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HM Bhuvu

Research Scientist (Agronomy),
Pearl millet Research Station,
Junagadh Agricultural University,
Jamnagar, Gujarat, India

Asha C Detroja

Assistant Research Scientist, Pearl
millet Research Station, Junagadh
Agricultural University, Jamnagar,
Gujarat, India

NN Chaudhari

Assistant Research Scientist, Pearl
millet Research Station, Junagadh
Agricultural University, Jamnagar,
Gujarat, India

PR Patel

Assistant Research Scientist, Pearl
millet Research Station, Junagadh
Agricultural University, Jamnagar,
Gujarat, India

SN Galani

Junagadh Agricultural University,
Jamnagar, Gujarat, India

KD Mungra

Research Scientist (Pearl Millet),
Pearl millet Research Station,
Junagadh Agricultural University,
Jamnagar, Gujarat, India

Corresponding Author:

HM Bhuvu

Research Scientist (Agronomy),
Pearl millet Research Station,
Junagadh Agricultural University,
Jamnagar, Gujarat, India

Response of summer pearl millet (*Pennisetum glaucum* L.) to foliar application of nano urea

HM Bhuvu, Asha C Detroja, NN Chaudhari, PR Patel, SN Galani and KD Mungra

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Abstract

An experiment was conducted during the summer season of the years 2024 and 2025 at Pearl millet Research Station, Junagadh Agricultural University, Jamnagar, Gujarat on response of summer pearl millet (*Pennisetum glaucum* L.) to foliar application of nano urea. The experiment was laid out in randomized block design with three replications and ten treatments. The results of experiment revealed that 75% RDN (application of 40 kg N/ha as basal and 50 kg N/ha at 25 DAS) followed by foliar application of nano urea 4 ml/L at 30 and 45 days after sowing to summer pearl millet produced higher grain and fodder (4644 and 7007 kg/ha, respectively) yields and net returns (Rs. 85999/ha). This reduces 25 per cent of nitrogen quantity used in summer pearl millet. Alternatively, application of 40 kg N as basal and 50 kg N/ha at 25 days after sowing followed by foliar application of 2 per cent urea at 30 and 45 days after sowing for getting higher grain and fodder (4549 and 6878 kg/ha, respectively) yields and net returns (Rs. 85261/ha). This also reduces 19 per cent of nitrogen quantity used in summer pearl millet.

Keywords: Pearl millet, urea, nano urea, foliar application, growth, yield

Introduction

Pearl millet (*Pennisetum glaucum* L.) is an important millet crop of India. It is commonly known as bajra or bajri, which is belong to *Poaceae* family. It is the upmost widely grown staple food of majority of poor and small land holders in Asia and Africa. It is consumed as both feed and fodder for livestock. It is a C₄ plant with high photosynthetic efficiency and high dry matter production capacity. It is well adapted to grow under most adverse agro-climatic conditions characterized by drought, low soil fertility and high temperatures. Pearl millet grain contains about 11.6% protein, 5% fat, 67% carbohydrates and 2.7% minerals (Gill, 1991)^[5]. Pearl millet is considered as more efficient in utilization of soil moisture and has a higher level of heat tolerance than sorghum and maize. It has the maximum potential of all the millets and is mainly grown in drought prone areas and marginal soils. Because of its tolerance to difficult growing conditions such as drought, low soil fertility and high temperature, it can be grown in areas where other cereal crops would not survive (Asodariya *et al.*, 2021)^[2].

Urea contributes about 82% of the total fertilizer consumption in India and about 55% of the total fertilizer nitrogen consumed in the world. Around 30-40% of nitrogen from urea fertilizer is utilized by plants and the rest gets wasted due to quick chemical transformation as a result of runoff, volatilization, leaching and denitrification, thereby low use efficiency. Whereas, nano urea has high nitrogen use efficiency and also it is environment friendly. Currently, modern agriculture is heavily supported by the use of high rates of agrochemicals. Synthetic chemical fertilizers are used for the optimal growth and productivity of crops, but they are not successful to enhance plant nutrient use efficiency and crop productivity (Ajith kumar *et al.*, 2021)^[1]. Though the nutrient deficiency and the responses of nutrient are reported, no systematic approaches has been made to find out the yield losses due to deficiency or toxicity of a particular elements. Nitrogen is an essential nutrient that is required by plants in great quantities particularly in pearl millet. Nitrogen is a nutrient with high mobility in the soil-plant-atmosphere system, and it is easily lost through volatilization or leaching. Moreover, nitrogen fertilizers have low efficiency and are expensive to synthesize, and in addition to raising the cost of the final product, it can contaminate the

