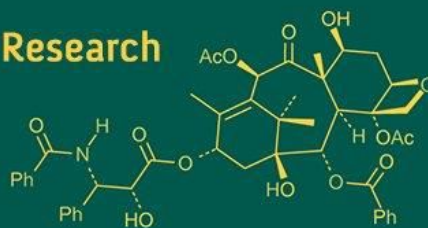
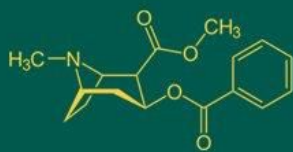


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(9): 1327-1331
www.biochemjournal.com
Received: 19-06-2025
Accepted: 24-07-2025

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Effect of INM based customised multinutrient briquette on yield, micronutrient content and nutrient use efficiency of rainfed BT cotton

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DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i9Sq.5692>

Abstract

A field experiment was conducted to study the "Effect of INM based customised multinutrient briquette on yield, micronutrient content and nutrient use efficiency of rainfed Bt cotton" at E. A. D. farm, College of Agriculture, Nagpur, (2024-25) to investigate the impact on yield, micronutrient content and nutrient use efficiency of rainfed Bt cotton. The results of the present study revealed that seed cotton yield was significantly influenced by the application of different treatments. The maximum yield of 14.30 q ha⁻¹ was recorded with the application of 100% RDF. An increase of 37.71 to 50.34 per cent in seed cotton yield was observed across the various treatments over the absolute control, highlighting the beneficial effect of balanced fertilization. The available micronutrient status of soil, as influenced by various treatments. Among micronutrients, zinc remained in the low fertility range, indicating the possibility of its deficiency for cotton growth. The highest nutrient use efficiency was observed with 100% RDF, recorded 35.88% for nitrogen, 20.08% for phosphorus and 44.70% for potassium when compared with absolute control. These results clearly demonstrate that balanced fertilization, either through RDF or multinutrient briquettes, significantly enhanced seed cotton yield and nutrient use efficiency without causing major changes in soil reaction or organic matter status.

Keywords: Cotton, yield, nutrient content and nutrient use efficiency

Introduction

Cotton (*Gossypium herbaceum* L.) is one of the most critical fibre and cash crops in India, playing a pivotal role in the nation's agrarian economy. India is the second largest producer of cotton with 53.85 lakh tones equivalent to 316 lakh bales of 170 kg. In Maharashtra, cotton occupied an area of 42.34 lakh ha with production of 82.43 lakh bales and yield 338 kg ha⁻¹. The major cotton producing states are Maharashtra, Gujarat, Telangana, Andhra Pradesh and Karnataka (ICAR-AICRP on cotton, 2023-24) [5].

Bt cotton has emerged as one of India's most extensively cultivated commercial crops, grown across diverse soil types and accounting for over 90% of the total cotton cultivation area nationwide (ICAC, 2022) [6]. Bt-cotton exhibits varying nutrient requirements at different stages of growth, which can influence both total and partial nutrient utilization. Consequently, there exists an opportunity to enhance nitrogen use efficiency, thereby contributing to the goal of increased agricultural output (Hallikeri *et al.*, 2008) [3]. Although Bt cotton is engineered for pest resistance, it does not inherently improve nutrient absorption or enhance tolerance to environmental stresses like drought. In this setting, Integrated Nutrient Management (INM) presents a viable strategy by combining organic amendments and chemical fertilizers to maintain soil health and improve crop performance (Ingle *et al.*, 2024; Kuchanwar *et al.*, 2025) [7, 13]. The introduction of Bt in cotton has changed the vegetative and reproductive growth patterns. These manipulations alter the nutrient requirement of Bt cotton. Balanced fertilization is a must for realizing higher efficiency of fertilizer use (Bhalerao *et al.*, 2012) [1].

An innovative advancement in this area is the introduction of Customized Multinutrient Briquettes (CMNBs) developed under the INM framework. The design of these briquettes allows for controlled and sustained nutrient release, improving both nutrient use efficiency (NUE) and water use efficiency (WUE) under rainfed conditions (Kakde, & Patil, 2022) [10].

