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EFFECT OF NANO UREA ON GROWTH, YIELD AND QUALITY OF TOMATO (*Solanum lycopersicum* L.)

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ABSTRACT

A field experiment was conducted during the *Rabi* season of 2025–26 at the research farm of the Department of Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar, to evaluate the effect of nano urea on the growth, yield and quality of tomato (*Solanum lycopersicum* L.). The trial was laid out in a Randomized Complete Block Design with three replications and ten treatments comprising three levels of the recommended dose of nitrogen (100, 75 and 50% RDN), each combined with zero, one or two foliar sprays of nano urea at 30 and 50 days after transplanting (DAT), together with an absolute no-nitrogen treatment. Application of 100% RDN with two foliar sprays of nano urea (T3) produced the tallest plants (88.1 cm), the highest number of branches (7.9 plant^{-1}), the maximum fruits per plant (32.6), the largest fruit size, the highest fruit yield (337.2 q ha^{-1}) and the highest total soluble sugar content (5.39%), and was significantly superior to all other treatments, while the lowest values were recorded under the no-nitrogen treatment (T10). Ascorbic acid content followed a different trend, being highest under 75% RDN with water spray (T4, 15.18 mg 100 g^{-1}), suggesting that excessive nitrogen nutrition may lower vitamin C accumulation in tomato fruit. Correlation analysis showed a strong positive association of fruit yield with plant height, branching, fruit dimensions, fruit weight and number of fruits per plant. Economic analysis revealed the highest net return (Rs2,07,870 ha^{-1}) and benefit:cost ratio (2.61) under T3, followed by T2 (100% RDN + one spray) and T6 (75% RDN + two sprays); since T6 performed statistically at par with T2 while saving 25% of the conventional nitrogen dose, it offers a sound economical alternative. It is concluded that 100% RDN supplemented with two foliar sprays of nano urea at 30 and 50 DAT is the most effective practice for realizing superior growth, yield and quality in tomato, while reduced nitrogen levels combined with nano urea sprays present a viable option for conserving conventional fertilizer without significant yield loss.

***Key words*:** Tomato; Nano urea; RDN; Growth; Yield

Introduction

Tomato (*Solanum lycopersicum* L.) is an annual vegetable crop grown across a wide range of agro-climatic conditions worldwide and is one of the most important members of the family Solanaceae (Atherton and Harris, 1986). It is often regarded as a “protective

food" because of its nutritional and antioxidant properties, which are largely attributed to lycopene and flavonoids (Clinton, 2005). Tomato ranks as the world's third most widely grown vegetable after potato and sweet potato, with an estimated annual production of 192.32 million tonnes from 5.41 million hectares. Uttar Pradesh, Karnataka and Himachal Pradesh are among the leading tomato-producing states in India, where the crop is cultivated on about 0.84 million hectares with an annual production of 20.43 million tonnes and an average productivity of nearly 24.3 t ha^{-1} (FAOSTAT, 2023). In Odisha, tomato cultivation during 2023–24 covered approximately 0.098 million hectares and produced about 1.49 million tonnes, with an average productivity of nearly 15.2 t ha^{-1}, making it one of the important tomato-growing states of the country (Horticultural Statistics, 2024).

Crops require adequate amounts of macronutrients, particularly nitrogen (N), phosphorus (P) and potassium (K), for optimum growth and yield. Excessive or inefficient use of conventional fertilizers, however, can cause nutrient imbalance and substantial losses through leaching, volatilization, run-off and soil fixation, thereby lowering nutrient-use efficiency and increasing environmental risk. Foliar application offers an alternative route of nutrient supply by delivering nutrients directly to the leaves and can improve both the efficiency and speed of nutrient uptake.

With increasing population pressure and shrinking natural resources, sustainable nutrient-management strategies have become essential. Nanofertilizers have emerged as a promising option because their high specific surface area and controlled-release behaviour can enable targeted nutrient delivery, minimize nutrient losses and improve nutrient-use efficiency (Banik and Luque, 2017; Solanki *et al.*, 2015; Madzokere *et al.*, 2021). Because foliar application of nanofertilizers requires only small quantities and provides faster, more targeted nutrient delivery than conventional soil application, it is increasingly viewed as a component of sustainable crop production.

