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Effect of nitrogen management on yield and yield attributes of finger millet (*Eleusine coracana* L.)

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Abstract

The present study was conducted at the Crop Research Center of S.V. Patel University of Agriculture & Technology, Meerut, India, during *kharif* 2025. Ten treatments consisting of T₁ Control, T₂ 100% RDN, T₃ 75% RDN, T₄ 75% RDN + *Azospirillum* seed treatment @ 10 ml/kg, T₅ 75% RDN + Vermicompost @ 1 t ha⁻¹, T₆ 50% RDN + Vermicompost @ 1 t ha⁻¹ + *Azospirillum*, T₇ 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS, T₈ 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + *Azospirillum*, T₉ 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹, and T₁₀ 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + *Azospirillum* + Vermicompost @ 1 t ha⁻¹ were evaluated in a Completely randomized Block Design with three replications. The soil of the experimental field was low in available N and medium in P and K with a slightly alkaline nature. The finger millet crop was grown with the recommended package of practices except for the specific nutrient treatments. The highest growth & yield attributes, yield, nutrient content & uptake, gross & net return, and benefit-cost ratio were recorded with the application of 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + *Azospirillum* + Vermicompost @ 1 t ha⁻¹ (T₁₀). This treatment was statistically at par with 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ (T₉) for yield and economic returns, but it was significantly higher than the rest of the treatments.

On the basis of the present study, the application of 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + *Azospirillum* + Vermicompost @ 1 t ha⁻¹ is recommended for achieving higher yield and economic returns from finger millet.

Keywords: Finger millet, nitrogen management, nano urea, *Azospirillum*, vermicompost, nutrient uptake, yield

1. Introduction

Finger millet (*Eleusine coracana* L.) is a vital crop in India that is prized for its ability to withstand drought. It is widely grown in dryland and rainfed regions, particularly in red soil (Katre *et al.*, 2026) [1]. Finger millet (*Eleusine coracana* L.) is one of the most important millets grown in India for both grain and fodder. According to Michaelraj and Shanmugam (2013) [2], finger millet, or ragi, has ten times more calcium than wheat or rice. Finger millet (*Eleusine coracana* L.) is the most extensively grown crop among tiny millets. It is widely grown throughout East Africa and Southeast Asia, where it is regarded as a staple crop that provides energy and nutrients to a significant portion of the population, especially smallholders (Mukesh *et al.*, 2024) [3]. The amount of carbohydrates in ragi is 72g/100g with 1.04% free sugars, and 11.5% non-starchy polysaccharides (Kandel *et al.*, 2019) [4]. The composition of starch granules contains 80-85% of amylopectin along with 15-20% of amylase (ICMR 2010) [5]. Finger millet contains 7.16g of protein per 100g mostly all cereals and millets contain the lowest amount of lysine compared to legumes and animal proteins but finger millet is rich in amino acids, such as methionine, tryptophan and lysine (Shingote *et al.*, 2021) [6]. India stands as the world's largest producer of finger millet. In India, finger millet was cultivated over approximately 1.27 million hectares, with a production of 2.27 million tonnes and an average productivity of 1792 kg ha⁻¹ during 2025–26 (Second Advance Estimates) (Ministry of Agriculture & Farmers Welfare, Government of India, 2025–26) [7]. The finger millet cultivation faces a formidable challenge such as soil degradation. Furthermore, its labor intensive nature, particularly for transplanting, weeding and harvesting, makes production costly and inefficient. These agronomic challenges are compounded by

socioeconomic hurdles, including limited access to formal markets, a lack of affordable mechanization and competition from government-subsidized major cereals like rice and wheat which often make finger millet a less economically attractive option for farmers. Solution, Appropriate soil nutrient and crop management techniques can increase crop yield and quality (Pathak *et al.*, 2012) ^[10]. It is necessary to apply organic sources, biofertilizers, and micronutrients sparingly in order to achieve optimal crop production management of nutrients (Ghaffari *et al.*, 2011) ^[8]. For improved plant growth and development, use the right amount of nitrogenous fertilizer and apply nano urea topically. This improved soil health, in turn, increases water-use efficiency. Optimum nitrogen application increases the number and length of fingers on the ear head, dry matter production and vegetative development. It was crucial for the production of proteins, enzymes, chlorophyll and other metabolic processes (Bhatt *et al.*, 2001) ^[9].

