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Effect of boron and molybdenum on growth and yield of groundnut (*Arachis hypogaea* L.)

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Abstract

The present investigation was conducted to evaluate the effect of Boron and Molybdenum application on the growth, yield, and nutrient uptake of groundnut (*Arachis hypogaea* L.) during the *Rabi* season (Jan to May). The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications, using the groundnut variety “Kadiri Lepakshi K1812”. The treatments are T₁: 100% RDN + Soil Application of Boron @ 5 kg/ha, T₂: 75% RDN + Soil Application of Boron @ 5 kg/ha, T₃: 100% RDN + Soil Application of Molybdenum @ 5 kg/ha, T₄: 75% RDN + Soil Application of Molybdenum @ 5 kg/ha, T₅: 100% RDN + Foliar Application of Boron @ 0.5%, T₆: 75% RDN + Foliar Application of Boron @ 0.5%, T₇: 100% RDN + Foliar Application of Molybdenum @ 0.3%, T₈: 75% RDN + Foliar Application of Molybdenum @ 0.3%, T₉: Control 100% RDN (25:50:75 kg/ha). The study revealed significant impact among treatments with respect to plant height, number of branches, yield attributes (pegs, pods and matured pods), and final pod yield. Among all the treatments, foliar application of Boron at 0.5% along with 100% RDN (T₅) registered the highest plant height (46.50 cm), number of branches per plant (31.93), number of pegs per plant (70.92), number of pods per plant (44.84), number of matured pods per plant (43.02), and pod yield (2268.98 kg/ha). This was closely followed by T₇ (100% RDN + Foliar Application of Molybdenum @ 0.3%), which also exhibited superior growth and yield attributes like pegs, pods, etc. Foliar applications generally outperformed soil applications, indicating better nutrient absorption and physiological response. Treatments receiving 100% RDN consistently showed better results compared to 75% RDN combinations, highlighting the importance of adequate nitrogen supply for optimal crop performance. The control (T₉), which received only 100% RDN without any micronutrient supplementation, recorded the lowest statistical values in all measured parameters, emphasizing the essential role of micronutrients in groundnut productivity. The findings underscore the importance of integrated nutrient management, particularly the use of foliar micronutrient application, to enhance crop yield and improve economic returns in legume cultivation.

Keywords: Groundnut, boron, molybdenum, Kadiri Lepakshi K1812

Introduction

Groundnut (*Arachis hypogaea* L.) is a vital oilseed legume grown extensively in tropical and subtropical regions of the world. In India, it holds a pivotal role in oilseed production and rural livelihoods, particularly in rainfed Agro-ecosystems. Its economic significance lies not only in its oil-rich seeds (comprising approximately 45-50% oil and 25-30% protein) but also in its contribution to sustainable agriculture through biological nitrogen fixation, which enhances soil fertility (Revoredo & Fletcher, 2002) [14]. The groundnut kernel is highly nutritious, containing about 20% carbohydrates, 25-30% protein, 50% oil, and 5% fiber and ash. The oil is rich in unsaturated fatty acids such as oleic (50-65%) and linoleic acid (18-30%), which contribute to its high dietary value. Groundnut proteins also contain essential amino acids, including cysteine, which are critical for animal and human health.

Despite its agronomic and nutritional value, achieving optimal productivity in groundnut remains a challenge due to various abiotic and biotic constraints, particularly micronutrient deficiencies. Coarse-textured, sandy, and intensively cultivated soils common in groundnut-growing regions are often deficient in essential micronutrients such as boron (B) and molybdenum (Mo), which limits the crop's potential yield (Ramesh *et al.*, 2018; Movalia *et al.*, 2020) [12, 8]. Boron and molybdenum are crucial for various physiological and biochemical

processes in legumes. Boron plays a vital role in cell wall formation, pollen tube elongation, flower retention, and seed development (Kumar & Umesha, 2023) ^[6]. Molybdenum, on the other hand, is a key component of the enzymes nitrogenase and nitrate reductase, which are essential for nitrogen assimilation and biological nitrogen fixation (Latha & Dawson, 2023) ^[7]. Their roles are especially critical in legumes like groundnut, where symbiotic nitrogen fixation by *Rhizobium* is fundamental for crop productivity (Haneena *et al.*, 2021) ^[4].

