



RESEARCH ARTICLE

Effect of foliar feeding of nano urea fertilisers on growth, yield and quality parameters on eggplant (*Solanum melongena* L.)

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Received: 29 November 2025; Accepted: 30 January 2026; Available online: Version 1.0: 08 April 2026

Cite this article: Nirmalya D, Alok N, Anup S. Effect of foliar feeding of nano urea fertilisers on growth, yield and quality parameters on eggplant (*Solanum melongena* L.). Plant Science Today. 2026; 13(sp1): 1-7. <https://doi.org/10.14719/pst.12997>

Abstract

A field experiment was conducted on eggplant at the agricultural research station, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan Deemed to be University (SOADU), Bhubaneswar, during winter season of 2023–2024 in order to assess the efficacy of nano fertilisers through foliar feeding and reduce the use of conventional fertilisers, which have significant adverse effects on the soil and the environment. It was laid out in the randomized block design (RBD) with 10 treatments and 3 replications. The treatments comprised of different concentrations of nano nitrogen and nano nitrogen, phosphorous and potassium (NPK). The treatment T₁₀ (75 % recommended dose of nitrogen (RDN) + foliar spray of 1 % urea produced the highest yield (301.83 q ha⁻¹) which was at par with T₅ (75 % RDN + nano-urea foliar spray at 4 mL/L) and T₃ (100 % RDN as conventional fertiliser in soil). The highest total phenol was recorded in T₅ (1.75 mg GAE/g) and the lowest (0.93 mg GAE/g) in T₁ (control). The highest glucose concentration of fruit was observed in T₇ (7.38 %).

Keywords: brinjal; nano nitrogen; nano NPK

Introduction

Nanotechnology is an emerging scientific approach that includes the use of equipment and materials capable of utilising the physical and chemical properties of substances at the molecular and nano level. It enables exploration of the biological and material worlds on a nanometre scale and finds applications in various fields ranging from medicine to agriculture. Nanotechnology deals with the study and manipulation of extremely small objects typically smaller than 100 nm in size (1 nm = 10⁻⁹ m).

The concept of nanotechnology was first introduced in 1959 by the renowned physicist Richard Feynman in his lecture titled "There's Plenty of Room at the Bottom," where he highlighted the potential of synthesising materials through the direct manipulation of atoms. Inspired by Feynman's ideas, K Eric Drexler coined the term "nanotechnology" and laid the conceptual foundation for its development (1).

Eggplant (*Solanum melongena* L.) is a member of the Solanaceae family. It is widely consumed in India for both nutritional and medicinal purposes. These bioactive constituents exhibit therapeutic properties such as anticancer, anti-inflammatory, anti-asthmatic, anti-platelet, hypolipidemic and hypotensive effects. Foliar spray of nanofertiliser increases the total phenol content of the fruit (2).

Materials and Methods

The experiment was conducted at the agriculture research station, Binjhagiri, Chatabara, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, during winter season of 2023–2024. The experiment was laid out in a randomized block design with 10 treatments and 3 replications (Table 1). Nano urea used in the present experiment was manufactured by IFFICO (Indian farmers fertiliser cooperative limited). Another nano fertiliser namely Geolife (N: P: K – 19:19:19) was used in the experiment. The frequency of fertilisers was applied in 3 doses in 15 days interval after transplanting and for volume per hectare requirement was 625 mL to 1.25 L/ha. Nano urea's composition primarily features nano-sizes nitrogen particles (20–50 nm) dispersed in water, typically containing 4 % total nitrogen (weight/volume).

Spacing of 60 × 45 cm was adopted. Recommended Fertiliser dose was 125 kg N₂, 50 kg P₂O₅, 75 kg K₂O/ha. Observations were recorded on plant height, stem girth, branches per plant, leaves per plant, leaf length, leaf width, leaf area, plant spread east-west, plant spread north-south, days to first flowering, days to 50 % flowering, fruit girth, fruit length, fruit weight, fruits per plant, fruit yield per plant, fruit yield, glucose concentration, refractive index, total phenol. Data were analysed by following the standard procedure (3).

