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Effect of multinutrient briquette on soil NPK availability, microbial population and dehydrogenase activity under rainfed *Bt* cotton

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Abstract
A field investigation was undertaken during kharif season of 2025-26 at EAD Farm, College of Agriculture, Nagpur in Randomised Block Design with seven treatments. The treatment comprised following levels of organic fertilizers, inorganic fertilizers and micronutrients *viz.*, T_1- 100% NPK + micronutrient (50%N, 100%P,K, micronutrients at sowing and 50% N at 30-35 DAS), T_2- 100% RDF through MNB at sowing, T_3- 100% RDF through MNB (50% at sowing and 50% at 30-35 DAS), T4- 75% RDF through MNB (50% at sowing and 25% at 30-35 DAS), T_5- 100% RDF through MNB (50% at sowing and 25% at 30-35 DAS and 25% at 50-55 DAS), T_6- 75% RDF through MNB (25% at sowing, 25% at 30-35 DAS and 25% at 50-55 DAS) and T_7- Absolute control. The results of the present study revealed that, the available nitrogen content in soil ranged between 193.52 to 209.74 kg ha^{-1}. The highest nitrogen availability was noted under T_3 (100% RDF through MNB in 2 splits). Available phosphorus content was observed between 20.18 to 24.22 kg ha^{-1}. Available potassium showed significant variation, with the highest value of 343.6 kg ha^{-1} under 100% NPK + micronutrients, followed closely by 339.3 kg ha^{-1}, 337.3 kg ha^{-1} and 332.7 kg ha^{-1} under treatment T_3, T_2 and T_5 respectively. Microbial population of bacteria, fungi and actinomycetes at vegetative stage of cotton shows variation as influenced by application of multinutrient briquette. The significant increase in bacteria, fungi and actinomycetes was observed with the addition of 100% RDF through MNB and inorganic fertilizers with micronutrients. The dehydrogenase activity observed maximum with increased dose of inorganic fertilizers with organic source.

Keywords: *Bt* cotton, Multinutrient briquette (MNB), Bacteria, Fungi, Actinomycetes, Dehydrogenase activity

Introduction
Cotton (Gossypium spp.) is one of the most important commercial, non-edible commodity, produced on India's farms playing a key role in the economical and social status of world. The country ranks first in cotton area and second in cotton production in the world. About 15 million farmers in the country spread across 10 states are engaged in cotton production i.e Gujarat, Maharashtra, Haryana, Punjab, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamilnadu are considered the major cotton growing states in India.

It is grown on an area of 11.76 million hectares, which constitutes around 38% of the world area under cotton cultivation. Government of Maharashtra (2025) reported that the area under cotton in Maharashtra during 2023-24 was 42.87 lakh ha, with a productivity of 354 kg ha^{-1} (Final Advance Estimates of Area, Production and Productivity of Crops in Respect of Maharashtra State for the Year 2023-24).

In modern agriculture, the imbalanced use of chemical fertilizers has become a major cause of soil fertility loss, leading to reduced productivity and accelerated soil degradation. To achieve sustainable crop production, scientific and efficient fertilizer management is essential. Several studies have established that high-yielding crop varieties have a definite and relatively constant requirement for nitrogen, phosphorus, and potassium. Among these, nitrogen is considered the most critical nutrient globally because of its large crop demand and its instability in the soil environment, there is a need of research on development of INM based briquette for balanced nutrients which will help to minimize the nutrient losses, increase NUE, balanced nutrient consumption, enhancing microbial activity and ultimately improving the soil fertility and crop productivity.

Materials and Methods

The research trial was conducted at the Extra Assistant Director Farm, College of Agriculture, Nagpur, Maharashtra during *kharif* season of 2025-2026. The site experiences a sub-tropical climate with an erratic rainfall during the *kharif* season, cool in the *rabi* season and hot and dry in summer. The soil of experimental plot was clayey in texture, fairly uniform and levelled. After completion of all pickings, plot wise soil samples were taken from the experimental field. These samples were then dried in shade and gently ground using a mortar and pestle before being sieved through a 2 mm sieve to determine available nitrogen (N), phosphorus (P), potassium (K) and to determine biological properties such as bacteria, fungi, actinomycetes and dehydrogenase activity, soil samples were collected at 0-10 cm depth from different plots at vegetative stage of cotton.

The per cent of nitrogen was calculated as by alkaline potassium permanganate method described by Subbiah and Asija (1956) [9], available phosphorus was determined by Olsen's method (Jackson, 1973) [6] using 0.5 M sodium bicarbonate (pH 8.5) as extractant and darco G-60 free from soluble phosphorus to absorb the dispersed organic matter and make the filtrate colourless for further spectrophotometric analysis, available potassium was determined by flame photometer using neutral normal ammonium acetate extractant (Jackson, 1973) [6]. Microbial properties determined by serial dilution plate technique method as described by (Dhingra and Sinclair, 1993) [4] and dehydrogenase activity determined by iodonitrotetrazolium chloride (INT) as described by (Mersi and Shinner, 1990) [8].

