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Evaluate the Growth and Yield of Chickpea Influenced by Biofertilizers and Molybdenum on Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Evaluate the growth and yield of chickpea influenced by Biofertilizers and Molybdenum on Chickpea (*Cicer arietinum* L.)" was conducted during *rabi,* 2022 at Crop Research Farm in the Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh. The experiment was layout in Randomized Block Design (RBD). The treatment consisted of three levels of Biofertilizer (*Rhizobium*, PSB and *Rhizobium* + PSB), Molybdenum (0.5, 1.0 and 1.5 kg/ha) and control. 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). Seeds are sown at a spacing of 30 × 10 cm to a seed rate of 80 kg/ha. The application of *Rhizobium* + PSB and

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Molybdenum 1.0 kg/ha significantly increased the Plant height (49.90 cm), No. of nodules/plant (32.60), Dry weight (35.33 g), Number of Pods/plant (60.20), Number of seeds/pod (1.80), Seed yield (1638.35 kg/ha) and Stover Yield (3539 kg/ha) of chickpea over the control.

Keywords: Chickpea; rhizobium; PSB; molybdenum; nodulation; growth; yield; seed treatment; quality.

1. INTRODUCTION

"India is largest pulse-growing country which accounts for nearly one-third of the total world area under pulses and one-fourth of the total world production. The English word pulse is taken from the Latin *puls*, meaning pottage or thick pap. Pulse is an important source of protein" [1]. "These food legumes have been grown by farmers since millennia providing nutritionally balanced food to the people of India [2] and many other countries in the world. The major pulse crops those have been domesticated and are under cultivation are black gram, chickpea, cowpea, mung bean, lentil, moth bean, pea and pigeon pea etc". Chickpea (*Cicer arietinum* L.) belongs to family *fabaceae* originated in south-eastern turkey and derived from the greek word '*kikus*' meaning force or strength. Chickpea is known by various name in different countries like- *garbanzo* (Spanish), *pois chiche* (French), *kichar* or *chicher* (German), *chana* (Hindi) and gram or bengal gram (English). In some countries of world (Turkey, Romania, Bulgaria, Afghanistan) it is also called '*nakhut'* or '*nohut'*.

"In addition to being used to make a range of snacks, sweets, and sauces that are extremely beneficial for stomach illnesses and blood cleansing, gramme is primarily consumed in the form of processed whole seed and dal. The primary source of high quality and nutritional value of livestock feed is pulses and their crop wastes. Chickpea contains 18-22 per cent protein, 52-70 per cent carbohydrate, 4-10 per cent 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". "Many legumes have the ability to form nitrogen (N_2) fixing root nodules with soil bacteria called rhizobia [5] and thus contribute to biological nitrogen fixation".

"During 2020-21, chickpea a had a lion's share of 49.3% in the total pulses production. In India chickpea area 9.85 million hectare, with 11.99 MT production and 1217 kg/ha productivity in 2020-2021" [6].

"By supplying crops with more nutrients and growth stimuli, biofertilizers can colonise the rhizosphere and encourage development. In order to feed the plant with nitrogen and phosphorus and enable the application of nitrogen and phosphate fertilisers in a sustainable manner, nitrogen fixer and phosphate solubilizing bacteria are crucial" [7]. "Zinc (Zn), Boron (B) and Molybdenum (Mo) are the most important micronutrients, as they perform several physiological functions in the plant to cause adequate infection for good nodulation, N_2 -fixation and growth of the crop. Numerous studies revealed the importance of applying micronutrients wherever they are lacking when cultivating legumes intensively because they are directly involved in biological nitrogen fixation through the activity of the nitrogenase enzyme" [8].

The cheapest source to improve P availability, particularly in legumes, which increases agricultural yield, has been identified as phosphorus solubilizing bacteria (PSB). The PSB possess the ability to bring sparingly soluble inorganic or organic phosphates into soluble form by secreting organic acids. In soils with a high organic matter content but little accessible phosphorus, phosphobacterin is present. A crucial characteristic in sustainable farming for boosting plant yields is PSB capacity to transform insoluble forms of P into an accessible form.

"In order to maintain the optimal yield level, it is frequently advised to apply inadequate micronutrients. Micronutrient deficit causes a large yield loss in chickpea" [9]. "Among the micronutrients, Mo deficiency affects crop growth and yield of grain legumes including chickpea" [10]. "Because it is an essential component of the enzymes nitrate-reductase, nitrogenase, xanthine-reductase, and SO_3-oxidase, molybdenum (Mo) plays a crucial role in critical processes such nitrogen metabolism, nitrogen-fixation and the transportation of sulfur-containing amino acids in legumes" [11]. "Particular to chickpea, Mo deficiency causes deep chlorosis of old leaflets [12], abnormality in the reproductive physiology like reduction in flower number and size and many flowers fail to open or to mature" [10].

