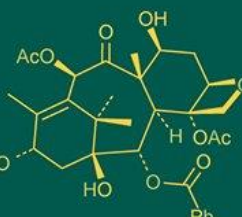
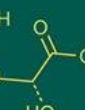
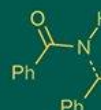


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## Effect of foliar application of Nano urea on growth and yield of pearl millet (*Pennisetum glaucum* L.)

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### Abstract

A field experiment entitled “Response of Pearl Millet (*Pennisetum glaucum* L.) to Foliar Application of Nano Urea” was conducted during the *kharif* season of 2024 at the National Agriculture Research Project (NARP) Chhatrapati Sambhajinagar. The experiment was laid out in Randomized Block Design (RBD) with three replications and ten treatments to evaluate the effect of different nutrient management strategies combining soil-applied nitrogen and foliar sprays of nano urea or conventional urea on the growth and yield of pearl millet. The hybrid AHB 1200 Fe was sown on July 1st, 2024 with a spacing of 45 cm × 10 cm. The study revealed that all nutrient treatments significantly influenced growth and yield parameters. Among all treatments, T<sub>2</sub> RDN (1/4 at basal, 1/2 after 3 weeks and 1/4 after 5 weeks) recorded the highest grain yield (2946 kg ha<sup>-1</sup>) and straw yield (6071 kg ha<sup>-1</sup>). However, T<sub>6</sub> (75% RDN + foliar spray of nano urea @ 4 ml L<sup>-1</sup> between 3-4 weeks of sowing) proved to be agronomically superior by consistently recording higher values for plant height, number of functional leaves, dry matter accumulation, ear head length and girth and harvest index, while producing a comparable grain yield (2705 kg ha<sup>-1</sup>). The performance of T<sub>6</sub> indicates that nano urea can improve nitrogen use efficiency and reduce dependence on conventional fertilizers without compromising productivity.

**Keywords:** Pearl millet, Nano urea, foliar nutrition, yield, RDN

### Introduction

Pearl millet (*Pennisetum glaucum* L.) is a major cereal crop widely cultivated in the arid and semi-arid regions of India, particularly during the *kharif* season. It plays a significant role in ensuring food and fodder security due to its excellent adaptability to drought, high temperatures and low-fertility soils. Maharashtra is one of the leading states in pearl millet cultivation, where the crop is often grown under rainfed conditions.

Nitrogen is a key macronutrient for pearl millet, influencing vegetative growth, chlorophyll formation and grain development. To improve nitrogen use efficiency and reduce environmental losses, innovative approaches such as foliar nutrient application are gaining prominence. Nano urea, a novel nitrogen fertilizer developed in nanometric form, offers potential advantages in crop nutrition due to its high surface area, targeted delivery and rapid absorption through leaves. Foliar application of nano urea at critical growth stages ensures direct nutrient uptake, enhances photosynthesis and minimizes nutrient losses.

Research findings suggest that integrating reduced soil-applied nitrogen with foliar sprays of nano urea can support sustainable intensification by improving growth, stress resilience and yield components. This study evaluates the impact of different nitrogen management practices involving nano and conventional urea on growth, yield and economics of pearl millet under rainfed conditions, aiming to promote efficient and sustainable nutrient strategies for semi-arid regions.

### Material and methods

The field experiment was conducted at the research farm of National Agricultural Research Project (NARP) Chhatrapati Sambhajinagar during the *kharif* season of 2024. The soil of the experimental field was clayey in texture, alkaline in reaction, low in available nitrogen, moderate in phosphorus and very high in potassium content. The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments and 3 replications. Each replication consisted of 10 plots randomly allotted to the treatments. The gross and net plot sizes were 4.5 × 4.0 m<sup>2</sup> and 3.6 × 3.8 m<sup>2</sup> respectively. The hybrid variety AHB 1200 Fe of pearl millet