Nanoparticles possess a high surface-area-to-volume ratio that facilitates rapid interaction with plant tissue, thereby improving nutrient absorption and use efficiency, and their application in small quantities may reduce the nutrient losses typical of conventional fertilizers (Solanki *et al.*, 2015). Nano urea is a liquid nitrogen fertilizer formulated to improve nitrogen-use efficiency through foliar application; IFFCO nano urea contains 40,000 ppm nitrogen and is promoted as a supplement to conventional urea, offering improved nutrient absorption with reduced losses (IFFCO, 2022). Foliar application at critical crop growth stages may enhance plant growth, yield and quality while lowering dependence on conventional nitrogen fertilizers. The present study, entitled "Effect of Nano Urea on Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.)", was therefore undertaken to assess the effect of graded nitrogen levels and foliar nano urea sprays on the growth and yield attributes, fruit quality and cost of cultivation of tomato.

Materials and Methods

Experimental site and season

The experiment was carried out during the *Rabi* season of 2025–26 at the research farm of the Department of Vegetable Science, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha. Tomato seedlings (cv. Utkal Deepti) were transplanted on 2nd December 2025 at a spacing of 60 cm × 45 cm, with a gross plot size of 2.7 m × 3.0 m (8.1 m^2).

Soil properties of the experimental site

The soil of the experimental site was analysed before transplanting for its chemical properties, the results of which are presented in Table 1. The soil was acidic in reaction (pH 4.46) with an electrical conductivity of 0.04 dS m^{-1} and an organic carbon content of 0.7 g kg^{-1}, and contained 250, 28.1 and 319.0 kg ha^{-1} of available nitrogen, phosphorus and potassium, respectively. Soil pH and electrical conductivity were determined in a 1:2.5 soil-water suspension using a glass electrode pH meter and a conductivity meter, respectively, and organic carbon was estimated by the modified Walkley and Black method (Jackson, 1973). Available nitrogen was estimated by the alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by the Bray-1 method (Bray and Kurtz, 1945), and available potassium by

Table 1: Chemical properties of the experimental field at the initial stage.

Properties	Result	Method adopted
Soil reaction (pH)	4.46	1:2.5 (soil:water) suspension using glass electrode pH meter (Jackson, 1973)
Electrical conductivity (dS/m)	0.04	Conductivity meter (Jackson, 1973)
Organic carbon (g/kg)	0.7	Modified Walkley and Black method (Jackson, 1973)
Available nitrogen (kg/ha)	250	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg/ha)	28.1	Bray-1 method (Bray and Kurtz, 1945)
Available potassium (kg/ha)	319.0	Neutral normal ammonium acetate extractable K (Jackson, 1973)

Table 2: Details of treatments.

Treatment	Treatment details
T1	100% RDN + water spray (control)
T2	100% RDN + one spray of nano urea at 30 DAT
T3	100% RDN + two sprays of nano urea at 30 and 50 DAT
T4	75% RDN + water spray
T5	75% RDN + one spray of nano urea at 30 DAT
T6	75% RDN + two sprays of nano urea at 30 and 50 DAT
T7	50% RDN + water spray
T8	50% RDN + one spray of nano urea at 30 DAT
T9	50% RDN + two sprays of nano urea at 30 and 50 DAT
T10	No nitrogen

extraction with neutral normal ammonium acetate followed by flame photometry (Jackson, 1973).

Experimental design and treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten treatments replicated thrice. The treatments comprised three levels of the recommended dose of nitrogen (RDN) – 100, 75 and 50% – each combined with zero, one or two foliar sprays of nano urea at 30 and 50 days after transplanting (DAT), along with an absolute no-nitrogen treatment (Table 2). The recommended dose of nitrogen, phosphorus and potassium adopted for the crop was 125:60:70 kg N-P_2O_5 -K_2O ha^{-1}, applied through urea, single super phosphate and muriate of potash, respectively; the full doses of phosphorus and potassium and the basal dose of nitrogen were applied uniformly to all plots at the time of transplanting, and the remaining nitrogen was top-dressed in accordance with the treatments.