Table 1. Treatment details

Sl. No.	Treatment	Symbol used
1	Control (no fertiliser)	T ₁
2	75 % RDN (recommended dose of nitrogen)	T ₂
3	100 % RDF (recommended dose of fertiliser)	T ₃
4	75 % RDN + Nano urea (Foliar spray) at 3 mL/L	T ₄
5	75 % RDN + Nano urea (Foliar spray) at 4 mL/L	T ₅
6	75 % RDN + Nano urea (Foliar spray) at 5 mL/L	T ₆
7	75 % RDN+ Nano NPK (19:19:19) at 1 g/L	T ₇
8	75 % RDN+ Nano NPK (19:19:19) at 2 g/L	T ₈
9	75 % RDN+ Nano NPK (19:19:19) at 3 g/L	T ₉
10	75 % RDN + Foliar spray of 1 % Urea	T ₁₀

Note: RDN- recommended dose of nitrogen; NPK- nitrogen, phosphorous and potassium.

Results and Discussion

Growth parameters

Plant height (cm)

The data presented in Table 2 shows that the maximum plant height (46.11 cm) was recorded in treatment T10 (75 % RDN + foliar spray of 1 % urea), which was significantly superior to treatments T1 (control), T2, T4, T6, T7 and T9, but statistically at par with T3, T5 and T8. A consistent increase in plant height was observed with increasing nano urea concentration up to 4 mL/L. However, a further increase to 5 mL/L showed a detrimental effect. The minimum plant height (27.58 cm) was recorded in T1 (control). Similar results were previously reported (4–9).

Stem girth (cm)

The maximum stem girth (3.79 cm) was observed in T10, which was significantly better than treatments T1, T2, T4, T6, T7 and T9, but statistically similar to T3, T5 and T8 (Table 2). Stem girth increased steadily with nano urea application up to 4 mL/L but declined at 5 mL/L. The minimum stem girth (2.83 cm) was recorded in T1. Similar result was previously reported (5, 9, 10).

Branches per plant

As stated in Table 2 T10 showed the maximum number of branches per plant (16.90), significantly outperforming T1, T2, T4, T6, T7 and T9 and was statistically on par with T3, T5 and T8. A concentration of 4 mL/L of nano urea showed a positive effect, but 5 mL/L led to a decline. The lowest branch count (12.60) was observed in T1. Similar

result was previously reported (5–9).

Leaves per plant

Based on the data provided in Table 2, the highest number of leaves per plant (33.80) was recorded in T10, significantly higher than T1, T2, T4, T6, T7 and T9 and at par with T3, T5 and T8. Again, the optimal concentration was 4 mL/L, with detrimental effects observed at 5 mL/L. The lowest leaf count (19.20) was found in T1. Similar result was previously reported (5, 6, 9, 10).

Leaf length (cm)

As reported by Table 2, the highest leaf length (13.76 cm) was observed in T10, significantly higher than T1, T2, T3, T4, T6, T7 and T9 and on par with T5 and T8. Leaf length increased up to 4 mL/L nano urea, with a decline at higher concentrations. T1 recorded the minimum (8.82 cm).

Leaf width (cm)

As masoned by the data on Table 2 T10 had the highest leaf width (6.17 cm), significantly different from T1, T2, T3, T4, T6, T7 and T9 and on par with T5 and T8. The detrimental effect of nano urea at 5 mL/L was evident, especially with reduced conventional urea. T1 had the minimum (4.70 cm).

Leaf area (sq. cm)

As per Table 2 T10 recorded the maximum leaf area (58.03 sq. cm), significantly better than T1, T2, T3, T4, T6, T7 and T9 and on par with T5 and T8. The increase in leaf area may be attributed to better absorption and utilisation of nano urea, even when the conventional urea dose was reduced by 25 %. The lowest leaf area (28.55 sq. cm) was in T1. Similar results were previously reported (4–6, 9, 10).

Plant spread (cm) East-West

The data given in Table 2, T10 recorded the highest plant spread (97.39 cm), significantly superior to T1, T2, T4, T6, T7 and T9 and statistically similar to T3, T5 and T8. The minimum spread (56.13 cm) was found in T1. Similar result was previously reported (9).