was sown on 1st July 2024 using the dibbling method at a spacing of 45 × 10 cm<sup>2</sup> with a seed rate of 5 kg ha<sup>-1</sup>. The treatments were as follows: T<sub>1</sub> : Control (no nitrogen) T<sub>2</sub> : RDN (¼ at basal, ½ after 3 weeks, ¼ after 5 weeks) T<sub>3</sub> : 75% RDN + foliar spray of urea @ 1.5% at 3 and 5 weeks, T<sub>4</sub>: 75% RDN + foliar spray of nano urea @ 2 ml L<sup>-1</sup> at 3 and 5 weeks, T<sub>5</sub> : 75% RDN + foliar spray of urea @ 2.5% at 3 and 5 weeks, T<sub>6</sub>: 75% RDN + foliar spray of nano urea @ 4 ml L<sup>-1</sup> between 3-4 weeks after sowing, T<sub>7</sub> : 50% RDN + foliar spray of urea @ 1.5% at 3 and 5 weeks, T<sub>8</sub> : 50% RDN + foliar spray of nano urea @ 2 ml L<sup>-1</sup> at 3 and 5 weeks, T<sub>9</sub> : 50% RDN + foliar spray of urea @ 2.5% at 3 and 5 weeks and T<sub>10</sub> : 50% RDN + foliar spray of nano urea @ 4 ml L<sup>-1</sup> between 3-4 weeks after sowing. The crop was harvested on 9th September 2024.

Result and discussion

A) Growth studies

Growth parameters such as plant height, number of functional leaves and dry matter accumulation were significantly influenced by various nitrogen management

treatments involving soil and foliar applications of urea and nano urea. Among all treatments, T<sub>2</sub> (RDN: ¼ at basal, ½ at 3 weeks and ¼ at 5 weeks) recorded the highest plant height (194.59 cm) number of functional leaves (7.89 at harvest) Leaf area plant<sup>-1</sup>(168.8 dm<sup>2</sup> at harvest) and dry matter production (167.27 g at harvest) significantly outperforming other treatments. However, it was statistically at par with T<sub>6</sub> (75% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing) which also showed superior growth with (190.49 cm) height, (17.16) leaves and (162.74 g) dry matter at harvest. The lowest values for all growth attributes were observed in T<sub>1</sub> (absolute control) indicating the critical role of nutrient management in crop growth. The enhanced performance in T<sub>2</sub> and T<sub>6</sub> may be attributed to better nitrogen availability and absorption with nano urea improving leaf nutrient uptake, prolonging photosynthetic activity and increasing biomass accumulation. These findings are supported by previous studies conducted by Sharma *et al.* (2022) [3] Arya *et al.* (2022) [10] and Vegda *et al.* (2024) [7] also reported improved growth in pearl millet under nano urea and efficient nitrogen scheduling.

Table 1: Plant height (cm), number of leaves plant<sup>-1</sup>, leaf area plant-1 and dry matter production influenced by various treatments and at harvest in pearl millet.

Sr. no	Treatment	Growth parameters			
		At Harvest			
		Plant Height (cm)	Number of leaves Plant <sup>-1</sup>	Leaf area plant-1 (dm <sup>2</sup> )	Dry matter plant <sup>1</sup> (g)
T <sub>1</sub>	Control (No nitrogen)	168.46	3.01	147.96	122.08
T <sub>2</sub>	RDN (1/4 at basal, ½ after 3 weeks and ¼ after 5 weeks)	194.59	7.89	168.85	167.27
T <sub>3</sub>	75% RDN + foliar spray of urea @ 1.5 % at 3 and 5 weeks	182.12	5.22	151.69	152.28
T <sub>4</sub>	75% RDN + foliar spray of nano urea @ 2 ml/l at 3 and 5 weeks	184.00	6.32	156.06	159.69
T <sub>5</sub>	75% RDN + foliar spray of urea @ 2.5 % at 3 and 5 weeks	189.45	7.25	163.86	163.17
T <sub>6</sub>	75% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing	190.49	7.37	166.53	164.43
T <sub>7</sub>	50% RDN + foliar spray of urea @ 1.5 % at 3 and 5 weeks	177.07	3.88	148.72	124.88
T <sub>8</sub>	50% RDN + foliar spray of nano urea @ 2 ml/l at 3 and 5 weeks	178.19	3.97	149.22	138.25
T <sub>9</sub>	50% RDN + foliar spray of urea @ 2.5 % at 3 and 5 weeks	178.58	4.51	149.46	147.05
T <sub>10</sub>	50% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing	181.40	5.18	150.17	149.89
	SE±	2.47	0.71	2.91	2.14
	C.D at 5%	7.34	2.13	8.73	6.35
	G.M.	182.43	5.46	156.25	148.90