Keeping in the view the above facts, the present experiment was to undertaken to find out "Evaluate the growth and yield of chickpea influenced by Biofertilizers and Molybdenum on Chickpea (*Cicer arietinum* L.)".

2. MATERIALS AND METHODS

This experiment was laid out during the *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 250 39" 42" N latitude, 810 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 *Rhizobium* and Molybdenum with ten treatments and each was replicated thrice. The recommended dose of Nitrogen (20 kg/ha), Phosphorus (50 kg/ha) and Potassium (20 kg/ha) and *Rhizobium* and Molybdenum were applied as per the treatments. Data recorded on different aspects of crop, *viz*., growth, yield attributes were subjected to statistically analysis by analysis of variance method and economic data analysis mathematical method.

2.1 Treatment Combination

1. Control (N:P:K 20-50-20 kg/ha)
2. *Rhizobium* + Molybdenum 0.5 kg/ha
3. *Rhizobium* + Molybdenum 1.0 kg/ha
4. *Rhizobium* + Molybdenum 1.5 kg/ha
5. PSB + Molybdenum 0.5 kg/ha
6. PSB + Molybdenum 1.0 kg/ha
7. PSB + Molybdenum 1.5 kg/ha
8. *Rhizobium* + PSB + Molybdenum 0.5 kg/h
9. *Rhizobium* + PSB + Molybdenum 1.0 kg/ha
10. *Rhizobium* + PSB + Molybdenum 1.5 kg/ha

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

At 80 DAS, significantly and higher plant height (49.90 cm) was recorded in treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] as compare to the rest of the treatment. However, the treatment-10 [*Rhizobium* + PSB+ Molybdenum 1.5 kg/ha] (48.63 cm) was found to be statistically at par with treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha]. "Significant increase in plant height with *Rhizobium* and PSB might be due to increase in uptake of N and P by the plants, which might be due to more N-fixation and P-solubilization through micro-organisms" [13]. Further increase Mo led to a rise in plant height, which may have been caused by improved chlorophyll development, which in turn improved photosynthesis and increased yield. Results were similar to Sarmad Iqbal et al., [14].

3.1.2 Number of nodules/plant

Significantly maximum number of nodules/plant (32.60) was recorded in treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] which was superior over all treatments. However, treatment-10 [*Rhizobium* + PSB + Molybdenum 1.5 kg/ha] (31.67), treatment-4 [*Rhizobium* + Molybdenum 1.5 kg/ha] (31.20), treatment-7 [PSB + Molybdenum 1.5 kg/ha] (30.67) was found to be statistically at par with treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha]. "Iron and Molybdenum significantly enhanced nodules number in legumes crops" [15]. The number of nodules and fresh and dry weight of nodules/plant were significantly increased after PSB and *Rhizobium* inoculation due to the nitrogenase enzyme that is present in the bacterium and is introduced through infection. Similar findings have also been reported by Yadav et al., [16], Bhuiyan et al., [17] and Swarnkar et al., [18].

3.1.3 Plant dry weight (g)

Significantly maximum plant dry weight (35.33 g) was recorded in treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] which was superior over all other treatments. However, the treatment-10 [*Rhizobium* + PSB + Molybdenum 1.5 kg/ha] (34.35 g), treatment-8 [*Rhizobium* + PSB + Molybdenum 0.5 kg/ha] (34.28 g), treatment-4 [*Rhizobium* + Molybdenum 1.5 kg/ha] (33.76 g), treatment-7 [PSB + Molybdenum 1.5 kg/ha] (33.47 g) and treatment 6 [PSB + Molybdenum 1.0 kg/ha] (33.01) is statistically at par with treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] in (Table 1). Significant increase in plant dry weight with inoculation of *Rhizobium* and PSB along with soil application of Molybdenum at 1.0 kg/ha increased the availability of nutrients like N and P. Increased physiological processes such cell division, elongation and meristematic tissue creation resulted from the availability of more nutrients, which enhanced growth characteristics and dry matter production. Similar results have also been reported by Karwasra [19], Chaudhary et al. [20].

