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Influence of phosphorus levels and Bio-fertilizers on yield and economics of chickpea under sub-tropical conditions of Madhya Pradesh

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ABSTRACT

A field experiment was conducted at Crop Research Centre of School of Agriculture, ITM University, Gwalior, (M.P.) during *Rabi* 2021–22 to study the influence of phosphorus levels and Bio-fertilizers on yield and economics of chickpea. The experiment was laid out in factorial randomized block design by taking four levels of phosphorus *viz*. 0 kg P_2O_5 ha^{-1}, 30 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1}, 50 kg P_2O_5 ha^{-1} and bio-fertilizers (No inoculation, PSB, *Rhizobium*, PSB + *Rhizobium* which were replicated thrice. The chickpea variety "JG-16" was uniformly fertilized by 20 kg N/ha through Urea. However, phosphorus and bio-fertilizers were applied as per the requirement of the treatments. The crop was managed as per the recommended package and practices. The experimental study revealed that among the phosphorus levels, the application of 50 kg P/ha recorded significantly highest seed and stover yield. However, among the bio-fertilizers, application of Phosphate solubilizing bacteria + *Rhizobium* resulted in highest seed and stover yield of chickpea. Among the economic analysis, application of 50 kg ha^{-1} phosphorus and combined treatment of Phosphate solubilizing bacteria + *Rhizobium* incurred the highest cost of cultivation, highest gross return, net return and Benefit cost ratio. Therefore, for chickpea cultivation, application of 50 kg ha^{-1} phosphorus and treatment of Phosphate solubilizing bacteria+ *Rhizobium* was proved to be profitable.

Key words: *Biofertilizers, Chickpea, Economics, Phosphorus and Yield.*

Introduction

Pulses are a significant group of crops in India, which accounts for one-third of the world's total area cultivated and because they make up a substantial percentage of the country's exports. Pulses serve as a main crop, green manure crop, catch crop, cover crop, and intercrop. They are equally essential in Indian agriculture because of their high productivity and low-input requirement. Of the major pulses, chick pea is the third most significant pulse crop grown worldwide, which has the ability to fix 140 kg of atmospheric nitrogen per hectare with its ability of symbiotic nitrogen fixation. However, excessive cultivation and growing of nutrient-exhausting crops have caused the soil deficient in macro- as well as in micronutrients due to nutrient mining. Nowadays, the use of only nitrogenous fertilizers has contributed to soil nutrient imbalance, notably in terms of the availability of micronutrients. The nutrient application must be adjusted for agricultural production because unbalanced use lowers crop yields. A key macronutrient that is needed by plants for growth and development is phosphorus.

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It is a major component of ATP, RNA, and DNA and hence plays a crucial role in the transmission of genetic information and intracellular energy within living cells (Ogola *et al.*, 2012). Phosphorus boosts the symbiotic organic process because it makes bacterium cells mobile, which is necessary for their migration to plant organs for nodulation. Phosphorus aids in healthy root growth, which increases root nodules and then speeds up the organic process. Accordingly, 80% of India's soils require the use of P at recommended amounts (Motsara, 2002), and the application of some P fertilizer would be necessary to stop P mining from the soils in order to maintain high agricultural yields.

Bio-fertilizers, also known as microbial inoculants, are substances used to treat soil and seeds that contain living or dormant cells of beneficial microorganism strains (Mishra *et al*., 2010). These organism aids crop plants in absorbing nutrients through their interaction in the rhizosphere and have the capacity to biologically change nutritionally important elements from an unavailable to an available form. They raise the levels of the powerful plant growth hormones gibberellic acid and indole acetic acid in plants. They can be utilized for leguminous crops, vegetables, food, and fodder (Ali *et al*., 2006). Three regularly used microorganisms as biofertilizers (PGPR) are rhizobia, plant growth-promoting rhizobacteria, and phosphate-solubilizing bacteria (PSB). Rhizobium and phosphate solubilizing bacteria (PSB) play a crucial part in N_2 fixation and P solubilizations, which gives them a significant amount of significance. Rhizobium and PSB use have been beneficial in raising chickpea productivity (Rudresh *et al*., 2005). Hence, applying phosphatic fertilizers coupled with PSB enhances the uptake of phosphorus by plants as well as significantly raising crop production (Kachave *et al*., 2018). In order to increase yield and economic return from chickpea, it is essential to apply sufficient fertilizers and the right strain of biofertilizers. Thus, keeping the above fact in view, an experiment was conducted to assess the study the influence of phosphorus levels and Bio-fertilizers on yield and economics of chickpea.

