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Effect of nitrogen management on economics of Pearl millet (*Pennisetum glaucum* L.) hybrids

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Abstract

A field investigation was carried out during the *Zaid* season of 2025 at the Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experiment was conducted using a Randomized Block Design (RBD) comprising twelve treatment combinations with three replications. The treatments included six pearl millet hybrids, namely 86 M 25, 86 M 15, PA 9666, RBX 6066, US 7306, and MP 7793, evaluated under two nitrogen management practices: 100% Recommended Dose of Nitrogen (RDN) through urea and 50% RDN through urea + 4% nano urea. The experimental results indicated that treatment T₃ (86 M 15 receiving 100% RDN through urea) produced superior yield performance compared to other treatments. This treatment recorded the highest grain yield (3.48 t/ha) and stover yield (4.74 t/ha), gross return (INR. 119400.00/ha), net return (INR. 87685.88/ha) and BC ratio (2.76).

Keywords: Hybrids, nitrogen, nano urea, yield, gross return.

Introduction

Pearl millet (*Pennisetum glaucum* L.) is one of the most important cereal crops cultivated in the arid and semi-arid regions of Asia and Africa. It is highly valued for its exceptional tolerance to drought, high temperature, and low soil fertility conditions. Owing to its resilience under adverse climatic conditions, pearl millet plays a vital role in ensuring food and nutritional security, particularly in rainfed agriculture. The crop is rich in carbohydrates, proteins, dietary fiber, iron, zinc, and other essential micronutrients, making it a nutritious food source for millions of people (Satyavathi *et al.*, 2021) ^[7].

Pearl millet has gained considerable importance under climate change scenarios due to its superior water-use efficiency, rapid growth, and adaptability to marginal environments. Compared with other cereal crops, pearl millet can sustain productivity under moisture stress and high-temperature conditions, thereby contributing to sustainable agricultural production systems (Satyavathi *et al.*, 2021; Perumal *et al.*, 2024) ^[7, 6].

Nitrogen is the most critical nutrient governing the growth and productivity of pearl millet. It is a major constituent of chlorophyll, amino acids, proteins, enzymes, and nucleic acids, which directly influence photosynthesis, vegetative growth, and yield formation. Adequate nitrogen supply promotes plant height, tillering, leaf area development, dry matter accumulation, and grain yield. However, conventional nitrogen fertilizers often exhibit low nitrogen-use efficiency due to losses through volatilization, leaching,

denitrification, and runoff (Sharma *et al.*, 2022) ^[8].

Among the nitrogenous fertilizers, urea is the most commonly used source because of its high nitrogen content (46% N), ease of availability, and economic viability. Application of recommended doses of nitrogen through urea has been reported to improve growth parameters, nutrient uptake, yield attributes, and grain yield of pearl millet. Nevertheless, the low recovery efficiency of applied nitrogen necessitates the adoption of improved nutrient management strategies for enhancing nitrogen-use efficiency and reducing environmental pollution (Sharma *et al.*, 2022) ^[8].

Recent advances in nanotechnology have introduced Nano Urea as an innovative nitrogen fertilizer for sustainable crop production. Nano Urea contains nitrogen particles in nano form, which facilitate efficient absorption through leaf surfaces and ensure greater nutrient-use efficiency. Foliar application of Nano Urea has been reported to enhance chlorophyll content, dry matter production, nutrient uptake, and productivity of pearl millet while reducing nitrogen losses to the environment (Sharma *et al.*, 2022; Arya *et al.*, 2022) ^[8, 1].

Studies have demonstrated that Nano Urea can supplement conventional urea application by improving nitrogen-use efficiency and maintaining crop productivity with reduced fertilizer requirements. The combined use of soil-applied urea and foliar-applied Nano Urea offers a promising strategy for sustainable nitrogen management in cereal crops (Kumar *et al.*, 2024) ^[5].

The development of high-yielding pearl millet hybrids has significantly enhanced crop productivity in recent decades. Modern hybrids possess superior genetic potential, greater responsiveness to nutrient application, enhanced stress tolerance, and higher yield stability than traditional cultivars. However, the productivity of these hybrids is largely influenced by nitrogen availability and nutrient management practices. Different hybrids may vary in their response to nitrogen fertilization due to differences in nutrient uptake and utilization efficiency. Therefore, evaluating the response of pearl millet hybrids to nitrogen management through conventional urea and Nano Urea is essential for optimizing crop productivity and profitability under diverse agro-climatic conditions (Satyavathi *et al.*, 2021) [7].

Therefore, the present investigation was undertaken to study the effect of nitrogen management through urea and Nano Urea on the growth, yield attributes, yield, and economics of pearl millet hybrids.

Materials and Methods

A field experiment was conducted during the *Zaid* season of 2025 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India. The experimental site is geographically located at 25°24'42" N latitude and 81°50'56" E longitude, with an altitude of 98 m above mean sea level. The research farm is situated on the right bank of the *Yamuna* River, opposite the Prayagraj–Rewa Road, approximately 6 km from Prayagraj city.