Result and Discussion

Available nitrogen in soil (kg ha^{-1})

Available nitrogen is the fraction of total soil nitrogen that plants can absorb directly and utilize, primarily consisting inorganic NH_4^+ and NO_3^- (Nitrate) which is essential for plant growth and formation of chlorophyll. The present data revealed that, the highest available nitrogen in soil (209.74 kg ha^{-1}) was observed with the application of 100% RDF through MNB (50% at sowing and 50% at 30 DAS) which remained at par with the treatment receiving 100% RDF through MNB with 3 splits (206.10 kg ha^{-1}) and 100% RDF through MNB at sowing (204.30 kg ha^{-1}). The slight increases in soil available nitrogen, might be attribute to the more nitrogen fixation in soil, multiplication of microbes which helps to convert inorganic form and it's slow release by briquettes helps to minimize the losses of nutrient due to volatilization and leaching. The value of soil available nitrogen was found under low in category among different treatments. The lowest value was noted under absolute control (193.52 kg ha^{-1}). Ashwini *et al.*, (2017) [2] resulted that soil available nitrogen was 257.2 kg ha^{-1} with 50% nitrogen through inorganic and 50% nitrogen through FYM and it found at par with 50:50 N through fertilizer and glyricidia sources.

Available phosphorus in soil (kg ha $^{-1}$)

The available phosphorus in soil after picking of cotton is presented in table1. The available phosphorus was recorded from 20.18 to 24.22 kg ha^{-1} under the application of inorganic fertilizer and multinutrient briquette. The value of available phosphorus in soil was observed under low in category in the present study. Among the different treatments, the highest soil available phosphorus was recorded under the treatment receiving 100% NPK + micronutrients (24.22 kg ha^{-1}) and this treatment found at par with the application of 100% RDF through MNB at 2 splits (23.33 kg ha^{-1}) and 3 splits (23.96 kg ha^{-1}).The combine application of organic, inorganic and micronutrients through briquette helps in increasing soil carbon and release acids which not only interact with the organic compound that fix the phosphorus resulted lower phosphorus fixation and its availability in the soil. The available phosphorus in soil was recorded more by 12.88 per cent with the treatment T_1 over the 75% RDF through MNB with 2 splits, means balanced amount of major nutrients along with micronutrient is essential to build-up the slight amount of available P in soil. The results reviewed in conformity with the finding by Ashwini *et al.*, (2017) [2] and Viju and Thakare (2024).

Available potassium in soil (kg ha^{-1})

Available K in soil is a primary macronutrient acts as essential for plant growth, disease resistance, optimal crop yields and protein synthesis. It play a catalytic role in activating enzymes and improves the quality of produce. Data on available K is depicted in table 1. The significantly maximum available potassium was observed under the treatment consisting 100% NPK + micronutrients (343.6 kg ha^{-1}) and it found at par with the treatment receiving 100% RDF through MNB at sowing (337.3 kg ha^{-1}), 100% RDF through MNB at 2 splits (339.3 kg ha^{-1}) and 3 splits (332.7 kg ha^{-1}). The available potassium in the present study was registered very high category. The data on the available potassium indicated that the soil have no deficiency. The highest availability of K may be due to occurrence of potash rich minerals like mica and feldspar and addition of chemical K fertilizer, reduction in K fixation and release K with interaction between native K minerals and clay. Vora *et al.*, (2015) [10] presented available K in soil found significant with the availability of 80 kg N + 10 t compost ha^{-1} + castor cake + PSM + biofertilizer.

Table 1: Effect of multinutrient briquette on soil NPK availability

	Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{1})
T_1	100% NPK + micronutrient (50% N, 100% P, K, micronutrients at sowing and 50% N at 30-35 DAS)	199.67	24.22	343.6
T_2	100% RDF through MNB at sowing	204.30	22.52	337.3
T_3	100% RDF through MNB (50% at sowing and 50% at 30-35 DAS)	209.74	23.33	339.3
T_4	75% RDF through MNB (50% at sowing 25% at 30-35 DAS)	200.92	21.10	328.7
T_5	100% RDF through MNB (50% at sowing, 25% at 30-35 DAS and 25% at 50-55 DAS)	206.10	23.96	332.7
T_6	75% RDF through MNB (25% at sowing, 25% at 30-35 DAS and 25% at 50-55 DAS)	200.95	21.24	330.0
T_7	Absolute control	193.52	20.18	318.5
	S. E. (m ±)	2.19	0.34	4.59
	C. D. @ 5%	6.75	1.04	14.13

