Effect of Phosphorus and Biofertilizers on Yield and Economics of Chickpea (*Cicer arietinum* L.)

ABSTRACT

At Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P. India), a field experiment was carried out during *Rabi* season of 2022, to study the yield and economics of chickpea (*Cicer arietinum* L.). The soil texture of the experimental plot was Sandy loam, with a pH 7.2, that was neutral with EC- 0.26 (dS/m), organic carbon (0.72%), available N (178.48kg/ha), available P (27.80kg/ha) and available K (233.24kg/ha). *Rhizobium sp.* (5g/kg seed), *Pseudomonas striata* (10g/kg seed), PSB (20g/kg seed) were used as biofertilizers, and phosphorus (40kg P_2O_5/ha, 50kg P_2O_5/ha, 60kg P_2O_5/ha) were used as fertilizers in 3 levels. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and replicated thrice. The treatment of Phosphorus (60kg/ha) + PSB (20g/ha) resulted in highest No. of pods/plant (30.90), No. of seeds/pod (1.53), seed yield (2570.74kg/ha) and stover yield (3583.33kg/ha), were all determined to be significant. The treatment (T_9) with application of Phosphorus (60kg/ha) + PSB (20g/kg seed) also observed maximum gross returns (1, 54,165.87 INR/ha), net returns (1,13,725.57 INR/ha) and benefit cost ratio (2.81) in chickpea crop.

Keywords: Biofertilizers, Chickpea, PSB, Rhizobium, Pseudomonas striata, Yield*, Rabi.*

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most cultivated legume in the world. India stands out as one of the largest producers and consumers of its seeds (or seed); however, its production is insufficient to meet the needs of the internal market, and chickpea imported. It is recognized as a legume with high concentrations of proteins, nutrients, and carbohydrates. It is adaptable to wide climatic variation, has low production cost, and promotes biological fixation of atmospheric nitrogen [1]. India is the leading producer of chickpea contributing to about 70% of the world's chickpea production. In India, Madhya Pradesh (39%), Maharashtra (14%), Rajasthan (14%), Uttar Pradesh (7%), Karnataka (6%), and Gujarat (5%) are the major chickpea growing states. In India pulses are grown nearly in 28.83 m ha with an annual production of 25.72 m t and productivity of 0.8 t ha Some of the states like Uttar Pradesh is about 8.24 m ha with an annual production of 9.97 m t and productivity of 1.08 t ha major producer of chickpea in India as advocated by Ministry of agriculture and Farmers Welfare". [2]

Phosphorus fertilization is among the main practices of crop management; yet, it is considered complex in tropical soils because of the high capacity of phosphorus for covalent adsorption to soil oxides and because of low natural availability of P to plants. In chickpea, balanced phosphorus nutrition is fundamental for establishing symbiosis with N_2 fixing rhizobacteria, and it stimulates nodulation, initial development of roots, plant growth, and seed yield and quality, among other aspects. It is affirm that fertilization with 60 kg $ha^{-1}$of P_2O_5 is sufficient for maximum production of chickpea seeds in *Vertisols* in India. A positive effect on relative growth rate, dry matter accumulation, nodulation, yield, and harvest index with application of 60 kg/ha of P_2O_5. Economic efficiency and high degree of protein are also reported by using this same phosphorus application rate [1]. The response of phosphorus depends upon many factors like climate, variety and soil type and availability of nutrients during the period of growth. The requirement of phosphorus in legumes like chickpea is higher than other crops for their root development and metabolic activities. Phosphorus is the vital component of DNA, RNA, ATP and photosynthetic system and catalyses a number of bio chemical reactions from the beginning of seedling growth through to the formation of grain at maturity [3].