2. Materials and Methods

This chapter provides a description of the materials and methodology used in the study "Effect of Integrated Nutrient management on Growth, Yield attributes and Yield of Finger millet (*Eleusine coracana* L.)." At a latitude of 29.081833 North, longitude of 77.700589 East, and elevation of 237 meters above mean sea level, the field experiment was conducted at the Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.). Meerut has a subtropical climate and is located in the center of Western Uttar Pradesh. The geography of the trial field was uniform, and the drainage system was effective.

The experimental field's soil had a sandy loam texture, low levels of accessible nitrogen and organic carbon, medium levels of available phosphorus and potassium, and a reaction that was almost neutral. VL MADUA 376 was sown on 23 August 2025. The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments with 3 replications. Ten plots of gross plot size (5 m × 4 m) and net plot size (4 m × 3.2 m) were included in each replication.

3. Results and discussion

1. Yield attributing characters

The yield-attributing characters, viz., effective tillers m⁻², finger length, ear weight, number of fingers ear-head⁻¹, number of grains ear-head⁻¹ and test weight (1000-grain weight), as influenced by Tables 1(a) and 1(b) show the various nitrogen management strategies.

1.1 Effective Tillers m⁻²

The data was given effective tillers m⁻² of finger millet at different crop growth as influenced by the different nitrogen management treatments. The highest number of effective tillers m⁻² were recorded under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ of (119.20), which was remained statistically at par with 75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS + Vermicompost @ 1 ha⁻¹ of 117.30. The lowest number of effective tillers m⁻² 60.90 under the control treatment.

1.2 Finger Length (cm)

The research findings regarding the finger length was significantly as influenced by the different nitrogen management treatments. The finger length maximum was recorded under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ of (7.55 cm), which was remained statistically at par with 75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ of 7.50 cm. The minimum finger length 4.81 cm was recorded under the control treatment.

1.3 Ear Weight (g)

The analysis indicates that the ear weight was significantly as influenced by the different nitrogen management treatments. The ear weight higher was recorded under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ of (7.54 g), which was continued to be statistically equivalent to 75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ 7.48g, but was noticeably greater than the other treatments. Under the control therapy, the lowest recorded ear weight was 4.52 g.

1.4 Number of Fingers Ear-head⁻¹

The study's findings showed that the various nitrogen management strategies had a substantial impact on the number of ear-head infections. The ear-head maximum no. of fingers is 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ (8.70), his was considerably greater than the other treatments but remained statistically comparable to 75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ of 8.30. The control plot had the fewest fingers ear-head⁻¹ 5.83.

1.5 Number of Grains Ear-head⁻¹

The data presented in the number of grains ear-head⁻¹ significantly affected by the different nitrogen management treatments. The number of grains ear-head⁻¹ 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ of (1230.00), which was remaining statistically at par with 75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ of 1220.30, but was significantly higher than rest of the treatments. The lowest number of grains ear-head⁻¹ of 710.00 was recorded in the control plot.

1.6 Test Weight (g)

The test weight (g) was significantly impacted by the various nitrogen control strategies. The test weight maximum was 3.52 g under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹. This was significantly higher than the other treatments, but statistically comparable to 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ 3.39 g. The control plot had the lowest test weight, 3.02 g. This ensures that the grains grow larger and denser, confirming the findings of Patel *et al.*, (2021) ^[12] and Ullasa *et al.*, (2020) ^[13]. Hatti *et al.*, (2018) ^[11].

Table 1.1a: Effect of nitrogen management on finger millet in different yield attributes

Symbol	Treatments	Yield attributes		
		Effective tillers / m ²	Finger length (cm)	Ear head weight(g)
T ₁	Control	60.90	4.81	4.52
T ₂	100% RDN	88.67	6.22	6.12
T ₃	75%RDN	84.80	5.89	5.71
T ₄	75% RDN + Azospirillum (seed treatment @ 10 ml/kg)	90.12	6.03	6.40
T ₅	75%RDN + Vermicompost @ 1 ton/ha	107.13	6.78	6.70
T ₆	50% RDN +Vermicompost @ 1ton /ha + Azospirillum	102.62	6.52	6.60
T ₇	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS	112.30	7.28	6.90
T ₈	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS + Azospirillum	113.01	7.35	7.04
T ₉	75% RDN + Nano urea spray @ 5ml/ liter at 30DAS and 60DAS + Vermicompost @ 1 ton/ha	117.30	7.50	7.48
T ₁₀	75% RDN + Nano urea spray @ 5ml/liter at 30DAS and 60DAS + Azospirillum + Vermicompost @ 1 ton/ha	119.20	7.55	7.54
SEm±		2.00	0.06	0.16
CD (P= 0.05)		5.94	0.19	0.47