Soil biological properties as affected by multinutrient briquette

The data pertaining to microbial population under various treatments by *Bt* cotton is presented in table 2. The significant increase in bacteria, fungi and actinomycetes was observed with the addition of 100% RDF through MNB and inorganic fertilizers with micronutrients. Data indicated that, the bacterial, fungal and actinomycetes population at vegetative growth stage ranged from 3.72 to 5.91x10^8 cfu g^{-1} of soil, 3.10 to 4.80x10^4 cfu g^{-1} soil and 2.94 to 4.53x10^6 cfu g^{-1} soil respectively, where treatments receiving 100% RDF or 75% RDF through MNB and 100% inorganic fertilizers + micronutrients. The significantly highest bacterial count (5.91x10^8 cfu g^{-1} soil) at vegetative stage was recorded with 100% RDF through MNB (50% at sowing and 50% at 30-35 DAS) and found statistically on par with the treatments T_1, T_2 and T_5. The increment in bacterial population during vegetative growth stage of *Bt* cotton under the study was reflected with increasing doses of MNB and sufficient amount of inorganic + micronutrients fertilizers. This could be attributed to vermicompost + inorganic (MNB) which supply the amount of carbon resulting diverse microbial system than lower doses or without application of fertilizers. similarly lower doses of MNB or imbalanced dose caused slight decline in microbial population as compared to balanced dose of MNB or inorganic fertilizers.

Among various treatment, significantly highest fungal population (4.80x10^4 cfu g^{-1} soil) was recorded at vegetative growth stage of cotton, where treatment consisting 100% NPK + micronutrients and this treatment found statistically at par with treatments T_2, T_3 and T_5. Whereas the actinomycetes population was registered highest with 100% RDF through MNB at sowing but this treatment remains at par with treatments T_3, T_4 and T_5. Jayshree *et al.,* (2013) reported maximum microbial population at growth stages, due to application of 10 t FYM and lowest population recorded under absolute control. The increase in count might be due to addition of organic matter into the soil. Channagouda *et al.,* (2014) [3] also reported that application of compost + vermicompost equivalent to RDF recorded significantly higher bacteria, fungi, actinomycetes population and dehydrogenase activity (DHA).

The data on dehydrogenase activity are summarised in table 2. The dehydrogenase activity serves as a primary bio-indicator of soil microbial health. DHA indicates how actively soil microorganisms are respiring and breaking down organic materials. It is widely used as a generalized comparative index of microbial activity increased with increase in the dose of fertilizers with organic source. The results showed that the application of 100% RDF through MNB at sowing and 30-35 DAS recorded significant highest DHA at vegetative growth (54.96 µg TPF g^{-1} soil hr^{-1}) and treatment found statistically at par with the treatment T_2 and T_5, receiving 100% RDF through MNB. The DHA found increased by 10.68 per cent with 100% RDF through MNB (T_3) over treatment 100% NPK + micronutrients (T_1). The value of DHA recorded lowest (43.45 µg TPF g^{-1} soil hr^{-1}) under absolute control. This increase in DHA is associated with organic source along with inorganic acting as a source of carbon and energy for heterotrophs. Significantly lower DHA was observed with the application of 75% RDF through MNB with 2 to 3 splits. The higher dehydrogenase activity may be due to combination of organic + inorganic fertilizers as well as higher microbial population and availability of moisture. Khuspure *et al.,* (2019) [7] reviewed significantly higher DHA with the application of RDF + FYM. Ingale *et al.,* (2014) also recorded the DHA between 34.75 to 53.45 µg TPF g^{-1} soil hr^{-1} at 40 DAS among the different treatments receiving lower to higher doses of inorganic fertilizer or in combination of balanced dose of inorganic + FYM.

Table 2: Soil biological properties as affected by multinutrient briquette

	Treatments	Bacteria X 10^8 cfu g^{-1} soil	Fungi X10^4 cfu g^{-1} soil	Actinomycetes X10^6 cfu g^{-1} soil	Dehydrogenase activity µg TPF g^{-1} soil hr^{-1}
T_1	100% NPK + micronutrient (50% N, 100% P, K, micronutrients at sowing and 50% N at 30-35 DAS)	5.40	4.80	3.33	49.10
T_2	100% RDF through MNB at sowing	5.50	4.58	4.53	54.71
T_3	100% RDF through MNB (50% at sowing and 50% at 30-35 DAS)	5.91	4.30	4.40	54.96
T_4	75% RDF through MNB (50% at sowing 25% at 30-35 DAS)	4.37	3.67	4.20	51.03
T_5	100% RDF through MNB (50% at sowing, 25% at 30-35 DAS and 25% at 50-55 DAS)	5.11	3.25	4.38	53.67
T_6	75% RDF through MNB (25% at sowing, 25% at 30-35 DAS and 25% at 50-55 DAS)	4.33	4.00	3.67	52.00
T_7	Absolute control	3.72	3.10	2.94	43.45
	S. E. (m ±)	0.32	0.31	0.22	0.76
	C. D. @ 5%	0.97	0.94	0.66	2.34

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