



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(8): 345-349
Received: 06-05-2026
Accepted: 08-06-2026

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Effect of foliar spray of nano urea and novel organic liquid nutrient on growth performance of *kharif* rice (*Oryza sativa* L.) under Southern Gujarat conditions

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i8e.6253>

Abstract

A field experiment was conducted during the *kharif* seasons of 2023 and 2024 to evaluate the effects of different nitrogen levels, foliar application of nano urea and a novel organic liquid nutrient, and different spray schedules on the growth performance of rice (*Oryza sativa* L.) under southern Gujarat conditions. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three factors: two nitrogen levels [N_1 : 50% recommended dose of nitrogen (RDN) and N_2 : 75% RDN], five foliar nutrient treatments [U_1 : nano urea @ 2 ml L⁻¹, U_2 : nano urea @ 4 ml L⁻¹, U_3 : nano urea @ 6 ml L⁻¹, U_4 : novel organic liquid nutrient @ 1%, and U_5 : novel organic liquid nutrient @ 2%], and two spray schedules [S_1 : one spray at 30 days after transplanting (DAT) and S_2 : two sprays at 30 and 45 DAT]. A control treatment receiving 100% RDF was maintained separately outside the factorial experiment. The results revealed that the individual effects of N_2 (75% RDN), U_3 (nano urea @ 6 ml L⁻¹), and S_2 (two foliar sprays at 30 and 45 DAT) significantly enhanced plant height at 60 DAT, 90 DAT, and harvest, number of tillers m⁻² at 60 DAT, effective tillers m⁻² at 75 DAT, dry matter accumulation at 60 DAT, 90 DAT, and harvest, and leaf area index at 90 DAT during both years as well as in the pooled analysis. These treatments consistently promoted greater crop vigour, canopy development, and biomass production, indicating that the integration of 75% RDN with foliar application of nano urea at 6 ml L⁻¹ applied twice can improve rice growth while reducing the requirement for conventional nitrogen fertilizer.

Keywords: Nano urea, novel organic liquid nutrient, foliar nutrient spray, yield

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops worldwide and serves as the staple food for nearly half of the global population. In India, rice is the principal food crop, contributing significantly to national food and nutritional security. However, sustaining rice productivity has become increasingly challenging due to rising input costs, declining resource-use efficiency, and the adverse impacts of climate change. Therefore, the adoption of sustainable nutrient management strategies is essential to enhance productivity while minimizing environmental degradation.

Nitrogen (N) is the most important nutrient for the growth, development, and productivity of rice. It is an essential component of chlorophyll, amino acids, proteins, enzymes, and nucleic acids, thereby playing a pivotal role in photosynthesis, tillering, biomass accumulation, and grain development. Despite its importance, the nitrogen use efficiency (NUE) of conventional nitrogen fertilizers in rice remains low because of substantial losses through ammonia volatilization, leaching, denitrification, and surface runoff. Consequently, excessive application of nitrogen fertilizers not only increases production costs but also contributes to soil degradation, environmental pollution, and greenhouse gas emissions. Improving NUE has therefore become a key objective for achieving sustainable rice production.

Recent advances in nanotechnology have led to the development of nano-fertilizers as an innovative approach to improving nutrient-use efficiency. Nano urea, developed by the Indian Farmers Fertiliser Cooperative Limited (IFFCO), is a liquid nano-fertilizer designed to enhance nitrogen absorption and utilization through foliar application.

Its higher nutrient-use efficiency offers the potential to reduce the requirement for conventional nitrogen fertilizers without compromising crop growth and productivity. Likewise, the novel organic liquid nutrient (NOL), developed by Navsari Agricultural University from fermented banana pseudostem sap, represents an eco-friendly nutrient source rich in essential plant nutrients and bioactive compounds. Besides supplying nutrients, it has the potential to improve crop growth, physiological performance, and soil health through sustainable nutrient recycling.

Although several studies have demonstrated the beneficial effects of nano urea and organic nutrient sources individually, information on their combined application under reduced nitrogen levels in rice is limited, particularly under the agro-climatic conditions of Southern Gujarat. Understanding the interactive effects of these nutrient management strategies is essential for developing efficient and environmentally sustainable fertilizer recommendations.

Therefore, the present investigation was undertaken to evaluate the effects of different nitrogen levels, foliar application of nano urea and novel organic liquid nutrient, and spray schedules on the growth performance of rice (*Oryza sativa* L.) under the agro-climatic conditions of Southern Gujarat.

