



RESEARCH ARTICLE

Response of integrated application of nano urea, nano diammonium phosphate and microbial inoculants on yield and economics of fodder sorghum (*Sorghum bicolor* (L.) Moench)

Priyanka Devi^{1*}, S B Singh¹, Mahendra Singh², A K Singh¹, Shipra Yadav¹ & S M S Ramya¹

¹Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya 224 229, Uttar Pradesh, India

²Department of Soil Science and Agricultural Chemistry, University of Agriculture and Technology, Kumarganj, Ayodhya 224 229, Uttar Pradesh, India

*Correspondence email - priyankadevi_1998@yahoo.com

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Abstract

A field experiment was conducted during the kharif season of 2024 and 2025 at the research farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh to understand the response of integrated application of nano urea, nano diammonium phosphate (DAP) and microbial inoculants on yield and economics of fodder sorghum (*Sorghum bicolor* (L.) Moench.). The experiment was laid out in randomised block design (RBD) with 10 treatments replicated thrice, using the variety CSH24MF. The treatments consisted of different combinations of conventional, nano and biofertilisers applied to the crops such as: control [no nitrogen (N) and phosphorous (P), only, potassium (K)] (T₁); recommended dose of fertiliser (RDF) consisting of 120–60–40 kg NPK ha⁻¹ (T₂); 75 % recommended dose of N and P together with nano urea and nano DAP at 2 mL L⁻¹ of water, respectively (T₃); 75 % recommended dose of N and P together with nano urea and nano DAP at 4 mL L⁻¹ of water, respectively (T₄); 75 % recommended dose of N and P together with nano urea and nano DAP at 6 mL L⁻¹ of water, respectively (T₅); 75 % recommended dose of N and P together with urea and DAP spray at 2 %, respectively (T₆); T₃ combined with soil application of *Azospirillum* and phosphate-solubilising bacteria (PSB) at 2 kg ha⁻¹, each (T₇); T₄ combined with soil application of *Azospirillum* and PSB at 2 kg ha⁻¹, each (T₈); T₅ combined with soil application of *Azospirillum* and PSB at 2 kg ha⁻¹, each (T₉) and T₆ combined with soil application of *Azospirillum* and PSB at 2 kg ha⁻¹ (T₁₀). Among the various treatment combinations, application of 75 % recommended dose of N and P together with nano urea and nano DAP spray at the rate of 6 mL L⁻¹, respectively and soil application of *Azospirillum* at the rate 2 kg ha⁻¹ and PSB at the rate 2 kg ha⁻¹ (T₉) resulted in substantial increase in yield performance. It recorded the highest green fodder yield (335, 295, 270 q ha⁻¹ during 2024 at and 344.67, 310.56 and 279 q ha⁻¹ during 2025 at first, second and third cuts, respectively), corresponding dry matter yield (93.10, 82.50 and 75.15 q ha⁻¹ during 2024 and 93.40, 81.87 and 74 q ha⁻¹ during 2025 at successive cuts) and total green fodder yield. The pooled economic analysis conducted thereafter resulted in highest net returns (₹54062 ha⁻¹), gross returns (₹91712 ha⁻¹) and benefit cost (2.44) throughout both the year of experimentation with treatment T₉. Thus, the combined application of nanofertilisers and biofertilisers with conventional fertilisers can be considered as an effective nutrient management approach for boosting crop productivity and profitability.

