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Effect of nano urea on growth, yield attributes, yield and economics of wheat (*Triticum aestivum* L.) in central zone of Uttar Pradesh

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ABSTRACT

A field experiment was conducted during Rabi season of 2024-25 at the Student's Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology (CSAUA&T), Kanpur, Uttar Pradesh, India to study the effect of nano urea on growth, yield attributes, yield and economics of wheat (*Triticum aestivum* L.) cv. DBW-187. The experiment was laid out in Randomized Block Design (RBD) with six treatment combinations and three replications. Treatments comprised different levels of conventional NPK fertilization combined with foliar sprays of nano urea (10 ml L⁻¹) applied at 25 and 50 days after sowing (DAS). Results revealed that treatment T₄ [100% NPK + 2 sprays of nano urea at 25 and 50 DAS] recorded significantly the highest plant height (111.2 cm), dry matter accumulation (704.3 g m⁻²), spike length (10.9 cm), grains per spike (51.4), 1000-grain weight (45.7 g), grain yield (4.71 t ha⁻¹), straw yield (6.61 t ha⁻¹) and harvest index (41.6%), outperforming T₃ (100% NPK alone, 4.18 t ha⁻¹) by 12.7% in grain yield. Notably, T₆ [50% N + 100% PK + 2 sprays of nano urea], using only half of the recommended nitrogen dose, produced a grain yield of 4.39 t ha⁻¹, exceeding T₃ (full 100% NPK) by 5.0%, demonstrating the potential of nano urea to substantially reduce conventional nitrogen inputs without yield penalty. Maximum gross returns (Rs. 96,893 ha⁻¹), net returns (Rs. 51,893 ha⁻¹) and benefit-cost ratio (2.15) were also recorded under T₄, establishing it as the most agronomically and economically superior treatment for wheat production in the central zone of Uttar Pradesh.

Keywords: Nano urea, Wheat, DBW-187, Yield attributes, Economics, Nitrogen use efficiency, Central Uttar Pradesh

1. Introduction

Wheat (*Triticum aestivum* L.) is the world's most widely cultivated cereal crop and a primary staple food for more than 35% of the global population. India is the second largest producer of wheat with a production of 119 million tonnes, contributing approximately 14.20% to the world's total wheat output (Govt. of India, 2025-26) [2]. Uttar Pradesh stands as the top wheat-producing state, contributing over 30% of India's total wheat production, equivalent to 35.65 million tonnes (Economic Survey, 2025-26). Despite this impressive production, productivity in the central zone of UP remains suboptimal and requires targeted agronomic interventions.

Nitrogen is the most critical macronutrient for wheat, influencing virtually every aspect of plant growth and grain formation. Urea, containing 46% nitrogen, is the dominant nitrogenous fertilizer in India. However, a major constraint of conventional urea application is the significant nitrogen loss through volatilization, leaching and denitrification, estimated at 40 to 70 percent of applied N (Solanki *et al.*, 2015; Trenkel *et al.*, 2010) [7]. These losses not only represent a financial burden to farmers but also contribute to environmental degradation through eutrophication and greenhouse gas emissions.

Nanotechnology offers a transformative solution to these challenges. Nano urea, developed and commercialized by IFFCO (Indian Farmers Fertiliser Cooperative), is a liquid nano fertilizer containing 4% nitrogen (40,000 mg L⁻¹) in nano form (particle size 20-50 nm). Due to the extremely small particle size and high surface area-to-volume ratio, nano urea particles can penetrate plant leaves through stomatal openings and be rapidly translocated to metabolically active tissues, bypassing soil-based losses entirely. One 500 ml bottle of nano urea is equivalent in nitrogen impact to one bag of conventional urea while being approximately 10% cheaper (IFFCO, 2021).

Several researchers have demonstrated the superiority of nano fertilizers over conventional inputs. Yogendra *et al.* (2020) [8] reported that 50% N + full PK + two nano urea sprays produced the highest grain yield and benefit-cost ratio in wheat. Despite growing evidence, limited studies have evaluated the effect of nano urea under the specific agro-climatic conditions of central Uttar Pradesh using the newly recommended variety DBW-187. The present investigation was therefore undertaken with the objectives of: (i) assessing the effect of nano urea on growth, yield attributes and yield of wheat; (ii) evaluating its impact on the economics of

wheat cultivation; and (iii) identifying the most agronomically and economically optimal treatment combination.