Materials and Methods

The current study, entitled "Effect of Foliar Spray of Nano Urea and Novel Organic Liquid Nutrient on Growth Performance of *Kharif* Rice (*Oryza sativa* L.) under Southern Gujarat Conditions," was conducted during the *kharif* seasons of 2023 and 2024 at the Main Rice Research Station, Navsari Agricultural University, Navsari, Gujarat. The study aimed to evaluate the effects of different nitrogen levels, foliar application of nano urea and novel organic liquid nutrient, and spray schedules on the growth parameters of *kharif* rice. The experiment was laid out in a Factorial Randomized Block Design (FRBD) comprising three factors: nitrogen levels [N₁: 50% recommended dose of nitrogen (RDN) and N₂: 75% RDN], foliar spray treatments [U₁: nano urea @ 2 ml L⁻¹, U₂: nano urea @ 4 ml L⁻¹, U₃: nano urea @ 6 ml L⁻¹, U₄: novel organic liquid nutrient @ 1%, and U₅: novel organic liquid nutrient @ 2%], and spray schedules [S₁: one spray at 30 DAT and S₂: two sprays at 30 and 45 DAT]. In addition, a control treatment receiving 100% recommended dose of fertilizers (RDF) was maintained outside the factorial design. The experimental soil was classified under the order, *Inceptisol* with a clayey texture, slightly alkaline reaction, medium available nitrogen and phosphorus, high available potassium, adequate micronutrient status, and normal electrical conductivity.

A brief perusal of the weekly meteorological data recorded during the crop growth period revealed that the maximum temperature ranged from 28.3 to 36.1 °C and 29.6 to 35.7 °C, while the minimum temperature varied from 18.1 to 28.1 °C and 15.8 to 27.5 °C during 2023 and 2024, respectively. The morning relative humidity ranged from 75 to 97% in 2023 and 69 to 99% in 2024, whereas the evening relative humidity varied from 31 to 94% and 34 to 92%, respectively. Bright sunshine hours ranged from 0.3 to 9.3 h day⁻¹ during 2023 and 0.4 to 8.9 h day⁻¹ during 2024. Similarly, evapotranspiration varied from 0.9 to 5.6 mm day⁻¹ in 2023 and 0.3 to 6.1 mm day⁻¹ in 2024. Rainfall was distributed from the second week of June to the last week of September, with an additional rainfall event during the last week of November in 2023, whereas in 2024 rainfall continued from the second week of June until the last week of October. A total of 56 and 72 rainy days were recorded during the crop growth periods of 2023 and 2024, respectively.

Plant height was recorded at 60 and 90 DAT and at harvest from

five randomly selected and tagged plants in each net plot by measuring the distance from the base of the plant to the tip of the last fully expanded leaf using a wooden metre scale. The mean plant height was expressed in centimetres (cm). The total number of tillers was recorded at 60 DAT from two randomly selected one-metre row lengths in each net plot. The observations were averaged and multiplied by a factor of five to express the total number of tillers per square metre (m⁻²). Effective tillers were recorded at 75 DAT by counting the panicle-bearing tillers from the same observation units and expressed as number m⁻². Leaf area was measured at 90 DAT using five randomly selected plants from each treatment. Fresh green leaves were immediately passed through a leaf area meter (Model LI-300, LI-COR Inc., Nebraska, USA), and the mean leaf area was expressed as cm² plant⁻¹. The leaf area index (LAI) was calculated as the ratio of total leaf area to the corresponding ground area occupied by the crop, following the method proposed by Watson (1952). Dry matter accumulation was recorded at 60 and 90 DAT and at harvest. Five plants from each net plot were uprooted, sun-dried, and subsequently oven-dried at 60±1 °C until a constant weight was attained. The dry weight was recorded and expressed as g plant⁻¹ by dividing the total dry weight by the number of sampled plants.

