

Effects of Biofertilizer with and without Molybdenum on Growth and Seed Yield of Chickpea under Doon Valley of Uttarakhand

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Authors' contributions

Author GC designed the whole study, conducted the field work and data collection and performed the statistical analysis. Author LG wrote the first draft of manuscript and did the bio-fertilizers preparation.

Author RU helped in data collection, search and provide the literature to write manuscript. All three authors read and approved the final manuscript.

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ABSTRACT

The availability of micronutrients in the niche defines the growth and yield parameters of chickpea. The present study was conducted to investigate the effect of different levels of biofertilizer with and without molybdenum on growth and seed yield of chickpea, at Seed Production Block, SGRR University, Dehradun, Uttarakhand. The experiment included seven treatment groups replicated thrice in Randomized Block Design. It was observed that all growth and seed yield parameters varied significantly with the application of different levels of biofertilizers with or without molybdenum. The observed results showed that all the plant growth parameters like plant height (54.67 cm), number of primary branches (5.34/ plant), number of pods per plants (64.00), fresh weight of plant (81.66 g) were maximum with treatment T₆ (20 g Rhizobium+25 g PSB +0.3 g

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molybdenum/kg seeds). The number of nodules per plant (28.00) and 1000 seed weight (142 g) were recorded maximum with the application of treatment T₇ (25 g Rhizobium + 30 g PSB + 0.3 g molybdenum per kg of seeds). The seed yield of chickpea was recorded maximum (15.67 q/ha) with the application of 20 g Rhizobium along with 25 g PSB and 0.3 g molybdenum per kg of seeds (T₆). Thus, our findings indicate that, among all other treatments, the application of 20 g Rhizobium along with 25 g PSB and 0.3 g molybdenum per kg of seeds is suitable for higher seed yield of chickpea in Doon valley of Uttarakhand.

Keywords: Chickpea; biofertilizer; seed yield; rhizobium and molybdenum.

1. INTRODUCTION

Pulses are the second most important group of crops after cereals. Chickpea is a member of leguminosae family and was originated in southwest Asia. It plays an important role in sustaining soil productivity by improving its physical, chemical and biological properties. It further enhances soil nitrogen content by increased trapping of atmospheric nitrogen in their root nodules [1]. It is an important protein-rich grain legume cultivated in the world. Seed of chickpea contains essential amino acids like isoleucine, leucine, lysine, valine, and aniline. The protein in chickpea is highly digestible (70-90%) [2]. The highly nutritious crop chickpea seed contains about 18-22% protein, 61-62% carbohydrate, 4.5% fat, 280 mg/ 100 g calcium, 12.3 mg/ 100 g iron and phosphorus 301 mg/ 100 g [3]. India is the largest chickpea producing country in the world. It contributes about 70% in area and 67% in the production of the world. The major chickpea growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, and Bihar [4].

Biofertilizers are carrier based preparations containing beneficial microorganisms in the rhizosphere. Biofertilizers are the source of increasing the productivity and sustainability of the soil. The application of biofertilizers reduces the risk of soil acidification and contamination of the groundwater. Rhizobium inoculation, as biofertilizer, was shown to induce an increase in nodulation of roots, plant growth, seed yield (upto 35%) and nitrogen fixation in Chickpea [5]. The combined application of Rhizobium and phosphate solubilizing bacteria (PSB) also enhance nodulation, crop growth, seed protein and yield in chickpea. These biofertilizers play a vital role in nitrogen fixation and phosphate solubilization. Thus, biofertilizers have been recognized as eco-friendly nutrient enhancement system which further benefits the farmer by reducing the cost of production [6]. The chickpea crop which grown under under atmospheric

nitrogen fixation condition is more drought resistant that crop grown under inorganic nitrogen application [7]. The inoculation of seeds with biofertilizers is known to efficiently increase nodulation, nitrogen uptake, growth and yield parameters of chickpea.