The soil of the experimental field was sandy loam in texture, with a pH of 7.2, organic carbon content of 0.40%, and available nitrogen, phosphorus, and potassium levels of 186, 24, and 90 kg/ha, respectively. Prior to sowing, soil samples were collected and analyzed using standard laboratory procedures to determine the physicochemical properties of the soil.

The experiment was laid out in a Randomized Block Design (RBD) comprising twelve treatment combinations with three replications. The treatment combinations are, T₁ (86 M 25 + 100% Recommended Dose of Nitrogen), T₂ (86 M 25 + 50% Recommended Dose of Nitrogen + 4% Nano Urea), T₃ (86 M15 + 100% Recommended Dose of Nitrogen), T₄ (86 M15 + 50% Recommended Dose of Nitrogen + 4% Nano Urea), T₅ (PA 9666 + 100% Recommended Dose of Nitrogen), T₆ (PA 9666 + 50% Recommended Dose of Nitrogen + 4% Nano Urea), T₇ (RBX 6066 + 100% Recommended Dose of Nitrogen), T₈ (RBX 6066 + 50% Recommended Dose of Nitrogen + 4% Nano Urea), T₉ (US 7306 + 100% Recommended Dose of Nitrogen), T₁₀ (US 7306 + 50% Recommended Dose of Nitrogen + 4% Nano Urea), T₁₁ (MP 7793 + 100% Recommended Dose of Nitrogen), T₁₂ (MP 7793 + 50% Recommended Dose of Nitrogen + 4% Nano Urea).

The field was prepared to a fine tilth through repeated ploughing followed by leveling. Sowing was carried out on 25 March 2025 using a seed rate of 5 kg/ha, while maintaining a spacing of 45 cm between rows and 10 cm between plants. Fertilizers were applied according to the treatment requirements, and the recommended doses of phosphorus and potassium were applied uniformly to all

experimental plots. Standard agronomic practices, including irrigation, weed management, and plant protection measures, were adopted uniformly throughout the crop-growing period.

Observations on yield-attributing characters such as the number of ear heads/m², ear head length, number of grains per ear head, and test weight were recorded at harvest. Grain yield and stover yield were determined from the net plot area and expressed on a hectare basis. Plant and soil samples collected during the investigation were analyzed using standard analytical procedures.

The experimental data were subjected to statistical analysis using the analysis of variance (ANOVA) technique appropriate for a Randomized Block Design, as described by Gomez and Gomez (1984) [3]. The significance of treatment effects was tested at the 5% level of probability, and treatment means were compared using the Critical Difference (CD) test. Economic analysis of the treatments was carried out by estimating gross returns, net returns, and benefit-cost ratio based on the prevailing market prices of inputs and produce.

Results and Discussion

Yield parameters

1. Grain Yield (t/ha)

Higher grain yield (3.48 t/ha) was significantly recorded in treatment T₃ (86 M15 + 100% Recommended Dose of Nitrogen). And the treatment T₄ (86 M15 + 50% Recommended Dose of Nitrogen + 4% Nano Urea) statistically at par with treatment T₃ (86M15 + 100% RDN). The lower grain yield (1.79 t/ha) was observed in treatment T₈ (RBX 6066 + 50% Recommended Dose of Nitrogen + 4% Nano Urea).

The enhanced grain yield observed under higher nitrogen application and nano urea supplementation could be attributed to increased nitrogen availability throughout the crop growth period, which promoted chlorophyll synthesis, photosynthetic efficiency, and effective translocation of photosynthates from source to sink. This facilitated improved grain development and yield formation. These results are in agreement with the findings of Karnot *et al.* (2024) [4] and Bharathi *et al.* (2024) [2], who reported that balanced nitrogen management, including nano nitrogen sources, significantly improved grain yield in pearl millet by enhancing nutrient uptake and physiological efficiency.

2. Stover Yield (t/ha)

Maximum stover yield (4.74 t/ha) was significantly recorded in treatment T₃ (86 M15 + 100% Recommended Dose of Nitrogen). And the treatment T₄ (86 M15 + 50% Recommended Dose of Nitrogen + 4% Nano Urea) statistically at par with treatment T₃ (86M15 + 100% RDN). The minimum stover yield (2.44 t/ha) was observed in treatment T₈ (RBX 6066 + 50% Recommended Dose of Nitrogen + 4% Nano Urea).

The higher stover yield recorded under adequate nitrogen nutrition may be attributed to improved vegetative growth, greater leaf area development, and enhanced dry matter accumulation throughout the crop growth period. Nitrogen plays a vital role in promoting cellular proliferation, chlorophyll formation, and biomass production, thereby contributing to increased fodder yield. These findings are in

close agreement with those reported by Karnot *et al.* (2024) [4], who also observed a significant improvement in stover yield of pearl millet with optimum nitrogen management.