Biofertilizers are low cost, renewable sources of plant nutrients, which supplement chemical fertilizers. Biofertilizers solubilize plant nutrients like nitrogen and phosphors through their activities in the soil or rhizosphere and make available to plants in a gradual manner. PSB solubilizes the insoluble forms of phosphates like tricalcium, iron and aluminium phosphates into available forms. PSB solubilizes insoluble inorganic phosphorus compounds by exerting organic acids, which is the primary mechanism of solubilizing of insoluble inorganic phosphates. Besides organic acids, production of chelating substances, mineral acids, siderophores and proton extrusion mechanism are also involved [4]. Biofertilizers may colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients and growth stimulus to crop. Nitrogen fixer and phosphate solubilizing microorganisms play an important role in supplementing nitrogen and phosphorus to the plant, allowing a sustainable use of nitrogen and phosphate fertilizers. Some important strains are mentioned as plant growth promoting rhizobacteria (PGPR) and that can be used as biofertilizers i.e., *Rhizobium*, *Pseudomonas*, *Azospirillum*, *Azotobacter*, *Bacillus*, *Burkholdaria, Erwinia*, *Mycobacterium*, *Flavobacterium* etc [5]. Phosphate–solubilizing bacteria exist in most soils. In *in vitro* conditions, they can improve P bioavailability by lowering the soil pH, solubilizing Pi, activating synthesized phosphatases, mineralizing organic P, and/or chelating P from Al^{3+}, Ca^{2+}, and Fe^{3+} [6]. Phosphate solubilizing bacteria, when inoculated, secret acidic substances and solubilize otherwise unavailable soil phosphorus. The culture can hence prove broad spectrum biofertilizers which may increase yield of crops (Legumes, vegetables etc) by 10-30%. Use of PSB culture increases nodulation, crop growth, nutrient uptake and crop yield [7]. Certain microorganisms such as phosphate solubilizing bacteria and fungi associated with the plant rhizosphere are known to convert insoluble inorganic phosphorus (P) into a soluble form that could be utilized by the plants [8].Thus, adopting proper nutrient management practices in conjunction with PSB will help to improve the yield and quality of chickpea besides maintaining the soil fertility [9].

The present study was therefore, carried out to study the effect of phosphorus and biofertilizers on yield and economics of chickpea.

2. MATERIAL AND METHODS

The experiment was conducted during *Rabi* season of 2022, at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. India which is located at 25° 24’ 42” N latitude above the mean sea level (MSL). The soil has sandy loam texture, with a pH of 7.2, organic carbon (0.72%), available N (178.48kg/ha), available P (27.80kg/ha) and available K (233.24kg/ha). The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The experiment comprised three biofertilizer treatments and three levels of phosphorus when applied in combinations as follows;

Table 1. Treatment combination

S. No.	Treatment combination
1.	Phosphorus 40kg/ha + *Rhizobium sp.*
2.	Phosphorus 40kg/ha + *Pseudomonas striata*
3.	Phosphorus 40kg/ha + PSB
4.	Phosphorus 50kg/ha + *Rhizobium sp.*

5.	Phosphorus 50kg/ha + *Pseudomonas striata*
6.	Phosphorus 50kg/ha + PSB
7.	Phosphorus 60kg/ha + *Rhizobium sp.*
8.	Phosphorus 60kg/ha + *Pseudomonas striata*
9.	Phosphorus 60kg/ha + PSB
10.	Control (20-50-20 NPK kg/ha)

Five plants were tagged randomly at third week of germination for recording observations. At maturity of the pods, chickpea crop was harvested treatment wise. Followed by bundles and sun dried and later weighed by weighing balance for calculating biological yield. The seed yield was recorded after threshing of plants from each treatment and then converted into kg/ha. The observation like number of pods/plant, number of seeds/pod, seed yield and stover yield were recorded from each plot. Net returns, gross returns and benefit cost ratio were computed based on the cost of cultivation with their prevailing market price. Data was statistically analyzed by using Gomez and Gomez [10].

3. RESULTS AND DISCUSSION

3.1. Yield Parameters

According to yield attributes and yield that was collected at harvest, significant and higher number of pods/plant (30.90), number of seeds/pod (1.53), seed yield (2570.74kg/ha) and stover yield (3583.33kg/ha) was observed in treatment 9 [Phosphorus 60kg/ha + PSB] in (Table 2).

Application of phosphorus had significantly influenced the number of pods/plant (30.90), number of seeds/pod (1.53), seed yield (2570.74kg/ha) and stover yield (3583.33kg/ha) in contrast to control [11] [12].