Results and Discussion

Plant height

The results on the effect of different treatments on plant height of rice at 60 DAT, 90 DAT and at harvest are presented in Table 1. Plant height was significantly influenced by nitrogen levels and foliar nutrient application at 60 DAT during both the years as well as in the pooled analysis. At 90 DAT, nitrogen levels and foliar nutrient application exerted a significant effect only in the pooled analysis. At harvest, nitrogen levels significantly affected plant height during 2023 and in the pooled analysis, whereas foliar nutrient application remained significant during both the years as well as in the pooled analysis. The spray schedule had a significant effect only in the pooled analysis. The interaction effects among nitrogen levels, foliar nutrient treatments and spray schedules were non-significant at all stages of crop growth. Among the nitrogen levels, application of 75% RDN (N₂) recorded significantly taller plants at 60 DAT, 90 DAT and at harvest than 50% RDN (N₁). Among the foliar nutrient treatments, nano urea @ 6 ml L⁻¹ (U₃) produced significantly taller plants, followed by nano urea @ 4 ml L⁻¹ (U₂), whereas the lowest plant height was recorded with the application of 1% novel organic liquid nutrient (U₄). The two-spray schedule (S₂) also recorded significantly greater plant height than the single-spray schedule (S₁) in the pooled analysis. The increase in plant height under 75% RDN coupled with foliar application of nano urea might be attributed to the adequate and sustained supply of nitrogen, which enhanced chlorophyll synthesis, photosynthetic activity, cell division and cell elongation, thereby promoting vigorous vegetative growth. Similar findings have also been reported by Kowsalya *et al.* (2023) [2] in rice.

Number of tillers/m²

The effects of nitrogen levels, foliar nutrient treatments and spray schedules on the number of total tillers m⁻² and effective tillers m⁻² during both the years and in the pooled analysis are presented in Table 2. The individual effects of nitrogen levels (N), foliar nutrient treatments (U) and spray schedules (S) were significant, whereas their interaction effects and the control vs. rest comparison were non-significant. Application of 75% RDN (N₂) recorded significantly higher number of total tillers m⁻² at 60 DAT and effective tillers m⁻² at 75 DAT than 50% RDN (N₁).

Among the foliar nutrient treatments, nano urea @ 6 ml L⁻¹ (U₃) recorded the highest total and effective tillers m⁻², followed by nano urea @ 4 ml L⁻¹ (U₂). The two-spray schedule (S₂; at 30 and 45 DAT) also recorded significantly higher total and effective tillers m⁻² than the single-spray schedule (S₁). The higher tiller production under 75% RDN and foliar application of nano urea @ 6 ml L⁻¹ may be attributed to improved nitrogen availability and utilization, which enhanced vegetative growth and tiller initiation. These findings are in close agreement with those reported by Lemraski *et al.* (2017) [3] and Namasharma *et al.* (2023) [4] in rice.

Leaf Area Index (LAI)

The effect of different treatments on leaf area index (LAI) at 90 DAT is presented in Table 2. The results revealed that nitrogen levels (N) and spray schedules (S) had no significant effect on LAI, whereas foliar nutrient treatments (U) significantly influenced LAI. The interaction effects among the treatments and

the control vs. rest comparison were also found to be non-significant.

Plant Dry Matter Production (g/plant)

The results on the effect of different treatments on dry matter production (DMP) (g plant⁻¹) of rice at 60 DAT, 90 DAT and harvest are presented in Table 3. The individual effects of nitrogen levels (N) and foliar nutrient treatments (U) on DMP were significant at 60 DAT, 90 DAT and at harvest during both the years as well as in the pooled analysis. The effect of spray schedule (S) was significant at 60 DAT during 2023 and in the pooled analysis, whereas at 90 DAT, it was significant only in the pooled analysis. At harvest, the spray schedule had no significant effect. The interaction effects among nitrogen levels, foliar nutrient treatments and spray schedules, as well as the control vs. rest comparison, were non-significant at all stages. The present observation is in conformity with the findings reported by Pediredy *et al.* (2024) [5] and Benzon *et al.* (2015) [1] in rice.

Table 1: Plant height of rice at 60,90 DAT and at harvest stage as influenced by different treatments