Chickpea is valued in legumes as a source of protein, vitamins and minerals. It is being used in large proportion to overcome the protein limited food diet in Sub Saharan populations. WHO/FAO has recommended the use of chickpea for infants as carbohydrate and protein supplementation economically viable crop. Chickpea is mainly cultivated as a rainfed crop and the soils of these cultivable areas generally degraded with poor fertility. The availability of molybdenum in soil has been shown to enhance the production of leguminous crops. Molybdenum is required by legumes as a cofactor for enzymes involved in nitrogen fixation and metabolism. The availability of micronutrients is abundant in very low to medium acidic soil except molybdenum. It was found that each tonne of chickpea grain removes 1.5 g of molybdenum [8]. The present study was undertaken to investigate the potential of molybdenum to alter the potential of biofertilizers to enhance the seed yielding parameters of chickpea.

2. MATERIALS AND METHODS

2.1 Experimental Site

The present investigation was carried out during the rabi season of 2018-19 at Seed Production Block, SGRR University, Dehradun, Uttarakhand. The experimental site was situated at 30.316°N Latitude and 78.032°E Longitude with an average altitude of 450 m above sea level under subtropical and humid region of Dehradun. The soil of the experimental field was sandy loam to clay in texture containing a pH of 6.5.

2.2 Treatment Groups

The treatments comprise different levels of Rhizobium and PSB biofertilizer with and without

application of molybdenum used for seed treatment. There was a total seven treatments combinations *i.e.* T₁ (Control), T₂ (15 g Rhizobium + 20 g PSB/kg seed), T₃ (20 g Rhizobium + 25 g PSB/kg seeds), T₄ (25 g Rhizobium + 30 g PSB/kg seeds), T₅ (T₂ + Molybdenum 0.3 g/kg seeds), T₆ (T₃+ molybdenum 0.3 g/kg seeds) and T₇ (T₄+ molybdenum 0.3 g/k seeds), which replicated thrice in randomize block design.

2.3 Agronomic Practices

The different treatment solutions were prepared separately and mixed uniformly with seeds. After treatment, seeds were dried in the shade for few hours before sowing. The field was well prepared, cleaned and leveled before sowing. The Breeder seed of chickpea variety PG-186 was sown in lines at 30 cm×15 cm spacing on 16th November. All other agronomic packages of practices like weeding, irrigation, nipping etc. were used as per crop requirements.

2.4 Crop Parameters

The crop growth parameters like plant height (cm), number of primary branches per plant number of pods per plant, number of root nodules per plant and fresh weight of plant (g) were recorded in five randomly selected plants from each plot at physiological maturity stage. The crop was manually harvested in fully mature stage and threshed on a clean threshing floor. The seed yield per hectare and 1000 seed weight (g) were also calculated with each treatment. The average value of five selected plants were calculated for each parameter in each treatment and used for statistical analysis.

2.5 Statistical Analysis

The experimental data were statistically analyzed by analysis of variance (ANOVA) using the program SPSS. The significance of the treatment effect was determined using *F*-test. Multiple comparisons of mean value were performed using the least significant difference method (LSD).

3. RESULTS AND DISCUSSION

3.1 Plant Height

Mean comparisons of different treatment results have been shown in Table 1. It was observed that the plant height of chickpea was significantly

affected by different treatments. The maximum plant height at maturity was recorded (54.67 cm) with treatment T₆ (20 g Rhizobium+25 g PSB/kg seeds+ molybdenum 0.3 g/kg seeds) which was significantly higher compared to treatments T₇ (54.00 cm), T₅ (53.67 cm), T₄ (51.00 cm), T₃ (49.33 cm) and T₂ (49.00 cm). The minimum plant height was recorded (44.33 cm) with treatment T₁ (Control). It has been reported that inoculation of chickpea seed with both Rhizobium and PSB fix the atmospheric nitrogen in the root zone and make it available to plants. This results in enhancement of the stem height, root length and dry weight [9]. Significantly increased response in plant height of chickpea was observed when inoculated with Rhizobium and PSB [10]. As evident from the obtained results, the application of molybdenum along with Rhizobium and PSB enhanced the plant height indicating the significance of combinable application.

