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Impact of Bio Inoculant and Phosphorus Application on Chickpea to Improve Yield and Profitability

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Authors' contributions

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

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ABSTRACT

A Field experiment was conducted at JNKVV, Research Farm, College of Agriculture, Tikamgarh (Madhya Pradesh) during *Rabi* 2019-20 to assess the effect of basal and foliar application of phosphorus and PSB inoculation on growth and yield of chickpea. The experiment was laid out in Randomized block design with three replications. Among the Treatments, 50 kg P_2O_5 + PSB + 2% DAP foliar spray resulted in significant enhancement in all the yield attributing parameters (except seeds pod^{-1}), grain yield (2238 kg ha^{-1}), straw yield (3620 kg ha^{-1}) as well as harvest index (38.2%) over the other treatments. The highest net income of Rs 82967 ha^{-1} with 2.55 B:C ratio was also obtained from this treatment followed by treatment 25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage Rs 78510 ha^{-1} with 2.52 B:C ratio and 50 kg P_2O_5 + 2% DAP spray before flowering stage Rs 75230 ha^{-1} with 2.32 B:C ratio. The net income decreased with the decrease in P levels with each of the PSB and 2% DAP spray.

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1. INTRODUCTION

Chickpea (*Cicerarietinum* L.) is the most important pulse crop grown in semi- and tropical climate. Chickpea having high protein content (23%), rich in carbohydrates (47%), starch (6%), ash (3%), fat (5%) and 6% crude fiber [1,2]. India is the major chickpea producing country in the world with a total production of 11.22 million tonnes cultivated over an area of 10.56 million hectare with a productivity of 1063 kg ha^{-1}. In M.P., total production of 8.12 million tonnes and cultivated area of 7.48 million hectare with an average yield of 1160 kg ha^{-1} [3].

Among all plant nutrients, phosphorus is the most important essential macro-nutrient element required for proper growth and yield of grain legumes because the process of symbiotic nitrogen consumes a lot of energy [4]. It plays a key role in high energy (ATP and ADP compound) storage and transfer in the plant system and has been termed as “master key” element in crop production. About 98 percent of the Indian soils have insufficient supply of available phosphorus and hence need to supplement the P in the form of fertilizers for optimum crop production [5]. The cultivation of legumes without phosphatic fertilizer is major factor responsible for their low productivity. The basal and foliar application of phosphorus nutrient in legumes like chickpea plays significant role in increasing their productivity [6].

On the other hand, bio-inoculants are also improving the soil fertility level by fixing atmospheric nitrogen, solubilizing insoluble soil phosphates and releasing plant growth substances in the soil [7]. Most of the phosphorus present in the soil unavailable to the plants which may be available through the activities of beneficial soil microbes like phosphate solubilizing bacteria (PSB) by mineralizing organic phosphorus compound [2]. Considering these facts, this study was carried out to assess the effect of basal and foliar application of phosphorus and inoculant on yield and economics of chickpea

2. MATERIALS AND METHODS

A field experiment was conducted to assess the effect of basal and foliar application of phosphorus and bioinoculant on yield and economics of chickpea at JNKVV, Research Farm, College of Agriculture, Tikamgarh (24˚ 43’ N latitude and $78^0$49’ E longitude at an altitude of 358 m above sea level), Madhya Pradesh during *rabi* 2019-20. The soil of the experimental field was clay loam having pH 7.20, electrical conductivity 0.26 dsm^{-1}, organic carbon 0.62 %, available N, P_2O_5 and K_2O 233, 16.7 and 497 kg ha^{-1}, respectively. The experiment was laid out in Randomized block design with nine treatments [T_1-Control, T_2-50 kg $P_2O_5ha^{-1}$, T_3-25 kg $P_2O_5ha^{-1}$, T_4-50 kg P_2O_5 +PSB (5 g kg^{-1} seed),T_5-25 kg P_2O_5+PSB (5 g kg^{-1} seed),T_6-50 kg P_2O_5+ 2% DAP spray before flowering stage,T_7-25 kg P_2O_5+2% DAP spray before flowering stage,T_8-50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage and T_9-25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage] and three replications. The chickpea var. JG 12 was sown @ 80 kg seed ha^{-1} in rows 30 cm apart on 17 November 2019. A uniform dose of 20 kg N and 20 kg K_2O ha^{-1} was applied in all the treatments through urea and MOP, respectively. The P levels, PSB and 2% DAP foliar spray were applied as per treatments. The chickpea was grown as per recommended package of practices.