The crop sown with treatments of phosphorus with inoculation of PSB significantly increased the values of yield attributing characters and yields viz., number of pods/plant (30.90), number of seeds/pod (1.53), seed yield (2570.74kg/ha) and stover yield (3583.33kg/ha) of chickpea compared to control [7] [13].

Table 2. Influence of phosphorus and biofertilizers on yield attributes of chickpea.

S.No.	Treatments	No. of pods/plant	No. of seeds/pod	Seed yield (kg/ha)	Stover yield (kg/ha)
1.	Phosphorus 40kg/ha + *Rhizobium sp.*	26.27	1.13	1521.34	2606.67
2.	Phosphorus 40kg/ha + *Pseudomonas striata*	25.90	1.13	1465.56	2570.00
3.	Phosphorus 40kg/ha + PSB	28.07	1.20	1758.56	2983.33
4.	Phosphorus 50kg/ha + *Rhizobium sp.*	27.30	1.20	1658.17	2783.33

5.	Phosphorus 50kg/ha + *Pseudomonas striata*	26.87	1.13	1533.27	2746.67
6.	Phosphorus 50kg/ha + PSB	28.53	1.47	2276.39	3470.00
7.	Phosphorus 60kg/ha + *Rhizobium sp.*	28.10	1.33	1975.50	3256.67
8.	Phosphorus 60kg/ha + *Pseudomonas striata*	27.70	1.20	1701.20	2836.67
9.	Phosphorus 60kg/ha + PSB	30.90	1.53	2570.74	3583.33
10.	Control (20-50-20 NPK kg/ha)	25.13	1.13	1396.27	2496.67
	F test	S	S	S	S
	SEm(±)	0.93	0.05	101.85	79.42
	CD (p=0.05)	2.77	0.16	302.63	235.99

3.2. Economics.

The total cost of cultivation (40,440.30 INR/ha) was observed to be maximum in treatment 9 (Phosphorus 60kg/ha + PSB) and gross returns (1, 54,110.00 INR/ha), net returns (1, 13,669.70 INR/ha) and B: C ratio (2.81) was also recorded highest in treatment 9 (Table 3).

It is evident from the Table 3 that the highest net returns (1, 13,669.70 INR/ha) and B: C ratio (2.81) were obtained with the application of Phosphorus 60kg/ha. This could be attributed to higher yields of chickpea [3] [14].

Application of phosphorus with inoculation of PSB exhibited excessive values of gross returns (1, 54,110.00 INR/ha), net returns (1, 13,669.70 INR/ha) and B: C ratio (2.81). It also recorded highest growth attributes, yield attributes and yield. [14] [15].

Table 3. Influence of phosphorus and biofertilizers on yield attributes and yield of chickpea.

S.No.	Treatments	Total cost of cultivation (INR)	Gross return (INR/ha)	Net return (INR/ha)	Benefit cost ratio (B:C)
1.	Phosphorus 40kg/ha + *Rhizobium*	40,208.30	93,610.00	53,401.70	1.32
2.	Phosphorus 40kg/ha + *Pseudomonas striata*	40,214.30	90,760.00	50,545.70	1.25
3.	Phosphorus 40 kg/ha + PSB	40,220.30	1,08,180.00	67,861.70	1.68
4.	Phosphorus 50kg/ha + *Rhizobium*	40,318.30	1,01,880.00	61,561.70	1.52
5.	Phosphorus 50kg/ha + *Pseudomonas striata*	40,324.30	94,840.00	54,515.70	1.35
6.	Phosphorus 50 kg/ha + PSB	40,330.30	1,34,480.00	94,149.70	2.33
7.	Phosphorus 60kg/ha + *Rhizobium*	40,428.30	1,21,240.00	80,811.70	1.99
8.	Phosphorus 60kg/ha + *Pseudomonas striata*	40,434.30	1,04,300.00	63,865.70	1.57

9.	Phosphorus 60kg/ha + PSB	40,440.30	1,54,110.00	1,13,669.70	2.81
10.	Control	39,624.38	86,700.00	47,075.62	1.18

4. CONCLUSION

It was concluded that application of Phosphorus 60kg/ha in combination with PSB (Treatment 9) recorded highest seed yield and benefit cost ratio in chickpea crop.

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