3.2 Number of Primary Branches

A higher number of branches in chickpea is an indication of the development of a higher number of pods per plant. The highest number of primary branches per plant was recorded (5.34) in plants that received the application treatment T₆ (20 g Rhizobium + 25 g PSB/kg seeds + molybdenum 0.3 g/kg seeds), which is 31% higher than control. The treatment T₆ which gave the maximum number of primary branches in chickpea plant is at par to treatments T₃ (5.33), T₄ (4.66), T₅ (4.00), and T₇ (4.90). The minimum number of primary branches was recorded (3.67) with treatment T₁ (control). The Rhizobium and PSB Bacteria had a beneficial effect on plant growth, because they fix atmospheric nitrogen and release auxins to the root zone to enhance growth [11].

3.3 Number of Pods per Plant

The average number of pods per plant was also significantly affected by the application of biofertilizers and molybdenum. The number of pods per plant was found highest (64.00) with treatment T₆ *i.e.*, Rhizobium (20 g/ kg seeds) + PSB (25 g/ kg seeds) + Molybdenum (0.3 g/ kg seeds) and lowest (48.00) with treatment T₁ (without application of biofertilizers and molybdenum). It might be due to a higher number of branches and plant height was also found with this treatment's application. The number of pods is significantly correlated with total pod and seed weights per plant and also with seed yield. Mekki and Amel [12] were also

Table 1. Effect of biofertilizers with and without application of molybdenum on growth and seed yield of chickpea

Treatments	Plant Height (cm)	Number of primary branches	Number of Pods/plant	Fresh weight of plant (g)	Number of root nodule per plant	Seed yield (q/ha)	1000 seed weight (g)
T ₁ (Control)	44.33	3.67	48.00	58.33	20.00	11.86	126
T ₂ (15 g Rhizobium+20 g PSB/kg seed)	49.00	3.68	55.33 ^a	66.67	22.00	12.3	135 ^a
T ₃ (20 g Rhizobium+25 g PSB/kg seeds)	49.33	5.33 ^a	58.33 ^a	75.00 ^a	22.67	12.20	136 ^a
T ₄ (25 g Rhizobium+30 g PSB/kg seeds)	51.00	4.66	61.00 ^a	70.33	23.15	13.34	136 ^a
T ₅ (T ₂ +Molybdenum 0.3 g/kg seeds)	53.67 ^a	4.00	62.67 ^a	63.67	23.67	13.66	139 ^a
T ₆ (T ₃ +molybdenum 0.3 g/kg seeds)	54.67 ^a	5.34 ^a	64.00 ^a	81.66 ^a	27.00a	15.67 ^a	141 ^a
T ₇ (T ₄ +molybdenum 0.3 g/k seeds)	54.00 ^a	4.90	62.00 ^a	78.67 ^a	28.00a	15.51 ^a	142 ^a
Cv	8.40	19.71	6.99	12.03	12.89	11.30	2.06
Cd (at 5%)	8.35	1.45	6.93	14.71	5.48	2.98	4.99

'a' refers to p≤0.05 compared with control

found that the number of pods per plant was increased by applying biofertilizer. It was also observed from the data that the combined effect of biofertilizers and molybdenum was very effective to increase the number of pods per plant. Kumari et al. [3] also observed a higher yield of chickpea yield with combined application of Zn, B, Mo and Rhizobium.

3.4 Fresh Weight of Plant (g)

Mean comparison of the treatment's effect show that plants with the treatment of Rhizobium (20 g/ kg seeds) + PSB (25 g/ kg seeds) with molybdenum (0.3 g/ kg seeds) gained maximum fresh plant weight *i.e.* 81.66 g than all other treatments. It can be easily observed that biofertilizer with molybdenum showed better results for fresh plant weight than sole biofertilizer application. The treatment T₆, which has maximum plant weight is statistically at par to the treatments T₇ (78.67 g/plant) T₄ (70.33 g/plant), T₃ (75.00 g/plant). The plants without treatment of biofertilizer and molybdenum *i.e.* T₁, showed minimum fresh plant weight (58.33 g/plant). The higher fresh weight of plants can be correlated to increased growth of plant due to combined effects of Rhizobium and PSB which provides an ease of nutrient rich niche in soil. These findings in the present investigation are also in agreement with the findings of Thenua et al. [13]. Praminik and Bera [14] also recorded higher stalk yield and harvest index in response to biofertilizer inoculations.