B) Yield contributing character studies

The yield contributing characters of pearl millet, such as the number of effective tillers per plant, grain weight per plant and harvest index, were significantly influenced by different nitrogen management treatments. Among these, T<sub>2</sub> (RDN applied as ¼ at basal, ½ at 3 weeks and ¼ at 5 weeks) recorded the highest number of tillers (3.4) grain weight per plant (78.14 g) grain yield (2946 kg ha<sup>-1</sup>) fodder yield (6071 kg ha<sup>-1</sup>) and harvest index (47.12%) which was at par with

T<sub>6</sub> (75% RDN + nano urea @ 4 ml L<sup>-1</sup>) (3.1) tillers, (76.90 g) grain weight, (2705 kg ha<sup>-1</sup>) grain yield and (45.51%) harvest index, demonstrating the effectiveness of nano urea even at reduced nitrogen levels. The lowest values were observed in T<sub>1</sub> (control) which recorded only (1.8) tillers (53.71 g) grain weight and (1691 kg ha<sup>-1</sup>) grain yield. These findings are supported by previous studies conducted by Karanjlikar *et al.* (2024) [12] Sharma *et al.* (2022) [6] Vegda *et al.* (2024) [7] and Ojha *et al.* (2023) [8].

**Table 2:** number of effective tillers plant<sup>-1</sup>, Grain weight plant<sup>-1</sup>, Grain yield (Kg ha<sup>-1</sup>), Fodder yield (kg ha<sup>-1</sup>) and Harvest index of pearl millet as influenced by various treatments.

Sr. No	Treatment	Number of effective tillers plant <sup>-1</sup>	Grain weight Plant <sup>-1</sup>	Grain yield (kg ha <sup>-1</sup> )	Fodder yield (kg ha <sup>-1</sup> )	Harvest index
T <sub>1</sub>	Control (No nitrogen)	1.8	53.71	1691	3713	43.29
T <sub>2</sub>	RDN (1/4 at basal, ½ after 3 weeks and ¼ after 5 weeks)	3.4	78.14	2946	6071	47.12
T <sub>3</sub>	75% RDN + foliar spray of urea @ 1.5 % at 3 and 5 weeks	2.7	72.55	2386	5486	44.64
T <sub>4</sub>	75% RDN + foliar spray of nano urea @ 2 ml/l at 3 and 5 weeks	2.7	74.56	2394	5512	44.65
T <sub>5</sub>	75% RDN + foliar spray of urea @ 2.5 % at 3 and 5 weeks	2.8	75.75	2420	5590	44.87
T <sub>6</sub>	75% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing	3.1	76.90	2705	5760	45.51
T <sub>7</sub>	50% RDN + foliar spray of urea @ 1.5 % at 3 and 5 weeks	2.1	58.50	2349	5262	43.29
T <sub>8</sub>	50% RDN + foliar spray of nano urea @ 2 ml/l at 3 and 5 weeks	2.3	61.55	2360	5294	43.29
T <sub>9</sub>	50% RDN + foliar spray of urea @ 2.5 % at 3 and 5 weeks	2.5	65.83	2364	5338	44.24
T <sub>10</sub>	50% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing	2.6	69.44	2377	5452	44.64
	SE±	0.18	0.98	179.83	187.11	1.95
	C.D at 5%	0.54	2.90	538.71	562.88	NS
	G.M.	2.67	68.69	2399	5408	44.53

**C) Yield studies**

The grain and fodder yield of pearl millet were significantly influenced by different nitrogen management treatments. The highest grain yield of (2946 kg ha<sup>-1</sup>) and fodder yield of (6071 kg ha<sup>-1</sup>) were recorded in T<sub>2</sub> RDN (1/4 at basal, ½ after 3 weeks and ¼ after 5 weeks) indicating that a well-timed and balanced nitrogen supply plays a vital role in maximizing productivity. This treatment also recorded the highest harvest index of 47.12%, reflecting efficient partitioning of assimilates towards economic yield.

Succeeding T<sub>2</sub>, the treatment T<sub>6</sub> (75% RDN + nano urea @ 4 ml L<sup>-1</sup>) also performed exceptionally well, producing (2705 kg ha<sup>-1</sup>) grain yield and (5760 kg ha<sup>-1</sup> fodder yield) with a harvest index of 45.51%. These results highlight the efficiency of nano urea in enhancing yield with reduced nitrogen input. Treatments T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub> also produced yields above the general mean (2399 kg ha<sup>-1</sup>) showing that both conventional and nano foliar applications had a positive impact on yield components when combined with adequate base nitrogen.

