International Journal of Environment and Climate Change

Volume 13, Issue 8, Page 391-395, 2023; Article no.IJECC.100647
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i81965

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/100647

Original Research Article

Received: 10/04/2023
Accepted: 23/05/2023
Published: 25/05/2023

ABSTRACT

At the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, a field experiment was undertaken during the *Rabi* season 2022. 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). *Rhizobium sp* (20g/kg seed), PSB (20g/kg seed), and *Rhizobium sp* + PSB (10g/kg seed + 10g/kg seed) were used as bio-fertilizers, and phosphorus (50 kg P2O5/ha, 60kg P2O5/ha, 70 kg P2O5/ha) were used as fertilizers in 3 levels. The experiment used a Randomized Block Design with ten treatments and was repeated three times. The treatment

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of *Rhizobium sp* + PSB (10 g/kg seed + 10 g/kg seed) + Phosphorus (70 kg/ha) resulted in the highest plant height (57.67cm) (Treatment-10) recorded in the study. Number of nodules per plant (47.80), plant dry weight (10.32 g/plant), number of pods per plant (30.17), number of seeds per pod (1.65), seed yield (2975.44 kg/ha) and in treatment-8 [*Rhizobium sp.* + PSB + Phosphorus (50 kg/ha)] stover yield (4080.63 kg/ha) was recoded maximum, were all determined to be significant. The treatment (T10) with the application of *Rhizobium sp* + PSB (10g/kg seed + 10g/kg seed) + Phosphorus (70 kg/ha) produced the highest gross returns (157698.10 INR/ha), net returns (118348.64 INR/ha), and B:C ratio (3.01).

Keywords: Kabuli chickpea; bio-fertilizer; phosphorus; yield; economics; rabi.

1. INTRODUCTION

Chickpeas are an important food plant in India, Africa, and Central and South America. The seeds are high in fibre and protein and are a good source of iron, phosphorus, and folic acid. The bushy 60-cm (2- foot) plants bear feather light pinnately composite leaves. The small white or sanguine flowers frequently have distinctive modes in blue or grandiloquent and are generally self- pollinated. The yellow- brown or dark green beans are borne one or two to a cover. There are large- and small- seeded kinds. The Fabaceae or Leguminosae (generally known as the legume, pea, or bean) family is the third largest family of flowering plants, conforming of over 20,000 species. Chickpea, (Cicer arietinum), also called garbanzo bean or Bengal gram, periodic plant of the pea family (Fabaceae), extensively grown for its nutritional seeds. Desi chickpea (chromosome number 2n = 14, 16) and *kabuli* chickpea (chromosome number 2n = 16) are the two types of chickpea.

“Chickpea is grown in about 50 countries around the world covering an area of 149.66 lakh ha with an average global productivity of 1252 kg/ha. 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” [1].

“The importance of bio-fertilizers, which provide the macro and micronutrients required for plant growth, is also well acknowledged. By preserving soil fertility, soil physical qualities, ecological balance, and providing stability to the production without contaminating soil, water, or air, bio-fertilizers also help to establish a sustainable agriculture system. Crop productivity and nutrient use efficiency are increased when biofertilizers are used in conjunction with chemical fertilizers, organic manures, and crop wastes” [2]. “The seed inoculation of chickpea with *Rhizobium sp*. + PSB (Phosphate Solubilizing Bacteria) increased dry matter accumulation, grain yield and protein content of chickpea, dry fodder yield of succeeding maize and total N and P uptake by the cropping system over no inoculation and inoculation with *Rhizobium sp*. alone. *Rhizobium sp*. with and without PSB also increased soil N content over no inoculation. However, soil P content and bacterial count remained unaffected by *Rhizobium sp*. alone but improved with *Rhizobium sp*. + PSB over no inoculation” [3]. “The seed inoculation of chickpea with *Rhizobium sp*. significantly gave higher number of nodules per plant and nodule weight per plant as compared to un-inoculated treatment” [4].

“Phosphorus (P) is regarded as one of the most crucial nutrients for plants” [5]. “In chickpea, phosphorus has a sizable impact on nodule growth, plant height, branches/plant, pods/plant, grain yield, and harvest index (HI)” [6].

Additionally, phosphorus is essential for pod filling, which eventually increases grain output. By providing sufficient amounts of nutrients, particularly phosphorus (P) and sulphur (S), legumes' ability to fix nitrogen can be improved [7].