3.1.4 Number of pods/plant

At Harvest Treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] was recorded significantly maximum number of pods/plant (60.29) which was superior over all other treatments. However, the treatment- 10 [*Rhizobium* + PSB + Molybdenum 1.5 kg/ha] (58.47), treatment-8 [*Rhizobium* + PSB + Molybdenum 0.5 kg/ha] (57.00), treatment-5 [PSB + Molybdenum 0.5 kg/ha] (56.13) and treatment-7 [PSB + Molybdenum 1.5 kg/ha] (55.60) was found to be statistically at par with the treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha]. (Table 2) It might be because Molybdenum is used more effectively, increasing yield qualities. [21]. These results are supported by Khan et al. [22], they resulted that application of Molybdenum improved number of pods/plant.

3.1.5 Number of seeds/pod

At Harvest Treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] was recorded a significant and the maximum number of seeds/pod which was superior over all other treatments. However, the treatment-10 [*Rhizobium* + PSB + Molybdenum 1.5 kg/ha] (1.67) and treatment-8 [*Rhizobium* + PSB + Molybdenum 0.5 kg/ha] (1.60) was found to be statistically at par with the treatment-9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha] (Table 2). Significantly increase in number of seeds/pod probably may be due to balanced nutrition and proper vegetative growth which later converted into reproductive phase and resulted might in more number of seeds. The results were similar to Venkatesh et al. [23].

Table 1. Evaluate of biofertilizer and molybdenum on growth of chickpea

S. No.	Treatment combinations	At 80 DAS		
		Plant height (cm)	No. of Nodules/plant	Dry weight (g/plant)
1.	Control (NPK 20-50-20 kg/ha)	39.79	23.60	29.96
2.	*Rhizobium* + Molybdenum 0.5 kg/ha	41.56	27.13	32.82
3.	*Rhizobium* + Molybdenum 1.0 kg/ha	46.44	26.40	31.74
4.	*Rhizobium* + Molybdenum 1.5 kg/ha	44.47	31.2	33.76
5.	PSB + Molybdenum 0.5 kg/ha	42.35	25.27	32.01
6.	PSB + Molybdenum 1.0 kg/ha	45.94	28.27	33.01
7.	PSB + Molybdenum 1.5 kg/ha	43.71	30.67	33.47
8.	*Rhizobium* + PSB + Molybdenum 0.5 kg/ha	45.59	28.8	34.28
9.	*Rhizobium* + PSB + Molybdenum 1.0 kg/ha	49.9	32.6	35.33
10.	*Rhizobium* + PSB + Molybdenum 1.5 kg/ha	48.63	31.67	34.35
	F-test	S	S	S
	SEm(±)	1.38	0.83	0.98
	CD (p=0.05)	4.11	2.46	2.92

Table 2. Evaluate of biofertilizer and molybdenum on yield attributes of chickpea

S. No.	Treatment combination	Number of pods/plant	Number of seeds/pod	Test weight (g)
1.	Control (NPK 20-50-20 kg/ha)	51.53	1.27	216.75
2.	*Rhizobium* + Molybdenum 0.5 kg/ha	52.40	1.33	226.55
3.	*Rhizobium* + Molybdenum 1.0 kg/ha	52.73	1.33	218.53
4.	*Rhizobium* + Molybdenum 1.5 kg/ha	53.80	1.40	222.69
5.	PSB + Molybdenum 0.5 kg/ha	56.13	1.40	227.58
6.	PSB + Molybdenum 1.0 kg/ha	54.80	1.47	232.62
7.	PSB + Molybdenum 1.5 kg/ha	55.60	1.40	234.25
8.	*Rhizobium* + PSB + Molybdenum 0.5 kg/ha	57.00	1.60	235.7
9.	*Rhizobium* + PSB + Molybdenum 1.0 kg/ha	60.20	1.80	238.04
10.	*Rhizobium* + PSB + Molybdenum 1.5 kg/ha	58.47	1.67	237.55
	F-test	S	S	NS
	SEm(±)	1.59	0.10	5.95
	CD (p=0.05)	4.73	0.29	-