This targeted delivery system helps minimize nutrient losses due to leaching and volatilization and supports beneficial microbial activity in the root zone. This research holds significance for its comprehensive assessment of CMNBs not just in terms of cotton yield, but also their effects on essential soil characteristics like organic carbon levels, nutrient availability, and biological processes.

Materials and Methods

During the kharif season of 2024-2025, experiment was conducted at E. A. D. farm, College of Agriculture, Nagpur (Maharashtra). The research site has sub-tropical climate with dry conditions prevailing for most of the year. An average annual rainfall of 1064.1 mm. The average maximum temperature is 33.70 °C in *Kharif* (June-Sept), 27.50 °C in *Rabi* (Oct-Jan).

For the preparation of briquette, the vermicompost was collected from the dairy science section and was analyzed for its C:N ratio using standard procedures. The nutrient-rich moringa leaves and twigs were shade-dried for 6-7 days, ground, and incorporated with vermicompost, inorganic fertilizers, botanicals, micronutrients, and a small quantity of binder. The mixture was hand-mixed thoroughly, and organic liquid was added to maintain 30-32% moisture. The prepared material was fed into a briquetting machine to produce multi-nutrient briquettes of 2.5-3.0 g size, designed according to Bt cotton plant population, spacing, and nutrient requirements. The briquettes were packed in polythene bags and applied at sowing, one per plant, to ensure site-specific nutrient delivery. The moringa leaves were collected from the college farm, air-dried for 4-5 days until complete moisture loss, and ground into fine powder. The powder was mixed with 2 L of water and allowed to ferment in a bucket for two days. The extract was then filtered and stored in plastic bottles. For field application, 1500 ml of moringa leaf extract was diluted in a 10 L sprayer and applied to the crop during square formation and boll development stages.

The quantity of vermicompost and fertilizers required for preparation of MNB of 100% RDF (90:45:45 NPK kg ha⁻¹) to rainfed Bt cotton. The briquette formulation comprised a combination of organic, inorganic, and micronutrient sources. Vermicompost (1588 kg ha⁻¹) served as the primary organic base material, supplemented with moringa leaves (100 kg ha⁻¹) to enhance nutrient enrichment. Inorganic fertilizers including urea (69 kg ha⁻¹), DAP (74 kg ha⁻¹), and MOP (35 kg ha⁻¹) were incorporated to meet the nitrogen, phosphorus, and potassium requirements. Additionally, micronutrients such as FeSO₄, MnSO₄, ZnSO₄ (10 kg ha⁻¹ each), and borax (5 kg ha⁻¹) were added to correct potential deficiencies and ensure balanced nutrient supply.

In order to conduct a chemical study of the soil in the experiment area prior to planning, a soil sample was collected randomly from experimental area at a depth of 0-20 cm to examine different soil properties. The soil type at the experimental location was, with available soil nutrients (N, P, K S, Fe, Mn, Zn, Cu) total of 241.3 kg ha⁻¹, 19.11 kg ha⁻¹, 342.0 kg ha⁻¹, 9.50 kg ha⁻¹, 6.51 mg kg⁻¹, 6.20 mg kg⁻¹, 0.50 mg kg⁻¹ and 0.38 mg kg⁻¹, respectively. The soil organic carbon was 5.28 g kg⁻¹ and the pH of soil was 7.70 at the time of sowing. The experiment was set up using a

randomized block design (RBD), with 10 treatments combination with three replications having a total of 30 plots. The results obtained was statistically analysed as per methods suggested by Gomez and Gomez (1984)^[2].

Results and Discussion

Effect of multinutrient briquette on yield of rainfed Bt cotton

The data pertaining to yield after all pickings of the Bt cotton is comprehensively presented in Table 1; including seed cotton and cotton stalk yield and the graph is illustrated in figure 1.

Seed cotton yield (q ha⁻¹)

The results clearly demonstrate that seed cotton yield is significantly affected by the combined application of moringa leaf extract with multinutrient briquettes. The highest seed cotton yield (14.30 q ha⁻¹) was achieved with the application of 100% RDF (T₁) and it was found at par with the application of 100% RDF through MNB (50% at sowing and 50% at 45 DAS) along with 2 foliar spray of MLE at square formation and boll development stage (13.80 q ha⁻¹) and 100% RDF through MNB (50% at sowing and 50% at 45 DAS) (13.10 q ha⁻¹).

