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Effect of nano fertilizers on growth, yield and economics of summer pearl millet

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Abstract

The investigation entitled “Effect of nano fertilizers on growth, yield and quality of summer pearl millet” was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer 2025. The objectives of the study were to find out effect of nano fertilizers on growth, yield and quality of summer pearl millet, to evaluate the efficiency of nano fertilizers and to work out the economical feasibility of different treatments. The experiment was laid out using a Randomized Block Design (RBD) consisting of ten treatments and three replications. The results of field experiment revealed that the application of 75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS recorded significantly higher values of growth parameters viz., plant height at harvest, dry matter accumulation at 60 DAS and at harvest, number of total tiller per plant and effective tiller per plant; yield attributes and yield viz., ear head length, ear head girth, grain yield and stover yield; over control. While significantly the maximum plant height at 45 DAS, dry matter accumulation at 30 DAS was recorded with the application of 100% RDF (120:60:00 kg N:P₂O₅:K₂O/ha).

Keywords: Summer pearl millet, nano DAP, nano urea, growth, quality

Introduction

Pearl millet (*Pennisetum glaucum* L.) belongs to the Poaceae family and has a chromosome number of $2n = 14$. It is commonly known as cattail millet or bulrush millet, it is known as “bajra” in Hindi. Pearl millet is classified as a coarse grain cereal crop. It is consumed as feed and fodder for livestock. India accounts for half of global millet production in the country. It is the 6th important cereal crop in the world next to wheat, rice, maize, barley and sorghum. In India, it holds significant importance among millet crops, demonstrating remarkable adaptability to extreme environmental conditions. It serves as a crucial dietary staple, particularly in arid and drought-prone regions, offering a reliable source of nutrition within a short growth cycle. It is a hot and warm weather crop and grows between 28°C to 37°C. The rainfall requirement for pearl millet crop is between 350 to 500 mm. Pearl millet grain has a rich nutritional profile, containing approximately 11.6% protein, 5% fat, 67% carbohydrates and 2.7% minerals. In addition to being consumed by humans, a sizable amount of pearl millet is utilized in the manufacturing of alcohol, cattle feed and poultry, demonstrating its economic adaptability (Basavaraj *et al.*, 2010) ^[2]. Phosphorus is vital for the development of robust roots and seeds in plants. It also plays a crucial role in DNA replication, enabling the formation of cell walls and facilitating the entire reproductive process. Since nitrogen is essential to many plant structures and their internal and exterior metabolic activities, it is a critical element for plant growth. Nano fertilizers applied filially is superior to traditional fertilizer because it directly contacts the leaves and is absorbed by the intended organs, producing a more focused and prompt reaction. Because they are more reactive and have the potential to pierce the cuticle, nano fertilizers can be released and delivered in controlled amounts. The nano DAP formulation comprises 8.0% nitrogen (N w/v) and 16.0% phosphorus (P₂O₅ w/v), striking a balanced and concentrated nutrient blend that supports robust plant growth, elevates crop quality and amplifies yields. The nano urea formulation comprises 20.0% nitrogen (N w/v), Nano urea promotes healthy plant growth, leading to improved crop yields and quality.

Methodology

An experiment was conducted during the summer season of 2025 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The mean maximum and minimum temperature during the crop growth and development period ranged between 33.7 to 41.2 °C and 20.6 to 27.6 °C, respectively. The soil of the experimental site was clayey in texture (Sand 23.10%, silt 14.11% and clay 62.79%) with a pH of 7.9. The soil was found medium in organic carbon (0.58%), available N (262 kg/ha), available P (30.21 kg/ha) and available K (217 kg/ha). The experiment was laid out in randomized block design (RBD) with three replications and ten treatments. As per recommendation, half dose of nitrogen and full dose of phosphorus were applied as basal dose in the previously opened furrows to all the plots in the form of urea and DAP, respectively. Remain half dose of nitrogen was applied at 30 DAS through urea as top dressing.

Results and Discussion

Growth parameters

Plant height (cm)

Plant height was significantly produced a much larger plant height of 205 cm in treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS). Combining foliar spraying of nano fertilizers with basal application of

conventional fertilizers could have led to a substantial increase in plant height by increasing the plant auxin metabolism and enzyme activity. Because of the cells subsequent expansion and elongation, plants may have grown taller. Furthermore, the surface area of nano fertilizers is significantly greater than that of conventional fertilizers, increasing the plant metabolic efficiency. Khandare *et al.* (2024) ^[9], Tomar *et al.* (2024) ^[16], Dobariya *et al.* (2025) ^[7] and Jivtode *et al.* (2025) ^[8], all reported results that were consistent with our study.

