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Impact of N-nano fertilizer on yield attributes, economic and quality of pearl millet (*Pennisetum glaucum* L) under rainfed condition

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Abstract
A field experiment was conducted during Kharif season of 2021 at Agronomy Section, College of Agriculture, Latur (Maharashtra) to study the impact of n-nano fertilizer on yield attributes, economic and quality of pearl millet (*Pennisetum glaucum* L) under rainfed condition. The experiment was laid out in Randomized Block Design. The results showed that the application of 75% RDN through urea as soil application + 25% RDN through 1 spray of nano- urea @ 45 DAS (T_5) recorded significantly highest yield attributes, seed yield (3967 kg ha^{-1}) and test weight (20.77 g) over all the treatments except 75% RDN through urea soil application + 25% RDN through 1 spray of @ 45 DAS (T_8) and 50% RDN through as soil application + 50% RDN through 2 sprays of nano-urea @ 30,45 DAS (T_4). The highest gross monetary return GMR (85291 ₹ ha^{-1}), net monetary return NMR (53825 ₹ ha^{-1}) and B:C ratio (2.71) was observed with the 75% RDN through urea as soil application + 25% RDN through 1 spray of nano- urea @ 45 DAS. Among the different treatments that application of urea through soil and application of nano urea through spray may increase both quantitative and qualitative yield of pearl millet.

Keywords: Commercial urea, nano-urea, foliar application, pearl millet, RDN

Introduction
Pearl millet, a significant cereal in rainfed regions of Africa and Asia, is known by various names and thrives in arid and semi-arid areas of India. It sustains rural communities and is used as human food, animal feed, and green fodder. The crop is highly adaptable, matured in 90-120 days, and has a substantial cultivation area in India, particularly in states like Rajasthan, Maharashtra, Gujarat, Punjab, Haryana, and Uttar Pradesh. Pearl millet is a resilient crop in arid regions, providing sustenance for communities and livestock. Its cultivation methods, especially in India, are outlined, showcasing its suitability for dryland areas with limited rainfall.

Nitrogen is considered a major and essential nutrient to increase the crop growth rate, development and obtained the highest grain yield. Different ecological variables such as temperature that effects on crop growth and development of plants consider as main determinants for regulation of various phenomenon (Ritchie and Smith 1991) [8]. Increasing the level of nitrogenous fertilizer also boost up the crop growth, development and photosynthesis rate (Fayyaz-ul-Hassan Cheema *et al.*, 2005) [5]. The many studies were reported about application of nitrogen and their effect on crop. The text underlines the significance of nitrogen in millet production and discusses issues with conventional nitrogenous fertilizers like urea, leading to the introduction of nano urea liquid as a potential solution.

The development and advantages of nano fertilizers in improving crop growth, yield, and nutrient efficiency are highlighted. Nano urea, due to its ultra-small size, offers increased absorption by plants when applied as a foliar spray. The narrative underscores the potential of nano fertilizers in reducing nutrient wastage, water and soil pollution, and improving crop quality while addressing environmental concerns. This drought-tolerant millet is rich in nutrients and is well-suited for harsh conditions, including heat, drought, saline, and acid soils. However, the excessive use of conventional nitrogenous fertilizers like urea contributes to environmental pollution.

To address this, nano urea has been developed, aiming to improve nutrient use efficiency (NUE) and reduce pollution. Indian Farmers Fertilizer Cooperative Limited (IFFCO) launched Nano Urea Liquid, marking a significant advancement in agricultural technology.

Nano fertilizers offer promise in enhancing NUE by reducing fertilizer rates and improving nutrient release patterns, leading to better crop growth, yield, and quality. This innovation is a response to the limitations of conventional fertilizers, providing a more efficient and eco-friendly solution for agriculture. Finally, it proposes an investigation to study the effects of N-nano fertilizer on pearl millet yield, and quality under rainfed conditions, aiming to evaluate the impact of nano urea on agricultural outcomes