Nano urea and its application

IFFCO liquid nano urea (4% N, w/v) was used as the source of foliar nitrogen. It was diluted at the rate of 4 mL L^{-1} of water and sprayed uniformly on the crop foliage during the morning hours as per the treatment schedule, i.e., a single spray at 30 DAT (T2, T5, T8) or two sprays at 30 and 50 DAT (T3, T6, T9), while the corresponding water-spray treatments (T1, T4, T7) received a plain water spray in place of nano urea. Treatment T10 received no basal or foliar nitrogen throughout the crop period.

Observations recorded

Plant height (cm) was measured from the base of the plant to the tip of the main shoot, and the number of primary branches per plant was counted on five randomly tagged and labelled plants per plot at 40, 60 and 80 DAT. Days to flower initiation, days to 50% flowering and days to first picking were recorded on a whole-plot basis by regular field observation. At harvest, the equatorial and polar diameters of ten randomly selected fruits were measured with a digital vernier caliper, and their combined weight was recorded on an electronic balance. The number of fruits per plant, the fruit yield per plot and the fruit yield per hectare were recorded from the net harvestable area of each plot.

Table 3: Effect of nano urea on the vegetative growth parameters of tomato.

Treatments	Plant height (cm)			No. of branches		
	40 DAT	60 DAT	80 DAT	40 DAT	60 DAT	80 DAT
T1	37.0	56.2	74.2	2.2	4.1	6.5
T2	42.8	63.4	83.1	2.5	4.8	7.2
T3	42.3	72.1	88.1	2.6	5.5	7.9
T4	32.9	50.0	72.8	1.9	3.8	5.7
T5	39.2	54.3	78.1	2.3	4.1	6.1
T6	40.3	61.5	80.1	2.2	4.6	7.0
T7	28.1	42.1	53.1	1.6	3.2	4.7
T8	30.5	44.8	57.9	1.8	3.4	4.8
T9	29.8	51.1	62.8	1.7	3.7	5.5
T10	25.1	38.4	44.1	1.3	2.6	3.8
SEm(±)	0.74	2.12	1.64	0.08	0.19	0.23
CD (5%)	2.2	6.3	4.9	0.2	0.6	0.6
CV (%)	7.9	6.9	5.7	6.6	8.0	6.7

Fruit quality was assessed on composite fruit samples drawn at the peak harvest stage. Total soluble sugar (expressed as total soluble solids, °Brix, reported here as per cent) was estimated using a hand refractometer as described by Ranganna (1986), and ascorbic acid content (mg 100 g^{-1}) was determined by the 2,6-dichlorophenol indophenol visual titration method (Sadasivam and Manickam, 2005).

Economics of cultivation

The cost of cultivation for each treatment was worked out based on the prevailing costs of inputs (land preparation, seedlings, fertilizers, nano urea, plant protection chemicals, irrigation and labour) and the cost of nano urea application. Gross return was computed using the prevailing market price of tomato, net return was obtained by subtracting the cost of cultivation from the gross return, and the benefit:cost (B:C) ratio was calculated as the ratio of gross return to the cost of cultivation.

Statistical analysis

The data recorded for various characters were statistically analysed by the analysis of variance (ANOVA) technique applicable to RCBD, and the treatment means were compared using the critical difference (CD) at the 5% level of probability (Gomez and Gomez, 1984). Simple correlation coefficients were

Table 4: Effect of nano urea on the phenology of tomato.

Treatments	DFI	DF	DFP
T1	28.3	36.6	67.6
T2	30.0	37.6	71.3
T3	31.3	38.3	72.3
T4	27.6	35.3	67.6
T5	28.3	35.0	68.0
T6	29.6	37.0	69.6
T7	25.6	33.3	65.3
T8	26.0	34.0	65.0
T9	25.3	34.6	66.3
T10	23.1	31.3	62.5
SEm(±)	0.94	1.04	1.21
CD (5%)	2.8	3.1	3.6
CV (%)	5.6	5.9	6.6

DFI: Days to flower initiation (DAT); DF: Days to 50% flowering (DAT); DFP: Days to first picking (DAT)

also worked out among the growth, yield-attributing and yield characters of tomato to examine their mutual association.