Dry matter accumulation (g/plant)

The amount of dry matter buildup by each plant was significantly accumulates the greater dry matter (87.46 g) was T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS). The beneficial effects of nano fertilizers on plant height and tiller count are responsible for the significant increase in dry matter accumulation per plant. Another explanation for the notable rise in dry matter in the treatments of nano applied at optimal fertility levels could be the enhanced photosynthetic rate and increased food production in leaves. Increased dry matter accumulation may have resulted from improved use of available nutrients and solar radiation due to a larger leaf area. These results closely match those of Borana *et al.* (2024a) ^[4], Khandare *et al.* (2024) ^[9], Meena *et al.* (2024) ^[13] and Dobariya *et al.* (2025) ^[7].

Table 1: Effect of different treatments on the growth parameters of summer pearl millet

Treatments	Plant height (cm)		Dry matter accumulation per plant (g/plant)			Number of total tillers per plant at harvest
	At 45 DAS	At harvest	At 30 DAS	At 60 DAS	At harvest	
T ₁	77.20	150.93	14.33	33.93	62.04	3.45
T ₂	117.47	198.40	22.97	44.70	85.15	5.18
T ₃	108.00	192.40	21.17	43.27	84.07	5.13
T ₄	103.27	183.53	19.81	40.53	72.91	4.37
T ₅	105.86	190.80	20.67	42.80	79.12	5.01
T ₆	111.87	205.00	22.00	46.87	87.46	5.44
T ₇	93.60	177.53	17.33	39.93	67.57	3.92
T ₈	91.80	173.73	16.40	39.20	66.70	3.73
T ₉	95.60	182.20	18.00	40.27	70.12	4.13
T ₁₀	98.13	186.00	18.37	40.60	74.05	4.66
S.E.m.±	4.84	6.31	1.11	2.04	3.84	0.26
C.D. at 5%	14.37	18.74	3.28	6.05	11.40	0.77
C.V.%	8.35	5.93	10.02	8.56	8.87	9.96

Number of total tillers per plant

The treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS) was found to have a significantly greater total tillers/plant (5.44). The combined effect between conventional fertilizer and nano fertilizer, which improves nutrient absorption by plant cells and eventually promotes optimal development and metabolic processes like photosynthesis, is responsible for this impressive impact. Higher photosynthate accumulation and transfer to economically significant plant sections follow, increasing the total tillers. The results of this research were consistent with those of Borana *et al.* (2024b) ^[4], Maloth *et al.* (2024) ^[12], Chaudhari *et al.* (2025) ^[5] and Dobariya *et al.* (2025) ^[7].

Yield parameters and Yield

Effective tillers per plant

The effective tillers/plant was significantly higher (4.16) when treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS) was applied. Because of their smaller particle size, which enables better absorption by the plant tissues, nano fertilizers are renowned for their increased nutrient uptake efficiency. The higher photosynthetic efficiency

and increased metabolic activity that facilitate the growth of tillers capable of generating viable grains can also account for the increased number of effective tillers under treatments utilizing nano DAP. Borana *et al.* (2024b) ^[4], Meena *et al.* (2024) ^[13] Chaudhari *et al.* (2025) ^[5] and Kumar *et al.* (2025) ^[11] also reported similar outcomes.

Ear head length (cm)

Treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS) produced the largest ear head length (31.04 cm). The improved nutrient uptake and utilization efficiency attained by the combined application of conventional fertilizer and nano fertilizer may be the cause of the significantly increase in ear head length because of its high reactivity and small particle size, nano fertilizer increases the availability and absorption of nutrients, particularly nitrogen and phosphorus, which are necessary for cell division, ear head growth, and elongation, resulting in longer ears. These results are consistent with those reported by Chinnappa *et al.* (2023) ^[6], Meena *et al.* (2024) ^[13], Borana *et al.* (2024b) ^[4], Chaudhari *et al.* (2025) ^[5] and Dobariya *et al.* (2025) ^[7].

Ear head girth (cm)

Treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS) produced the ear head girth that was significantly larger (8.63 cm). The balanced and constant supply of nutrients, especially nitrogen and phosphorus, which are essential for the development of reproductive organs and grain sink capacity, is responsible for the rise in ear head girth. The administration of nano DAP probably improved ear girth by ensuring higher nutrient availability throughout the growth period, particularly during the stages of grain development and ear head differentiation. The findings are consistent with those of Chaudhari *et al.* (2025) ^[5] and Dobariya *et al.* (2025) ^[7].

Grain yield (kg/ha)

The highest notable grain yield (4,535 kg/ha) was achieved by

treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS). This could be because applying conventional and nano fertilizers together guaranteed optimal and balanced nutrient availability throughout the growing season. Because of their smaller size and greater effective surface area, nanoparticles can more readily enter plants and improve their uptake of phosphorus and nitrogen. Higher uptake leads to the best possible growth of plant parts and metabolic processes like photosynthesis, which boost the accumulation and translocation of photosynthates to the economically productive parts of the plant, increasing biomass, yield-attributing characteristics, and ultimately yield by increasing the translocation of assimilates to grains. The findings are consistent with those of by Borana *et al.* (2024b) ^[4], Dobariya *et al.* (2025) ^[7], Jivtode *et al.* (2025) ^[8], Kumar *et al.* (2025) ^[11] and Yewale *et al.* (2025) ^[17].