The crop was harvested on 14^{th}March in 2020 when the leaves turned yellow and 90 percent pods become yellow- brown. The net plots were marked and harvesting was done plot wise. The plants of each plot were sun dried for few days in the field and tied in bundles with proper labeled. The bundles were weighed with the help of a spring balance. The harvested bundles were threshed manually and the grain yield of each plot was recorded. The straw yield was obtained by deducting grain yield from total biomass (stover weight) produced per plot, and then the values were converted into kg ha^{-1} based on net plot size. Thereafter yield-attributes yield and economics were also recorded/calculated as per standard procedures.

3. RESULTS AND DISCUSSION

3.1 Yield- Attributing Parameters

Following observations on various yield attributing characters were made at the time of harvesting on the five randomly selected plants in each plot.

3.2 Number of Pods Plants^{-1}

The data on average number of pods $plant^{-1}$, seed yield $plant^{-1}$ and 100-seed weight was augmented almost significantly but the number of seeds pod^{-1} was non–significant (Table 1). Among the treatments, T_8 (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) recorded significantly maximum number of pods plant^{-1}(52.4), seed yield (24.9 g plant^{-1}) and 100- seed weight (18.4 g) than all other treatments. Alone T_3, (25 kg P_2O_5 ha^{-1}) registered significantly lower yield attributing characters but was significantly higher than control plot.

3.3 Number of Seed Pod^{-1}

The data presented in Table 1 on number of seeds pod^{-1} produced non–significantly highest number of seeds pod^{-1} (2.43) in treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) closely followed by T_9, (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage 2.33) and T_6, (50 kg P_2O_5 + 2% DAP spray before flowering stage 2.17). However, all the treatments registered non-significantly higher number of seeds pod^{-1} over control plot (1.43). The results are in close conformity with the finding of Singh et al. [8], Prajapati et al. [9] and Singh et al. [2].

3.4 Seed Yield Plant^{-1}

The seed yield is the resultant of coordinated growth and development characters. The crop yield is a function of all components of source and sinks operating at different phenophases of growth during life cycle of plant. The different sink components are number of pods plant^{-1}, number of seeds pod^{-1}, seed yield plant^{-1} and 100-seed weight.

The data pertaining to seed yield are presented in Table 1. The study of data indicated that the seed yield ha^{-1} was significantly influenced due to different phosphorus level and treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) produced significantly the highest seed yield of 2238 kg ha^{-1} as compared to other treatments including control treatment (1102 kg ha^{-1}). Followed by T_9, (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) and T_6, (50 kg P_2O_5 + 2% DAP spray before flowering stage) which recorded significantly higher seed yield over control. The lowest seed yield (1102 kg ha^{-1}) was recorded in control treatment. Under the higher supply of plant nutrients particularly phosphorus chickpea plants synthesized more photo synthates and the storage, seed was better developed. The present findings are closely related with the findings of Shukla et al. [6], Singh et al. [8], Prajapati et al. [9].

3.5 Seed Index

The data pertaining to seed index (100-seed weight in g) as influenced by different phosphorus levels, foliar spray of phosphorus and PSB inoculation are summarized in Table 1. Treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) registered significantly the highest seed weight pod^{-1}(18.4 g) followed by T_9, (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) (18.0 g) and T_6 (50 kg P_2O_5 + 2% DAP spray before flowering stage) (17.8 g). However, all the treatment registered significantly higher seed weight pod^{-1} over T_1 (control plot) (16.1 g).

3.6 Productivity Parameters

Biological yield (Kg ha^{-1}): The findings Indicated that the (Table 2) highest biological yield of (5858 Kg ha^{-1}) was recorded in the treatment T_8 (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) in comparison to all the remaining varies treatments, followed by T_9, (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) (5657 Kg ha^{-1}) while the lowest of (3652 kg ha^{-1}) was noted under control.