Results and Discussion

Vegetative growth parameters

Significant variation was observed among treatments for plant height and number of branches at 40, 60 and 80 DAT (Table 3). Plant height was maximum under T3 (100% RDN + two sprays of nano urea) at 60 DAT (72.1 cm) and 80 DAT (88.1 cm), while at 40 DAT the tallest plants were recorded under T2 (100% RDN + one spray of nano urea, 42.8 cm), statistically at par with T3 (42.3 cm). The shortest plants were recorded under T10 (no nitrogen) at all three stages (25.1, 38.4 and 44.1 cm at 40, 60 and 80 DAT, respectively). This response may be attributed to the penetration of nano urea particles through leaf stomata and their slow, sustained release of nitrogen during the active growth phase, which favours cell division and elongation (Subramani *et al.*, 2023). Comparable improvement in plant height with nano urea was reported in tomato by Kumar *et al.*, (2025), Helal *et al.*, (2023) and Mishra *et al.*, (2020), while Dey *et al.*, (2025) recorded about 51% higher biomass under foliar nano urea over an equimolar dose of bulk urea in A *Rabi* dopsis.

A similar trend was noted for branching: T3 produced the highest number of branches at 40, 60 and 80 DAT (2.6, 5.5 and 7.9 branches plant^{-1}, respectively), followed by T2 (2.5, 4.8 and 7.2 branches plant^{-1}), while the minimum branching occurred under T10 (1.3, 2.6 and 3.8 branches plant^{-1}). Overall, 100% RDN combined with two foliar sprays of nano urea (T3) markedly promoted vegetative growth and branching compared with the

Table 5: Effect of nano urea on fruit equatorial diameter, polar diameter and average fruit weight of tomato.

Treatments	ED	PD	AWF
T1	5.1	4.3	44.7
T2	5.5	4.6	54.1
T3	6.0	5.1	59.3
T4	4.9	3.9	41.0
T5	4.9	4.1	46.1
T6	5.3	4.5	52.5
T7	4.1	3.5	35.7
T8	4.4	3.8	37.5
T9	4.6	3.8	40.2
T10	3.9	3.4	31.8
SEm(±)	0.10	0.13	1.99
CD (5%)	0.3	0.4	5.9
CV (%)	5.6	5.2	6.8

ED: Equatorial diameter (cm); PD: Polar diameter (cm); AWF: Average weight of 10 fruits (g)

reduced or no-nitrogen treatments, most likely because the additional nitrogen supplied through nano urea stimulated lateral bud activity and supported vigorous vegetative growth. A similar improvement in branching under nano urea has been reported in tomato by Mishra *et al.*, (2020) and Kumar *et al.*, (2025), as well as in other vegetable crops such as radish (Bharathi and Kamalakannan, 2024), garlic (Choudhary *et al.*, 2023) and okra (Al-Kaby *et al.*, 2021), while Dey *et al.*, (2025) linked the foliar nano urea response to up-regulation of growth- and hormone-related genes.

Phenological parameters

Significant differences were observed among treatments for days to flower initiation, days to 50% flowering and days to first picking (Table 4). T3 (100% RDN + two sprays of nano urea) recorded the latest flower initiation (31.3 days) and 50% flowering (38.3 days), statistically at par with T2 (30.0 and 37.6 days) and T6 (29.6 and 37.0 days), whereas T10 (no nitrogen) recorded the earliest flower initiation (23.1 days) and 50% flowering (31.3 days). A similar pattern was observed for days to first picking, with T3 recording the latest first picking (72.3 days), at par with T2 (71.3 days) and T6 (69.6 days), while T10 recorded the earliest picking (62.5 days). Adequate nitrogen nutrition supplemented with nano urea sprays thus prolonged the vegetative phase and delayed flowering relative to the nitrogen-deficient plants, which appeared to flower early as a stress-escape response rather than from any physiological advantage. This delay was agronomically beneficial because the extended vegetative phase allowed the plants to build a larger canopy and more branches, which subsequently supported a heavier fruit load. A similar influence of nano

Table 6: Effect of nano urea on yield and yield attributes of tomato.