The findings clearly indicate that the application of moringa leaf extract along with 100% RDF through multinutrient briquette enhances nutrient release. This results in a continuous supply of major, secondary and micronutrients in the soil, sustaining higher seed cotton yield. 37.71 to 50.34 per cent increase in seed cotton yield in the various treatments of RDF and remaining fertilized treatments over absolute control. Kote *et al.*, (2005)^[11] reported that the application of 100 per cent of recommended dose of fertilizers produced significantly higher seed cotton yield. The increased in yields of cotton with the application of higher doses of fertilizers might be due to increase in growth and yield attributing characters of cotton. Harmalkar *et al.*, (2019)^[4] also reported the promising results with Konkan Annapurna briquette.

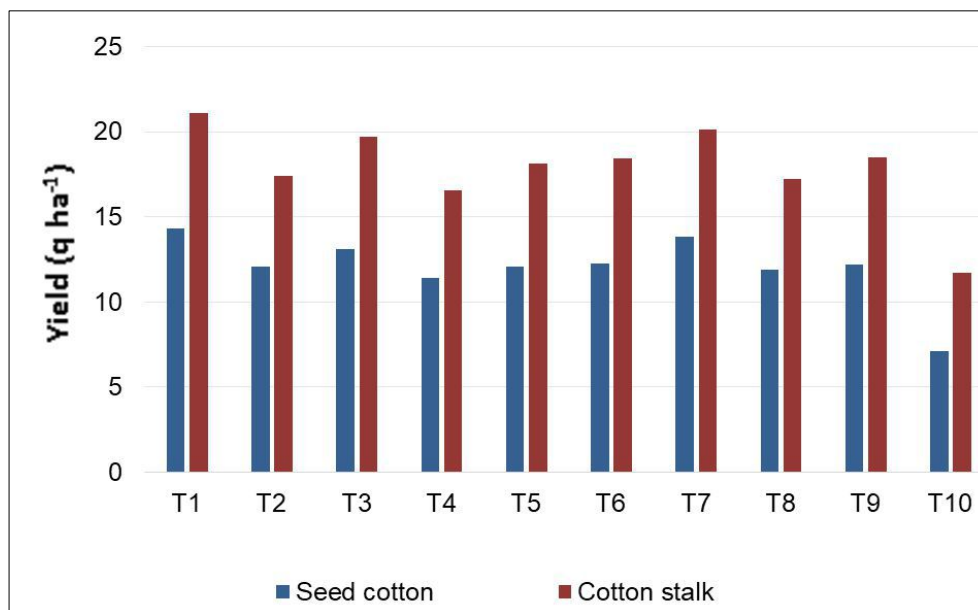
The seed cotton yield increased by 12.97% with the application of RDF through MNB at 50% at sowing & 50% at DAS over the 25% lowered dose i.e. 75% RDF through MNB sowing. Hence, it is clearly indicated that whole quantity of lowered dose of nutrient once at sowing reflected too much on seed cotton yield. There was 5 per cent increase in seed cotton yield observed in treatment T₇ with the application of 2 sprays of moringa leaf extract over the treatment excluding the application of moringa leaf extract i.e. in the treatment T₃. Sunil *et al.*, (2017)^[15] reported application of 100:60:60 N P K ha⁻¹ + ZnSO₄ through briquettes showed better result in seed cotton yield.

Stalk cotton yield (q ha⁻¹)

In present study, the significant higher stalk yield of cotton was observed (21.07 q ha⁻¹) with the application of 100% RDF which was found at par with 100% RDF through MNB (50% at sowing and 50% at 45 DAS) along with 2 foliar spray of MLE at square formation and boll development stage. The increase in stalk 29.22 to 44.47 per cent increase in cotton stalk yield in the various treatments of RDF and remaining fertilized treatments over absolute control.