Seed yield (Kg ha^{-1}): The result revealed that the (Table 2) seed yield was significantly highest (2238 kg ha^{-1}) under T_8 (50 kg P_2O_5+PSB + 2% DAP spray before flowering stage) followed by T_9 (25 kg P_2O_5+PSB + 2% DAP spray (before flowering stage) (2123 kg ha^{-1}) and T_6 (50 kg P_2O_5 +2% DAP spray (before flowering stage) (2085 kg ha^{-1}). and these treatments were found significantly superior over T_2 (50 kg P_2O_5 ha^{-1}) (1692 kg ha^{-1}) and T_3 (25 kg P_2O_5 ha^{-1}) (1572 kg ha^{-1}). However, all the various treatments produced significantly higher seed yield over T_1 (control) (1102 kg ha^{-1}). The present findings are closely related with the findings of Chalchissa, et al. [4], Chauhan and Raghav [1] and Singh et al. [2].

Stover yield (Kg ha^{-1}): The data presented in Table 2 on stover yield indicated that the stover yield ha^{-1} was significantly influenced due to different phosphorus level. Significantly highest stover yield of 3620 kg ha^{-1} was registered in the treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) as compared to other treatments including control treatment (2550 kg ha^{-1}). Among the treatments T_9, (25 kg P_2O_5

Table 1. Yield attributes of chickpea as influenced by P levels, foliar spray of P and PSB inoculation

S. No.	Treatments	Pods plant^{-1}	Seeds pod^{-1}	Seed yield plant^{-1} (g)	Seed index (g)
T1	Control	33.2	1.43	11.8	16.1
T2	50 kg $P_2O_5ha^{-1}$	38.0	1.83	17.24	17.0
T3	25 kg $P_2O_5ha^{-1}$	36.0	1.77	15.8	16.8
T4	50 kg P_2O_5 +PSB (5 g kg^{-1} seed)	41.7	2.13	20.7	17.5
T5	25 kg P_2O_5+PSB (5 g kg^{-1} seed)	44.0	1.97	19.0	17.3
T6	50 kg P_2O_5+ 2% DAP spray (before flowering stage)	49.2	2.17	23.7	17.8
T7	25 kg P_2O_5+2% DAP spray (before flowering stage)	47.3	2.03	21.8	17.5
T8	50 kg P_2O_5 +PSB + 2% DAP spray (before flowering stage)	52.4	2.43	24.9	18.4
T9	25 kg P_2O_5 +PSB + 2% DAP spray (before flowering stage)	50.5	2.33	23.8	18.0
S. Em±		1.64	0.19	0.31	0.20
CD (P=0.05)		4.94	NS	0.95	0.62

Table 2. Final yield and harvest index of chickpea as influenced by P levels, foliar spray of P and PSB inoculation

S. No.	Treatments	Biological yield Kg ha^{-1}	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	HI (%)
T1	Control	3652	1102	2550	30.9
T2	50 kg $P_2O_5ha^{-1}$	4692	1692	3000	36.0
T3	25 kg $P_2O_5ha^{-1}$	4699	1572	3127	33.5
T4	50 kg P_2O_5 +PSB (5 g kg^{-1} seed)	5096	1885	3210	37.0
T5	25 kg P_2O_5+PSB (5 g kg^{-1} seed)	4938	1769	3169	35.8
T6	50 kg P_2O_5+ 2% DAP spray (before flowering stage)	5552	2085	3467	37.6
T7	25 kg P_2O_5+2% DAP spray (before flowering stage)	5308	1989	3319	37.5
T8	50 kg P_2O_5 +PSB + 2% DAP spray (before flowering stage)	5858	2238	3620	38.2
T9	25 kg P_2O_5 +PSB + 2% DAP spray (before flowering stage)	5657	2123	3534	37.5
S. Em±		55.6	23.4	50.7	0.47
CD (P=0.05)		166.7	70.2	152.1	1.42

+PSB + 2% DAP spray before flowering stage) and T_6 (50 kg P_2O_5 + 2% DAP spray before flowering stage) recorded significantly higher seed yield than the remaining of the treatments. Whereas lowest seed yield (2550 kg ha^{-1}) was recorded in control treatment. These finding are close conformity with the findings of Raj et al*.* [10], Shukla et al*.* [6] and Prajapati et al*.* [9].