Keywords: *Azospirillum*; nano diammonium phosphate; nano urea; sorghum; yield

Introduction

The intensive use of chemical fertilisers since green revolution although increased foodgrain production and enabled the country to achieve self-sufficiency in food; however, it has resulted in yield stagnation, declining nutrient use efficiency and serious environmental concerns. In most crops nitrogen use efficiency (NUE) ranges between 30–50 %, with the remaining nitrogen lost through leaching, volatilisation and denitrification contributing to environmental contamination. Development of algal blooms is one of the major environmental issues arising from runoff loss of nitrogen and phosphorus, resulting in increased biological oxygen demand (BOD) (1). Furthermore, emissions of nitrous oxide and nitric oxide during nitrogen transformations contribute to greenhouse gas, formation of tropospheric ozone and acid rain (2, 3). Similarly, phosphorus use efficiency is also limited, rarely

exceeding 20 % primarily due to fixation in soils as iron, aluminium or calcium phosphates and coprecipitation, depending on soil pH (4–6). Consequently, the excessive application of fertilisers to compensate for these losses increase production costs and further aggravates environmental degradation. In recent years, nanotechnology has emerged as a promising approach in agriculture to enhance nutrient use efficiency and reduce environmental pollution. Nanofertilisers, typically ranging from 1–100 nm in size, facilitate controlled and targeted nutrient release owing to its high surface area, enhanced reactivity, improved nutrient penetrability and mobility within the soil-plant system (7, 8). Among them, nano urea and nano diammonium phosphate (DAP) commercialised by Indian Farmers Fertiliser Cooperative Limited (IFFCO) have come up as an alternative to conventional fertilisers. In addition, biofertilisers such as nitrogen fixing and phosphorus solubilising microorganisms improve nutrient

availability via several processes such as biological nitrogen (N) fixation, production of organic acids for solubilising fixed phosphorus (P), secretion of enzymes, production of plant growth promoters, suppressing pathogens and enhances plants' capacity to endure abiotic stress (9, 10). Therefore, the integration of nanofertilisers and biofertilisers represents a sustainable nutrient management strategy capable of boosting crop productivity while maintaining soil health and environmental sustainability.

Livestock plays a crucial role in the Indian agricultural economy, contributing significantly to national agriculture income, accounting to almost 5.49 % to the total gross value added (GVA). However, its productivity remains constrained largely due to inadequate availability of quality feed and fodder further aggravated by the limited land allocation for fodder cultivation. India currently faces substantial deficits in green fodder, dry fodder and concentrate feed, by almost 35.6 %, 10.95 % and 44 %, respectively and fodder cultivation occupying only 1.54 % of the gross cropped area (11, 12). Under such circumstances, increasing the productivity of high biomass fodder crops becomes essential to ensure feed and nutritional security. Sorghum (*Sorghum bicolor* (L.) Moench), often referred to as the King of millets, is an important C₄ grain cum fodder crop belonging to the family Poaceae and is widely cultivated in semi-arid regions due to its remarkable tolerance to drought, heat and soil salinity. Its high photosynthetic efficiency, rapid growth, ratooning ability and substantial biomass production make it one of the most suitable fodder crops for livestock feeding systems (13). Sorghum also possesses favourable nutritional attributes and high-water soluble carbohydrates, making it an excellent crop for silage preparation for year-round fodder supply (14). However, despite these agronomic advantages, sorghum is considered as an exhaustive crop due to its potentiality to deplete soil nitrogen and hence have high nitrogen demand. Thus, to sustain high biomass production, farmers often rely heavily on conventional nitrogenous fertilisers which only degrade soil, reduce nutrient use efficiency and ultimately lead to yield stagnation in long run. Therefore, the

development and adoption of alternative nutrient management approach, such as the combined application of nanofertilisers and biofertilisers together with conventional fertilisers, is essential for sustaining sorghum productivity while maintaining soil fertility and environmental sustainability. Considering these aspects, a field experimentation was undertaken to evaluate the response of integrated application of nano urea, nano DAP and microbial inoculants on yield and economics of fodder sorghum (*S. bicolor*).