Treatment	Plant height (cm) of rice at 60 DAT			Plant height (cm) of rice at 90 DAT			Plant height (cm) of rice at harvest stage		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Effect of Nitrogen level (N)									
N ₁ : 50% RDN	55.42	56.43	55.93	68.08	69.67	68.87	87.88	89.42	88.65
N ₂ : 75% RDN	65.03	66.31	65.67	72.82	74.14	73.48	92.79	93.94	93.37
SEm ±	1.14	1.28	0.86	1.68	1.69	1.19	1.63	1.93	1.26
C.D. @ 5%	3.26	3.67	2.41	NS	NS	3.35	4.66	NS	3.55
Effect of foliar spray (U)									
U ₁ : 2 ml/l Nano urea	57.78	58.53	58.16	68.27	70.03	69.15	87.60	89.47	88.54
U ₂ : 4 ml/l Nano urea	62.92	63.87	63.40	73.49	73.88	73.69	94.00	93.29	93.65
U ₃ : 6 ml/l Nano urea	66.27	67.51	66.89	78.06	79.82	78.94	97.82	99.83	98.83
U ₄ : 1% Novel Organic Liquid	55.08	56.14	55.61	61.83	63.76	62.80	81.81	83.49	82.65
U ₅ : 2% Novel Organic Liquid	59.08	60.81	59.95	70.59	72.03	71.31	90.43	92.33	91.38
SEm ±	1.80	2.03	1.36	2.65	2.67	1.88	2.58	3.04	1.99
C.D. @ 5%	5.16	5.80	3.82	7.58	7.66	5.30	7.37	8.71	5.62
Effect of spray schedule (S)									
S ₁ : One spray (30 DAT)	58.78	59.80	59.29	68.22	69.76	68.99	88.33	89.62	88.98
S ₂ : Two sprays (30 and 45 DAT)	61.67	62.94	62.31	72.68	74.05	73.37	92.34	93.75	93.05
SEm ±	1.14	1.28	0.86	1.68	1.69	1.19	1.63	1.93	1.26
C.D. @ 5%	NS	NS	2.41	NS	NS	3.35	NS	NS	3.55
CV%	10.36	11.44	10.92	13.02	12.88	12.95	9.88	11.50	10.73
Sig. Interactions	-	-	-	-	-	-	-	-	-
Control v/s Rest									
Control mean	66.78	69.81	68.29	72.01	73.51	72.76	91.73	93.49	92.61
Treatment mean	60.23	61.37	60.80	70.45	71.90	71.18	90.33	91.68	91.01
SEm ±	2.66	2.51	2.23	3.92	3.95	4.88	3.81	4.80	5.37
C.D. @ 5%	NS	7.53	6.69	NS	NS	NS	NS	NS	NS
CV%	10.05	10.19	10.65	12.68	12.55	12.61	9.62	11.96	10.87

Table 2: Number of tillers/m² and leaf Area Index (LAI) of rice as influenced by different treatments

Treatment	Number of total tillers/m ² of rice at 60 DAT			Number of effective tillers/m ² of rice at 75 DAT			Leaf Area Index (LAI) of rice at 90 DAT		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Effect of Nitrogen level (N)									
N ₁ : 50% RDN	348	377	362	278	306	292	2.66	2.67	2.67
N ₂ : 75% RDN	402	435	419	332	364	348	2.73	2.74	2.74
SEm ±	12.05	12.51	8.68	12.05	12.51	8.68	0.05	0.05	0.04
C.D. @ 5%	35	36	24	35	36	24	NS	NS	NS
Effect of foliar spray (U)									
U ₁ : 2 ml/l Nano urea	324	362	343	254	291	273	2.48	2.49	2.49
U ₂ : 4 ml/l Nano urea	408	432	420	338	361	350	2.83	2.85	2.84
U ₃ : 6 ml/l Nano urea	485	513	499	415	442	428	2.89	2.91	2.90
U ₄ : 1% Novel Organic Liquid	290	327	308	220	256	238	2.46	2.47	2.47
U ₅ : 2% Novel Organic Liquid	369	396	383	299	325	312	2.81	2.83	2.82
SEm ±	19.06	19.78	13.73	19.06	19.78	13.73	0.09	0.08	0.06

C.D. @ 5%	55	57	39	55	57	39	0.25	0.22	0.16
Effect of spray schedule (S)									
S ₁ : One spray (30 DAT)	356	387	372	286	316	301	2.67	2.68	2.68
S ₂ : Two sprays (30 and 45 DAT)	394	425	410	324	354	339	2.72	2.73	2.73
SEm ±	12.05	12.51	8.68	12.05	12.51	8.68	0.05	0.05	0.04
C.D. @ 5%	35	36	24	35	36	24	NS	NS	NS
CV%	17.59	16.88	17.23	21.62	20.46	21.02	11.16	9.95	10.57
Sig. Interactions	-	-	-	-	-	-	-	-	-
Control v/s Rest									
Control mean	433	468	450	363	397	380	2.91	2.92	2.92
Treatment mean	375	406	391	305	335	320	2.69	2.71	2.70
SEm ±	28.50	29.32	35.84	28.50	29.32	35.84	0.13	0.12	0.15
C.D. @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	17.22	16.39	16.79	17.22	16.39	16.79	10.84	9.66	10.26

