosphorus fertilization at 40 and 60 kg/ha remarkably increased the yield attributes viz., pods per plant, grains per pod, grams per plant, grain yield per plant, 100-grain weight, grain yield, haulm yield and biological yield. **(Yadav *et al*., 2016)**

Seed Yield (kg/ha)

At harvest, Significant and higher seed yield (2975.44 kg/ha) was observed in treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)]. However, the treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50 kg/ha)], treatment 9 [*Rhizobium spp* + PSB + Phosphorus (60 kg/ha)], treatment 7 [PSB + Phosphorus (70 kg/ha)], treatment 6 [PSB + Phosphorus (60kg/ha)], was found to be statistically at par with the treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70kg/ha)] in (Table 2).

Maximum seed yield (24.04 q/ha) was observed under 60 kg P/ha + NPK consortia. **(Narendra *et al*., 2020)**
The combined seed inoculation (PSB+ *Rhizobium sp*.) significantly increased the seed yield of chickpea by 20.1% over control. **(Singh *et al*., 2017)**

Stover Yield (kg/ha)

At harvest, Significant and higher stover yield (4080.63 kg/ha) was observed in treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50 kg/ha)]. However, the treatment 9 [*Rhizobium spp* + PSB + Phosphorus (60 kg/ha)], treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)], treatment 7 [PSB + Phosphorus (70 kg/ha)], treatment 6 [PSB + Phosphorus (60kg/ha)], treatment 5 [PSB + phosphorus (50 kg/ha)], was found to be statistically at par with the treatment 8 [*Rhizobium spp* + PSB + Phosphorus (50kg/ha)] in (Table 2).

The application of phosphorus at 60 kg/ha produced the topmost mean seed yield of 1761 kg/ha and stalk yield of 2754 kg/ha. Likewise, the levels of sulphur up to 40 kg/ha showed linear increase in the growth, yield attributes, seed and stalk yield of chickpea. The application of 40 kg

Sulphur/ha generate the maximum mean seed yield of 1665 kg/ha and stalk yield of 2665 kg/ha. (**Yadav *et al*., 2011)**

CONCLUSION:

It can be concluded that the application of *Rhizobium spp* and PSB in combination with Phosphorus 70 kg/ha (Treatment 10) recorded highest plant height, no. of nodules, dry weight(g), no. of pods/plant, no. of seeds/pod and seed yield(kg/ha).

Table: 1 Effect of Bio-fertilizer and Phosphorus on growth of Chickpea.

S.No.	Treatment combinations	At 80 DAS		
		Plant height (cm)	**Number of nodules/plant**	**Dry weight (g/plant)**
1.	Control (NPK 20-60-40 kg/ha)	43.37	38..27	6.69
2.	*Rhizobium sp.* + Phosphorus 50 kg/ha	52.25	42.93	7.24
3.	*Rhizobium sp.* + Phosphorus 60 kg/ha	53.98	43.03	7.71
4.	*Rhizobium sp.* + Phosphorus 70 kg/ha	51.41	43.23	8.48
5.	PSB + Phosphorus 50 kg/ha	49.55	43.87	8.35
6.	PSB + Phosphorus 60 kg/ha	50.05	45.87	8.53
7.	PSB + Phosphorus 70 kg/ha	51.59	45.27	8.26
8.	Rhizobium *sp.* + PSB + Phosphorus 50 kg/ha	53.54	45.33	7.93
9.	*Rhizobium sp.* + PSB + Phosphorus 60 kg/ha	50.75	46.97	9.11
10.	*Rhizobium sp.* +PSB + Phosphorus 70 kg/ha	57.67	47.80	10.32
	F-test	S	S	S
	SEm(±)	2.07	1.31	0.48
	CD (p=0.05)	6.17	3.91	1.43

Table: 2 Effect of Bio-fertilizer and Phosphorus on yield attributes and yield of Chickpea

S.No.	Treatment combination	Number of pods/plants	Number of seeds/pod	Seed Yield (kg/ha)	Stover Yield (kg/ha)
1.	Control (NPK 20-60-40 kg/ha)	26.37	1.35	2077.75	2988.64
2.	*Rhizobium sp.* + Phosphorus 50 kg/ha	26.90	1.42	2231.33	3242.02
3.	*Rhizobium sp.* + Phosphorus 60 kg/ha	27.83	1.41	2294.52	3317.09
4.	*Rhizobium sp.* + Phosphorus 70 kg/ha	28.30	1.36	2247.70	3193.95
5.	PSB + Phosphorus 50 kg/ha	28.80	1.49	2511.78	3546.35
6.	PSB + Phosphorus 60 kg/ha	29.43	1.53	2641.93	3708.85
7.	PSB + Phosphorus 70 kg/ha	29.52	1.56	2706.48	3823.84
8.	*Rhizobium sp.* + PSB + Phosphorus 50 kg/ha	29.79	1.62	2848.72	4080.63
9.	*Rhizobium sp.* + PSB + Phosphorus 60 kg/ha	29.78	1.60	2836.96	4036.44
10.	*Rhizobium sp.* + PSB + Phosphorus 70 kg/ha	30.17	1.65	2975.44	3999.90
	F-test	S	S	S	S
	SEm(±)	0.82	0.04	154.64	219.87
	CD (p=0.05)	2.46	0.14	403.56	635.27

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