Materials and Methods

Experimental site

A field trial was performed during the kharif season of 2024 and 2025 to determine the yield and economics of fodder sorghum (*S. bicolor*) under integrated application of conventional fertilisers, nanofertilisers and biofertilisers at the Genetics and Plant Breeding Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh. The experimental site was geographically situated within the subtropical climatic zone marked by high humidity, located between 26°32'14.956" N latitude and 81°49'20.388" E longitude and having an elevation of about 113 m above the mean sea level. The physical, chemical and biological properties of the soil of the experimental site was analysed prior to conducting the experiment and the results along with the methods adopted are presented in the Table 1.

Climatic conditions

Meteorological observations throughout the crop growing period during the kharif season for both the experimental years (2024 and 2025) were recorded from the meteorological observatory of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, located adjacent to the experimental field. Weather parameters including weekly rainfall distribution, maximum and minimum temperature, relative humidity, vapour pressure, sunshine hours, total evaporation and soil temperature were monitored throughout the crop season. During 2024, the

Table 1. Physical, chemical and biological properties of experimental site

Sl. No	Particulars	Values		Methods employed	References
		2024	2025		
Mechanical analysis					
1.	Sand (%)	29.25	29.25	Hydrometer method	(15)
	Silt (%)	57.45	57.45		
	Clay (%)	13.30	13.30	Triangular method	(16)
	Soil texture	Silty loam	Silty loam		
Physical properties					
2.	Bulk density (Mg m ⁻³)	1.52	1.52	Core method	(17)
Chemical properties					
3.	pH	8.03	8.05	Soil water suspension	(18)
4.	EC (dS/m)	0.255	0.252	Soil water suspension	(18)
5.	Oxidizable organic carbon content (%)	0.43	0.42	Wet digestion method	(19)
6.	Available N (kg ha ⁻¹)	185.12	185.22	Alkaline potassium permanganate method	(20)
7.	Available P (kg ha ⁻¹)	15.55	15.92	NaHCO ₃ method	(21)
8.	Available K (kg ha ⁻¹)	272	273.57	NH ₄ OAc method	(16)
Biological properties					
9.	Dehydrogenase enzyme activity (µg TPF g ⁻¹ soil hr ⁻¹)	29.76	30.63	Colorimetry	(22)
10.	Soil microbial population				
	Bacteria (cfu × 10 ⁷ g ⁻¹ soil)	30.00	36.6	Serial dilution	(23)
	Actinomycetes (cfu × 10 ⁴ g ⁻¹ soil)	20.98	20.78		
	Fungi (cfu × 10 ³ g ⁻¹ soil)	18.90	19.03		

mean weekly maximum and minimum temperatures ranged from 30.0 to 43.6 °C and 17.2 to 28.5 °C, respectively, while in 2025 they varied from 27.57 to 39.5 °C and 9.85 to 27.0 °C. Relative humidity ranged from 54.9–81.1 % in 2024 and 66.1–83.2 % in 2025. The mean weekly vapour pressure varied between 15.2–27.5 mm during 2024 and 11.77–26.5 mm during 2025. Total rainfall received during the crop growing period was 811.8 mm in 2024 and 1050.6 mm in 2025, with peak rainfall of 199.6 mm recorded in the fourth week of September 2024 and 255.4 mm during the first week of August 2025. Sunshine hours ranged from 3.5–10.7 hr in 2024 and 2–9 hr in 2025, whereas total evaporation varied from 3.3–10.3 mm and 3.68–7.6 mm, respectively. Soil temperature recorded at depths of 5, 10 and 20 cm ranged between 23.8–36.6 °C, 23.9–36.5 °C and 23.9–36.5 °C during 2024 and 17.3–34.1 °C, 17.3–34.2 °C and 17.2–32.5 °C during 2025, respectively.

Treatment details

The crop under the study was multicut fodder sorghum and the variety chosen was CSH24MF. The seeds were sown during the second week of June before the monsoon showers in both the years. Owing to its multicut nature, the crop was harvested thrice, beginning at 60 days after sowing (DAS) and subsequently at 90 and 120 DAS. Each cut was performed at 12 cm above the ground level to facilitate efficient development of ratoon shoots.