Table 1.1b: Effect of nitrogen management on finger millet in different yield attributes

Symbol	Treatments	Yield attributes		
		No of finger /ear head	No of grains /ear head	1000 grain weight (g)
T ₁	Control	5.83	710.00	3.02
T ₂	100% RDN	6.57	930.00	3.11
T ₃	75%RDN	6.03	910.00	3.09
T ₄	75% RDN + Azospirillum (seed treatment @ 10 ml/kg)	6.80	950.00	3.15
T ₅	75%RDN + Vermicompost @ 1 ton/ha	7.17	1130.00	3.22
T ₆	50% RDN +Vermicompost @ 1ton /ha + Azospirillum	7.00	1125.93	3.19
T ₇	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS	7.60	1170.00	3.28
T ₈	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS + Azospirillum	8.00	1193.00	3.31
T ₉	75% RDN + Nano urea spray @ 5ml/ liter at 30DAS and 60DAS + Vermicompost @ 1 ton/ha	8.30	1220.30	3.39
T ₁₀	75% RDN + Nano urea spray @ 5ml/liter at 30DAS and 60DAS + Azospirillum + Vermicompost @ 1 ton/ha	8.70	1230.00	3.52
SEm±		0.15	11.08	0.05
CD (P= 0.05)		0.44	32.91	0.16

2. Yield

2.1 Grain Yield (q ha⁻¹)

The highest grain yield was found in 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ (28.60 q ha⁻¹), which was statistically comparable to 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS Vermicompost @ 1 t ha⁻¹ (27.60 q ha⁻¹). Grain yield increased by 50.5% and 45.3%, respectively, under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ and 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹. At 19.00 q ha⁻¹, the lowest grain yield was recorded in the control treatment. These field results match the conclusions of Feyanbule *et al.*, (2022) ^[14] and Kumar *et al.*, (2023) ^[15].

2.2 Straw Yield (q ha⁻¹)

The highest straw yield was found in 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ (58.60 q ha⁻¹), which was significantly higher than the other treatments but statistically comparable to 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ (56.99 q ha⁻¹). Under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ and 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹, the mean increase in straw yield over the control treatment was 34.6 and 30.9%, respectively. The lowest straw yield (43.55 q ha⁻¹) was

recorded in the control plot.

2.3 Biological Yield (q ha⁻¹)

The heighest biological yield was recorded under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ which remined statistically at par with 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ of (84.58 q ha⁻¹), but significantly superior than rest of the treatments. Over the control treatment the mean increase in biological yield was 39.4 and 35.2 per cent under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ and 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹, respectively. The lowest biological yield (62.56 q ha⁻¹) was found in the control treatment. Confirming the findings of Harika *et al.*, (2020) ^[16].

2.4 Harvest Index (%)

The maximum harvest index was observed under in 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ of (32.84%), which was remained statistically at par with (75% RDN + Vermicompost @ 1 t ha⁻¹ of 32.45%), (50% RDN + Vermicompost @ 1 t ha⁻¹ + Azospirillum of (32.33%), (75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS of 32.69%), (75% RDN + Nano urea spray @ 5 ml/l at 30 & 60 DAS + Azospirillum of (32.32%) and 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost

@ 1 t ha⁻¹ (32.61%), but was significantly higher than rest of the treatments. The minimum harvest index was recorded in the

control treatment (30.15%). Supporting the observations of Reddy *et al.*, (2024) ^[17].

Table 2: Effect of nitrogen management on finger millet in grain, straw, biological yield and harvest index (%)

Symbol	Treatments	Yield (q/ha)			
		Grain (q/ha)	Straw (q/ha)	Biological (q/ha)	Harvest index (%)
T ₁	Control	19.00	43.55	62.56	30.15
T ₂	100% RDN	22.12	48.52	70.64	31.21
T ₃	75%RDN	20.13	45.30	65.43	30.66
T ₄	75% RDN + Azospirillum (seed treatment @ 10 ml/kg)	22.21	49.70	71.92	30.79
T ₅	75%RDN + Vermicompost @ 1 ton/ha	25.10	52.00	77.10	32.45
T ₆	50% RDN +Vermicompost @ 1ton /ha + Azospirillum	24.81	51.75	76.55	32.33
T ₇	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS	25.44	52.40	77.84	32.69
T ₈	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS + Azospirillum	25.65	53.70	79.35	32.32
T ₉	75% RDN +Nano urea spray @ 5ml/ liter at 30DAS and 60DAS + Vermicompost @ 1 ton/ha	27.60	56.99	84.58	32.61
T ₁₀	75% RDN + Nano urea spray @ 5ml/liter at 30DAS and 60DAS + Azospirillum + Vermicompost @ 1 ton/ha	28.60	58.60	87.20	32.84
SEm±		0.73	1.44	2.05	0.49
CD (P= 0.05)		2.16	4.28	6.10	1.46