Treatments	No. of fruits per plant	Per plot yield (kg)	Fruit yield (q/ha)	Increase in yield over T10 (%)
T1: 100% RDN + water spray	27.9	21.8	269.5	83.7
T2: 100% RDN + 1 spray nano urea	30.5	24.6	304.2	107.4
T3: 100% RDN + 2 sprays nano urea	32.6	27.3	337.2	129.9
T4: 75% RDN + water spray	25.5	18.1	223.6	52.4
T5: 75% RDN + 1 spray nano urea	27.3	21.1	260.4	77.5
T6: 75% RDN + 2 sprays nano urea	30.0	23.9	295.2	101.2
T7: 50% RDN + water spray	23.1	14.0	173.2	18.1
T8: 50% RDN + 1 spray nano urea	24.3	14.7	181.8	23.9
T9: 50% RDN + 2 sprays nano urea	25.2	17.1	211.4	44.1
T10: No nitrogen	20.3	11.9	146.7	–
SEm (±)	0.65	0.51	5.89	
CD (5%)	1.9	1.5	17.5	
CV (%)	7.6	8.1	7.4	

fertilizer on flowering behaviour in tomato was reported by Panda *et al*., (2020) and Kumar *et al*., (2025).

Fruit size and weight

Significant variation was observed among treatments for fruit equatorial diameter, polar diameter and average fruit weight (Table 5). T3 recorded the maximum equatorial diameter (6.0 cm), polar diameter (5.1 cm) and fruit weight (59.3 g per 10 fruits), significantly superior to the remaining treatments, followed by T2 and T6 with equatorial diameters of 5.5 and 5.3 cm, polar diameters of 4.6 and 4.5 cm, and fruit weights of 54.1 and 52.5 g per 10 fruits, respectively. The minimum equatorial diameter (3.9 cm), polar diameter (3.4 cm) and fruit weight (31.8 g per 10 fruits) were recorded under T10. These results indicate that combining 100% RDN with two nano urea sprays improved fruit size and weight, most likely through enhanced nutrient availability and assimilate accumulation during fruit development. A comparable enlargement of fruit size and weight under foliar nano fertilizer sprays in tomato was reported by Sivakumar (2024), Helal *et al*., (2023) and Kumar *et al*., (2025).

Yield and yield attributes

Significant variation was observed among treatments for the number of fruits per plant, per-plot yield and fruit yield (Table 6). The maximum number of fruits per plant (32.6) was recorded under T3, significantly superior to all other treatments, followed by T2 (30.5) and T6 (30.0), which were statistically at par; the minimum (20.3 fruits plant^{-1}) was recorded under T10. The comparable performance of T6 with T2 indicates that two nano urea sprays could partially compensate for a 25% reduction in soil-applied nitrogen.

Fruit yield followed a similar trend (Table 6), ranging from 146.7 to 337.2 q ha^{-1} across treatments, with T3 recording the maximum yield (337.2 q ha^{-1}), representing about a 130% increase over T10, and significantly outperforming all other treatments. T2 produced 304.2 q ha^{-1} and remained statistically at par with T6 (295.2 q ha^{-1}). Combined soil and foliar nitrogen application thus markedly improved tomato productivity, and the comparable yield of T6 and T2 indicated the potential of two nano urea sprays to reduce the conventional nitrogen requirement by 25% without a significant yield penalty. These findings corroborate Panda *et al*., (2020), Mishra *et al*., (2020) and Helal *et al*., (2023), who reported substantial yield gains under nano-fertilizer regimes in tomato, and Sivakumar (2024), who recorded enhanced tomato productivity with two foliar nano-fertilizer sprays at 75% of the recommended dose. A comparable yield advantage of nano urea has also been reported across other crops, including onion (Dubey *et al*., 2023), chickpea (Khandare *et al*., 2024), wheat (Sisodiya *et al*., 2024) and rice (Sahu *et al*., 2022), while at the systems level Kumar *et al*., (2024) showed that partial substitution of conventional urea with nano nitrogen sustained or improved yield while reducing energy input in a rice–wheat cropping system.