Micronutrient deficiencies, particularly of B and Mo, are increasingly reported in Indian soils due to continuous cropping, imbalanced fertilization, and limited farmer awareness or affordability of micronutrient application (Prusty *et al.*, 2020) ^[11]. These deficiencies often manifest as poor pod development, reduced seed set, stunted growth, and ultimately low yields, even under adequate macronutrient supply (Ramya & Singh, 2022) ^[13]. Moreover, sandy and acidic soils in several parts of India are inherently low in available B and Mo, further exacerbating the issue.

Recent studies have demonstrated that soil and foliar application of boron and molybdenum can significantly enhance pod set, flowering, seed development, and overall yield and quality of groundnut (Kalpana *et al.*, 2024) ^[5]. However, the effectiveness of these micronutrients depends on their dose, method, and frequency of application. Optimizing these parameters is essential not only for improving crop productivity but also for promoting sustainable nutrient management without harming the soil ecosystem (Sanjay *et al.*, 2023) ^[16]. Given the strategic importance of enhancing oilseed production to reduce India's dependency on imports and to improve farmers' incomes, there is a growing need to evaluate the role of B and Mo in groundnut cultivation under field conditions. Therefore, the present study aims to investigate the impact of boron and molybdenum application on the growth and yield attributes of groundnut and to identify the best treatment combinations for maximizing yield and profitability under Rabi season conditions.

Materials and Methods

Field and Experimental Site Description

A field experiment was conducted during the *Rabi* season (Jan to May) of the year 2025 at a farmer's field located in Deevanur village, Tindivanam Taluk, Villupuram District, Tamil Nadu, India, situated at 12.251496° N latitude and 79.556305° E longitude. The study area falls under the Northern Agro-climatic Zone of Tamil Nadu. This research aims to promote sustainable nutrient management strategies and improve groundnut productivity, particularly during the *Rabi* season under the prevailing Agro-climatic conditions of the region.

The experimental field was characterized by loamy soil with available nutrient levels of 102 kg N ha⁻¹, 12.5 kg P₂O₅ ha⁻¹, and 112 kg K₂O ha⁻¹. The soil had a pH of 7.2, an electrical conductivity (EC) of 0.2 dS m⁻¹, and contained 0.27% organic carbon, indicating moderate fertility. Prior to the commencement of the experiment, composite soil samples were collected and subjected to physical and chemical analysis to assess the baseline fertility status. These results were instrumental in designing site-specific nutrient management practices suited to the Agro-ecological conditions of the study area.

Experimental Design and Treatment Details

The field experiment was laid out using a Randomized Block Design (RBD) comprising nine treatment combinations, each replicated three times, resulting in a total of 27 plots. Each experimental plot measured 20 m² (5 m × 4 m), and plants were spaced at 30 x 10 cm to ensure a uniform plant population. A buffer space of 1 meter was maintained between blocks to minimize the risk of treatment interference. The groundnut variety used for the study was Kadiri Lepakshi (K1812), a high-yielding, semi-spreading type known for its adaptability and effective nodulation. This variety is known for its tolerance to biotic and abiotic stresses and has a good pod-to-kernel ratio, making it ideal for evaluating responses to micronutrient applications. Sowing was done manually by placing seeds at the recommended depth to ensure proper germination. All plots received the recommended dose of fertilizer (RDF) at 25:50:75 kg/ha of N, P₂O₅, and K₂O, except for treatments with 75% RDN, where the nitrogen dose was reduced accordingly. Observations for growth parameters were recorded at 20, 40, 60 days after sowing (DAS) and at harvest, while yield parameters were assessed at harvest. Plant protection measures against biotic stress were followed as per Crop Production Guide, 2020.