environment. The foliar application of N as urea or DAP showed higher fertilizer efficiency than soil application. In comparison to urea the uptake efficiency of nano urea is more. It is thus, required in lesser quantity as compared to the conventional urea fertilizer to fulfill plant's nitrogen requirement. All India efficacy trials have been conducted on 20 ICAR research institutes and State Agricultural Universities on 43 crops. It has been recorded in the trials that nano urea increases crop productivity and can reduce the requirement of conventional urea by 50%. Further, application of nano fertilizers at critical growth stages of crops improves yield, biomass, soil health and nutritional quality of the produce (Kumar *et al.*, 2021) [8]. Application of conventional fertilizer along with foliar spray of nano urea increased maize yield reported by Rathore *et al.* (2022) [12]. Farmers can easily carry bottles of nano urea over bulkier urea bags, which have a substantial influence on relative logistics and warehousing costs (Meena and Verma, 2022) [9].

Materials and Methods

A field experiment was conducted at Pearl millet research station, Junagadh Agricultural University, Jamnagr (22°47' N, 70°07' E, 18.00 m above the mean sea level), Gujarat for two consecutive years from 2024 to 2025. The site is situated in the North Saurashtra agro-climatic region of Gujarat under Gujarat plains and hills zone of India. The climate of this region is semi-arid and sub-tropical with fairly dry and hot summer. The rainy season commences in the second fortnight of June and ends in September, with an average annual rainfall of 550 mm. July and August are the peak months of rainfall. Winter season sets in the month of November and continues till the middle of February. December and January are the coldest months of winter with the mean minimum temperature ranging from 15°C to 17°C. Summer season commences in the second fortnight of February and ends in the middle of June. The experimental soil was clayey (14.78% sand, 17.63% silt and 67.59% clay) in texture and slightly alkaline in reaction with pH 7.9 and EC 0.43 dS/m. It was moderately fertile being low in organic carbon (4.1 g/kg), medium in available nitrogen (203.2 kg/ha) and phosphorus (10.6 kg/ha) and high in available potassium (282.5 kg/ha). The initial DTPA extractable Fe and Zn were 7.0 and 0.68 mg/kg respectively. The soil moisture content at field capacity and permanent wilting point in the upper 30 cm soil depth were 28.50 and 16.70%, respectively. In 100% RDN, 1/3 of nitrogen each at basal, 25 and 45 DAS was used. In the remaining treatments, 40 kg N/ha was applied as basal and remaining dose of N at 25 DAS was used. 60 kg P₂O₅/ha was applied to all the treatments. Water volume 300 L/ha for first spray and 500 L/ha for second spray was used. Nano urea of IFFCO was used. The statistically data was examined

using the approach for analysis of variance as outlined by Gomez and Gomez (1984) [6]. At a 5% probability level, the crucial difference (CD) was used to test for differences in the treatment means.