2. Materials and methods

2.1 Experimental site and season

The field experiment was conducted during Rabi season of 2024-25 at the Student's Instructional Farm, Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology (CSAUA&T), Kanpur, Uttar Pradesh (26°29'35" N latitude; 80°18'35" E longitude; elevation 125.9 m MSL). The climate of the region is semi-arid and sub-tropical with hot dry summers and cold winters. Average annual rainfall is approximately 845 mm, with 80-90% received during the monsoon months (June-September). The crop was sown on 9 December 2024 and harvested on 26 April 2025.

2.2 Soil characteristics

Pre-experiment soil analysis (0-15 cm depth) revealed sandy loam texture with slightly alkaline reaction. Details are presented in Table 1.

Table 1. Physicochemical properties of the experimental soil (0-15 cm depth)

S.No.	Soil Property	Value	Method
1	Texture	Sandy loam	Bouyoucos hydrometer (1962)
2	Bulk density (Mg m ⁻³)	1.35	Core sampler (Blake, 1965)
3	Soil pH	7.6	Glass electrode pH meter (Jackson, 1973)
4	EC (dS m ⁻¹)	1.7	Conductivity meter (Jackson, 1973)
5	Organic carbon (%)	0.485	Walkley and Black method (Jackson, 1973)
6	Available N (kg ha ⁻¹)	222.56	Alkaline KMnO ₄ method (Subbiah & Asija, 1956)
7	Available P ₂ O ₅ (kg ha ⁻¹)	13.16	Olsen's method (Olsen <i>et al.</i> , 1954)
8	Available K ₂ O (kg ha ⁻¹)	212.34	Ammonium acetate method (Hanway & Heidel, 1952)

2.3 Experimental details and treatments

The experiment was laid out in Randomized Block Design (RBD) with six treatments and three replications. Wheat variety DBW-187 was sown at 100 kg ha⁻¹ seed rate with 22.5 cm row spacing. The

recommended fertility level was N:P₂O₅:K₂O @ 120:60:40 kg ha⁻¹. Nano urea (IFFCO, 4% N, 10 ml L⁻¹) was applied as two foliar sprays at 25 and 50 DAS. Treatment details are given in Table 2.

Table 2. Treatment details

Treatment	Description
T ₁	Absolute control (no fertilizer)
T ₂	T ₁ + 2 foliar sprays of nano urea (25 & 50 DAS)
T ₃	100% NPK (N:P ₂ O ₅ :K ₂ O — 120:60:40 kg ha ⁻¹)
T ₄	100% NPK + 2 foliar sprays of nano urea (25 & 50 DAS)
T ₅	50% N + 100% PK
T ₆	50% N + 100% PK + 2 foliar sprays of nano urea (25 & 50 DAS)

2.4 Observations recorded

Growth parameters: plant height (cm), dry matter accumulation (g m⁻²) and number of tillers per plant were recorded at 30, 60 and 90 DAS and at harvest. Yield attributes including spike length (cm), number of grains per spike, test weight (g) and 1000-grain weight (g) were recorded at maturity. Grain yield (t ha⁻¹), straw yield (t ha⁻¹), biological yield (t ha⁻¹) and harvest index (%) were computed at harvest. Economic analysis included cost of cultivation, gross returns, net returns and benefit-cost ratio based on the prevailing minimum support price (MSP) of Rs. 2,275 per quintal for wheat.

2.5 Statistical analysis

Data were subjected to Analysis of Variance (ANOVA) using the method of Gomez *et al.* (1984) [1] for RBD. Significance of treatment effects was determined by *F*-test and mean separation was done using Critical Difference (CD) at 5% level of probability. Statistical analysis was performed using SPSS Version 10.0.