Statistical Analysis

The data collected from the experimental plots were subjected to statistical evaluation using Analysis of Variance (ANOVA) to determine the significance of treatment effects. The overall differences among treatments were tested using the F-test at a 5% probability level ($p \leq 0.05$), as recommended by Gomez and Gomez (1984). Graphical representations and charts were generated using the data analysis tool Pack in Microsoft Excel 365. Further statistical computations were performed using R software (version 4.2.2) through RStudio (version 2022.12.0+353), employing the 'Agricole' package for agricultural data analysis.

Results and Discussion

1. Plant Height

Plant height increased progressively with crop growth, and significant differences were observed among treatments at all growth stages (Table 1). At harvest, the highest plant height (46.50 cm) was recorded under T₅ (100% RDN + foliar application of Boron @ 0.5%), followed by T₇ (41.05 cm). The control (T₉) recorded the lowest height (26.78 cm). The increase in plant height under foliar B and Mo application can be attributed to enhanced cell elongation and meristematic activity, particularly due to Boron's role in cell wall synthesis and membrane integrity (Kumar & Umesha, 2023) ^[6].

These findings align with Kalpana *et al.*, (2024) ^[5], who reported improved plant height in groundnut with foliar Boron applications under rainfed conditions. Soil application also enhanced height, but foliar delivery appeared more efficient in mobilizing B and Mo during critical growth phases. When this base nutrition was supplemented with critical micronutrients like Boron and Molybdenum, the synergistic effect led to enhanced vegetative growth, seen in increased plant height and branching (Moharana *et al.*, 2022) ^[8].

Table 1: Effect of Boron and Molybdenum on plant height (cm) at 20, 40, 60 DAS and at harvest.

Treatment		Plant Height (cm)			
		20 DAS	40 DAS	60 DAS	At Harvest
T ₁	100% RDN + Soil Application of Boron @ 5kg/ha	10.80	12.23	24.75	35.64
T ₂	75% RDN + Soil Application of Boron @ 5kg/ha	7.73	8.47	21.07	30.86
T ₃	100% RDN + Soil Application of Molybdenum @ 5kg/ha	9.76	11.21	23.63	31.43
T ₄	75% RDN + Soil Application of Molybdenum @ 5kg/ha	7.26	7.67	20.21	31.37
T ₅	100% RDN + Foliar Application of Boron @ 0.5%	6.76	15.33	27.66	46.50
T ₆	75% RDN + Foliar Application of Boron @ 0.5%	6.20	10.41	24.18	29.85
T ₇	100% RDN + Foliar Application of Molybdenum @ 0.3%	6.70	13.67	24.98	41.05
T ₈	75% RDN + Foliar Application of Molybdenum @ 0.3%	5.20	9.96	22.42	31.54
T ₉	Control 100% RDN (25:50:75 kg/ha)	5.96	6.21	18.26	26.78
SE (d)		0.21	0.66	0.56	0.57
CD (p<0.05)		0.44	1.40	1.19	1.21
RDN: Recommend Dose of Nitrogen					

2. Number of Branches per Plant

The number of branches per plant was significantly influenced among the treatments (Table 2). At harvest, the maximum number of branches (31.93) was recorded in T₅, followed by T₇ (28.66), while the control (T₉) recorded the least numerical value (16.46). The enhanced branching under B and Mo treatments, especially *via.*, foliar application, could be due to improved

peanut hormonal balance and nutrient assimilation, which stimulate lateral growth (Ghadiali *et al.*, 2023) ^[2].

Also, similar response was observed by Sanjay *et al.*, (2023) ^[16], who found that foliar-applied micronutrients significantly influenced groundnut canopy architecture by increasing the branching pattern and overall biomass production.

Table 2: Effect Boron and Molybdenum on number of branches per plant at 20, 40, 60 DAS and at harvest.

