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Influence of Microbial Inoculants and Molybdenum on Yield and Economics of Chickpea (*Cicer arietinum* L.)

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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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Original Research Article

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ABSTRACT

The purpose of this study is to study the influence of microbial inoculants and molybdenum on the yield and economics of chickpeas (*Cicer arietinum* L.). The research was carried out at Crop Research Farm, SHUATS, Prayagraj, India in Rabi 2022. The study included biofertilizer and three levels of Molybdenum (0.5, 1.0 and 1.5 kg/ha). The experiment was designed using a randomized block design with 10 treatments, each replicated thrice. The soil in the experimental area was sandy loam with pH (7.8), Organic Carbon (0.43%), Available N (181.58 kg/ha), Available P (15.45 kg/ha), and Available K (197.64 kg/ha). The results indicated that the higher seed yield (1638.35 kg/ha), stover yield (3539.00 kg/ha), gross return (105101.20 INR/ha), net return (71599.20 INR/ha), and benefit-cost ratio (2.14) were observed in treatment 9, which involved the seed inoculation of *Rhizobium* and PSB along with the soil application of Molybdenum 1.0 kg/ha.

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1. INTRODUCTION

"Pulses are the second most important group of crops worldwide. The English word pulse is taken from the Latin *puls*, meaning pottage or thick pap. Pulse is an important source of protein (approximately 21-25%)" [1].

"Chickpea (*Cicer arietinum* L.) is the most important *rabi* (winter) season food legume crop. In India, chickpea area is 9.85 million hectares, with 11.99 MT production and 1217 kg/ha productivity in 2020-2021" [2]. In India Madhya Pradesh leading state in the area and production of chickpeas. In Uttar Pradesh, it is cover 8.24 million hectares and production 9.97 million tonnes with a productivity 1.08 t/ha in 2020–2021 (GOI, 2021). Gram productivity is directly regulated by biotic and abiotic variables, with weed playing a significant role. "During 2020-21, chickpea as had a lion's share of 49.3% in the total pulses production. Chickpea contains 18-22 percent protein, 52-70 percent carbohydrate, 4-10 percent fat and sufficient quantity of minerals, calcium, phosphorus, iron and vitamins" [3]. "It also contains 50% Oleic and 40% Linolic acid. It can fix about N 25-30 kg/ha through symbiosis [4] and these minimize dependency on chemical fertilizers".

"Usage of biofertilizers - a category of organic fertilizers is an environmentally secure method of fertilization. Commonly used microorganisms as biofertilizers are *Rhizobium*, Phosphate solubilizing bacteria (PSB), Pseudomonas, Blue-green algae, and Plant growth promoting Rhizobacteria (PGPR). Biofertilizers augment the biochemical processes in the soil such as nitrogen fixation, phosphorus solubilization, and mobilization, zinc solubilization, production of plant growth-promoting substances and pathogen control. Biofertilizers provide an attractive, ecologically sound means of fertilization, and economically judicious [5] and are important for making agriculture more sustainable". "*Rhizobium* and phosphate solubilizing bacteria (PSB) assume countless importance on account of their dynamic role in N_2-fixation and P solubilizations. *Rhizobium* and PSB use has been beneficial for increasing chickpea productivity" [6].

"Micronutrients play an important role in increasing the yield of chickpea. Through their impact on the plant itself and on the symbiotic nitrogen-fixing process, micronutrients also play a significant role in boosting the output of pulses and oilseed legumes. If the soil has Mo deficient then chickpeas produce smaller flower size, lesser number of flowers and many of them fail to open or to mature and finally, this leads to decreases grain yield" [7]. Roy et al. [8] say that "Mo is directly related to N fixation by legumes. The availability of Mo is relatively poor when the pH of the soil is in the very slight to medium acid range". "Soil and foliar application are effective practices for the implementation of some micronutrients [8]. This research was designed to study the effect of *Rhizobium*, PSB, and different levels of Molybdenum dosages on chickpea yield and economics.

2. MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season-2022 at CRF, Department of Agronomy in SHUATS, Prayagraj. The location of the experiment was 25^0 39' 42" N latitude, 81^0 67' 56" E longitude, and at an altitude of 98 m above mean sea level. The experiment was laid out in randomized block design and comprised of Biofertilizer and Molybdenum with ten treatments and each was replicated thrice. Each plot was 9 m^2 or 3m x 3m in size. The treatments are T_1 : Control, T_2 : *Rhizobium* + Molybdenum 0.5 kg/ha, T_3 : *Rhizobium* + Molybdenum 1.0 kg/ha, T_4 : *Rhizobium* + Molybdenum 1.5 kg/ha, T_5 : PSB + Molybdenum 0.5 kg/ha, T_6 : PSB + Molybdenum 1.0 kg/ha, T_7 : PSB + Molybdenum 1.5 kg/ha, T_8 : *Rhizobium* + PSB + Molybdenum 0.5 kg/ha, T_9 : *Rhizobium* + PSB + Molybdenum 1.0 kg/ha, T_{10} : *Rhizobium* + PSB + Molybdenum 1.5 kg/ha. All plots were fertilized with the basal dose of 20 kg N/ha, 50 kg P_2O_5/ha, and 20 kg K_2O/ha in the form of Urea, SSP, and Muriate of Potash, respectively. Seeds were treated with the respective *Rhizobium sp*. and PSB inoculants by following the standard procedure and sown on 5th Nov. 2022 with a seed rate of 80 kg/ha at spacing 30 cm x 10 cm. Ammonium Molybdate, as a source of Molybdenum (Mo) were applied in the soil according to the selected doses in their respective plots. Ammonium Molybdate is applied at the time of sowing. In intercultural operations hand weeding was done manually with *Khurpi* at 25 DAS followed by second manual weeding was done at 45 DAS to minimize the crop weed competition. At 30-35 days after sowing nipping was done removing the tips of the younger plant. Chickpea crops