Plant spread (cm) North-South

The highest plant spread (97.79 cm) was also recorded in T10, significantly different from T1, T2, T3, T4, T6, T7 and T9 and on par with T5 and T8. The minimum spread (57.91 cm) was recorded in T1

Table 2. Effect of nano fertilisers on vegetative growth of brinjal (rabi 2023–2024)

Treatment details	Plant height (cm)	Stem girth (cm)	Branches per plant	Leaves per plant	Leaf length (cm)	Leaf width (cm)	Leaf area (sq. cm)	Plant spread (cm)	
								East-West	North-South
T ₁ = Control (no fertilisers)	27.58	2.83	12.60	19.20	8.82	4.70	28.55	56.13	57.91
T ₂ =75 % RDN (Conventional fertiliser in soil)	31.93	3.14	13.97	27.20	10.05	5.09	37.76	61.65	65.29
T ₃ =100 % RDN (Conventional fertiliser in soil)	43.61	3.63	16.13	32.13	12.80	5.99	57.66	93.75	90.59
T ₄ =75 % RDN + nano urea foliar spray at 3 mL/L	37.17	3.16	13.90	29.33	11.88	5.26	49.85	76.77	79.35
T ₅ =75 % RDN + nano urea foliar spray at 4 mL/L	42.47	3.57	16.03	32.60	12.25	5.95	57.06	93.39	89.98
T ₆ =75 % RDN + nano urea foliar spray at 5mL/L	34.55	3.12	14.14	32.17	10.41	5.18	38.09	71.67	72.95
T ₇ =75 % RDN + nano NPK (19:19:19) foliar spray at 1 g/L	33.37	3.09	12.90	27.73	10.96	5.40	39.33	68.23	71.18
T ₈ =75 % RDN + nano NPK (19:19:19) foliar spray at 2 g/L	41.55	3.55	15.79	31.43	11.67	5.83	49.85	93.20	88.79
T ₉ =75 % RDN + nano NPK (19:19:19) foliar spray at 3 g/L	31.88	3.05	13.33	29.73	10.09	5.25	36.97	66.79	68.99
T ₁₀ =75 % RDN + foliar spray of 1 % Urea	46.11	3.79	16.90	33.80	13.76	6.17	58.03	97.39	97.79
SE(m)±	1.97	0.8	0.49	2.55	0.11	0.1	1.20	1.50	2.70
CD (0.05)	5.85	0.24	1.47	7.57	0.34	0.3	3.55	3.34	8.03

Note: RDN- recommended dose of nitrogen; NPK- nitrogen, phosphorous and potassium; 100 % potassium was applied in all the treatments.

(Table 2). Similar result was previously reported (9).

Flowering, yield and yield attributes

Days to first flowering

According to Table 3, T₁₀ required the minimum days to first flowering (94.67 DAS), while T₁ required the maximum (100.33 DAS). All treatments were statistically similar. Similar findings were previously reported (4, 8, 9).

Days to 50% flowering

The earliest 50% flowering was seen in T₁₀ (104.32 DAS), while T₁ took the longest (110.67 DAS), though differences were not statistically significant (Table 3, Fig. 1) (9).

Fruit girth (cm)

As data mentioned in Table 4, T₁₀ had the largest fruit girth (7.77 cm), significantly better than T₁, T₂, T₄, T₆, T₇ and T₉ and on par with T₃, T₅ and T₈. The lowest (5.54 cm) was recorded in T₁. Similar findings were previously reported (5, 7–9).

Fruit length (cm)

The maximum fruit length (9.7 cm) was observed in T₁₀, significantly higher than T₁, T₂, T₄, T₆, T₇ and T₉ and similar to T₃, T₅ and T₈ (Table 4). The shortest fruits (6.87 cm) were in T₁. Similar findings were previously reported (7–9).

Fruit weight (g)

Based on the data in Table 4, T₁₀ produced the heaviest fruits (27.35 g), significantly more than T₁, T₂, T₄, T₆, T₇ and T₉ and on par with T₃, T₅ and T₈. The lowest fruit weight (17.35 g) was in T₁. Similar findings were previously reported (7–10) (Fig. 2).

Fruits per plant

T₁₀ had the highest number of fruits per plant (11.8), significantly more than all other treatments except T₃ and T₅ (Table 4). The minimum (6.27) was found in T₁. Similar findings were previously

Table 3. Effect of nano fertilisers on flowering of brinjal (rabi 2023–2024)

Treatment details	Days to first flowering	Days to 50 % flowering
T ₁ = Control (no fertilisers)	100.33	110.00
T ₂ =75 % RDN (Conventional fertiliser in soil)	98.00	107.00
T ₃ =100 % RDN (Conventional fertiliser in soil)	97.33	107.33
T ₄ =75 % RDN + nano urea foliar spray at 3 mL/L	97.67	106.33
T ₅ =75 % RDN + nano urea foliar spray at 4 mL/L	98.67	106.00
T ₆ =75 % RDN + nano urea foliar spray at 5 mL/L	98.33	105.67
T ₇ =75 % RDN + nano NPK (19:19:19) foliar spray at 1 g/L	97.33	106.67
T ₈ =75 % RDN + nano NPK (19:19:19) foliar spray at 2 g/L	98.33	110.67
T ₉ =75 % RDN + nano NPK (19:19:19) foliar spray at 3 g/L	96.00	106.33
T ₁₀ =75 % RDN + foliar spray of 1 % urea	94.67	104.33
SE(m)±	1.74	1.23
CD (0.05)	5.18	3.67