The lowest grain yield (1691 kg ha<sup>-1</sup>) and fodder yield (3713 kg ha<sup>-1</sup>) were recorded in the control treatment T<sub>1</sub>,

which received no nitrogen. This confirms the essential role of nitrogen in achieving optimal productivity in pearl millet. Overall, the data clearly indicate that both split application of RDN and foliar application of nano urea significantly improved grain and fodder yield, with T<sub>2</sub> and T<sub>6</sub> emerging as the most effective and efficient treatments.

**D) Economics**

The economic analysis revealed that T<sub>2</sub>: RDN (1/4 at basal, ½ after 3 weeks and ¼ after 5 weeks) recorded the highest grain monetary return (₹84,004 ha<sup>-1</sup>) and net return (₹52,504 ha<sup>-1</sup>) with a B: C ratio of (2.67) indicating its profitability under full nitrogen application. However, T<sub>6</sub> (75% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing) also performed remarkably well, achieving a net return of (₹46,566 ha<sup>-1</sup>) and a B: C ratio of (2.54) making it the most economical option among reduced nitrogen treatments. Treatments T<sub>4</sub>, T<sub>5</sub>, T<sub>8</sub> and T<sub>10</sub> also recorded net returns and B: C ratios above the general mean, whereas T<sub>1</sub> (control) showed the lowest returns (₹20,602 ha<sup>-1</sup>) and B: C ratio (1.75) confirming the importance of nitrogen and foliar nutrition in improving profitability.

**Table 3:** Grain monetary return (₹ ha<sup>-1</sup>), net monetary return (₹ ha<sup>-1</sup>) and B: C ratio of pearl millet as influenced by various treatments.

Sr. no	Treatment	Cost of cultivation (₹ ha <sup>-1</sup> )	Gross Monetary Return (₹ ha <sup>-1</sup> )	Net Monetary Return (₹ ha <sup>-1</sup> )	B:C Ratio
T <sub>1</sub>	Control (No nitrogen)	27500	48102	20602	1.75
T <sub>2</sub>	RDN (1/4 at basal, ½ after 3 weeks and ¼ after 5 weeks)	31500	84004	52504	2.67
T <sub>3</sub>	75% RDN + foliar spray of urea @ 1.5 % at 3 and 5 weeks	30800	68119	37319	2.21
T <sub>4</sub>	75% RDN + foliar spray of nano urea @ 2 ml/l at 3 and 5 weeks	30400	68355	37955	2.25
T <sub>5</sub>	75% RDN + foliar spray of urea @ 2.5 % at 3 and 5 weeks	31000	69115	38115	2.23
T <sub>6</sub>	75% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing	30200	76766	46566	2.54
T <sub>7</sub>	50% RDN + foliar spray of urea @ 1.5 % at 3 and 5 weeks	29800	66923	37123	2.25
T <sub>8</sub>	50% RDN + foliar spray of nano urea @ 2 ml/l at 3 and 5 weeks	29400	67244	37844	2.29
T <sub>9</sub>	50% RDN + foliar spray of urea @ 2.5 % at 3 and 5 weeks	30000	67393	37393	2.25
T <sub>10</sub>	50% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing	29200	67848	38648	2.32
	SE±	-	2572.05	2076.72	0.06
	C.D at 5%	-	7716.86	6229.03	0.19
	G.M.	29980	68387	38407	2.28

## Conclusion

The study demonstrated that different nitrogen management strategies, particularly those involving nano urea, significantly influenced the growth, yield and economic returns of pearl millet. Among all treatments, T<sub>2</sub>: RDN ((1/4 at basal, 1/2 after 3 weeks and 1/4 after 5 weeks)) recorded the highest grain and fodder yields, along with maximum net returns and B:C ratio, attesting most effective in maximizing productivity. However, T<sub>6</sub> (75% RDN + foliar spray of nano urea @ 4 ml/l between 3-4 weeks of sowing) also performed exceptionally well, producing comparable yields with reduced nitrogen input and superior growth attributes, indicating improved nitrogen use efficiency. The findings suggest that foliar application of nano urea can serve as a sustainable and cost-effective nutrient management strategy, especially under semi-arid and rainfed conditions.

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