Results and Discussion

Effect on grain and fodder yields

The data furnished in Table-1 revealed that different treatments had significant effect on grain and fodder yields. Significantly maximum grain yield of 4245, 5138 and 4691 kg/ha were recorded under treatment T₂ i.e. 100% RDN during 2024, 2025 and in pooled results, respectively, which was found statistically at par with treatment T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 25 & 45 DAS (4169, 5118 and 4644 kg/ha, respectively), T₅ i.e. application of 75% RDN + foliar spray of urea 2% at 25 & 45 DAS (4136, 4963 and 4549 kg/ha, respectively), T₄ i.e. application of 75% RDN + foliar spray of nano urea 2 ml/L at 25 & 45 DAS (4084, 4791 and 4438 kg/ha, respectively), during the year 2024, 2025 and in pooled results. While T₃ i.e. application of 75% RDN + foliar spray of urea 1% at 25 & 45 DAS (3805 and 4528 kg/ha) and T₁₀ i.e. application of 50% RDN + foliar spray of nano urea 4 ml/L at 25 & 45 DAS (3702 and 4503 kg/ha) only during 2024 and 2025. In case of fodder yield, treatment T₂ i.e. 100% RDN recorded the higher fodder yield during 2024 (7153 kg/ha), 2025 (7065 kg/ha) and in pooled results (7109 kg/ha). Treatment T₂ remain at par with the treatment T₆ (7102, 6913 and 7007 kg/ha), T₅ (6865, 6890 and 6878 kg/ha), T₄ (6832, 6604 and 6718 kg/ha) during 2024, 2025 and in pooled results. While, T₃ i.e. application of 75% RDN + foliar spray of urea 1% at 25 & 45 DAS (6229 and 6569 kg/ha) during 2024 and 2025, T₁₀ i.e. application of 50% RDN + foliar spray of nano urea 4 ml/L at 25 & 45 DAS (6130 and 6465 kg/ha) during 2024 and 2025. T₉ i.e. application of 50% RDN + foliar spray of nano urea 2 ml/L at 25 & 45 DAS (6233 kg/ha) only during 2025. This is due to the combined application of conventional and nano urea ensured optimum and balanced nutrient availability during the crop period. Due to smaller size and larger effective surface area of nano particles which can easily penetrate into the plant and lead to better uptake of nitrogen. The higher uptake results in maximum growth of plant parts and metabolic processes like photosynthesis that increase photosynthates accumulation and its translocation to the economical parts of the plant which results in increased growth, yield attributing characters and finally yield by amplifying the translocation of assimilates to grains. The present findings are in close agreement with the results obtained by Srivastava and Singh (2023) [15], Vegda *et al.* (2024) [17], Rajesh *et al.* (2021) [10], Bhargavi and Sundari (2022) [3], Ranjan *et al.* (2022) [11].

Table 1: Effect of foliar application of nano urea on grain and fodder yield of pearl millet

Treatments	Grain yield (kg/ha)			Fodder yield (kg/ha)		
	2024	2025	Pooled	2024	2025	Pooled
T ₁ :Control	2883	3833	3358	5268	5395	5331
T ₂ :100% RDN	4245	5138	4691	7153	7065	7109
T ₃ :75% RDN+FS of urea1%	3805	4528	4166	6229	6569	6399
T ₄ :75% RDN+FS of nano urea 2 ml/L	4084	4791	4438	6832	6604	6718
T ₅ :75% RDN+FS of urea 2%	4136	4963	4549	6865	6890	6878
T ₆ :75% RDN+FS of nano urea 4 ml/L	4169	5118	4644	7102	6913	7007
T ₇ :50% RDN+ FS of urea 1%	3304	4253	3779	5513	6155	5834
T ₈ :50% RDN+FS of nano urea 2 ml/L	3619	4412	4016	5934	6316	6125
T ₉ :50% RDN+FS of urea 2%	3567	4386	3977	5816	6233	6025
T ₁₀ :50% RDN+FS of nano urea 4 ml/L	3702	4503	4102	6130	6465	6297
S.Em.±	205	236	156	359	292	231
C.D. at 5%	608	702	449	1066	868	664
C.V.%	9.45	8.91	9.18	9.89	7.83	8.89

Effect on growth and yield attributes

Results furnished in Table-2 revealed that growth and yield attributes viz., plant height, total number of tillers per plant, effective tillers per plant, ear head length, ear head diameter and test weight were significantly influenced by different treatments. Treatment T₂ i.e. 100% RDN recorded significantly maximum plant height (181.27 cm), total number of tillers per plant (4.33), effective tillers per plant (3.67), ear head length (30.88 cm), ear head diameter (4.49 cm) and test weight (10.83 g) followed by treatment T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 30 & 45 DAS for plant height (179.60 cm), total number of tillers per plant (4.13), effective tillers per plant (3.57), ear head length (30.12 cm), ear head diameter (4.43 cm) and test weight (10.73 g) on pooled data basis. Foliar application of nano urea enhances protein synthesis and supply ample amount of nitrogen which plays an important role in accelerated the activity