Note: RDN- recommended dose of nitrogen; NPK- nitrogen, phosphorous and potassium; 100 % phosphorous and potassium were applied in all the treatments.

reported (5, 7, 8, 10) (Fig. 3).

Fruit yield per plant (g)

The highest fruit yield per plant (212.80 g) was observed in T₁₀, significantly better than T₁, T₂, T₄, T₆, T₇ and T₉ and on par with T₃, T₅ and T₈ (Table 4). The lowest yield (171.90 g) was in T₁. Similar findings were previously reported (6–9).

Fruit yield (q ha⁻¹)

T₁₀ gave the highest yield (301.83 q ha⁻¹), significantly superior to T₁, T₂, T₄, T₆, T₇, T₈ and T₉ and at par with T₃ and T₅ (Table 4). The minimum yield (154 q/ha) was in T₁. Similar findings were previously

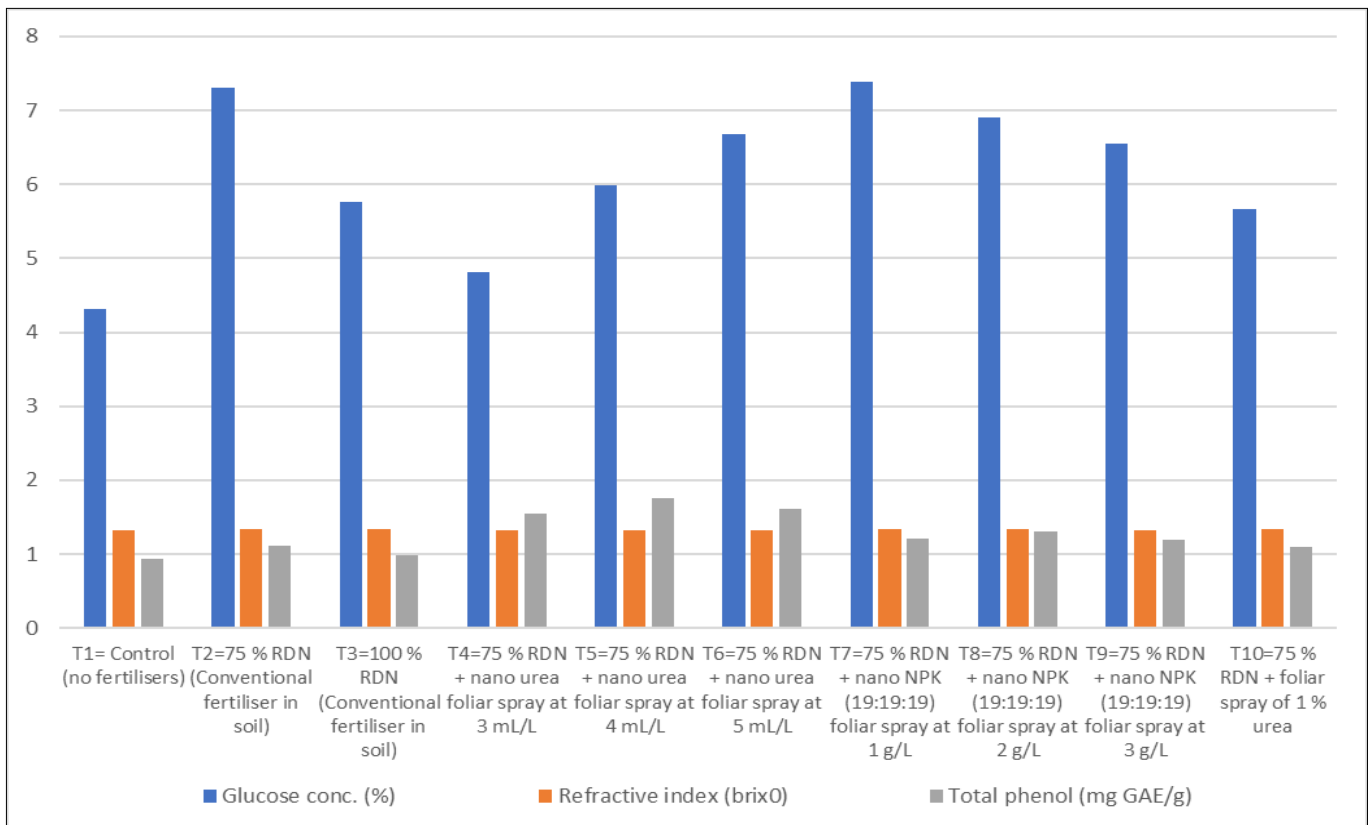


Fig. 1. Effect of nano fertilisers on fruit quality parameters of brinjal (Rabi 2023–2024).

Table 4. Effect of nano fertiliser on fruit yield and yield attributes of brinjal (rabi 2023–2024)

Treatment details	Fruit girth (cm)	Fruit length (cm)	Fruit weight (g)	Fruits per plant	Fruit yield per plant (g)	Fruit yield (q/ha)
T ₁ = Control (no fertilisers)	5.54	6.87	17.35	6.27	171.90	154
T ₂ =75 % RDN (Conventional fertiliser in soil)	6.60	9.17	18.26	8.33	187.80	211.55
T ₃ =100 % RDN (Conventional fertiliser in soil)	7.39	9.65	25.98	10.90	212.40	270.83
T ₄ =75 % RDN + nano urea foliar spray at 3 mL/L	6.53	8.65	23.30	7.53	192.33	214.64
T ₅ =75 % RDN + nano urea foliar spray at 4 mL/L	6.96	8.84	24.94	10.87	201.70	258.23
T ₆ =75 % RDN + nano urea foliar spray at 5 mL/L	6.37	8.39	23.62	7.60	183.53	198.58
T ₇ =75 % RDN + nano NPK (19:19:19) foliar spray at 1 g/L	5.76	7.47	19.81	6.60	172.87	180.80
T ₈ =75 % RDN + nano NPK (19:19:19) foliar spray at 2 g/L	6.33	8.39	23.86	8.60	194.50	209.45
T ₉ =75 % RDN + nano NPK (19:19:19) foliar spray at 3 g/L	5.49	7.31	16.89	6.60	170.67	179.32
T ₁₀ =75 % RDN + foliar spray of 1 % urea	7.77	9.70	27.40	11.80	212.80	301.83
SE(m)±	0.29	0.31	1.21	0.37	7.10	14.94
CD (0.05)	0.85	0.92	3.60	1.10	21.10	44.46

Note: RDN- recommended dose of nitrogen; NPK- nitrogen, phosphorous and potassium; 100 % phosphorous and potassium was applied in all the treatments.