3. Results and discussion

3.1 Plant height

Plant height showed progressive increase from 30 DAS to harvest across all treatments with significant differences (Table 3). At harvest, T₄ recorded the maximum plant height of 111.2 cm, followed by T₆ (109.1 cm) and T₃ (102.6 cm), while T₁ (absolute control) recorded the minimum of 82.1 cm. The improved plant height under nano urea treatment is attributed to enhanced cell elongation and division facilitated by better nitrogen assimilation from nano urea. Similar enhancement in plant height with nano fertilizer application in wheat was reported by Pal *et al.* (2023) [5].

Table 3. Effect of nano urea on plant height (cm) of wheat at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	At Harvest
T ₁ — Absolute control	28.4	52.1	74.6	82.1
T ₂ — T ₁ + nano urea	32.6	59.3	83.9	92.3
T ₃ — 100% NPK	36.4	66.8	92.4	102.6
T ₄ — 100% NPK + nano urea	39.5	72.6	100.2	111.2
T ₅ — 50% N + 100% PK	33.1	61.4	85.6	94.8
T ₆ — 50% N + PK + nano urea	38.1	70.3	98.4	109.1
CD (<i>P</i> = 0.05)	1.54	2.83	3.95	4.37
SEm±	0.52	0.96	1.34	1.48
CV (%)	2.5	2.5	2.5	2.5

3.2 Dry matter accumulation

Dry matter accumulation increased progressively from 30 DAS to harvest, with the steepest accumulation phase between 60 and 90 DAS corresponding to the active tillering, jointing and booting stages.

At final harvest, T₄ produced the highest dry matter of 704.3 g m⁻², representing a 46.0% increase over T₁ (482.3 g m⁻²). The enhanced dry matter accumulation under the nano urea treatment is explained by higher chlorophyll content, greater leaf area index and more effi

cient photosynthetic radiation use, as nano urea ensures sustained nitrogen supply throughout the vegetative period.

3.3 Yield attributing parameters

Yield attributes including spike length, number of grains per spike, test weight and 1000-grain weight were significantly influenced by treatments (Table 4). T_4 recorded the longest spikes (10.9 cm), high-

est grains per spike (51.4), test weight (87.1 g) and 1000-grain weight (45.7 g) among the treatments. Nano urea applied at 25 and 50 DAS, coinciding with the booting/heading and early grain-fill stages respectively, enhanced assimilate accumulation and reduced chaffy grain percentage, resulting in improved yield attributes. These results are in agreement with Pal *et al.* (2023) [5].

Table 4. Effect of nano urea on yield attributes of wheat

Treatment	Spike Length (cm)	Grains/Spike	Test Weight (g)	1000-GWT (g)
T_1	7.8	36.2	76.4	36.2
T_2	8.9	41.8	80.6	39.1
T_3	9.8	46.4	83.9	42.6
T_4	10.9	51.4	87.1	45.7
T_5	9.1	43.2	81.8	40.8
T_6	10.5	50	86	44.4
CD ($P = 0.05$)	0.42	1.8	1.2	0.86
SEm±	0.14	0.61	0.41	0.29
CV (%)	2.48	2.25	0.84	1.18

3.4 Grain yield, straw yield and harvest index

Grain yield, straw yield and harvest index were significantly influenced by all treatments (Table 5). The highest grain yield of 4.71 t ha⁻¹ was recorded under T_4 , which was significantly superior to all other treatments including T_3 (100% NPK, 4.18 t ha⁻¹), a 12.7% increase. The percentage yield increase over the absolute control ranged from 36.1% (T_2) to 95.4% (T_4). Notably, T_6 applying only 50% of the conventional soil nitrogen, produced 4.39 t ha⁻¹, exceeding T_3 (full NPK) by 5.0% in grain yield, underscoring the superior nitrogen use efficiency achievable with nano urea integration. This corroborates

findings of Yogendra *et al.* (2020) [8] and Kumar *et al.* (2020) [3], who reported that 50% N + foliar nano urea sprays maintained or exceeded yields of 100% conventional N across multiple locations in UP and Rajasthan.