Table 1: Effect of multinutrient briquette on yield of rainfed Bt cotton

Treatments		Yield (q ha ⁻¹)	
		Seed cotton	Cotton stalk
T ₁	100% RDF	14.30	21.07
T ₂	100% RDF through MNB at sowing	12.06	17.38
T ₃	100% RDF through MNB (50% at sowing and 50% at 45 DAS)	13.10	19.71
T ₄	75% RDF through MNB at sowing	11.40	16.53
T ₅	75% RDF through MNB (50% at sowing and 25% at 45 DAS)	12.10	18.13
T ₆	T ₂ + 2 foliar spray of MLE at square formation and boll development stage	12.24	18.41
T ₇	T ₃ + 2 foliar spray of MLE at square formation and boll development stage	13.80	20.13
T ₈	T ₄ + 2 foliar spray of MLE at square formation and boll development stage	11.90	17.21
T ₉	T ₅ + 2 foliar spray of MLE at square formation and boll development stage	12.20	18.50
T ₁₀	Absolute control	7.10	11.70
	S. E. (m ±)	0.64	0.94
	C. D. @ 5%	1.90	2.79

**Fig 1:** Seed cotton and cotton stalk yield (q ha⁻¹) of Bt cotton

Effect of multinutrient briquette on available micronutrients in soil (mg kg⁻¹) after all pickings of Bt cotton

The data pertaining to availability of micronutrients after all pickings of cotton is presented in Table 2.

The concentration range of micronutrients in soil was recorded between 6.66 to 6.80 mg kg⁻¹ for Fe, 6.20 to 6.27 mg kg⁻¹ for Mn, 0.51 to 0.56 mg kg⁻¹ for Zn and 0.35 to 0.41 mg kg⁻¹ for Cu, respectively after all pickings of cotton. The

highest available iron (6.80 mg kg⁻¹), manganese (6.27 mg kg⁻¹), zinc content (0.56 mg kg⁻¹) and copper (0.41 mg kg⁻¹) was recorded with the application of treatment T₁ i.e., 100% RDF.

In the present study, the zinc value was found to be in low range as against the critical limit (0.6 to 1.8 mg kg⁻¹) similar result closely painted by (Ingle *et al.*, 2018, 2019; Kuchanwar *et al.*, 2022) [9, 8, 12].

Table 2: Effect of multinutrient briquette on available micronutrients in soil (mg kg⁻¹) after all pickings of Bt cotton

Treatments		Fe (mg kg ⁻¹)	Mn (mg kg ⁻¹)	Zn (mg kg ⁻¹)	Cu (mg kg ⁻¹)
T ₁	100% RDF	6.80	6.25	0.52	0.38
T ₂	100% RDF through MNB at sowing	6.80	6.26	0.55	0.40
T ₃	100% RDF through MNB (50% at sowing and 50% at 45 DAS)	6.75	6.27	0.56	0.41
T ₄	75% RDF through MNB at sowing	6.78	6.20	0.52	0.38
T ₅	75% RDF through MNB (50% at sowing and 25% at 45 DAS)	6.66	6.22	0.53	0.38
T ₆	T ₂ + 2 foliar spray of MLE at square formation and boll development stage	6.70	6.26	0.56	0.41
T ₇	T ₃ + 2 foliar spray of MLE at square formation and boll development stage	6.70	6.25	0.56	0.41
T ₈	T ₄ + 2 foliar spray of MLE at square formation and boll development stage	6.72	6.23	0.54	0.38
T ₉	T ₅ + 2 foliar spray of MLE at square formation and boll development stage	6.80	6.25	0.55	0.40
T ₁₀	Absolute control	6.66	6.23	0.51	0.35
	S. E. (m ±)	0.03	0.01	0.01	0.01
	C. D. @ 5%	-	-	-	-

Nutrient use efficiency of Bt cotton as influenced by multinutrient briquette

The data regarding nutrient use efficiency by cotton under various treatments is presented in Table 3 and the graph is illustrated in figure 2.

The highest nutrient use efficiency of 35.88, 20.08, 44.70 per cent was observed with the application of 100% RDF over absolute control. The overall efficiency of applied fertilizer have been reported to be around or less than 50% for N, less than 15% for P and about 50% for K. The NUE depends on plant capacity to take up the nutrients efficiently from the soil but also depends on transport, storage and remobilization of nutrients (Barkha and Chakraborty, 2021; Patel *et al.*, 2024; Kumari *et al.*, 2025) ^[16, 14].