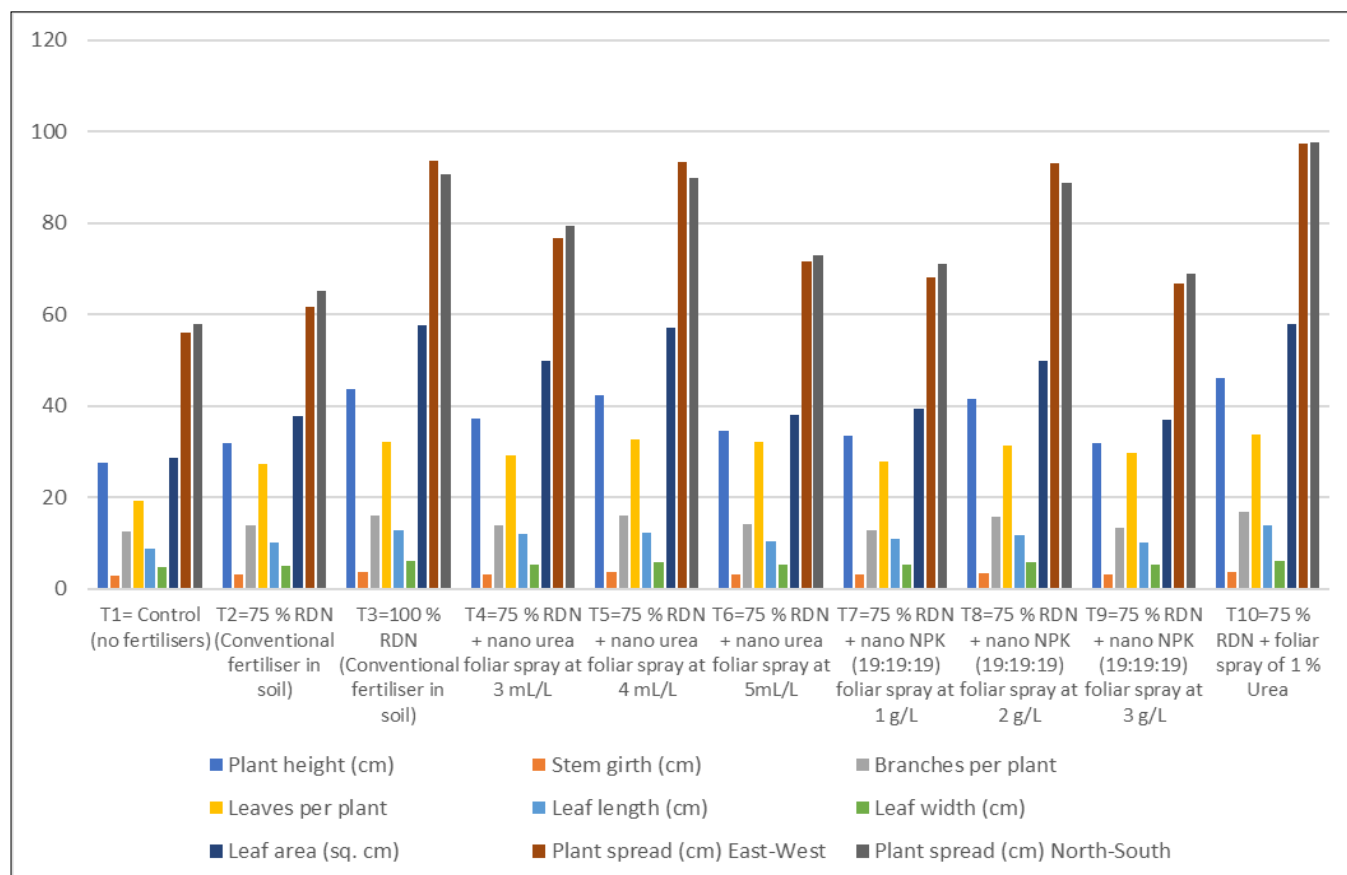


Fig. 2. Effect of nano fertiliser on fruit yield and yield attributes of brinjal (rabi 2023–2024).