Harvest index (HI): The data pertaining to harvest index (%) as influenced by different phosphorus levels, foliar spray of phosphorus and PSB inoculation are given in Table 2. The results Indicate that the highest harvest index was calculated in T_8 (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) (38.2%) followed by T_9 (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) (37.5%) while the lowest (30.9%) was recorded under control.

3.7 Economics

The acceptance of improved production technology involving costly /scarce input like different treatments for chickpea crop by the farmers depend largely on the economic returns from input. In present study, the economics of different treatments net income and benefit cost ratio (BCR) were worked out (Table 3).

Table 3. Economics of different treatments in chickpea as influenced by P levels, foliar spray of P and PSB inoculation

S. No.	Treatments	Economics			
		Cost of cultivation (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
T1	Control	28420	57674	29254	1.03
T2	50 kg $P_2O_5 ha^{-1}$	31728	87638	55910	1.76
T3	25 kg $P_2O_5 ha^{-1}$	30324	81746	51422	1.70
T4	50 kg P_2O_5 +PSB (5 g kg^{-1} seed)	31828	97494	65666	2.06
T5	25 kg P_2O_5+PSB (5 g kg^{-1} seed)	30424	91627	61203	2.01
T6	50 kg P_2O_5+ 2% DAP spray (before flowering stage)	32488	107718	75230	2.32
T7	25 kg P_2O_5+2% DAP spray (before flowering stage)	31084	102786	71702	2.31
T8	50 kg P_2O_5 +PSB + 2% DAP spray (before flowering stage)	32588	115555	82967	2.55
T9	25 kg P_2O_5 +PSB + 2% DAP spray (before flowering stage)	31184	109694	78510	2.52

3.8 Cost of Cultivation (Rs ha^{-1})

The data indicated that the increase in the phosphorus levels increased the cost and it was maximum (Rs 32588 ha^{-1}) in treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) followed by T_6, (50 kg P_2O_5 + 2% DAP spray before flowering stage Rs 32488 ha^{-1}). The cost was found minimum (Rs 28420 ha^{-1}) under control plot followed by T_3, (25 kg P_2O_5 ha^{-1} Rs 30324 ha^{-1}).

3.9 Gross Monetary Return (Rs ha^{-1})

The gross monetary return was highest (Rs 115555 ha^{-1}) recorded for treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) followed by T_9, (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage Rs 109694 ha^{-1}). Among the treatments lowest GMR was observed in control plot (Rs 57674 ha^{-1}). The increase in GMR with alone application of phosphorus, PSB and their combined application was attributed to increase in seed and stover yield.

3.10 Net Monetary Return (Rs ha^{-1})

The presented data in Table 3 further indicated that the maximum net return of Rs 82967 ha^{-1} was realized under treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) followed T_9 (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage Rs 78510 ha^{-1}). Whereas the lowest net return of Rs 29254 ha^{-1} was observed under control treatment.

3.11 Benefit Cost Ratio

Data revealed that the maximum BCR (2.55) was secured under treatment T_8, (50 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) followed by treatment T_9, (25 kg P_2O_5 +PSB + 2% DAP spray before flowering stage) (2.52). The lowest BCR of 1.03 was recorded under control treatment.

The higher economical advantage from all these best treatments was due to increased market sale of the produce from such treatments. The complementary or supplementary use of chemical fertilizers through soil or foliar spray and PSB bio fertilizer has assumed greater importance now a days to maintain as well as sustain a higher level of soil fertility, crop productivity and reduced cost of cultivation. These results also agree with those of Shukla et al. [6], Raj et al. [10] and Singh et al. [8].

4. CONCLUSION

On the basis of foregoing finding it may be concluded that out of the nine treatments, T_8 having 50 kg P_2O_5 + PSB 5 g kg^{-1} seed + 2% DAP spray before flowering stage proved the most beneficial treatment under agro-climatic condition of Tikamgarh (Madhya Pradesh). This treatment resulted in yield attributing parameters and consequently the grain yield was found up to 2238 kg ha^{-1} yield with net income up to Rs 82967 ha^{-1} with maximum 2.55 B:C ratio. Followed by treatment T_9 25 kg P_2O_5 + PSB 5g kg^{-1} seed + 2% DAP spray (2123 kg ha^{-1} yield Rs 78510 ha^{-1} net income and 2.52 B:C ratio).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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