Treatment		Number of Branches per plant			
		20 DAS	40 DAS	60 DAS	At Harvest
T ₁	100% RDN + Soil Application of Boron @ 5kg/ha	9.80	11.67	16.62	24.33
T ₂	75% RDN + Soil Application of Boron @ 5kg/ha	7.56	8.39	13.68	20.26
T ₃	100% RDN + Soil Application of Molybdenum @ 5kg/ha	8.43	10.31	15.87	22.73
T ₄	75% RDN + Soil Application of Molybdenum @ 5kg/ha	6.76	7.21	13.02	19.53
T ₅	100% RDN + Foliar Application of Boron @ 0.5%	6.40	14.63	18.33	31.93
T ₆	75% RDN + Foliar Application of Boron @ 0.5%	4.33	9.28	14.98	21.93
T ₇	100% RDN + Foliar Application of Molybdenum @ 0.3%	5.80	12.41	17.06	28.66
T ₈	75% RDN + Foliar Application of Molybdenum @ 0.3%	3.83	8.76	13.87	21.20
T ₉	Control 100% RDN (25:50:75 kg/ha)	4.63	6.19	11.66	16.46
SE (d)		0.13	0.44	0.53	0.60
CD (p<0.05)		0.29	0.93	1.12	1.28
RDN: Recommend Dose of Nitrogen					

3. Number of Pegs per Plant

Pegs per plant, a critical reproductive trait, varied significantly across treatments (Table 3). The maximum number of pegs (70.92) was observed under T₅, followed by T₇ (63.20). The lowest number of pegs (39.19) was obtained in the control (T₉). Boron plays a crucial role in pollen tube elongation and peg initiation, while molybdenum aids in nitrogen fixation, indirectly influencing peg development (Ramya & Singh, 2022) ^[13]. Rezvany Vardom *et al.*, (2024) ^[15] reported that appropriate micronutrient management increased the peg-to-pod conversion ratio, a critical factor for reproductive success in legumes.

4. Number of Pods and Matured Pods per Plant

The treatment significance was observed in among the treatment combinations. The highest number of pods (44.84) and matured pods (43.02) per plant were observed in T₅, followed by T₇ number of pods (38.23) and matured pods (36.83), whereas the control T₉ had only (22.26) pods and (19.86) matured pods per plant. This indicates that foliar application of Boron, especially with full RDN, enhances pod filling and maturity due to better

flower retention and seed development, consistent with findings by Latha and Dawson (2023) ^[7].

The enhanced pod development under Molybdenum treated plots also supports earlier research (Movalia *et al.*, 2020) ^[8], which emphasized Molybdenum role in nitrate metabolism, contributing to better reproductive output of the crop.

5. Pod Yield

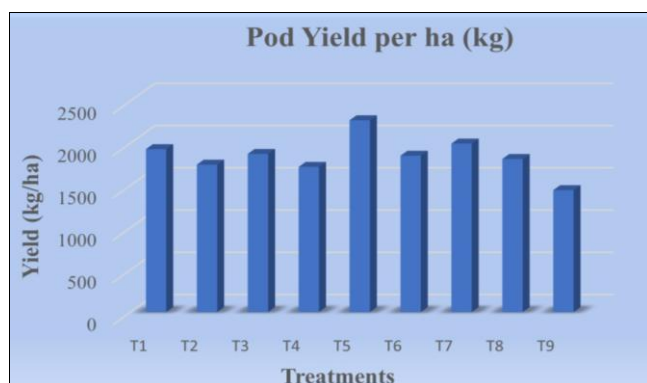
The highest yield was achieved in T₅ (2268.98 kg/ha), significantly higher than the control T₉, (1442.08 kg/ha). Yield improvement under T₅ was ~63% over control. Treatments T₇ (1993.16 kg/ha) also showed notable yield increases, indicating the synergistic effect of full RDN combined with either foliar or soil micronutrient application.