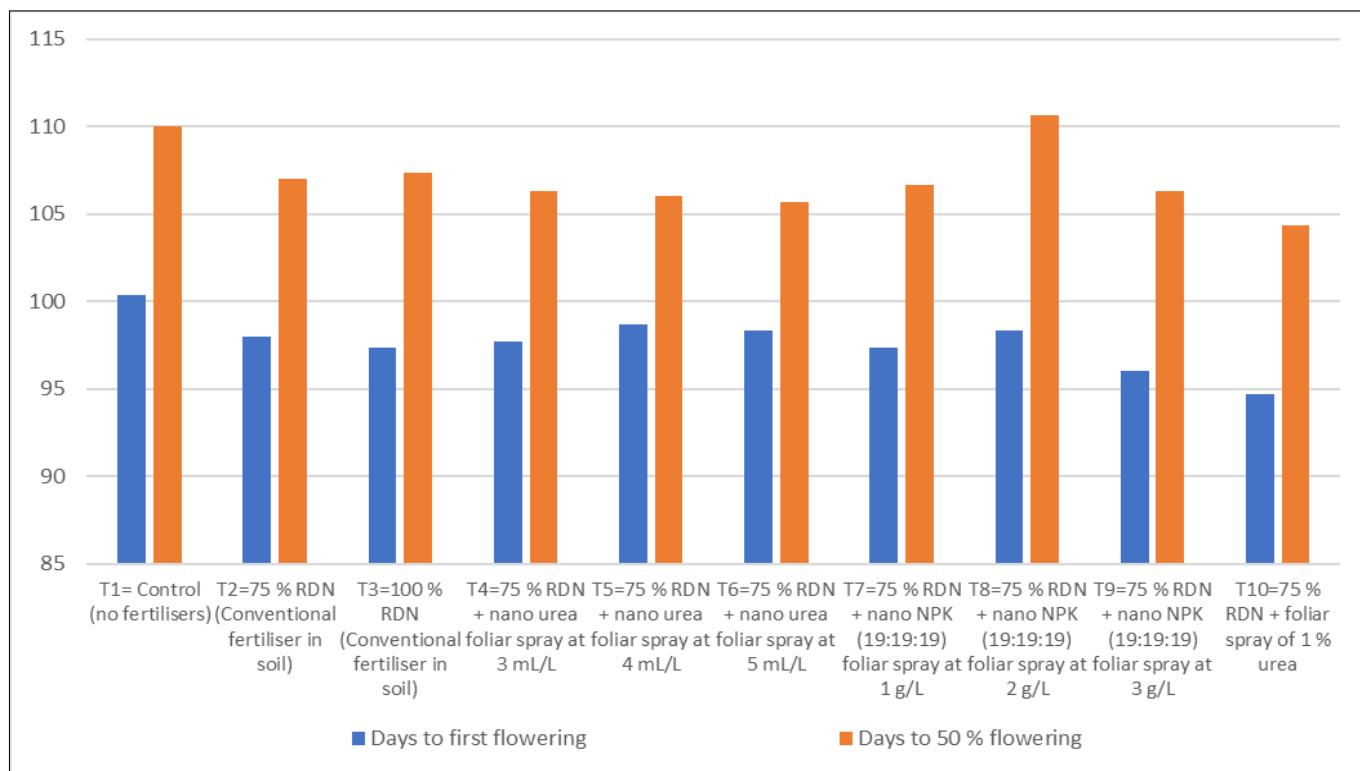


Fig. 3. Effect of nano fertilisers on flowering of brinjal (rabi 2023–2024).