Materials and Method

An investigation was conducted in the *Rabi* 2021–22 and 2022–23 at the at the Crop Research Centre of School of Agriculture, ITM University, Gwalior, (M.P.). The area received a total rainfall of 6.57 mm in the 1st year and 0.72 mm in the 2nd year. Additionally, the cumulative evaporation amounted to 2.21 mm in the 1st year and 2.60 mm in the 2nd year. The average minimum and maximum temperatures during the first and second years ranged from 9.28 to 24.5 °C and 9.43 to 26.73 °C, respectively. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH 7.57), low in organic carbon (4.0 g/kg), available nitrogen (183.50 kg/ha) and potassium (243.0 kg/ha) but medium in available phosphorus (14.40 kg/ha) with electrical conductivity in the safer range

The field experiment comprised of sixteen treatment combinations, which were laid out in factorial randomized block design with three replications. The treatments comprised of two factors i.e. phosphorus levels *viz*., 0 kg P_2O_5 ha^{-1}, 30 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1}, 0 kg P_2O_5 ha^{-1} and bio-fertilizers i,e no inoculation, PSB, *Rhizobium*, PSB + *Rhizobium*. The chickpea crop variety, JG-16 was sown in lines at a spacing of 30 cm between the rows × 10 cm between the plants. Chickpea crop was fertilized with recommended dose of nitrogen through Urea @ 20 kg ha^{-1} which was broadcasted in the field a day before the sowing. However, phosphorus application was made as per the requirement of the treatment and application of biofertilizers *i.e. Rhizobium* and Phosphate solubilizing bacteria (PSB), were applied through seed treatment method just before sowing as per the treatment. Further, the crop was managed as per regional recommendations of the crop. Data on yield was obtained at harvest. From the individual plot, net plot was harvested and subsequently, the grain, stover and biological yield thus obtained were weighed and expressed in kg ha^{-1}. Among economic parameters, net return per ha was calculated by deducting cultivation cost from gross returns.

The grain yield, which was recorded from the net plot, was converted into kilogram/hectare.

Stover yield per net plot was worked out by subtracting the total grain weight from the total biomass weight of each treatment. The straw yield obtained was expressed in kg/ha.

Benefit cost (B:C) ratio was calculated by dividing net returns with total cost of cultivation to evaluate the economic viability of treatments. Statistical analysis of yield and yield attributes was performed to examine the effect of different treatments. The harvest index was calculated by dividing the economic yield by the biological yield. It was calculated by a formula given by Nichiporovich (1967) and multiplied by 100. It was expressed in percent

$$\text{Harvest index (per cent)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

The analysis of variance was conducted using OP-Stat developed by CCSHAU, Hisar for all observation recorded during the years. Fisher's test of significance was used to compare the difference between means at 5 % probability level. Standard errors along with critical difference at 5 % of significance were computed for discriminating the treatment effects for chance effects.

Results and Discussion

Yield (kg ha^{-1})

The data on seed and stover yield of chickpea was influenced by varying levels of phosphorus and biofertilizers (Table 1) Among the varying levels of phosphorus, the application of 50 kg P ha^{-1}recorded highest grain yield, stover yield and ultimately the biological yield. On the other hand, the minimum grain yield, stover yield and ultimately the biological yield was observed with the application of phosphorus was applied @ 0 kg/ha. The maximum seed yield per plant as well as per hectare with optimum phosphorus rates was attributable to better nodulation and efficient functioning of nodule bacteria for fixation of nitrogen to be utilized by plants during seed development stage in the synthesis of protein which in turn led to increase in seed yield. Khan *et al.* (2004) found that the increase in phosphorus levels was significantly increased seed yield of chickpea. This could be attributed to better supply of phosphorus resulting in higher branch and pod and there by higher yield. It is an established fact that phosphorus plays an important role in the formation of new shoots and number of branches/ plant. In addition, it regulates the photosynthetic and carbohydrate metabolism which can be considered to be one the major factors limiting growth particularly during the reproductive phase.

Among the bio-fertilizers, the maximum grain yield, stover yield and biological yield was recorded with the application of PSB+ *Rhizobium* followed by application of PSB while the lowest grain yield, stover yield and biological yield was observed with no inoculation. This is due to Bulk inoculation of beneficial microbes plays important role in improving three major aspects of determination, i.e. strong sink development of reproductive structure, formation of vegetative higher photosynthesis and production of assimilates to fill economically to sink (Kumar *et al.*, 2015 and Saket and Rahi, 2019).