2. MATERIALS AND METHODS

The experiment was carried out during *Rabi*, 2022-2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) which is located at 25.39”42” N latitude, 81.50”56” E longitude, and 98m altitude above the mean sea level. This area is situated on the right side of the river Yamuna and by the opposite side of Prayagraj City. All the facilities required for crop cultivation were available. The soil of the experimental field constituting a part of central Gangetic alluvial is neutral and deep. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorus, and low in potassium. Nutrient sources were urea, and Muriate of potash to fulfill the requirement of nitrogen, and Potassium. The phosphorus was applied in 50, 60, and 70 kg/ha through Single Super Phosphate nutrient source. The crop was sown on 16th November 2022. The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice *viz*., T_1- Control, T_2- *Rhizobium sp.* + Phosphorus 50 kg/ha, T_3- *Rhizobium sp.* + Phosphorus 60 kg/ha, T_4- *Rhizobium sp.* + 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 sp.* + PSB + Phosphorus 50 kg/ha, T_9- *Rhizobium sp.* + PSB + Phosphorus 60 kg/ha, T_{10}- *Rhizobium sp.* + PSB + Phosphorus 70 kg/ha. Blanket application of a recommended dose of Nitrogen and Potassium (20:0:40 NPK kg/ha). Bio-fertilizer (*Rhizobium sp.* at 20g/kg seed, PSB at 20g/kg seed, *Rhizobium sp.* at 10g/kg seed and PSB 10g/kg seed) phosphorus levels are (50, 60, 70 kg/ha) was applied as soil application along with blanket application of fertilizers before sowing. The growth parameters reading such as plant height, number of nodules per plant, plant dry weight and also, yield parameters such as number of pods per plant, number of seeds per pod, seed index, seed yield, and harvest index. The growth parameters were recorded at an intervals of 20,40,60,80,100 DAS and at harvest stage, from the randomly selected five plants in each treatment. Statistically analysis was done using all the parameters in one-way Anova and means were compared at 0.05 probability level of significant results.

3. RESULTS AND DISCUSSION

3.1 Yield Parameters

According to yield attributes that was collected and at harvest, Significant and higher number of pods (30.17), number of seeds (1.65), seed yield (2975.44 kg/ha) was observed in treatment 10 [*Rhizobium sp.* + PSB + Phosphorus (70 kg/ha)] and maximum stover yield (4080.63 kg/ha) was observed in treatment 8 [*Rhizobium sp* + PSB + Phosphorus (50 kg/ha)] in (Table 1).

The application of phosphorus with inoculation of *Rhizobium sp*. and PSB significantly increased the values of yield attributing characters *viz*., number of pods per plant (33.5), number of seed per pod (2.5), seed yield (18.7 q/ha) and stover yield (28.9 q/ha) of chickpea compared to control [8].

Table 1. Effect of bio-fertilizer and phosphorus on yield attributes and yield of Chickpea

S. No.	Treatment combination	Numberof pods/plants	Number of seeds/pod	Seed Yield (kg/ha)	Stover Yield (kg/ha)
1.	Control (20-60-40 NPK 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

Table 2. Effect of bio-fertilizer and phosphorus on economics of Chickpea

S. No.	Treatment	Total Cost of Cultivation (INR/ ha)	Gross Return (INR/ ha)	Net Return (INR/ ha)	Benefit Cost Ratio
1.	Control (20-60-40 NPK kg/ha)	38018.46	112730.83	74712.37	1.97
2.	*Rhizobium sp.* + Phosphorus 50 kg/ha	38081.46	118260.66	80179.20	2.11
3.	*Rhizobium sp.* + Phosphorus 60 kg/ha	38706.46	121609.67	82903.21	2.14
4.	*Rhizobium sp.* + Phosphorus 70 kg/ha	39331.46	119127.94	79796.48	2.03
5.	PSB + Phosphorus 50 kg/ha	38117.46	133124.33	95006.87	2.49
6.	PSB + Phosphorus 60 kg/ha	38742.46	140022.47	101280.01	2.61
7.	PSB + Phosphorus 70 kg/ha	39367.46	143443.38	104075.92	2.64
8.	*Rhizobium sp.* + PSB + Phosphorus 50 kg/ha	38099.46	150981.98	112882.52	2.96
9.	*Rhizobium sp.* + PSB + Phosphorus 60 kg/ha	38724.46	150358.82	111634.36	2.88
10.	*Rhizobium sp.* + PSB + Phosphorus 70 kg/ha	39349.46	157698.10	118348.64	3.01

The crop sown with treatments *Rhizobium sp*. and PSB both as seed treatment recorded remarkably higher no. of pods per plant (44.01), seed index (22.20 g), seed yield (1824 kg/ha) and stover yield (2709 kg/ha) in contrast to control [9].

3.2 Economics

The total cost of cultivation (39367.46 INR/ha) was observed to be maximum in treatment 7 [PSB + Phosphorus (70 kg/ha)] and gross return (157698.10 INR/ha), net return (118348.64 INR/ha) and benefit cost ratio (3.01) was recorded maximum in treatment 10 [*Rhizobium spp* + PSB + Phosphorus (70 kg/ha)] in (Table 2).

The Phosphorus use efficiency decreased with the increase in phosphorus level. Net returns (INR 30334.8/ha) and benefit cost ratio (2.40) were the excessive with 60 kg P/ha [10].

The application of *Rhizobium sp*. + PSB + *Azotobacter* exhibited excessive values of gross return (INR 125077.2/ha), net return (INR 91212.0/ha) and B: C ratio (2.69). It also recorded highest growth attributes, yield and yield attributes accompanied by *Rhizobium sp*. + PSB [11].

4. CONCLUSION

It can be concluded that the application of *Rhizobium sp.* and PSB in combination with Phosphorus 70 kg/ha (Treatment 10) recorded highest seed yield and benefit cost ratio.

ACKNOWLEDGEMENT

The authors are thankfull to Dr. Rajesh Singh Associate professor in Department of Agronomy, and Thakur Indu, Ph.D Scholar, Department of Agronomy, SHUATS, Praygraj, U.P. For guiding us essential facilities to undertake the research and studies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/100647