The study was conducted using a randomised block design (RBD) with 10 treatments and 3 replications. A total of 30 number of plots were constructed, each with a dimension of 3m × 4m. The gross and net plot size was 12 m² and 5.4 m², respectively. The treatments consisted of different combinations of conventional, nano and biofertilisers applied to the crops as shown in Table 2. The foliar application of nano urea, nano DAP and urea and DAP were performed at 30 DAS, 70–75 DAS (10–15 days after the first cutting) and 100–105 DAS (10–15 days after the second cutting), respectively. Nitrogen was applied in split doses comprising of 50 % at basal, 25 % at 30 DAS and the remaining 25 % after first cut at 61 DAS. As per the treatment details depicted in Table 2, the biofertilisers utilised including *Azospirillum* and phosphate-solubilising bacteria (PSB) was applied as soil treatment by mixing with sand. Soil treatment of these biofertilisers were applied at the time of sowing after the application of the chemical fertilisers to prevent the death of the microorganism. The pure strains of *Azospirillum azomonas* and *Pseudomonas hilleri* strain ND 06 was procured from the Biofertiliser Production Unit, Department of Soil Science and

Agricultural Chemistry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya.

Estimation of yield parameters, economics and statistical analysis

Yield parameters

The green fodder yield was recorded at each harvest undertaken at 60, 90 and 120 DAS. Subsequently, the total green fodder yield was calculated by summing the yields obtained from all 3 harvests. Finally, the dry fodder yield was estimated using the dry matter content of the crop. For this purpose, a representative 500 g green fodder sample was collected from each plot and oven dried at 65–70 °C for 48–72 hr until constant weight was achieved to determine dry matter percentage. The dry fodder yield was then calculated by multiplying the green fodder yield with the corresponding dry matter percentage.

$$\text{Dry matter percentage} = \frac{\text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

$$\text{Dry fodder yield (q ha}^{-1}\text{)} = \frac{\text{Green fodder yield (q ha}^{-1}\text{)} \times \text{dry matter percentage}}{100}$$

Economics

The pooled economic analysis was carried out to evaluate the feasibility and profitability of the production system. The parameters estimated included cost of cultivation, gross returns, net returns and benefit cost (B : C) ratio. The cost of cultivation (₹ ha⁻¹) comprised all variable and fixed costs incurred during the crop production period, calculated based on the prevailing market prices of inputs during the experimentation period. Gross returns (₹ ha⁻¹) and net returns (₹ ha⁻¹) were estimated by multiplying the total fodder yield obtained at harvest with the prevailing market price and by subtracting the total cost of cultivation from the gross returns, respectively. The B : C ratio was determined by dividing the gross returns by the total cost of cultivation to assess the economic profitability of the treatments.

Statistical analysis

The data recorded for different parameters during the two years of experimentation were subjected to statistical analysis following the standard procedures described by Gomez and Gomez (24). The recorded observations were compiled and analysed using Microsoft Excel to perform analysis of variance (ANOVA) for the RBD. The significance of treatment effects was

Table 2. Treatment details

T ₁	: Control (No N and P, only K)
T ₂	: RDF (120 – 60 – 40 kg NPK/ha)
T ₃	: 75 % RD of N and P + Nano urea and Nano DAP at 2ml L ⁻¹ of water, respectively
T ₄	: 75 % RD of N and P + Nano urea and Nano DAP at 4ml L ⁻¹ of water, respectively
T ₅	: 75 % RD of N and P + Nano urea and Nano DAP at 6ml L ⁻¹ of water, respectively
T ₆	: 75 % RD of N and P + Urea and DAP spray at 2 %, respectively
T ₇	: T ₃ + soil application of <i>Azospirillum</i> at 2 kg ha ⁻¹ and PSB at 2kg ha ⁻¹
T ₈	: T ₄ + soil application of <i>Azospirillum</i> at 2 kg ha ⁻¹ and PSB at 2kg ha ⁻¹
T ₉	: T ₅ + soil application of <i>Azospirillum</i> at 2 kg ha ⁻¹ and PSB at 2kg ha ⁻¹
T ₁₀	: T ₆ + soil application of <i>Azospirillum</i> at 2 kg ha ⁻¹ and PSB at 2kg ha ⁻¹