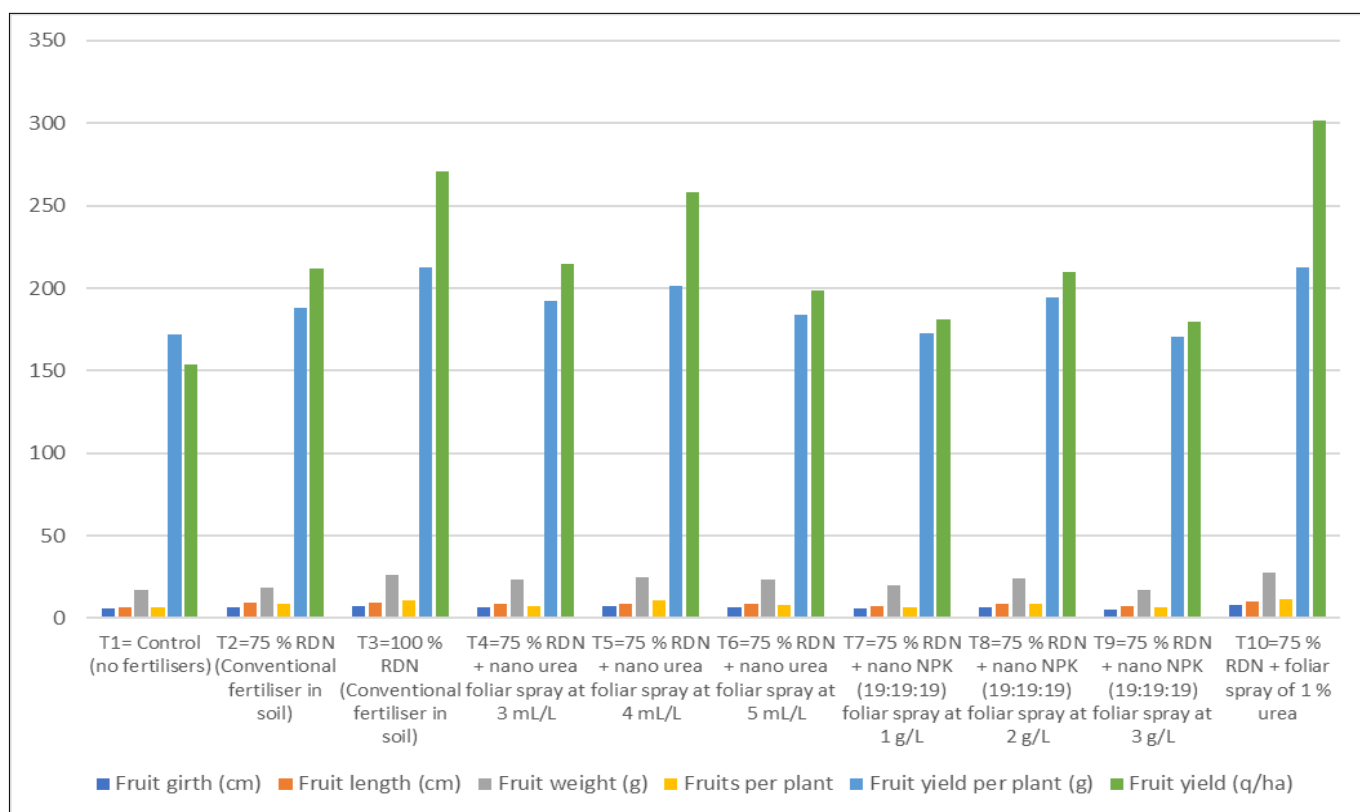


Fig. 4. Effect of nano fertiliser on fruit yield and yield attributes of brinjal (rabi 2023–2024). reported (4, 6–8, 10, 11) (Fig. 4).

Quality analysis of fruit

Glucose concentration (%)

As per the data provided in Table 5, the highest glucose concentration was recorded in T7 (7.38 %), significantly better than T1, T3, T4, T5, T9 and T10 and on par with T2, T6 and T8. The lowest concentration (4.31 %) was in T1.

Refractive index ($^{\circ}$ Brix)

In Table 5 show the highest refractive index (1.34 $^{\circ}$ Brix) was recorded in T2, T3, T7, T8 and T10, significantly better than T1 and on par with the rest. T1 had the lowest value (1.32 $^{\circ}$ Brix).

Total phenol (mg GAE/g)

As reported in Table 5, the highest total phenol content was found in T5 (1.75 mg GAE/g), significantly better than all other treatments except T4, which was at par. The lowest (0.93 mg GAE/g) was recorded in T1. Similar findings were previously reported (4).

Table 5. Effect of nano fertilisers on fruit quality parameters of brinjal (rabi 2023–2024)

Treatment details	Glucose conc. (%)	Refractive index (brix°)	Total phenol (mg GAE/g)
T ₁ = Control (no fertilisers)	4.31	1.32	0.93
T ₂ =75 % RDN (Conventional fertiliser in soil)	7.30	1.34	1.11
T ₃ =100 % RDN (Conventional fertiliser in soil)	5.76	1.34	0.99
T ₄ =75 % RDN + nano urea foliar spray at 3 mL/L	4.81	1.33	1.55
T ₅ =75 % RDN + nano urea foliar spray at 4 mL/L	5.99	1.33	1.75
T ₆ =75 % RDN + nano urea foliar spray at 5 mL/L	6.68	1.33	1.62
T ₇ =75 % RDN + nano NPK (19:19:19) foliar spray at 1 g/L	7.38	1.34	1.21
T ₈ =75 % RDN + nano NPK (19:19:19) foliar spray at 2 g/L	6.91	1.34	1.31
T ₉ =75 % RDN + nano NPK (19:19:19) foliar spray at 3 g/L	6.55	1.33	1.20
T ₁₀ =75 % RDN + foliar spray of 1 % urea	5.66	1.34	1.09