Economic Analysis

1. Cost of cultivation (INR)

The cost of cultivation was higher in treatments receiving 50% Recommended Dose of Nitrogen + 4% Nano-urea (INR. 32,644.56) compared to 100% RDN (INR. 31,714.12) due to the additional cost of nano-urea application.

The increase in cultivation cost under nano urea treatments was mainly due to the additional expenditure incurred on nano urea and its foliar application.

2. Gross return (INR)

The highest gross return was recorded in treatment T₃ (86 M15 + 100% RDN) (INR. 119,400.00), followed by treatment T₄ (86 M15 + 50% RDN + 4% Nano-urea) (INR. 115,475.00) and 86 M25 + 100% RDN (INR.110,375.00). The lowest gross return was recorded under RBX 6066 + 50% RDN + 4% Nano-urea (INR.61,425.00).

The higher gross return was primarily attributed to its superior grain and stover yields, which resulted in greater marketable produce. Economic returns are directly influenced by productivity, and treatments producing higher

yields consequently generated higher gross income.

3. Net return (INR)

The maximum net return was recorded in treatment T₃ (86 M15 + 100% RDN) (INR.87,685.88), which was followed by treatment T₄ (86 M15 + 50% RDN + 4% Nano-urea) (INR.82,830.44). The minimum net return was recorded under RBX 6066 + 50% RDN + 4% Nano-urea (INR.28,780.44).

The maximum net return may be attributed to the substantial increase in grain and stover yields, which more than compensated for the cultivation costs. Higher productivity coupled with efficient nutrient utilization resulted in enhanced profitability.

4. BC ratio

The highest BC ratio was recorded in treatment T₃ (86 M15 + 100% RDN) (2.76), followed by treatment T₄ (86 M15 + 50% RDN + 4% Nano-urea) (2.54). The lowest BC ratio was observed under RBX 6066 + 50% RDN + 4% Nano-urea (0.88).

The higher B:C ratio indicates superior economic efficiency resulting from higher yield and profitability relative to the cultivation cost.

Table 1: Effect of Nitrogen management on Yield and Harvest Index of Pearl millet Hybrids

S. No.	Treatments	Grain Yield (t/ha)	Stover Yield (t/ha)	Harvest Index (%)
1	86 M 25 + 100% Recommended Dose of Nitrogen	3.23	4.31	42.84
2	86 M 25 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	3.22	3.70	46.53
3	86 M15 + 100% Recommended Dose of Nitrogen	3.48	4.74	42.34
4	86 M15 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	3.39	4.45	43.24
5	PA 9666 + 100% Recommended Dose of Nitrogen	2.25	3.48	39.27
6	PA 9666 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	2.22	2.83	43.96
7	RBX 6066 +100% Recommended Dose of Nitrogen	1.93	2.78	40.98
8	RBX 6066 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	1.79	2.44	42.32
9	US 7306 + 100% Recommended Dose of Nitrogen	2.43	3.62	40.17
10	US 7306 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	2.26	3.32	40.50
11	MP 7793 + 100% Recommended Dose of Nitrogen	2.50	3.64	40.72
12	MP 7793 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	2.27	3.38	40.18
	F- test	S	S	S
	S.Em ±	0.06	0.11	0.78
	CD (P=0.05)	0.18	0.33	2.29

Table 2: Effect of Nitrogen management on Economics of Pearl millet Hybrids

S. No.	Treatments	Cost of Cultivation	Gross Return (INR)	Net Return (INR)	BC Ratio
1	86 M 25 + 100% Recommended Dose of Nitrogen	31714.12	110375.00	78660.88	2.48
2	86 M 25 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	32644.56	107050.00	74405.44	2.28
3	86 M15 + 100% Recommended Dose of Nitrogen	31714.12	119400.00	87685.88	2.76
4	86 M15 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	32644.56	115475.00	82830.44	2.54
5	PA 9666 + 100% Recommended Dose of Nitrogen	31714.12	79275.00	47560.88	1.50
6	PA 9666 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	32644.56	75200.00	42555.44	1.30
7	RBX 6066 +100% Recommended Dose of Nitrogen	31714.12	66975.00	35260.88	1.11
8	RBX 6066 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	32644.56	61425.00	28780.44	0.88
9	US 7306 + 100% Recommended Dose of Nitrogen	31714.12	84925.00	53210.88	1.68
10	US 7306 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	32644.56	78750.00	46105.44	1.41
11	MP 7793 + 100% Recommended Dose of Nitrogen	31714.12	86950.00	55235.88	1.74
12	MP 7793 + 50% Recommended Dose of Nitrogen + 4% Nano Urea	32644.56	79325.00	46680.44	1.43

Conclusion

Application of Treatment T₃ [86 M15 + 100% Recommended Dose of Nitrogen] has recorded highest

yield, gross return, net return and maximum BC Ratio in Pearl millet.

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