E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(8): 667-670
Received: 05-06-2025
Accepted: 07-07-2025

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Effect of nano urea on growth, yield and quality of Tomato (*Solanum lycopersicum* L.) cv. Azad T-6

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i8j.3617

Abstract
The field experiment was conducted during the *rabi* season 2024-25 at Department of Vegetable Science Kalyanpur of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.). Nine different treatments *viz.*,100% RDN + foliar spray with water (control) (T_1), 100% RDN + one spray of nano urea @ 4 ml/litre at 30 DAT (T_2), 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), 75% RDN + foliar spray with water (T_4), 75% RDN + one spray of nano urea @ 4 ml/litre at 30 DAT (T_5), 75% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_6), 50% RDN + foliar spray with water (T_7), 50% RDN + one spray of nano urea @ 4 ml/litre at 30 DAT (T_8) and 50% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_9) were tested against no nitrogen (T_{10}) in a RBD replicated thrice. The tomato variety Azad T-6 was used in experiment. The results of the experiment revealed that application of 100% RDN + two foliar sprays of nano urea @ 4 ml /lit at 30 and 50 DAT (T_3) recorded significantly highest plant height (35.96 and 43.23 cm at 60 and 90 DAT, respectively), number of branches (9.01),fruit equatorial diameter (5.59 cm), fruit polar diameter (5.14 cm), average fruits weight (59.89 gm 4th picking), number of fruits per plant (35.51), yield per plant (1.90 kg), yield per plot (56.84 kg), yield (438.66 q/ha), TSS (5.34 °Brix) and ascorbic acid (16.82 mg/100g). Based on the results, it can be concluded that application of 100% RDN + two foliar sprays of nano urea @ 4 ml /lit at 30 and 50 DAT (T_3) markedly enhanced the yield and fruit quality. Hence, this may be recommended for commercial cultivation of Tomato cv. Azad T-6 under Kanpur conditions to maximize productivity.

Keywords: Foliar application, nano urea, nitrogen and tomato.

Introduction
Tomato (*Solanum lycopersicum* L.) a member of the family Solanaceae, is one of the most important and widely cultivated vegetable crops in the world, ranking second after potato in terms of global importance. It is a dicotyledonous, herbaceous, self-pollinating and warm-season crop with a diploid chromosome number of 2n = 24. It is grown on every continent and global production reached approximately 192 million tonnes in 2023, with China (68.2 Mt) and India (21.32 Mt), Turkey (13.0 Mt), the United States (6.3 Mt) and Italy (4.2 Mt) leading the way. In India specifically, output rose from 20.43 million tonnes in 2022-23 to 21.32 million tonnes in 2023-24. (PIB, 2024). Tomatoes hold significant economic and nutritional importance. They are consumed in multiple forms-raw in salads, cooked in various dishes, or processed into value-added products such as sauces, ketchup, purees, juices, syrups, pastes and powdered. Nutritionally, tomatoes are often called "protective foods" due to their high content of essential minerals and vitamins. Uddain *et al.*, (2009) [15], 100 grams of edible tomato fruit contains about 93.1 gm water, 34 mg of calcium, 7.0 mg of magnesium, and other essential nutrients such as copper, iron, and vitamins like A (1000 IU) and B-complex. Pavani *et al.*, (2020) [11]. It is a rich source of (36.16 mg) vitamin C and malic acid. Their high lycopene content, approximately 12 mg per 100 g of fruit (Alda *et al.*, 2009) [1].

Nitrogen is an essential macronutrient that forms the backbone of many vital biological molecules such as amino acids, nucleotides, enzymes, hormones, and chlorophyll. It is integral for vegetative growth, photosynthesis and overall plant development. While nitrogen deficiency leads to stunted growth and pale leaves, an overdose results in excessive vegetative growth at the expense of reproductive development, delays fruit maturity, reduces dry matter accumulation and adversely affects flavour and cooking quality (Singh *et al.*, 2016) [14].

With the increasing need for sustainable agricultural practices and efficient nutrient management, conventional fertilizer use is being re-evaluated. Traditional nitrogen fertilizers, while effective, often suffer from issues like leaching, volatilization, and low nutrient use efficiency (NUE), leading to economic and environmental concerns. In this context of nano-fertilizers have emerged as a revolutionary innovation in agricultural science. These are engineered nutrient carriers developed using nanotechnology and are characterized by their ultra-small particle size (1-100 nm) increased surface area, enhanced reactivity and high absorption capacity. Foliar application of nano-fertilizers has shown promising results in improving crop nutritional value, yield and NUE (Kumar *et al.*, 2021) [6].