SE(m)±	0.25	0.00	0.04
CD (0.05)	0.73	0.01	0.11

Note: RDN- recommended dose of nitrogen; NPK- nitrogen, phosphorous and potassium; 100 % phosphorous and potassium was applied in all the treatments.

Conclusion

The treatment T₁₀ (75 % RDN + foliar spray of 1 % urea) produced the highest yield (301.83 q/ha) which was at par with T₅ (75 % RDN + nano urea foliar spray at 4 mL/L) and T₃ (100 % RDN as conventional fertiliser in soil). The research on eggplant on acknowledged that conventional fertiliser is required more amount in soil for better growth and development, but the nano-nitrogen fertiliser foliar spray reduces the application of conventional fertiliser which is helpful to make good soil health.

Acknowledgements

The authors express their sincere gratitude to the Dean, Faculty of Agricultural Sciences (IAS), SOADU, Bhubaneswar and faculty members of Department of Vegetable Science for providing essential facilities, guidance and continuous support throughout the research work. The co-operation of the laboratory and field staff is gratefully acknowledged for their timely assistance during experimentation. Finally, the authors appreciate all individuals who contributed, directly or indirectly, to the successful completion of this study.

Authors' contributions

All authors contributed significantly to the research work and preparation of the manuscript. The planning and experimental design of the study were done by ND and AN. Data collection, conducting field and laboratory work, data analysis, Interpretation of results and initial manuscript drafting was done by ND and AN. Literature review, and manuscript editing was done by AS. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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