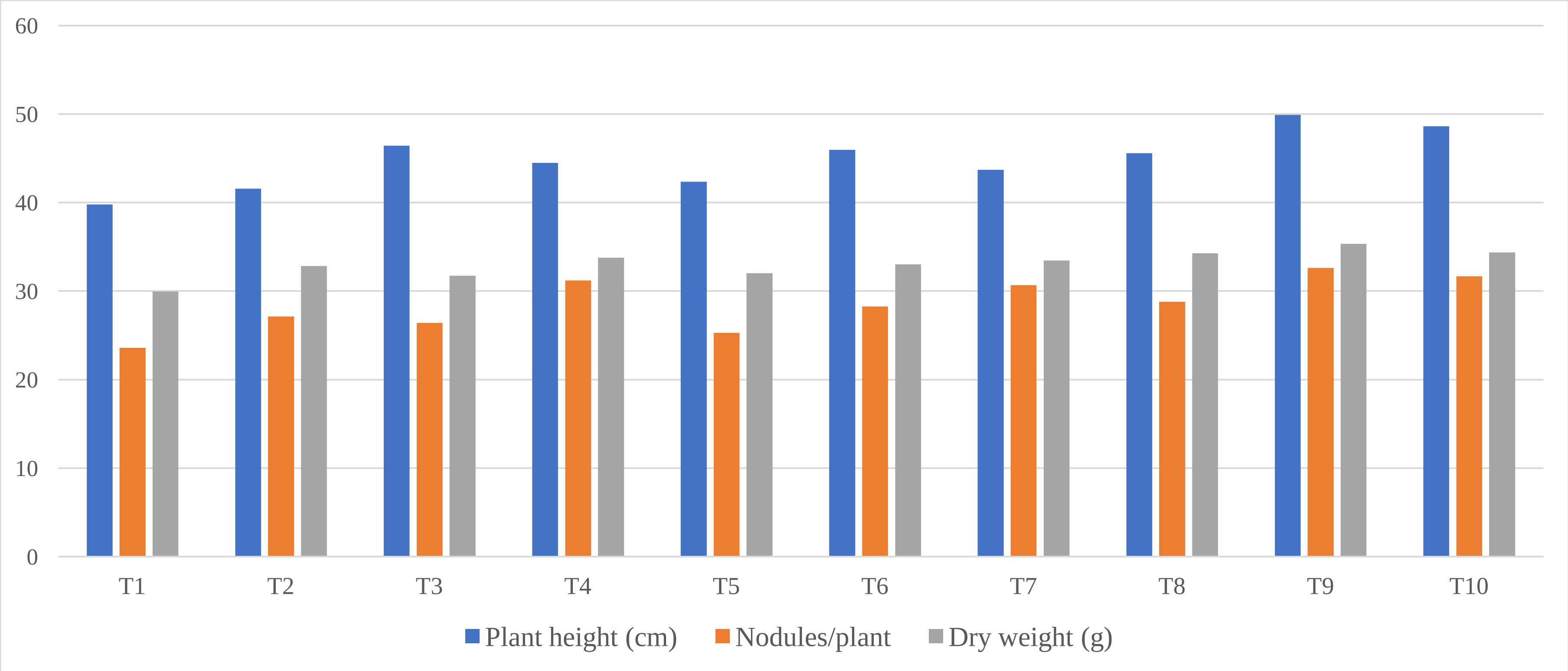

Fig. 1. Evaluate of biofertilizer and molybdenum on plant height, nodules/plant and dry weight on chickpea