Nano urea is one such innovation that has attracted significant attention. It contains nitrogen in nanoscale form usually with particle sizes between 20-50 nm and is uniformly dispersed in water. A 500 ml bottle of nano urea typically contains 4% nitrogen or about 40,000 ppm, which is equivalent to the nitrogen content in one bag (45 kg) of conventional urea. The small-sized particles easily penetrate the plant through stomata and cuticles during foliar application. Once absorbed, the nano-nitrogen is efficiently transported through the phloem from source (leaves) to sink (roots, fruits), ensuring that nitrogen reaches the plant parts where it is needed most (Vidyasree *et al.*, 2022) [16].

Material and Methods

The field experiment was conducted during the Rabi season 2024-25 at Department of Vegetable Science Kalyanpur of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh to evaluate the effects of nano urea on the growth traits, yield attributes, yield and quality of tomato. The experiment was laid out in a randomized block design (RBD) with three replications. Nine different treatments *viz.*,100% RDN + foliar spray with water (control) (T_1), 100% RDN + one spray of nano urea @ 4 ml/litre at 30 DAT (T_2), 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), 75% RDN + foliar spray with water (T_4), 75% RDN + one spray of nano urea @ 4 ml/litre at 30 DAT (T_5), 75% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_6), 50% RDN + foliar spray with water (T_7), 50% RDN + one spray of nano urea @ 4 ml/litre at 30 DAT (T_8) and 50% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_9) were tested against no nitrogen (T_{10}). Tomato variety 'Azad T-6' was used in the experiment. The soil of the experimental field was sandy loam with good fertility and a well-developed drainage system. The nursery was sown on 28 September, 2024 and seedlings were transplanted on 26 October, 2024 at a spacing of 60 cm × 60 cm. The Plot size was 3.60 × 3.60 m and each plot had 36 plants. Standard cultural practices were applied uniformly across all plots. In each plot, the five plants were selected randomly and tagged for the purposes of observations and recorded observations were analysed.

Result and Discussion

Plant height (cm) at 60 and 90 DAT

Height of the plant is represented by its growth and vigour. The maximum plant height at 60 DAT was recorded in (35.96 cm) 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) followed by T_2 (34.47 cm), whereas the minimum plant height was observed in T_{10} (26.85 cm) (Table 1). Similar trends were observed at 90 DAT maximum plant height was recorded in T_3 (43.23 cm) followed by T_2 (41.48 cm), whereas the minimum height was observed in T_{10} (35.81 cm). These results are in conformity with findings of Rostami Ajirloo *et al*., (2015) [13] and Rathod *et al*., (2022) [12].

Number of branches per plant

Increased number of branches per plant has been associated with higher flowering and fruiting potential. The maximum number of branches (9.01) per plant was obtained in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), followed by T_2 (8.29), while the minimum was noted in T_{10} (5.68) (Table 1). The increase in branches can be attributed to better nutrient availability (particularly nitrogen) which stimulates vegetative growth and branching. These findings are in agreement with those of Pandav *et al*., (2022) [10] and Babita Mishra *et al*., (2020) [20].

Days to flower initiation

Minimum days to flower initiation reflect vigorous growth and early reproductive development. The minimum days to flower initiation (30.13 days) were observed in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) followed by T_2 (31.79 days), whereas the maximum was recorded in T_{10} (38.19 days) (Table 1). Nano-urea application likely accelerated flower induction by enhancing the plant's metabolic and hormonal status through improved nutrition. These results are consistent with Malica *et al*., (2024) [7] and Panda *et al*., (2020) [4], who reported earlier flowering under nano-fertilizer regimes.

Days to 50% flowering

Minimum days to 50% flowering reflect vigorous growth and potential yield advantage from early flowering. The minimum days (39.86 days) to 50% flowering were recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) followed by T_2 (41.26 days), whereas the maximum was in T_{10} (46.62 days) (Table 1). The application of nano-urea likely hastened flowering by improving plant nutrient status, thereby inducing earlier bloom. These observations corroborate the findings of Malica *et al*., (2024) [7], who also noted earlier fruit set and flowering under nano-fertilizer application.

Days to first fruit picking

Early fruiting indicates better plant vigour and yield potential. The minimum of 54.06 days to first fruit picking were recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) followed by T_2 (55.76 days), while the maximum was in T_{10} (62.42 days) (Table 1). Nano-urea application likely promoted earlier fruit maturity by enhancing physiological processes such as photosynthesis and assimilate translocation. These findings agree with Malica *et al*., (2024) [7], who reported earlier fruit set and harvest in tomato under nano-fertilizer treatments.