Materials and Methods

A field experiment was conducted during *Kharif* season of 2021 at Agronomy Section, College of Agriculture, Latur (Maharashtra) to study the impact of n-nano fertilizer on yield attributes, yield, economic and quality of pearl millet under rainfed condition. The experiment was laid out in Randomized Block Design. The eight treatments were replicated thrice. The treatments were T_1 - Control, T_2 - RDN, T_3 - 25% RDN through urea as soil application + 75% RDN through 3 sprays of nano-urea @ 30, 45, 60 DAS, T_4 - 50% RDN through urea as soil application + 50% RDN through 2 sprays of nano-urea @ 30, 45 DAS, T_5 - 75% RDN through urea as soil application+ 25% RDN through 1 spray of nano- urea @ 45 DAS, T_6 - 25% RDN through urea as soil application + 75% RDN through 3 spray of urea @ 30, 45, 60 DAS, T_7 - 50% RDN through urea as soil application + 50% RDN through 2 sprays of urea @ 30, 45 DAS, T_8 - 75% RDN through urea soil application + 25% RDN through 1 spray of @ 45 DAS. The gross and net plot size of each experimental unit was 5.40 m x 4.50 m and 4.5 m x 3.9 m, respectively. Sowing was done by dibbling method using seed rate @ 3 kg ha^{-1}. The recommended dose of fertilizers i.e. 50: 25: 25 kg NPK ha^{-1}. was applied for pearl millet crop.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads

Effect of n-nano fertilizer on yield attributes and yield of pearl millet

Yield attributes and yield of pearl millet

A perusal of data presented in Table 1 indicated that length, breadth, weight of ear head, grain yield planT_1 and Test weight of pearl millet as influenced by various treatments. The maximum length (27.52 cm), breadth (14.35 cm) and weight (49.38 g plant-1) of ear head, grain yield plant^{-1} (35.53 g plant^{-1}) and grain yield (3967 kg ha^{-1}) was recorded with the application of **7**5% RDN through urea as soil application + 25% RDN through one spray of nano-urea (45 DAS) (T_5) which was found at par with the application of 75% RDN through urea as soil application + 25% RDN through one spray of urea (45 DAS) (T_8) (Table 1). Application of RDN (T_2) recorded significantly the lowest length, breadth and weight of ear head, grain yield plant^{-1} and grain yield (kg ha^{-1}). The results of this investigation are consonance with the findings of Al-juthery *et al.* (2018) [1] and Astaneh *et al.,* (2018) [2], and Salama and Bandry (2020) [9].

The maximum harvest index (31.84%) was recorded with the application of 75% RDN through urea as soil application + 25% RDN through 1 spray of nano-urea (45 DAS) (T_5) which was found at par with the application of 75% RDN through urea as soil application + 25% RDN through one spray of urea (45 DAS) (T_8) and 50% RDN through urea as soil application + 50% RDN through two spray of nano-urea (30, 45 DAS) (T_4) (Table 1). Application of RDN (T_1) recorded significantly the lowest harvest index (24.01%).

Effect of n-nano fertilizer on Economics and quality parameters of Pearl millet

Economics of pearl millet

The data presented in Table 2 indicated that gross and net monetary return (₹ ha^{-1}) of pearl millet is as affected by various treatments. Results revealed that maximum gross monetary return (85291 ₹ ha^{-1}) and net monetary return (53825 ₹ ha^{-1}) was recorded with the application of 75% RDN through urea as soil application + 25% RDN through one spray of nano-urea (45 DAS) (T_5) which was at par with the application of 75% RDN through urea as soil application + 25% RDN through one spray of urea (45 DAS) (T_8) and 50% RDN through urea as soil application + 50% RDN through two spray of nano-urea (30, 45 DAS) (T_4) (Table 2). Application of RDN (T_2) recorded significantly the lowest gross (56280 ₹ ha^{-1}) and net monetary return (26597 ₹ ha^{-1}).

The treatment with application of 75% RDN through urea as soil application + 25% RDN through one spray of nano-urea (45DAS) (T_5) recorded the highest B:C ratio (2.71) as compared to other treatments (Table 2). The similar results were in collaborative with the findings of Bhuva *et al.* (2018) [3].

Protein content

Data on protein content as affected by various treatments is presented in Table 2. Highest protein content recorded with the application of 75% RDN through urea as soil application + 25% RDN through one spray of nano-urea (45 DAS) (T_5), closely followed by 75% RDN through urea as soil application + 25% RDN through one spray of urea (45 DAS) (T_8) and 50% RDN through urea as soil application + 50% RDN through two spray of nano-urea (30, 45 DAS) (T_4). This might be due to, the fact that nano-fertilizers have large surface area and particle size, less than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve uptake and nutrient use efficiency of the nano-fertilizers. Because of more penetration and uptake of the nutrient, results in high nutrient content and their uptake. The results of this investigation are consonance with the findings of Dhansil *et al.*, (2018) [4]. and Ullah *et al.*, (2018) [11].