3.5 Number of Root Nodules per Plant

Plants from treated seeds with Rhizobium and PSB with molybdenum showed a significantly higher number of root nodules compared to control groups. It was also observed that the application of biofertilizers increased the number of root nodules in a dose dependent manner. The plants with treatment T₇ (Rhizobium 20 g/ kg seeds + PSB 25 g/ kg seeds + Molybdenum 0.3 g/ kg seeds) gave 28.57% higher number of root nodules than control (T₁). In combined inoculation the observed better nodulation may be due to increased phosphorus availability through PSB and enhanced biological N₂ fixation at root zones. Tagore et al. [15] showed that the inoculation with Rhizobium and PSB are most effective for higher nodules formation in chickpea roots. Singh et al. [16] also recorded significantly higher number of nodules after 30

days and 60 days of sowing with the seeds inoculated with Rhizobium + PSB in comparison to other.

3.6 Seed Yield

Mean comparison of treatments showed that the treatment containing Rhizobium (20 g/ kg seeds) + PSB (25 g/ kg seeds) + Molybdenum (0.3 g/ kg seeds) produced the highest seed yield *i.e.* 15.67 q/ ha among all other treatments. This highest seed yield was estimated to be 24.31% higher than the control treatment (T₁) *i.e.* 11.86 q/ha. It was also revealed from the data that the application of Rhizobium + PSB + molybdenum (which gave maximum yield *i.e.* treatment T₆) produced 14.86% higher seed yield than the application of only Rhizobium + PSB (treatment T₄), however, the increase was not significant. The addition of biofertilizer promotes bacterial response to nitrogen fixation and soil fertility. Higher rates of nitrogen fixation promote plant growth and assimilation of dry matter which results in better seed yield [17]. Gupta and Namdeo [18] showed that the inoculation of seeds with *Rhizobium* increased the yield of chickpea seeds by 9.6-27.9%. Khaitov and Abdiev [19] were observed that the seeds of chickpea inoculated with Rhizobium were significantly superior in yield over control treatments at all nitrogen fertilizer application rates. PSB might have helped to provide unavailable phosphorus from the soil that leads to more uptakes of nutrients and reflects better growth [10]. Singh et al. [16] also observed, significantly higher yield of chickpea with the application of microbial inoculants (Rhizobium + PSB).

3.7 1000 Seed Weight

The biofertilizer exerted a significant effect on the test weight of chickpea seed. Combined inoculation of Rhizobium (25 g/ kg seeds) + PSB (30 g/ kg seeds) + Molybdenum (0.3 g/ kg seeds) *i.e.* treatment T₇ showed maximum test weight of seed (142 g) and minimum test weight was observed with treatment T₁ *i.e.* 126 g. The obtained maximum value of test weight was statistically at par to treatment T₆ (141 g) and T₅ (139 g). A similar type of results was also reported by Praminik and Singh [20]. Tagore et al. [15] recorded a significantly higher 1000 seed weight of chickpea with the application of Rhizobium and PSB over no use of these biofertilizers.

4. CONCLUSION

Biofertilizers have been known to increase the biodiversity of the soil thereby increasing the nutrient availability in the niche and fertility in the soil. The present study highlights the importance of micronutrient, molybdenum, in synergistically enhancing the productivity of chick pea. Seed treatment with the combinatorial application of Rhizobium, PSB and molybdenum enhanced the crop yield as evident from crop yield parameters. Based on the experimental results, it can be concluded that the seed treatment with Rhizobium (20 g/ kg seeds) + PSB (25 g/ kg seeds) + Molybdenum (0.3 g/ kg seeds) shall be considered as the potent combination among all the treatment groups to obtain higher growth and seed yield of chickpea in Dun valley of Uttarakhand.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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