Fruit quality traits

Quality attributes, namely total soluble sugar and ascorbic acid content, differed significantly among treatments (Table 7). Maximum sugar accumulation (5.39%) was recorded under T3, well above all other treatments; T2 (5.01%) followed and was statistically at par with T6 (4.96%). The lowest sugar content (3.12%) was recorded under T10. This trend agrees with Kumar *et al*., (2025), who recorded the highest total soluble solids in tomato under the same 100% RDN plus two nano urea spray combination, and with Sivakumar (2024), who obtained the highest TSS under two foliar sprays of nano fertilizer at 75% of the recommended dose. Helal *et al*.,

Table 7: Effect of nano urea on the fruit quality traits of tomato.

Treatments	Total soluble sugar (%)	Ascorbic acid (mg/100g)
T1	4.43	14.65
T2	5.01	14.05
T3	5.39	13.87
T4	4.11	15.18
T5	4.66	14.52
T6	4.96	14.17
T7	3.55	12.18
T8	4.18	12.03
T9	4.20	11.59
T10	3.12	11.32
SEm (±)	0.112	0.397
CD (5%)	0.33	1.18
CV (%)	4.81	4.51

(2023) similarly reported that all controlled-release nano urea treatments raised tomato TSS above the control, and a comparable increase attributed to enhanced carbohydrate synthesis under improved nitrogen nutrition has also been reported in potato (Chauhan *et al.*, 2023) and onion (Lakshmikantha *et al.*, 2023).

For ascorbic acid, the trend departed from that of sugar content: T4 (75% RDN + water spray) recorded the highest value (15.18 mg 100 g^{-1}), remaining within the same statistical band as T1 (14.65), T5 (14.52), T6 (14.17) and T2 (14.05), whereas T3 – despite its highest sugar content – recorded a comparatively lower ascorbic acid content (13.87 mg 100 g^{-1}). The lowest ascorbic acid content (11.32 mg 100 g^{-1}) was again recorded under T10. This divergence between the two quality traits suggests that while sugar accumulation responded positively to higher nitrogen and additional nano urea sprays, ascorbic acid accumulation favoured a moderate nitrogen regime, indicating that excessive nitrogen may dilute vitamin C content in tomato fruit. This finding is consistent with Helal *et al.*, (2023), who reported lower vitamin C under all controlled-release nano urea treatments relative to the control and attributed it to nitrogen-induced oxidative changes, and with Al-Juthery and Al-Maamouri (2020), who observed that the ascorbic acid response depends on the source and form of applied nitrogen; Chauhan *et al.*, (2023) and Kanavi *et al.*, (2023) have likewise documented a strong influence of nitrogen regime on ascorbic acid and related quality traits in potato and chilli, respectively.

Economics of cultivation

The cost of cultivation and returns are presented in Table 8. The cost of cultivation was highest under T3 (Rs 1,29,297 ha^{-1}) because of the added expense of nano urea and its application, while T10 incurred the lowest cost (Rs 1,25,125 ha^{-1}). Despite the higher investment, T3 also produced the highest gross return (Rs 3,37,167 ha^{-1}), net return (Rs 2,07,870 ha^{-1}) and B:C ratio (2.61). T2 occupied the next position, with a net return of Rs 1,76,173 ha^{-1} and a B:C ratio of 2.38, closely followed by T6 with a net return of Rs 1,66,344 ha^{-1} and a B:C ratio of 2.29. The poorest economic performance, with a net return of only Rs 21,308 ha^{-1} and a B:C ratio of 1.17, was recorded under T10.

Table 8: Economics of nano urea application in tomato cultivation.