RDF: recommended dose of fertilisers; RD: recommended dose; DAP: diammonium phosphate; PSB: phosphate-solubilising bacteria; N: nitrogen; P: phosphorous; K: potassium.

tested using the *F*-test at the 5 % probability level ($p = 0.05$) and the critical difference (CD) was calculated wherever the *F*-test indicated significant differences among treatments.

Results and Discussion

Yield parameter

The statistical analysis of yield parameters ($p \leq 0.05$ %) showed that the integrated application of 75 % recommended dose of N and P, foliar spray of nano urea and nano DAP at the rate of 6 mL L⁻¹ and soil application of *Azospirillum* and PSB at the rate of 2 kg ha⁻¹ each (T₉) resulted in significantly maximum green fodder yield (335, 295, 270 q ha⁻¹ during 2024 and 344.67, 310.56 and 279 q ha⁻¹ during 2025 at first, second and third cuts, respectively), total green fodder yield and dry matter yield (93.10, 82.50 and 75.15 q ha⁻¹ during 2024 and 93.40, 81.87 and 74 q ha⁻¹ during 2025 at each successive cuts). T₉ was significantly superior over treatments T₁, T₂, T₃, T₄, T₅, T₆ and T₁₀ indicated by the CD value being less than the respective differences. However, treatment T₉ was found to be statistically at par with the combined application of 75 % recommended dose of N and P, foliar application of nano urea and nano DAP at the rate of 4 mL L⁻¹ and soil application of *Azospirillum* and PSB at the rate of 2 kg ha⁻¹, respectively (T₈) and also with the treatment involving 75 % recommended dose of N and P was combined applied with foliar spray of nano urea and nano DAP at the rate of 2 mL L⁻¹ and soil application of *Azospirillum* at the rate of 2 kg ha⁻¹ and PSB at the rate of 2 kg ha⁻¹ (T₇). Contrarily, treatment T₁ including the application of only potassic fertiliser resulted in the lowest green fodder yield (180, 165, 155 q ha⁻¹ during 2024 at and 182, 167 and 153 q ha⁻¹ during 2025 at first, second and third cuts, respectively), total fodder yield and dry matter yield (50, 45.80 and 43.15 q ha⁻¹ during 2024 and 52.09, 46 and 42.10 q ha⁻¹ during 2025 at each successive cuts). The CD value being greater than the treatment differences between Treatment T₉ and T₇ and T₈, respectively indicated that T₉ was statistically at par with T₇ and T₈. The data pertaining to the green fodder and dry matter yield are presented in Table 3. The treatment effect on the total green and dry fodder yield is graphically presented in Fig. 1. The enhanced yield observed with the application of 75 % recommended dose of N and P, foliar spray of nano urea and nano DAP at the rate of 6 mL L⁻¹ and soil application of *Azospirillum* and PSB at the rate of 2 kg ha⁻¹ each (T₉) may be primarily attributed to the cumulative improvement in growth attributes, which might have resulted from improved nutrient availability and enhanced physiological efficiency of the crop. This treatment led to the development of a balanced and sustained nutrient supply, that have helped achieve vigorous plant growth and higher biomass production. The improved availability