Table 2: Effect of different treatments on the yield parameters and yield of summer pearl millet

Treatments	Effective tillers per plant	Ear head length (cm)	Ear head girth (cm)	Grain yield (kg/ha)	Stover yield (kg/ha)
T ₁	2.40	20.35	6.45	2889	6307
T ₂	3.93	30.18	8.10	4384	8931
T ₃	3.72	29.72	7.89	4234	8659
T ₄	3.11	25.79	7.40	3779	7787
T ₅	3.65	28.30	7.73	4051	8289
T ₆	4.16	31.04	8.63	4535	9161
T ₇	2.85	24.40	7.04	3391	7066
T ₈	2.71	23.91	6.94	3155	6694
T ₉	3.02	25.36	7.21	3544	7356
T ₁₀	3.32	26.91	7.44	3816	7811
S.Em.±	0.20	1.72	0.39	218	452
C.D. at 5%	0.60	5.12	1.15	648	1344
C.V.%	10.71	11.22	8.99	10.00	10.04

Stover yield (kg/ha)

Treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS) produced the greatest stover (9,303 kg/ha). The rise in stover output after foliar spraying may have been caused by plants quick uptake and ease of translocation of nano fertilizers. A larger stover yield was the outcome of this improved rate of photosynthesis and dry matter accretion. Singh *et al.* (2023) ^[14], Khemshetty *et al.* (2024) ^[10], Suryawanshi *et al.* (2024) ^[15], Dobariya *et al.* (2025) ^[7], Kumar *et al.* (2025) ^[11] and Yewale *et al.* (2025) ^[17] all found similar results.

^[7] and Yewale *et al.* (2025) ^[17].

Net return

The greatest net returns of 83,886 ₹/ha were produced by treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS). Due to increased grain and stover yield as well as decreased treatment costs. These results are consistent with those published by Attri *et al.* (2023) ^[1], Balachandrakumar *et al.* (2024b) ^[3], Suryawanshi *et al.* (2024) ^[15], Dobariya *et al.* (2025) ^[7] and Yewale *et al.* (2025) ^[17].

Economics

Gross return

The maximum gross realization of 1,29,539 ₹/ha was attained by treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS), compared to the other treatments could account for the higher gross return. These findings closely align with those of Balachandrakumar *et al.* (2024b) ^[3], Suryawanshi *et al.* (2024) ^[15], Dobariya *et al.* (2025)

Benefit:Cost ratio

Plant height was significantly produced a much larger plant height of 205 cm in treatment T₆ (75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS) had the greatest B:C ratio of 2.84, due to large grain and stover production. These results are consistent with those published by Meena *et al.* (2024) ^[13], Suryawanshi *et al.* (2024) ^[15], Dobariya *et al.* (2025) ^[7] and Yewale *et al.* (2025) ^[17].

Table 3: Effect of different treatments on the economics of summer pearl millet

Treatments	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net return (₹/ha)	B:C ratio
T ₁ Absolute control	82997	39044	43953	2.13
T ₂ 100% RDF (120:60:00 kg N: P ₂ O ₅ : K ₂ O/ha)	125147	45352	79795	2.76
T ₃ 75% RDF + spray of nano urea 4 ml/L at 45 DAS	120908	45448	75460	2.66
T ₄ 75% RDF + spray of nano DAP 4 ml/L at 45 DAS	107988	47164	60824	2.29
T ₅ 75% RDF + spray of nano urea 2 ml/L + spray of nano DAP 2 ml/L at 45 DAS	115688	46306	69382	2.50
T ₆ 75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS	129361	45475	83886	2.84
T ₇ 50% RDF + spray of nano urea 4 ml/L at 45 DAS	96998	44085	52913	2.20
T ₈ 50% RDF + spray of nano DAP 4 ml/L at 45 DAS	90397	45801	44596	1.97
T ₉ 50% RDF + spray of nano urea 4 ml/L + spray of nano DAP 4 ml/L at 45 DAS	101339	46831	54508	2.16
T ₁₀ 50% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS	108980	44113	64867	2.47

Conclusion

Based on one year of field experimentation, it can be concluded that the application of 75% RDF + seed treatment with nano DAP 5 ml/kg + spray of nano urea 4 ml/L at 45 DAS proved to be the most effective in improving growth, yield and quality of summer pearl millet. Economically this treatment gives higher net returns under the South Saurashtra Agro-climatic zone. This treatment also demonstrated better economic viability compared to other nutrient management practices. The next best treatments were application of 100% RDF (120:60:00 kg N: P₂O₅:K₂O/ha) and 75% RDF + spray of nano urea 4 ml/L at 45 DAS.

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