Treatments	CC	GI	NI	BC
T1	127307	269533	142226	2.12
T2	128027	304200	176173	2.38
T3	129297	337167	207870	2.61
T4	126899	223633	96734	1.76
T5	127619	260367	132748	2.04
T6	128889	295233	166344	2.29
T7	126491	173167	46676	1.37
T8	127211	181800	54589	1.43
T9	128481	211367	82846	1.64
T10	125125	146700	21575	1.17

CC: Cost of cultivation (Rs/ha); GI: Gross income (Rs/ha); NI: Net income (Rs/ha); BC: B:C ratio

The economic analysis clearly shows that the additional expenditure on nano urea sprays is comfortably recovered through higher marketable yield, making T3 the most profitable treatment. T6 emerges as a sound alternative when conventional nitrogen supply is limited, returning healthy profits while saving a quarter of the recommended nitrogen dose. These results are in agreement with Mishra *et al.*, (2020) and Panda *et al.*, (2020), who reported the highest benefit:cost ratios in

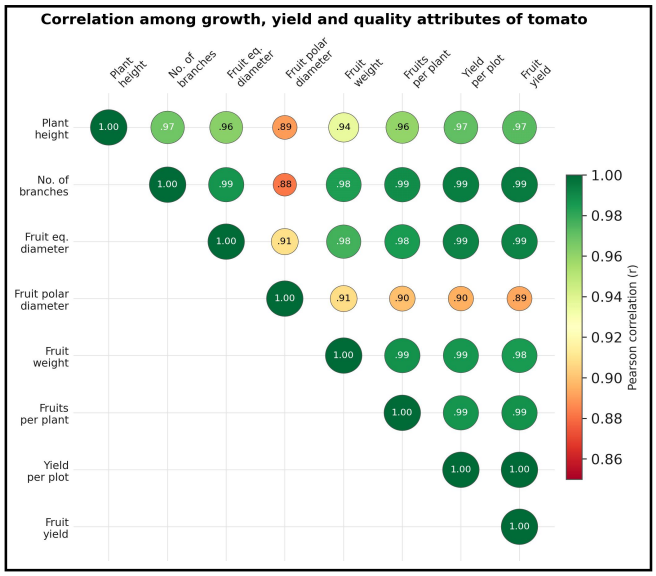


Fig. 1: Correlation among growth, yield and quality attributes of tomato.

tomato under nano-fertilizer-based nutrient schedules, and with Kumar *et al*., (2025), who obtained the maximum benefit:cost ratio under the identical 100% RDN plus two nano urea spray combination. A similarly favourable economics of nano urea use has been reported in paddy under the agro-climatic conditions of Odisha (Behera *et al*., 2025), while Kumar *et al*., (2024) demonstrated that nano nitrogen lowered energy use and improved energy-use efficiency relative to full-dose conventional urea in a rice–wheat system.

Correlation among growth, yield and quality attributes

Simple correlation analysis (Fig. 1) revealed strong positive associations among plant height, number of branches, fruit equatorial diameter, fruit weight, number of fruits per plant, per-plot yield and fruit yield (r = 0.94–1.00), indicating that treatments promoting vigorous vegetative growth also translated directly into higher fruit numbers and yield. Fruit polar diameter, although positively correlated with all other traits, showed comparatively weaker association (r = 0.88–0.91), suggesting that fruit elongation was less responsive to the nitrogen and nano urea treatments than fruit girth, weight and overall yield. As expected, per-plot yield and fruit yield were almost perfectly correlated (r ≈ 1.00), since the latter is a direct area-based expression of the former.

Conclusion

On the basis of the present investigation, it may be concluded that application of 100% RDN together with two foliar sprays of nano urea at 30 and 50 DAT (T3) is the most effective treatment for achieving superior vegetative growth, the highest fruit yield, better fruit quality in terms of sugar content, and the maximum economic returns in tomato. Where a reduction in conventional nitrogen use is desired, 75% RDN supplemented with two foliar sprays of nano urea (T6) offers a sound and economical alternative, performing at par with the higher-nitrogen treatments while saving 25% of the conventional urea requirement. As these findings are based on a single season of experimentation at one location, confirmation across locations and seasons is suggested before a general recommendation is formulated.

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