and efficient utilisation of nutrients under this treatment might have enhanced chlorophyll synthesis, enzyme and ATP production which have boosted key physiological processes such as photosynthesis, energy transfer and metabolic activities thus, better translocation of assimilates towards economically important plant parts (25). This contributed to a higher biomass accumulation and ultimately improved yield. The foliar application of nanofertilisers may have further improved nutrient use efficiency due to their higher surface area, better penetrability and controlled release characteristics. These properties ensured an uninterrupted and targeted delivery of nutrients throughout the growth stage, thereby minimising nutrient losses and enhancing nutrient assimilation within plant tissues. As a result, plants under treatment T₉ may have maintained higher physiological activity throughout the growth period. In addition, the application of biofertilisers such as *Azospirillum* and PSB might have played a crucial role in improving nutrient dynamics in the soil plant system. These microorganisms enhance nutrient availability through biological nitrogen fixation and solubilisation of P, while also producing plant growth promoting substances such as auxins, gibberellins and cytokinins. These phytohormones and bioavailability of nutrients stimulated root growth, increased root surface area, improved the resilience of plants to environmental stresses and thereby, improved nutrient absorption capacity, strengthening the overall growth and productivity (26). These results were in conformity with previous researchers (27–29).

Economics

The pooled economic analysis conducted for both the years of field trial revealed that the application of 75 % recommended dose of N and P combined with nano urea and nano DAP at the rate of 6 mL L⁻¹, soil application of *Azospirillum* and PSB at the rate of 2 kg ha⁻¹, respectively recorded the highest gross return, net return and B : C ratio, the results of which are presented in Table 4. This treatment resulted in a gross return of ₹91712 ha⁻¹ and net return of ₹54062 ha⁻¹ with a B : C ratio of 2.44. The higher profitability under this treatment can be attributed to the substantially higher green fodder yield obtained due to improved nutrient availability and efficient nutrient utilisation.

Conclusion

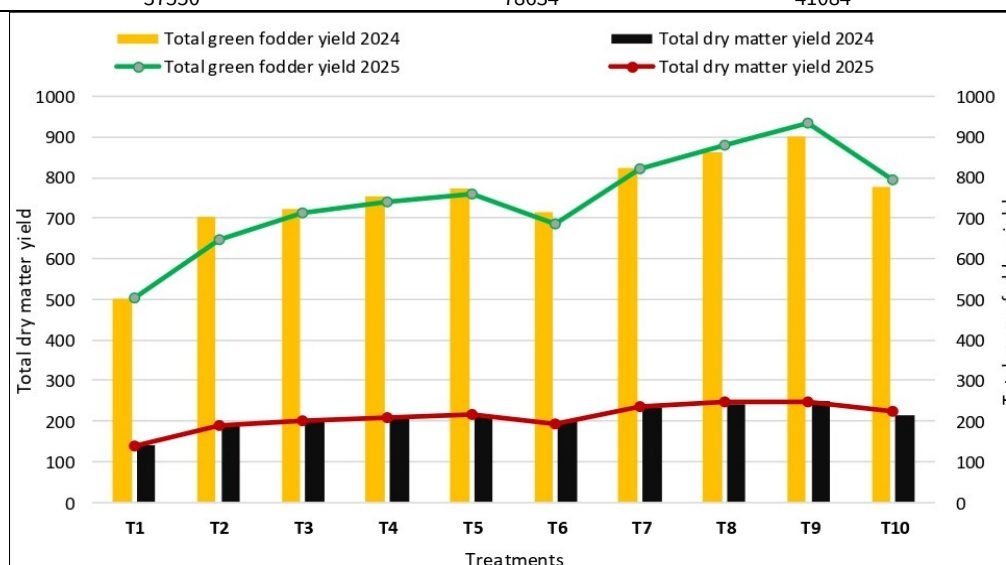
The results obtained from the two year experiment, demonstrated that the combined application of 75 % recommended dose of nitrogen (N) and phosphorus (P), foliar spray of nano urea and nano diammonium phosphate (DAP) at the rate of 6 mL l⁻¹ and soil application of *Azospirillum* and phosphate-solubilising bacteria (PSB) at the rate of 2 kg ha⁻¹, respectively, improved the growth and

