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Effect of molybdenum seed treatment on yield and economics of Chickpea (*Cicer arietinum* L.)

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Abstract

The on-farm trials were conducted during two consecutive Yasangi (Rabi) seasons, 2021–22 and 2022–23, in chickpea growing farmers fields of the erstwhile Mahabubnagar district to evaluate the effect of molybdenum application on yield and economics of chickpea (*Cicer arietinum* L.). The experiment comprised four treatments, viz., farmer's practice (T₁), recommended dose of fertilizers (RDF: 20-50-20-20 kg NPKS ha⁻¹) (T₂), RDF + seed treatment with sodium molybdate @ 1.0 g kg⁻¹ seed (T₃), and RDF + soil application of ammonium molybdate @ 1.0 kg ha⁻¹ (T₄). The results revealed that molybdenum application significantly improved chickpea yield and profitability over farmers practice and RDF alone. Among the treatments, T₃ recorded the highest seed yield (2267 kg ha⁻¹), net returns (₹94,861 ha⁻¹), and benefit cost ratio (2.98), followed by T₄ and T₂. Seed treatment with sodium molybdate proved more effective and economical than soil application due to its lower cost and higher efficiency. The study concludes that molybdenum seed treatment along with RDF is a promising strategy for enhancing productivity and profitability of chickpea under semi-arid conditions of Telangana.

Keywords: Chickpea, molybdenum, seed treatment, seed yield, economics

1. Introduction

Chickpea (*Cicer arietinum* L.), commonly known as Bengal gram, is an important pulse crop in India and plays a vital role in nutritional security as a major source of dietary protein. India is the largest producer and consumer of chickpea in the world, cultivating it over an area of about 10–11 million hectares with a production of approximately 11–12 million tonnes during 2023–24. Despite its significance, the average productivity remains moderate (around 1000–1100 kg ha⁻¹), mainly due to its cultivation under residual soil moisture conditions, imbalanced nutrient management, and limited adoption of improved agronomic practices (Ministry of Agriculture & Farmers Welfare, 2024) [9].

Telangana is one of the important chickpea growing states, with a considerable area under cultivation particularly during rabi season. The crop is predominantly grown in rainfed *Vertisols* and *Alfisols*, where soil moisture stress and micronutrient deficiencies, especially of zinc and molybdenum, often limit productivity. (Directorate of Economics and Statistics Telangana, 2024) [3].

Molybdenum (Mo) is an essential micronutrient required in trace amounts for plant growth, particularly in leguminous crops like chickpea (*Cicer arietinum* L.), where it plays a crucial role in biological nitrogen fixation and nitrogen metabolism. It is a key component of important enzymes

such as nitrogenase and nitrate reductase, which facilitate atmospheric nitrogen fixation and its assimilation in plants. Deficiency of molybdenum is commonly observed in light textured, acidic to neutral soils and even in alkaline soils where its availability becomes limited due to soil chemical interactions, thereby adversely affecting nodulation, growth, and yield of chickpea. Application of molybdenum, especially through seed treatment, ensures its immediate availability to germinating seedlings, resulting in enhanced root development, effective nodulation, and improved nitrogen fixation efficiency (Tisdale *et al.* 1993 and Brady and Weil 2017) [15,1].

Seed treatment with molybdenum has been found to be a cost-effective and efficient method of micronutrient application compared to soil application, as it requires smaller quantities and ensures uniform distribution. Sodium molybdate (Na₂MoO₄·2H₂O) and ammonium molybdate [(NH₄)₆Mo₇O₂₄·4H₂O] are commonly used sources of molybdenum (Mo) for agricultural applications due to their high solubility and availability to plants. Sodium molybdate contains approximately 39% Mo and is widely used for seed treatment, as it ensures uniform coating of seeds and provides an immediate supply of molybdenum during germination and early seedling growth. In contrast, ammonium molybdate contains a higher molybdenum concentration (about 54% Mo) and is generally applied to

the soil, where it gradually becomes available to plants. Similar observations were reported by Marschner (2012)^[8], who emphasized the essential role of molybdenum in enzyme activation and nitrogen metabolism in plants. Gupta and Lipsett (1981)^[6] also highlighted the importance of molybdenum in legume nutrition and its improved efficiency when applied in small quantities through seed treatment. Further, Togay *et al.* (2008)^[16] reported enhanced nodulation and yield in chickpea with molybdenum fertilization, while Chandra *et al.* (2020)^[2] found that seed-applied molybdenum significantly improved crop growth and productivity due to better nutrient uptake and biological nitrogen fixation. Therefore, molybdenum seed treatment emerges as a promising agronomic practice to improve chickpea productivity, particularly under conditions of micronutrient deficiency, by enhancing nitrogen fixation, nutrient use efficiency, and overall crop performance.

2. Materials and Methods

The on-farm trials were conducted during two consecutive Yasangi (*Rabi*) seasons, 2021–22 and 2022–23, in chickpea-growing farmers' fields of the erstwhile Mahabubnagar district. The experiment was carried out using chickpea (*Cicer arietinum* L.) variety JG 11 under field conditions. The study comprised four treatments, viz., T₁: farmer's practice (45-115-0 kg NPK ha⁻¹), T₂: recommended dose of fertilizers (RDF: 20-50-20-20 kg NPKS ha⁻¹), T₃: RDF + seed treatment with sodium molybdate @ 1.0 g kg⁻¹ seed, and T₄: RDF + soil application of ammonium molybdate @ 1.0 kg ha⁻¹. The treatments were evaluated under on-farm conditions to assess the effect of molybdenum application on crop performance and economics of chickpea. Standard agronomic practices were followed uniformly for all treatments except for the imposed nutrient management practices.