Protein yield

The data on mean protein yield of pearl millet as influenced by different treatments are presented in Table 2. The mean protein yield (350.5 kg ha^{-}) of pearl millet was influenced significantly due to different treatments. The application of 75% RDN through urea as soil application + 25% RDN through one spray of nano-urea (45 DAS) (T_5) produced significantly higher protein yield (454 kg ha^{-1}) over rest of the treatments and this treatment is closely resembles with 75% RDN through urea as soil application + 25% RDN through one spray of urea (45DAS) (T_8) and 50% RDN through urea as soil application + 50% RDN through two spray of nano-urea (30, 45 DAS) (T_4) (Table 2). The results of this investigation are consonance with the findings of Dhansil *et al.*, (2018) [4], Ullah *et al.*, (2018) [11] and Sharma *et al.*, (2022) [10].

Table 1: Length, breadth and weight of ear head, grain yield plant-1, test weight, grain yield and HI (%) of Pearl millet as influenced by various treatments

Treatments	Length of ear head (cm)	Breadth of ear head (cm)	Weight of ear head (g /plant)	Grain yield/ plant (g)	Test weight (g)	Grain yield (kg /ha)	HI (%)
T_1: Control	19.70	9.69	38.60	25.77	18.03	2402	24.01
T_2: RDN	20.83	10.90	40.07	27.00	18.4	2618	25.18
T_3: 25% RDN through urea as soil application + 75% RDN through 3 spray of nano-urea (30, 45, 60 DAS)	23.50	11.23	42.23	29.43	18.7	3032	27.35
T_4: 50% RDN through urea as soil application + 50% RDN through 2 spray of nano-urea (30, 45 DAS)	25.37	12.47	44.17	31.43	18.93	3414	29.31
T_5: 75% RDN through urea as soil application + 25% RDN through 1 spray of nano-urea (45 DAS)	27.52	14.35	49.38	35.53	20.77	3967	31.84
T_6: 25% RDN through urea as soil application + 75% RDN through 3 spray of urea (30, 45, 60 DAS)	22.33	11.00	41.07	28.17	18.6	2846	26.38
T_7: 50% RDN through urea as soil application + 50% RDN through 2 sprays of urea (30, 45 DAS)	24.47	12.13	43.43	30.70	18.8	3236	28.42
T_8: 75% RDN through urea as soil application + 25% RDN through 1 spray of urea (45 DAS)	26.53	12.97	44.87	32.43	19.17	3713	30.57
SE±	0.56	0.61	1.87	1.52	0.66	134	_
CD @ 5%	1.79	1.95	5.71	4.6	1.94	413	_

Table 2: Mean gross and net monetary returns, B:C ratio, protein content (%) and protein yield (kg ha^{-1}) of Pearl millet as influenced by various treatments

Treatments	Grain yield (kg ha^{-1})	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B:C Ratio	Protein content (%)	Protein yield (kg ha^{-1})
T_1: Control	2402	51650	24550	1.90	10.56	254
T_2: RDN	2618	56280	26597	1.89	10.87	285
T_3: 25% RDN through urea as soil application + 75% RDN through 3 spray of nano-urea (30,45,60DAS)	3032	65195	33762	2.07	11.05	335
T_4: 50% RDN through urea as soil application + 50% RDN through 2 spray of nano-urea (30, 45 DAS)	3414	73408	41958	2.33	11.25	384
T_5: 75% RDN through urea as soil application + 25% RDN through 1 spray of nano-urea (45 DAS)	3967	85291	53825	2.71	11.45	454
T_6: 25% RDN through urea as soil application + 75% RDN through 3 sprays of urea (30, 45, 60 DAS)	2846	61196	29712	1.94	10.97	312
T_7: 50% RDN through urea as soil application + 50% RDN through 2 sprays of urea (30, 45 DAS)	3236	69574	38090	2.20	11.12	360
T_8: 75% RDN through urea as soil application + 25% RDN through 1 spray of urea (45 DAS)	3713	79829	48345	2.53	11.33	420
SE±	134	3672	3672	_	1.05	21.34
CD @ 5%	413	11956	11956	_	3.56	65.87

Conclusion

It is concluded that the application of 75% RDN through urea as soil application + 25% RDN through one spray of nano-urea (45 DAS) (T_5) had significant effect on yield attributes and yield of pearl millet as well as found to be more remunerative for getting higher gross monetary return (Rs. 85291 ha^{-1}), gross monetary return (Rs. 53825 ha^{-1}) and B:C ratio (2.71). Combined application of nano urea spray and urea in soil had significantly better yield and net returns. The result of the study suggests that application of urea through soil and application of nano urea through spray may increase both quantitative and qualitative yield of pearl millet.

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