These results are in agreed with Haneena *et al.*, (2021) ^[3], who demonstrated that micronutrient-induced improvement in nodulation and nitrogen fixation leads to higher pod formation and yield in groundnut. Similarly, Prusty *et al.*, (2020) ^[11] concluded that Boron and Molybdenum enhanced productivity when used in appropriate formulations.

Table 3: Effect of Boron and Molybdenum on No. of pegs per plant, No. of pods per plant, No. of matured pods per plant and pod yield per ha.

Treatment		No. of pegs per plant	No. of pods per plant	No. of matured pods per plant	Pod yield per ha (kg)
T ₁	100% RDN + Soil Application of Boron @ 5kg/ha	58.22	35.81	34.81	1927.26
T ₂	75% RDN + Soil Application of Boron @ 5kg/ha	46.34	30.38	28.56	1743.89
T ₃	100% RDN + Soil Application of Molybdenum @ 5kg/ha	55.72	34.26	34.68	1870.95
T ₄	75% RDN + Soil Application of Molybdenum @ 5kg/ha	45.99	28.79	27.96	1717.31
T ₅	100% RDN + Foliar Application of Boron @ 0.5%	70.92	44.84	43.02	2268.98
T ₆	75% RDN + Foliar Application of Boron @ 0.5%	51.87	34.01	32.81	1849.81
T ₇	100% RDN + Foliar Application of Molybdenum @ 0.3%	63.20	38.23	36.83	1993.16
T ₈	75% RDN + Foliar Application of Molybdenum @ 0.3%	48.16	32.16	31.21	1811.11
T ₉	Control 100% RDN (25:50:75 kg/ha)	39.19	22.26	19.86	1442.08
SE (d)		2.97	2.06	1.65	85.09
CD (p≤0.05)		6.29	4.37	3.50	180.40

RDN: Recommend Dose of Nitrogen

**Fig 1:** Effect of Boron and Molybdenum on Pod yield per ha (kg)**Fig 2:** Treatment difference between T₅ (100% RDN + Foliar Application of Boron @ 0.5%) and T₉ (Control - 100% RDN 25:50:75 kg/ha).

Conclusion

The present study clearly demonstrated that, the positive impact of Boron and Molybdenum application on the growth and yield of groundnut under the *Rabi* season in Tamil Nadu. Among the various treatment combinations, foliar application of Boron at 0.5% along with 100% recommended dose of nutrients (T₅) recorded significantly superior results in terms of plant height, number of branches, peg formation, pod development, and ultimately pod yield. This was closely followed by foliar application of Molybdenum at 0.3% along with 100% recommended dose of nutrients (T₇), indicating that the method of application and full nutrient supply are critical for optimizing micronutrient efficiency. The superiority of foliar applications over soil applications observed in this study can be attributed to the efficient and timely uptake of nutrients, reduced losses through leaching or fixation, and better physiological responses during critical crop stages. Additionally, the importance of supplying full RDN was clearly evident, as treatments receiving

only 75% RDN consistently underperformed compared to their 100% RDN counterparts, even when supplemented with micronutrients. Foliar application of micronutrients, especially Boron (T₅) and Molybdenum (T₇) under full Recommended Dose of Nitrogen (RDN), consistently outperformed their soil-applied counterparts (Poonguzhali *et al.*, 2022)^[10]. The control treatment (T₉), which involved only 100% RDN without any micronutrient application, recorded the lowest performance across all measured parameters, indicating that macronutrients alone are insufficient to realize the crop's full potential. The findings suggest that the combined application of micronutrients through foliar feeding can complement soil-applied fertilizers, particularly in enhancing reproductive traits like pod and peg formation. These results support the potential for improving production, productivity and sustainability of groundnut cultivation. Therefore, integrating Boron and Molybdenum especially through foliar methods into nutrient management strategies could be a practical and cost-effective approach to boost yield performance in groundnut.

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Conflict of Interest

The authors affirm that there are no conflicts of interest associated with this publication.

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