The highest nutrient use efficiency was observed in treatment T₁ with 100% RDF (N- 35.88%, P- 20.08%, K- 44.70%) followed by treatments T₇ and T₉. The data further resulted that the value of NUE decreases to the tune of 20.19% with the application of 100% RDF through MNB at sowing than 100% RDF through MNB at (50% sowing and 50% at 45 DAS). The split application of MNB reflected the value of NUE with balanced amount. Similar findings were reported by Viju and Thakre (2024) ^[17] in his study of nitrogen use efficiency under potassium regimes using polyhalite-based multinutrient fertilizer in Bt cotton on Inceptisol.

Table 3: Nutrient use efficiency of Bt cotton as influenced by multinutrient briquette

Treatments		N (%)	P (%)	K (%)
T ₁	100% RDF	35.88	20.08	44.70
T ₂	100% RDF through MNB at sowing	23.35	11.42	23.69
T ₃	100% RDF through MNB (50% at sowing and 50% at 45 DAS)	29.26	15.62	36.10
T ₄	75% RDF through MNB at sowing	22.80	11.98	26.60
T ₅	75% RDF through MNB (50% at sowing and 25% at 45 DAS)	29.69	15.39	35.97
T ₆	T ₂ + 2 foliar spray of MLE at square formation and boll development stage	25.56	14.22	31.53
T ₇	T ₃ + 2 foliar spray of MLE at square formation and boll development stage	32.44	18.07	41.01
T ₈	T ₄ + 2 foliar spray of MLE at square formation and boll development stage	26.49	12.63	31.38
T ₉	T ₅ + 2 foliar spray of MLE at square formation and boll development stage	30.35	17.46	41.27
T ₁₀	Absolute control	-	-	-

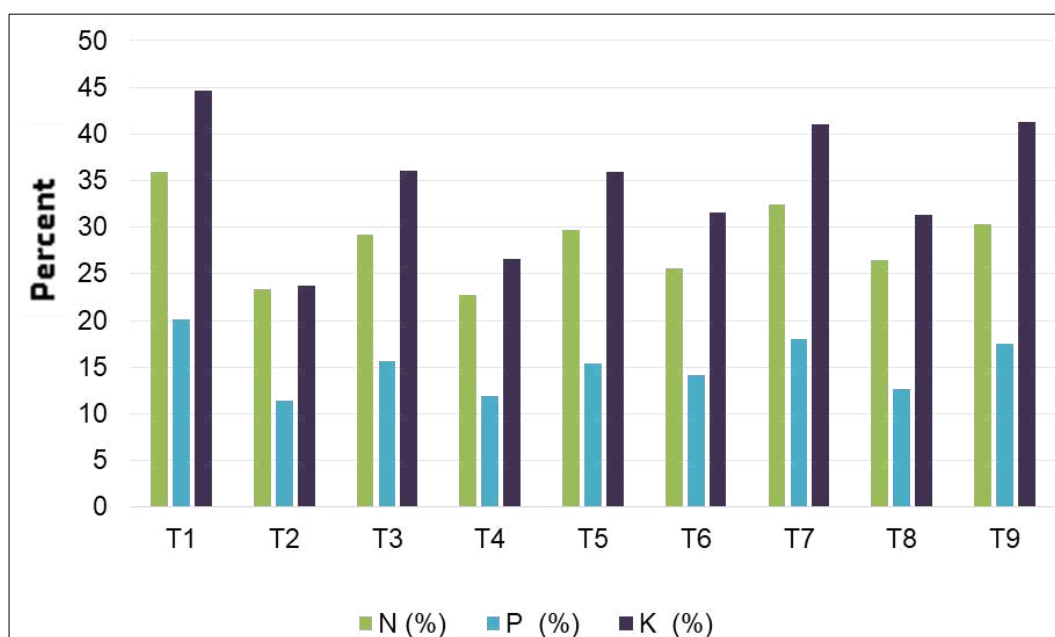


Fig 2: Nutrient use efficiency (%) of Bt cotton

Conclusion

It can be concluded that treatment receiving 100% RDF shows best results followed by treatment receiving 100% RDF through multinutrient briquette (50% at sowing and 50% at 45 DAS) in combination with 2 foliar spray of moringa leaf extract at square formation and boll development stage for obtaining better seed cotton yield, micronutrient content and nutrient use efficiency in rainfed Bt cotton.

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