of enzyme, cell division and plant growth. The chief function of nitrogen is multiplication and cell elongation and tissue differentiation that ultimately enhanced vegetative growth of plant resulting in taller plants. Similar findings have been reported by Samanta *et al.* (2022)^[13] and Sharma *et al.* (2022)^[14]. Nano fertilizer demonstrates a synergistic effect when used alongside conventional fertilizer, enhancing the plant cells capacity for nutrient absorption. This in turn promotes optimal growth of various plant components and vital metabolic processes like photosynthesis, leading to an accumulation of higher levels of photosynthates. As a results, the translocation of these photosynthates to economically vital plant parts results in an improvement in yield attributing parameters. These results are in conformity with the findings of Ranjan *et al.* (2022)^[11], Karanjikar *et al.* (2023)^[7], Udapudi *et al.* (2023)^[16] and Dobariya *et al.* (2025)^[4].

Table 2: Effect of foliar application of nano urea on growth and yield attributes of pearl millet

Treatments	Plant height (cm)	Total tillers /plant	Effective tillers /plant	Earhead length (cm)	Ear head dia.(cm)	Test weight (g)
T ₁ :Control	162.10	3.10	2.50	25.87	3.70	9.39
T ₂ :100% RDN	181.27	4.33	3.67	30.88	4.49	10.83
T ₃ :75% RDN+FS of urea1%	171.47	3.73	3.23	28.83	4.27	10.31
T ₄ :75% RDN+FS of nano urea 2 ml/L	173.07	3.83	3.30	29.25	4.32	10.45
T ₅ :75% RDN+FS of urea 2%	175.93	4.03	3.37	29.98	4.39	10.61
T ₆ :75% RDN+FS of nano urea 4 ml/L	179.60	4.13	3.57	30.12	4.43	10.73
T ₇ :50% RDN+ FS of urea 1%	164.70	3.23	2.63	26.94	4.00	9.81
T ₈ :50% RDN+FS of nano urea 2 ml/L	167.80	3.50	2.97	28.13	4.09	9.98
T ₉ :50% RDN+FS of urea 2%	166.03	3.33	2.83	27.73	4.09	9.89
T ₁₀ :50% RDN+FS of nano urea 4 ml/L	170.60	3.57	3.50	28.52	4.19	10.08
S.Em.±	1.94	0.12	0.10	0.65	0.08	0.17
C.D. at 5%	5.56	0.34	0.30	1.87	0.24	0.48
C.V.%	2.77	7.78	8.27	5.56	4.84	4.02

Effect on protein content, N uptake and soil available nitrogen

Data depicted in Table-3 revealed that the highest protein content from grain was recorded 10.61% by treatment T₂ i.e. 100% RDN followed by treatment T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 30 & 45 DAS (10.57%). The data revealed that the highest content of N from grain and fodder (1.70 and 0.54%) was recorded by treatment T₂ i.e. 100% RDN followed by treatment T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 30 & 45 DAS (1.69 and 0.53%). The highest total uptake of N was recorded by treatment T₂ i.e.100% RDN in pooled results (17.98 kg/ha) followed by treatment T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 30 & 45 DAS (115.70 kg/ha). The higher nitrogen content in seed

and fodder coupled with greater biological yield might have resulted in more total nitrogen uptake by crop with 75% RDN. These findings are in agreement with those of Samanta *et al.* (2022)^[13].

The same treatment T₂ i.e. 100% RDN recorded higher soil available nitrogen in pooled results (226.14 kg/ha) followed by treatment T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 30 & 45 DAS (219.83 kg/ha). The higher availability of N in soil at higher fertility level might be due to application of higher dose of fertilizer in soil and uptake of nutrient might not have substantiated the availability, resulting in higher available N in soil. Similar results have been advocated by Dobariya *et al.* (2025)^[4].