Economics

The data on economics as influenced by different levels of phosphorus and bio fertilizers are presented in Table 2 revealed that among the phospho-

Table 1. Effect of varying levels of phosphorous and biofertilizers on yield and harvest index of chickpea

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (%)
Phosphorus levels				
P_0 = 0 kg P_2O_5ha^{-1}	877.41	2266.58	3143.99	28.03
P_1 = 30 kg P_2O_5ha^{-1}	905.68	2322.67	3230.01	27.99
P_2 = 40 kg P_2O_5ha^{-1}	995.37	2439.67	3435.04	28.91
P_3 = 50 kg P_2O_5ha^{-1}	1066.56	2513.08	3579.64	29.66
SEm±	27.78	57.10	77.32	0.62
CD (P=0.05)	80.24	164.91	223.30	N.S
Biofertilizers				
B_0 = No inoculation (Control)	852.39	2217.67	3071.72	27.81
B_1 = PSB	993.75	2409.33	3403.08	29.16
B_2 = *Rhizobium*	921.64	2358.17	3279.81	28.14
B_3= PSB + *Rhizobium*	1077.24	2556.83	3634.07	29.47
SEm±	27.78	57.10	77.32	0.62
CD (p=0.05)	80.24	164.91	223.30	N.S
Phosphorus level × Biofertilizers				
CD (p=0.05)	N.S	N.S	N.S	N.S

Table 2. Effect of varying levels of phosphorous and biofertilizers on relative economics of chickpea

Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Application of P_2O_5@ 0 kgha^{-1} under without seed inoculation	27108.31	65312.29	38203.98	1.41
Application of P_2O_5@ 0 kgha^{-1} under seed inoculation with PSB	27258.31	69166.45	41908.14	1.54
Application of P_2O_5@ 0 kgha^{-1} under seed inoculation with *Rhizobium*	27258.31	66056.05	38797.74	1.42
Application of P_2O_5@ 0 kgha^{-1} under seed inoculation with PSB & *Rhizobium*	27258.31	72337.89	45079.58	1.65
Application of P_2O_5@ 30 kgha^{-1} under without seed inoculation	29005.92	67296.20	38290.28	1.32
Application of P_2O_5@ 30 kgha^{-1} under seed inoculation with PSB	29155.92	71407.56	42251.64	1.45
Application of P_2O_5@ 30 kgha^{-1} under seed inoculation with *Rhizobium*	29155.92	70644.05	41488.13	1.42
Application of P_2O_5@ 30 kgha^{-1} under seed inoculation with PSB & *Rhizobium*	29155.92	72580.54	43424.62	1.49
Application of P_2O_5@ 40 kgha^{-1} under without seed inoculation	29638.55	66261.20	36622.65	1.24
Application of P_2O_5@ 40 kgha^{-1} under seed inoculation with PSB	29788.55	80160.67	50372.12	1.69
Application of P_2O_5@ 40 kgha^{-1} under seed inoculation with *Rhizobium*	29788.55	74171.50	44382.95	1.49
Application of P_2O_5@ 40 kgha^{-1} under seed inoculation with PSB & *Rhizobium*	29788.55	87386.23	57597.68	1.93
Application of P_2O_5@ 50 kgha^{-1} under without seed inoculation	30271.18	66878.20	36607.02	1.21
Application of P_2O_5@ 50 kgha^{-1} under seed inoculation with PSB	30421.18	86426.33	56005.15	1.84
Application of P_2O_5@ 50 kgha^{-1} under seed inoculation with *Rhizobium*	30421.18	75486.11	45064.93	1.48
Application of P_2O_5@50 kgha^{-1} under seed inoculation with PSB & *Rhizobium*	30421.18	100003.24	69582.06	2.29

rus levels, the higher cost of cultivation was incurred with the application of 50 kg P_2O_5 ha^{-1} followed by the application of 40 kg P_2O_5 ha^{-1}. Further, the highest gross returns, net returns and benefit: cost ratio were fetched with the application of 50 kg P_2O_5 ha^{-1} followed by the application of 40 kg P_2O_5 ha^{-1}.

Among the biofertilizers, the highest cost of cultivation were obtained with the application of PSB+ Rhizobium followed by the application of PSB. Further, the highest gross returns, net returns and benefit:cost ratio was recorded with the application of PSB+ Rhizobium followed by the application of PSB. This was possibly due to proportionately highest net return as compared to the cost involved which contributed to B: C ratio. These results are in close agreement with the findings reported by Rabari *et al.* (2022).

Conclusion

It can be concluded that the among the phosphorus levels, application of 50 kg ha^{-1} phosphorus recorded significantly highest seed yield and stover yield. Among the treatment combination, application of 50 kg ha^{-1} phosphorus and bio-fertilizers (PSB + *Rhizobium*) recorded highest gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}) and benefit cost ratio (₹). Thus, for chickpea cultivation, application of 50 kg ha^{-1} phosphorus and application of Phosphate solubilizing bacteria + *Rhizobium* was found to be most promising treatment in enhancing the yield in chickpea

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