required two irrigations one after sowing and the second at pre flowering stage. For different observations samples of soil and plant were taken before and after the harvest of crop, like collection of soil samples (0-15 cm depth), processing of collected soil samples, analysis of processed samples for their physico-chemical properties, collection of plant samples at different intervals *viz*. 20, 40 60 and 80 DAS. Seed and stover yield was also observed at maturity and both seed and stover samples of chickpeas were collected from each plot. All agronomic practices are followed in the order in the crop period. "Experimental data collected were subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez. Critical Difference (CD) values were calculated wherever the 'F' test was found significant at a 5 percent level" [9].

3. RESULTS AND DISCUSSION

3.1 Yield Attributes

3.1.1 Seed yield (kg/ha)

Significantly higher seed yield (1638.35 kg/ha) (Table 1) was observed in treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha], which was superior over all other treatments. This result similarly finding by "increase in seed yield due to Mo application along with *Rhizobium* and PSB might be due to enhanced nodulation and BNF, N, and other complementary elements assimilation as a consequence of the favourable effect of Mo and Mo-Fe on nitrogenase activity in nodules and nitrate reductase activity in plant system" [10].

3.1.2 Stover yield (kg/ha)

Significantly higher stover yield (3539 kg/ha) (Table 1) was observed in treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha], which was superior over all other treatments. A similar result was reported by Manohar et al. [11].

3.2 Economics

3.2.1 Gross return (INR/ha)

Maximum (INR 105101/ha) (Table 2) gross return was obtained with the application of treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] while the lowest (INR 79318.07/ha) gross return was obtained with application of Treatment 1 [Control] as compared to all other treatments.

3.2.2 Net returns (INR/ha)

Maximum (71599.20 INR/ha) (Table 2) net return was obtained with the application of treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha], while the lowest (50988.07 INR/ha) net return was obtained with application of treatment 1 [Control] as compared to all other treatments.

3.2.3 Benefit-cost ratio (B:C)

The benefit Cost ratio (2.14) (Table 2) was found to be highest in treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] and the minimum benefit-cost ratio (1.53) was found to be in treatment-4 [*Rhizobium* + Molybdenum 1.5 kg/ha] as compared to all other treatments [12].

Table 1. Effect of Microbial inoculants and Molybdenum on yield of Chickpea

S. No.	Treatment combination	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
1.	Control (NPK 20-50-20 kg/ha)	1201.29	3045.85	28.28
2.	*Rhizobium* + Molybdenum 0.5 kg/ha	1441.67	3166.67	31.29
3.	*Rhizobium* + Molybdenum 1.0 kg/ha	1333.74	3098.00	30.10
4.	*Rhizobium* + Molybdenum 1.5 kg/ha	1411.36	3159.33	30.98
5.	PSB + Molybdenum 0.5 kg/ha	1317.78	3072.00	30.02
6.	PSB + Molybdenum 1.0 kg/ha	1341.64	3138.30	30.11
7.	PSB + Molybdenum 1.5 kg/ha	1418.25	3168.00	30.92
8.	*Rhizobium* + PSB + Molybdenum 0.5 kg/ha	1511.94	3267.00	31.55
9.	*Rhizobium* + PSB + Molybdenum 1.0 kg/ha	1638.35	3539.00	31.64
10.	*Rhizobium* + PSB + Molybdenum 1.5 kg/ha	1552.76	3454.00	31.01
	F-test	S	S	NS
	SEm(±)	41.15	95.67	0.91
	CD (p=0.05)	122.25	284.21	-