Table 3: Effect of foliar application of nano urea on nitrogen content, protein content, nitrogen uptake and soil available nitrogen status

Treatments	Nitrogen content (%)		Protein content (%)	Total N uptake (kg/ha)	Available Nitrogen (kg/ha)
	Grain	Fodder			
T ₁ :Control	1.41	0.41	8.82	68.69	178.44
T ₂ :100% RDN	1.70	0.54	10.61	117.98	226.14
T ₃ :75% RDN+FS of urea1%	1.58	0.50	9.89	97.57	205.59
T ₄ :75% RDN+FS of nano urea 2 ml/L	1.66	0.52	10.37	109.12	214.96
T ₅ :75% RDN+FS of urea 2%	1.68	0.51	10.52	111.50	210.78
T ₆ :75% RDN+FS of nano urea 4 ml/L	1.69	0.53	10.57	115.70	219.83
T ₇ :50% RDN+ FS of urea 1%	1.42	0.46	8.89	80.45	200.42
T ₈ :50% RDN+FS of nano urea 2 ml/L	1.47	0.47	9.19	87.90	204.86
T ₉ :50% RDN+FS of urea 2%	1.46	0.46	9.14	85.59	198.68
T ₁₀ :50% RDN+FS of nano urea 4 ml/L	1.56	0.49	9.74	94.35	205.88
S.Em.±	0.03	0.01	0.21	3.48	5.46
C.D. at 5%	0.10	0.03	0.60	10.00	15.68
C.V.%	5.28	4.51	5.28	8.81	6.48

Effect on economics

Economic viability of crop management is the foremost criteria in transforming new investigations to farmers' field. Economics was worked out by using current market prices of the produce and inputs used (Table-4). The mean data of two years indicated that maximum gross return (Rs.129075/ha), Net return (Rs.89555/ha) and B:C ratio (3.27) were obtained when crop was applied with

T₂ i.e. 100% RDN. Net return was followed by T₆ i.e. application of 75% RDN + foliar spray of nano urea 4 ml/L at 30 & 45 DAS (Rs.85999/ha) and T₅ i.e. application of 75% RDN + foliar spray of urea 2% at 30 & 45 DAS (Rs.85261/ha). The higher net gain per hectare could be attributed to significantly higher seed yield as compared to control. The results are in concurrence with those reported by Ranjan *et al.* (2022)^[11] and Vegda *et al.* (2024)^[17].

Table 4: Effect of foliar application of nano urea on economics of pearl millet

Treatments	Yield (kg/ha)		Gross returns (Rs/ha)	Total cost (Rs/ha)	Net Returns (Rs/ha)	BCR
	Grain	Fodder				
T ₁ :Control	3358	5331	92639	35608	57031	2.60
T ₂ :100% RDN	4691	7109	129075	39520	89555	3.27
T ₃ :75% RDN+FS of urea1%	4166	6399	114715	39254	75461	2.92
T ₄ :75% RDN+FS of nano urea 2 ml/L	4438	6718	122106	40521	81585	3.01
T ₅ :75% RDN+FS of urea 2%	4549	6878	125152	39891	85261	3.14
T ₆ :75% RDN+FS of nano urea 4 ml/L	4644	7007	127751	41752	85999	3.06
T ₇ :50% RDN+ FS of urea 1%	3779	5834	104088	38275	65813	2.72
T ₈ :50% RDN+FS of nano urea 2 ml/L	4016	6125	110541	39490	71051	2.80
T ₉ :50% RDN+FS of urea 2%	3977	6025	109427	38629	70798	2.83
T ₁₀ :50% RDN+FS of nano urea 4 ml/L	4102	6297	112949	40542	72407	2.79

Conclusion

On the basis of the results of two years field experimentation, it is concluded that application of 75% RDN (40 kg N/ha as basal and 50 kg N/ha at 25 DAS) followed by foliar application of nano urea 4 ml/L at 30 and 45 days after sowing to summer pearl millet produced higher grain and fodder yields. This reduces 25 per cent of nitrogen quantity used in summer pearl millet. Alternatively, application of 75% RDN (40 kg N as basal and 50 kg N/ha at 25 DAS) followed by foliar application of 2 per cent urea at 30 and 45 days after sowing for getting higher grain yield and net return.

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