3. Nitrogen content and uptake

3.1 Nitrogen Content

The table 3 give data on the nitrogen content of grain and straw, as well as how different nitrogen management methods affected the finger millet crop's uptake of those nutrients. Appendix XII discusses statistical analysis of variance.

An appraisal of the results reveals indicate the grain (1.37%) and straw (0.52%) had the highest nitrogen content under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹. These results were statistically comparable to 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ of 1.34% and 0.50%. The control treatment had the lowest nitrogen level in both grain and straw (1.15% and 0.36%, respectively). Matching the trends reported by Prabhakar *et al.*, (2023) ^[18].

3.2 Nitrogen Uptake (kg ha⁻¹)

The study found that the under in 75% RDN + Nano urea spray

@ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹, the maximum nitrogen uptake by grain and straw was recorded at 39.09 kg ha⁻¹ and 30.47 kg ha⁻¹. This was statistically comparable to 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 36.98 and 28.68 kg ha⁻¹, respectively, but significantly higher than the other treatments.

Similarly, the highest total nitrogen uptake was measured under 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 DAS and 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹ (69.56 kg ha⁻¹), which was significantly higher than the other treatments but statistically comparable to 75% RDN + Nano urea spray @ 5 ml L⁻¹ at 30 & 60 DAS + Vermicompost @ 1 t ha⁻¹ (65.66 kg ha⁻¹). The control treatment had the lowest nitrogen uptake in grain, straw, and totles (21.87, 15.68, and 37.55 kg ha⁻¹). Harika *et al.*, (2020) ^[16] and Sinchana *et al.*, (2025) ^[20] also observed this multi-nutrient improvement, proving that a balanced nitrogen supply accelerates the uptake of both phosphorus and potassium.

Table 3: Effect of nitrogen management on finger millet in nitrogen content (%) and nitrogen uptake (kg/ha)

Symbol	Treatments	Nitrogen content (%)		Nitrogen uptake (kg/ha)		Total uptake (kg/ha)
		Grain	Straw	Grain	Straw	
T ₁	Control	1.15	0.36	21.87	15.68	37.55
T ₂	100% RDN	1.20	0.39	26.62	19.08	45.70
T ₃	75%RDN	1.18	0.38	23.76	17.26	41.02
T ₄	75% RDN + Azospirillum (seed treatment @ 10 ml/kg)	1.22	0.40	27.17	19.88	47.06
T ₅	75%RDN + Vermicompost @ 1 ton/ha	1.27	0.43	31.88	22.36	54.24
T ₆	50% RDN +Vermicompost @ 1ton /ha + Azospirillum	1.25	0.41	31.01	21.22	52.23
T ₇	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS	1.28	0.45	32.57	23.54	56.10
T ₈	75% RDN + Nano urea spray @5ml/liter at 30DAS and 60DAS + Azospirillum	1.29	0.48	33.18	25.96	59.13
T ₉	75% RDN + Nano urea spray @ 5ml/ liter at 30DAS and 60DAS + Vermicompost @ 1 ton/ha	1.34	0.50	36.98	28.68	65.66
T ₁₀	75% RDN + Nano urea spray @ 5ml/liter at 30DAS and 60DAS + Azospirillum + Vermicompost @ 1 ton/ha	1.37	0.52	39.09	30.47	69.56
SEm±		0.02	0.01	0.82	0.84	1.55
CD (P= 0.05)		0.06	0.03	2.44	2.50	4.59

4. Conclusion

The best nitrogen management technique for finger millet was the application of 75% RDN + Nano urea spray @ 5 ml l⁻¹ at 30 & 60 DAS + Azospirillum + Vermicompost @ 1 t ha⁻¹, which greatly improved growth, yield attributes, yield, protein content, nutrient

uptake, nutrient use efficiency and profitability.

Although integrated nitrogen management control raised cultivation costs, the highest grain yield was achieved (28.60 q ha⁻¹), protein yield (244.29 kg ha⁻¹), net returns (₹112534 ha⁻¹) and benefit-cost ratio (3.51), making it the most profitable

treatment.

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