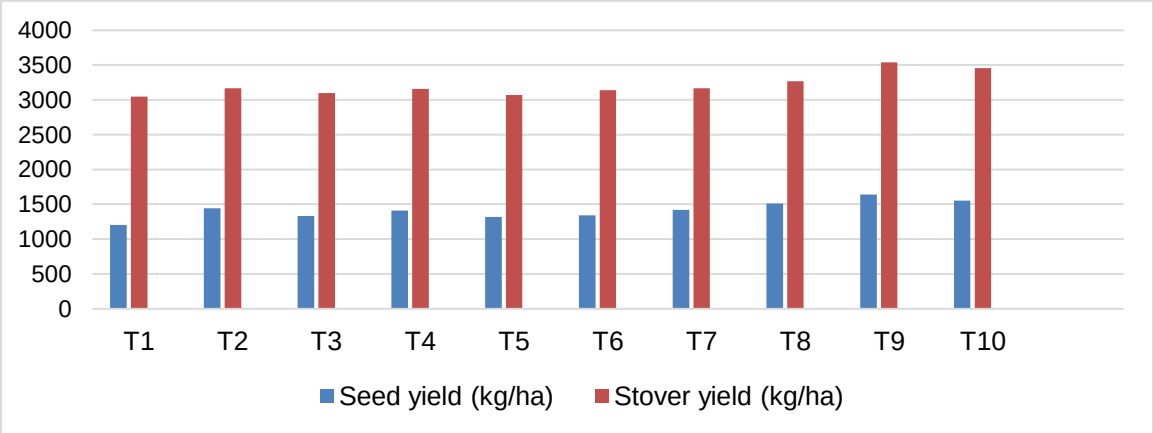

Fig. 1. Effect of Microbial inoculants and Molybdenum on yield of Chickpea

Table 2. Effect of microbial inoculants and molybdenum on economics of chickpea

S. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	Benefit: Cost ratio
1.	Control (N:P:K 20-50-20 kg/ha)	28330.00	79318.07	50988.07	1.79
2.	*Rhizobium* + Molybdenum 0.5 kg/ha	30986.00	92746.66	61760.66	1.99
3.	*Rhizobium* + Molybdenum 1.0 kg/ha	33482.00	86644.76	53162.76	1.59
4.	*Rhizobium* + Molybdenum 1.5 kg/ha	35978.00	91092.95	55114.95	1.53
5.	PSB + Molybdenum 0.5 kg/ha	31026.00	85663.66	54637.66	1.76
6.	PSB + Molybdenum 1.0 kg/ha	33482.00	87268.16	53786.16	1.61
7.	PSB + Molybdenum 1.5 kg/ha	36018.00	91503.79	55485.79	1.54
8.	*Rhizobium* + PSB + Molybdenum 0.5 kg/ha	31006.00	96997.13	65991.13	2.13
9.	*Rhizobium* + PSB + Molybdenum 1.0 kg/ha	33502.00	105101.20	71599.20	2.14
10.	*Rhizobium* + PSB + Molybdenum 1.5 kg/ha	35998.00	100109.81	64111.81	1.78

Rate of 1 kg Ammonium Molybdate- 2600/-, MSP of Chickpea: 5,335/q

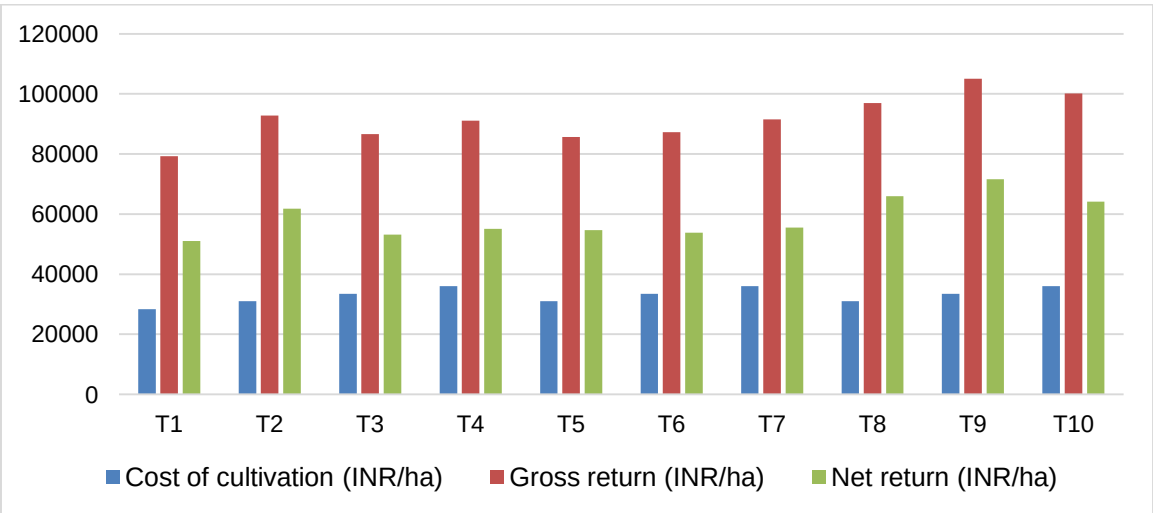

Fig. 2. Effect of microbial inoculants and molybdenum on economics of chickpea

4. CONCLUSION

From the results, it can be concluded that chickpeas with seed inoculation of *rhizobium* and PSB along with the soil application of Molybdenum 1.0 kg/ha recorded the highest seed yield, stover yield and Benefit: Cost ratio.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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