Straw yield followed a similar trend, with T_4 recording 6.61 t ha⁻¹ compared to 3.82 t ha⁻¹ in T_1 . Harvest index was highest in T_4 (41.6%), indicating superior partitioning of photosynthates towards grain. The improvement in harvest index reflects better sink strength and enhanced phloem loading during grain filling, attributed to the effect of nano urea on metabolic enzyme activity and assimilate transport.

Table 5. Effect of nano urea on grain yield, straw yield, biological yield and harvest index of wheat

Treatment	Grain Yield (t ha ⁻¹)	Straw Yield (t ha ⁻¹)	Bio. Yield (t ha ⁻¹)	H.I. (%)	% Increase over T_3
T_1 — Absolute control	2.41	3.82	6.23	38.7	-42.3
T_2 — T_1 + nano urea	3.28	4.73	8.01	40.9	-21.5
T_3 — 100% NPK	4.18	5.94	10.12	41.3	—
T_4 — 100% NPK + nano urea	4.71	6.61	11.32	41.6	+12.7
T_5 — 50% N + 100% PK	3.61	5.22	8.83	40.9	-13.6
T_6 — 50% N + PK + nano urea	4.39	6.34	10.73	40.9	+5.0
CD ($P = 0.05$)	0.18	0.24	0.38	0.91	—
SEm±	0.061	0.081	0.129	0.31	—
CV (%)	2.62	2.43	2.28	1.3	—

3.5 Economics

Economic analysis revealed that T_4 recorded the highest gross returns (Rs. 96,893 ha⁻¹), net returns (Rs. 51,893 ha⁻¹) and benefit-cost ratio (2.15) among all treatments (Table 6). T_6 recorded the second highest net return (Rs. 45,823 ha⁻¹), followed by T_3 and T_5 . The absolute control T_1 recorded the lowest BCR of 1.41. Adding a nano urea fo-

liar spray to conventional 100% NPK (T_4 vs T_3) cost approximately Rs. 2,500 ha⁻¹ extra but generated approximately Rs. 8,398 more net return per hectare — a highly favourable return on investment. These findings are consistent with Kumar *et al.* (2025) [4] and Singh *et al.* (2025) [6] who reported improved net returns and BCR under nano urea-supplemented reduced nitrogen management in wheat.

Table 6. Economics of wheat production as influenced by nano urea treatments

Treatment	Cost of Cultivation (Rs. ha ⁻¹)	Gross Returns (Rs. ha ⁻¹)	Net Returns (Rs. ha ⁻¹)	B:C Ratio
T_1	36,300	51,183	14,883	1.41
T_2	38,000	67,470	29,470	1.78
T_3	42,500	85,995	43,495	2.02
T_4	45,000	96,893	51,893	2.15
T_5	40,200	74,258	34,058	1.85

(continued on next page)

Treatment	Cost of Cultivation (Rs. ha ⁻¹)	Gross Returns (Rs. ha ⁻¹)	Net Returns (Rs. ha ⁻¹)	B:C Ratio
T ₆	44,500	90,323	45,823	2.03

4. Conclusion

The results of the present investigation clearly demonstrate that the treatment T₄ [100% NPK + 2 foliar sprays of nano urea at 25 and 50 DAS] was the most superior treatment for wheat production in central Uttar Pradesh. This treatment produced significantly the highest grain yield (4.71 t ha⁻¹), which exceeded the standard 100% NPK recommendation by 12.7%. It also recorded the highest harvest index (41.6%), net returns (Rs. 51,893 ha⁻¹) and benefit-cost ratio (2.15). Notably, T₆ [50% N + 100% PK + 2 foliar sprays of nano urea], using only half of the recommended nitrogen dose, produced a grain yield (4.39 t ha⁻¹) exceeding the full 100% NPK treatment by 5.0%, highlighting the potential of nano urea to reduce conventional nitrogen requirements without yield penalty. The findings establish that nano urea, applied as two foliar sprays at 25 and 50 DAS, represents an agronomically superior and economically viable strategy for sustainable intensification of wheat production in the region. Widespread adoption of this technology has significant potential to reduce fertilizer costs, improve nitrogen use efficiency and enhance farm profitability.

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