The initial soil of the experimental field was characterized as slightly alkaline in reaction with a pH of 8.12 and non-saline in nature, as indicated by a low electrical conductivity of 0.428 dS m⁻¹. The soil contained medium organic carbon (0.48%), suggesting moderate soil fertility status. The available nitrogen content (175 kg ha⁻¹) was in the low range, while available phosphorus (64.86 kg ha⁻¹) and potassium (378 kg ha⁻¹) were categorized under medium to high levels, indicating a relatively balanced supply of major nutrients except nitrogen. The available molybdenum content was very low (0.06 mg kg⁻¹), which may limit biological nitrogen fixation and crop productivity, thereby justifying the need for molybdenum supplementation in chickpea cultivation under these soil conditions. Similar observations on alkaline soils with low molybdenum availability affecting legume productivity were reported by Gupta and Lipsett (1981)^[6]. Further, Tisdale *et al.* (1993)^[15] emphasized that nitrogen deficiency in soils with moderate organic carbon necessitates external nutrient supplementation for optimum crop growth. The role of molybdenum in enhancing nitrogen fixation in deficient soils has also been highlighted by Marschner (2012)^[8], who reported that even trace deficiencies of molybdenum can significantly reduce enzyme activity and legume productivity.

Observations were recorded on seed yield and growth parameters. The cost of cultivation, gross returns, and net returns were computed based on prevailing input and output prices. The benefit-cost (B:C) ratio was calculated as the

ratio of gross returns to cost of cultivation. The experimental data were subjected to analysis of variance (ANOVA) appropriate for a split-plot design as described by Panse and Sukhatme (1985)^[10]. Standard error of mean (SEm±) and critical difference (CD) values were calculated for comparison of treatment means (Gomez and Gomez, 1984)^[4].

3. Results and Discussion

The pooled data on yield and economics of chickpea as influenced by molybdenum application revealed significant variation among treatments.

3.1 Yield Performance

Among all treatments, seed treatment with sodium molybdate (T₃) recorded the highest seed yield (2267 kg ha⁻¹), followed by soil application of ammonium molybdate (T₄: 2136 kg ha⁻¹) and RDF (T₂: 2073 kg ha⁻¹), while the lowest yield was observed under farmer's practice (T₁: 1867 kg ha⁻¹). The increase in yield under molybdenum treatments may be attributed to its vital role in nitrogen metabolism and symbiotic nitrogen fixation, leading to improved nodulation, growth, and yield attributes (Table 1). The superiority of seed treatment over soil application indicates better early availability of molybdenum to seedlings, enhancing root development and nodule formation. Similar findings were reported by Shil *et al.* (2008)^[13], who observed significant improvement in chickpea yield and nodulation due to molybdenum application. Likewise, Chandra *et al.* (2020)^[2] reported that seed treatment of molybdenum in combination with biofertilizers enhanced growth and yield attributes through improved biological nitrogen fixation. Shahana *et al.* (2025)^[11] reported the advantages of molybdenum seed treatment in soybean.

Further, studies have shown that molybdenum acts as a cofactor of enzymes like nitrogenase and nitrate reductase, thereby improving nitrogen assimilation and ultimately yield. Gupta and Gangwar (2010)^[5] reported that molybdenum application significantly enhanced nitrogen fixation and grain yield in chickpea. Similarly, Togay *et al.* (2008)^[16] observed a 13–17% increase in yield with molybdenum fertilization over control. Enhanced yield due to micronutrient interactions involving molybdenum was also reported by Kumar *et al.* (2012)^[7].

3.2 Economics

Economic analysis indicated that T₃ (seed treatment with sodium molybdate) recorded the highest net returns (₹94,861 ha⁻¹) and B:C ratio (2.98), followed by RDF (T₂) with net returns of ₹82,639 ha⁻¹ and B:C ratio of 2.72 (Table 2). Although soil application of ammonium molybdate (T₄) improved yield over farmer's practice, its higher cost of cultivation (₹49,760 ha⁻¹) resulted in comparatively lower net returns (₹84,808 ha⁻¹) and B:C ratio (2.70).

The higher profitability of seed treatment may be due to its low cost and higher efficiency, making it a more economical method of micronutrient application. Similar findings were reported by Singh *et al.* (2014)^[14], who concluded that seed-applied molybdenum is more economical than soil application due to reduced input cost and higher marginal returns. The enhanced profitability of molybdenum seed treatment in soybean reported by Shahana *et al.* 2023^[12].

Table 1: Yield and Economics of chickpea influenced molybdenum seed treatment (Pooled over 2 years)

S. No.	Treatment	Yield (kg ha ⁻¹)	Economics		
			COC (Rs.)	Net returns (Rs.)	B:C ratio
T ₁	Farmer's practice	1867	43,556	74,065	2.70
T ₂	RDF (20:50:20:20 kg NPKS ha ⁻¹)	2073	47,960	82,639	2.72
T ₃	1.0 g Sodium molybdate per kg seed as seed treatment	2267	47,960	94,861	2.98
T ₄	1.0 kg Ammonium molybdate per hectare as soil application	2136	49,760	84,808	2.70

**Fig 1:** Overall view of the on farm trials

4. Conclusion

The results clearly demonstrated that, the molybdenum application significantly improved chickpea productivity and profitability. Seed treatment with sodium molybdate proved superior over soil application and RDF alone, indicating that small quantities of micronutrients applied at the seed level can produce substantial yield and economic benefits.

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