Table 3: Plant dry matter (g/plant) of rice as influenced by different treatments

Treatment	Plant dry matter (g/plant) of rice at 60 DAT			Plant dry matter (g/plant) of rice at 90 DAT			Plant dry matter (g/plant) of rice at harvest		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Effect of Nitrogen level (N)									
N ₁ : 50% RDN	21.86	23.01	22.43	53.15	54.50	53.82	65.68	65.17	65.43
N ₂ : 75% RDN	28.42	30.44	29.43	69.47	71.17	70.32	84.82	87.19	86.01
SEm ±	0.54	0.64	0.42	1.18	1.37	0.90	1.93	1.77	1.31
C.D. @ 5%	1.53	1.84	1.18	3.37	3.93	2.55	5.54	5.07	3.69
Effect of foliar spray (U)									
U ₁ : 2 ml/l Nano urea	21.92	25.92	23.92	54.97	60.22	57.60	71.09	73.16	72.13
U ₂ : 4 ml/l Nano urea	24.91	28.92	26.92	65.36	66.09	65.73	76.91	79.62	78.27
U ₃ : 6 ml/l Nano urea	26.09	30.66	28.38	68.08	73.01	70.55	87.42	85.03	86.23
U ₄ : 1% Novel Organic Liquid	22.17	24.68	23.43	56.44	54.71	55.58	66.62	67.25	66.94
U ₅ : 2% Novel Organic Liquid	23.61	30.43	27.02	61.69	60.15	60.92	74.21	75.86	75.04
SEm ±	0.85	1.02	0.66	1.86	2.17	1.43	3.06	2.80	2.07
C.D. @ 5%	2.43	2.91	1.87	5.33	6.22	4.03	8.76	8.02	5.84
Effect of spray schedule (S)									
S ₁ : One spray (30 DAT)	24.56	25.88	25.22	59.78	61.61	60.70	73.60	74.75	74.18
S ₂ : Two sprays (30 and 45 DAT)	26.12	27.16	26.64	62.84	64.06	63.45	76.90	77.62	77.26
SEm ±	0.54	0.64	0.42	1.18	1.37	0.90	1.93	1.77	1.31
C.D. @ 5%	1.53	NS	1.18	NS	NS	2.55	NS	NS	NS
CV%	14.51	11.15	12.51	10.51	11.98	11.29	14.08	12.74	13.42
Sig. Interactions	-	-	-	-	-	-	-	-	-
Control v/s Rest									
Control mean	31.52	31.69	31.60	63.29	63.74	63.51	80.45	83.97	82.21
Treatment mean	25.84	26.02	25.93	61.31	62.83	62.07	75.25	76.18	75.72
SEm ±	1.35	1.50	1.77	2.75	3.21	3.71	4.58	4.14	5.41
C.D. @ 5%	NS	5.67	4.98	NS	NS	NS	NS	NS	NS
CV%	15.10	10.73	12.44	10.24	11.68	11.00	13.85	12.36	13.12

Conclusion

Among the nitrogen levels, application of 75% RDN (N₂) recorded significantly superior growth performance by producing taller plants, a higher number of total tillers m⁻² and effective tillers m⁻², greater leaf area index (LAI) and higher dry matter production than 50% RDN (N₁). Similarly, among the foliar nutrient treatments, nano urea @ 6 ml L⁻¹ (U₃) significantly enhanced plant height, total tillers m⁻², effective tillers m⁻², LAI and dry matter production over the other treatments. With respect to spray schedules, the two-spray schedule (S₂; at 30 and 45 DAT) recorded significantly better growth performance than the single-spray schedule (S₁). Overall, application of 75% RDN in combination with two foliar sprays of nano urea @ 6 ml L⁻¹ significantly enhanced the growth parameters of *kharif* rice. Therefore, the application of two foliar sprays of nano urea @ 6 ml L⁻¹ can reduce the soil-applied nitrogen requirement by 25% without compromising crop growth under the agro-climatic conditions of Southern Gujarat conditions.

Acknowledgement: The authors are grateful to the Honorable

Vice Chancellor, Navsari Agricultural University, the Director of Research, the Registrar, and the Principal and Dean, N. M. College of Agriculture, for providing the research facilities, equipment, experimental inputs and necessary support for the successful conduct of the experiment.

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