Table 3. Effect of integrated application of nano urea, nano DAP and microbial inoculants on green fodder yield (q ha⁻¹) and dry matter yield (q ha⁻¹)

Treatments	2024						2025					
	Green fodder yield			Dry matter yield			Green fodder yield			Dry matter yield		
	I cut	II cut	III cut	I cut	II cut	III cut	I cut	II cut	III cut	I cut	II cut	III cut
T ₁	180.00	165.00	155.00	50.00	45.80	43.15	182.00	167.00	153.00	52.09	46.00	42.10
T ₂	278.00	228.00	197.00	77.25	63.45	55.50	263.00	208.00	176.06	75.89	61.00	53.65
T ₃	282.00	235.00	206.00	78.15	65.35	57.50	274.00	230.78	209.99	77.00	65.00	57.01
T ₄	285.00	250.00	220.00	81.95	70.55	60.15	285.00	245.06	210.00	79.15	69.09	62.01
T ₅	295.00	252.00	226.00	81.95	70.65	61.50	292.33	253.78	215.45	81.00	73.01	63.24
T ₆	280.00	230.00	205.00	77.75	64.00	57.50	270.00	226.89	190.12	76.00	62.00	57.00
T ₇	310.00	272.00	240.00	90.00	78.10	67.25	310.00	278.00	233.56	87.00	80.60	68.54
T ₈	325.00	282.00	257.00	90.30	79.00	72.00	325.33	285.00	270.00	92.20	80.65	73.00
T ₉	335.00	295.00	270.00	93.10	82.50	75.15	344.67	310.56	279.00	93.40	81.87	74.00
T ₁₀	295.00	255.00	228.00	81.99	70.77	61.95	300.67	268.00	226.00	84.04	73.01	66.01
SEm(±)	13.42	12.75	12.65	3.73	3.94	3.95	14.35	13.14	17.67	6.96	2.92	2.69
CD (0.05)	39.87	37.87	37.59	11.08	11.71	11.74	42.62	39.05	52.49	20.68	8.67	7.99

Table 4. Pooled economic analysis on the integrated application of nano urea, nano diammonium phosphate (DAP) and microbial inoculants

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B/C ratio
T ₁	30639	50100	19461	1.64
T ₂	35500	67503	32003	1.90
T ₃	36050	71889	35839	1.99
T ₄	36450	74753	38303	2.05
T ₅	36850	76728	39878	2.08
T ₆	36750	70101	33351	1.91
T ₇	36850	82178	45328	2.23
T ₈	37250	87217	49967	2.34
T ₉	37650	91712	54062	2.44
T ₁₀	37550	78634	41084	2.09

**Fig. 1.** Graphical representation of the effect of different treatments on total green fodder and dry matter yield of fodder sorghum during 2024 and 2025.

yield, with an impressive benefit cost (B : C) ratio. Therefore, integrated application of conventional fertilisers, nanofertilisers and microbial inoculants can be considered an efficient and sustainable nutrient management strategy for improving productivity and profitability of fodder sorghum while reducing dependence on higher dose of conventional fertilisers and hence maintaining environmental sustainability. Hence, these findings are critical for achieving sustainable developmental goals, particularly Sustainable Development Goal (SDG) 2 (Zero hunger), SDG 12 (Responsible Consumption and Production) and SDG 15 (Life on Land). Moreover, considering this experimental as the baseline future research may be conducted to evaluate the long-term effect of this nutrient management strategy on soil health, nutrient dynamics, carbon sequestration and its adaptability across diverse agroclimatic conditions to reinforce holistic fodder production.

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Authors' contributions

PD conducted the experiment, collected data, analysed and interpreted the data and drafted the manuscript. SBS and MS supervised the experiment and assisted in data analysis. AKS and

SY provided valuable suggestions during the study. SMSR assisted in compiling and editing the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT and Gemini to improve language, grammar correction and clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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