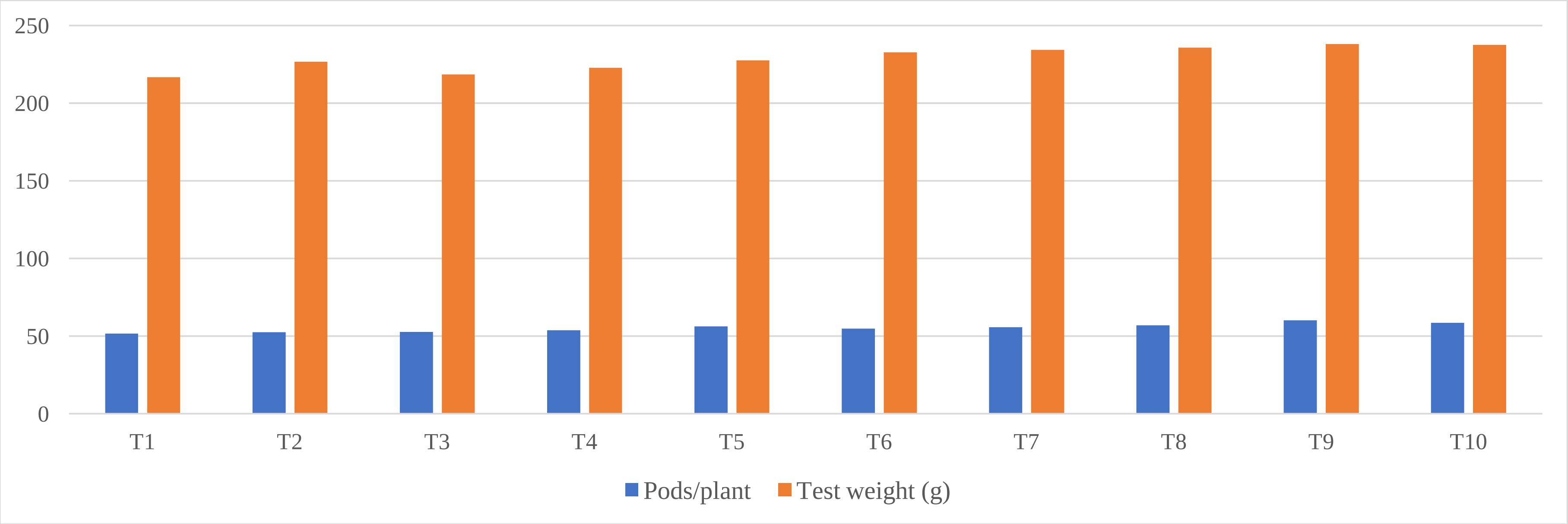

Fig. 2. Evaluate of biofertilizer and molybdenum on pods/plant and test weight on chickpea

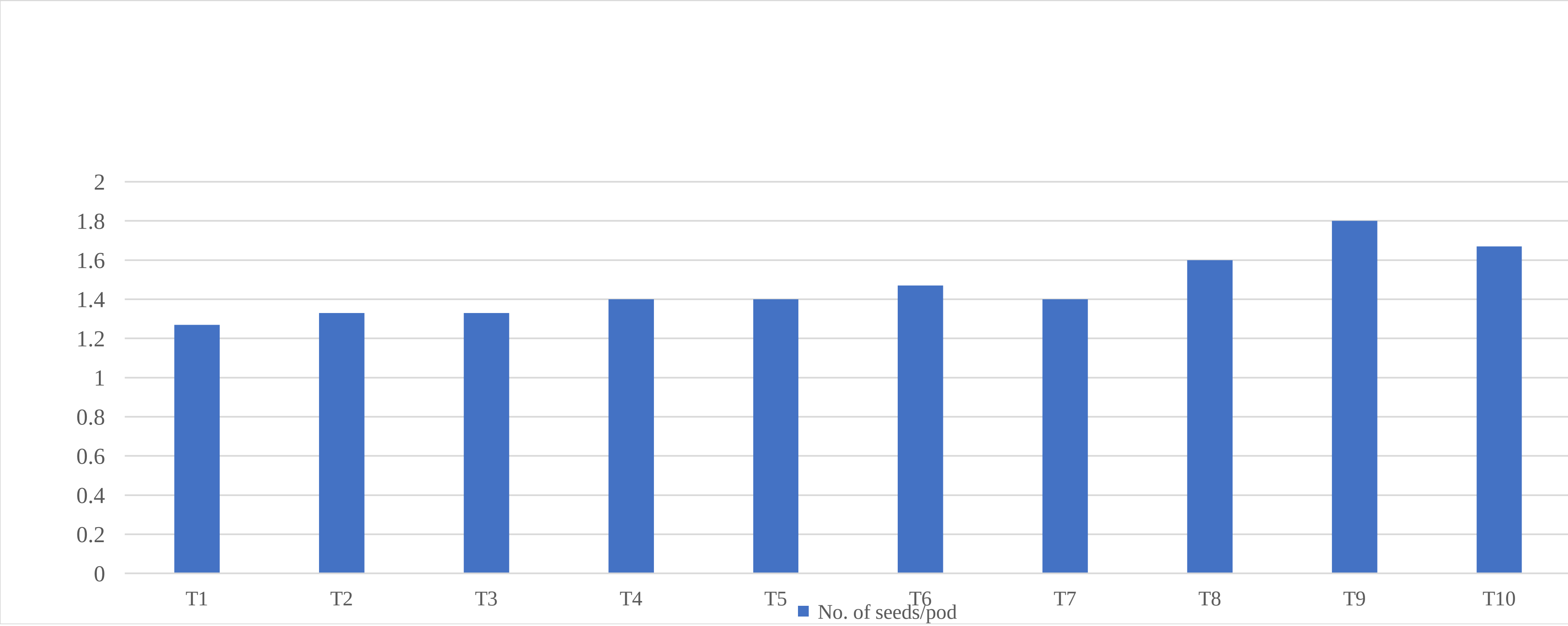

Fig. 3. Evaluate of biofertilizer and molybdenum on number of seeds/pod on chickpea

3.1.6 Test weight (g)

The data apparent highest test weight (238.04 g) was recorded in treatment 9 [*Rhizobium* + PSB + Molybdenum 1.0 kg/ha], through there was no significant difference among the treatment (Table 2).

4. CONCLUSION

From the present study it can be concluded that foe better crop growth and productivity of chickpea, seeds should be inoculated with *rhizobium* (10 g/kg seed) and PSB (10 g/kg seed) along with soil application of molybdenum 1.0 kg/ha was recorded highest growth and yield parameters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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