Fruit equatorial diameter (cm)

Fruit diameter is indicative of good fruit growth. The maximum fruit equatorial diameter (5.59 cm) was recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) (Table 1) followed by T_2 (5.23 cm), whereas the minimum was observed in T_{10} (3.96 cm). The increased fruit diameter under nano-urea treatments may be due to enhanced cell expansion and assimilate accumulation driven by better nutrient supply. These results align with previous studies by Malica *et al*., (2024) [7] and Rostami Ajirloo *et al*., (2015) [13], who reported larger fruit dimensions with nano-fertilizer applications.

Fruit polar diameter (cm)

The maximum fruit polar diameter (5.14 cm) was recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) followed by T_2 (4.96 cm), whereas the minimum was in T_{10} (3.51 cm) (Table 1). The larger polar diameter in nano-urea-treated plants indicates better overall fruit development. These results corroborate the reports of Rostami Ajirloo *et al*., (2015) [13] and Malica *et al*., (2024) [7], who found increased fruit diameter and related yield attributes with nano-fertilizer use.

Average fruit weight

Weight of fruit is determined by accumulation of photo-assimilates and nutrient translocation. The maximum average fruit weight (59.89 g) at 4th picking in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) followed by T_2 (58.59 g) and the minimum in T_{10} (47.23 g) (Table 1). The higher fruit weight under nano-urea treatments may be due to improved assimilate synthesis and partitioning as a result of enhanced plant nutrition. These findings corroborate the reports of Babita Mishra *et al*., (2020) [20] and Malica *et al*., (2024) [7], who observed higher fruit weights with nano-fertilizer applications.

Number of fruits per plant

A higher number of fruits per plant indicates vigorous growth and better fruit set. The maximum number of fruits per plant (35.51) was obtained in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), followed by T_2 (33.37), while the minimum was in T_{10} (19.31) (Table 1). The increase in fruit number under nano-urea treatment may be due to enhanced flowering and fruit set resulting from improved nutritional status. These findings are supported by Babita Mishra *et al*., (2020) [20] who reported increased fruit number with nano-fertilizer treatments.

Fruit yield

Fruit yield per plant, per plot and per hectare were significantly influenced by the treatments. The maximum fruit yield per plant (1.90 kg), per plot (56.84 kg) and per hectare (438.66 q) were recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), followed by T_2 (1.81 kg/plant, 54.92 kg/plot, 423.76 q/ha). The minimum yield was obtained in T_{10} (1.07 kg/plant, 31.15 kg/plot, 240.35 q/ha) (Table 1). The higher yield under nano-urea treatments could be attributed to the combined increase in fruit number and fruit size. These results conform to the findings of Babita Mishra *et al*., (2020) [20] and Panda *et al*., (2020) [4].

Total soluble solids (°Brix)

The maximum TSS (5.38 °Brix) was recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), followed by T_2 (5.22 °Brix), whereas the minimum was in T_{10} (4.01 °Brix) (Table 1). The increased TSS under nano-urea treatments may be due to enhanced sugar accumulation from more efficient photosynthesis and improved fruit maturity. These findings are consistent with reports by Babita Mishra *et al*., (2020) [20] and Malica *et al*., (2024) [7].

Ascorbic acid content (mg/100g)

The ascorbic acid content of tomato fruits varied significantly with the nutrient treatments. In our study, the highest ascorbic acid content (16.82 mg/100g) was recorded in 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3), followed by T_2 (16.41 mg/100g) and T_1 (16.26 mg/100g). The lowest ascorbic acid was in T_{10} (14.51 mg/100g) (Table 1). These results conform to the findings by Helal *et al*., (2023) [3] evaluated the effects of controlled-release nano-urea on ascorbic acid.

Table 1: Effect of nano urea on growth, yield and quality of tomato.

S. No.	Plant height (cm)		No. of branches	Days to flower initiation	Days to 50% flowering	Days to first fruit picking	Fruit diameter (cm)		Average fruit weight (g)	No. of fruits/plants	Fruit yield (kg)		Yield (q/ha)	TSS (°Brix)	Ascorbic acid (mg/100g)
	60 DAT	90 DAT					Equatorial	Polar			per plant	per plot			
T_1	33.31	41.34	8.07	31.84	42.57	57.07	5.01	4.59	57.35	31.13	1.72	52.89	408.1	4.73	16.26
T_2	34.47	41.48	8.29	31.79	41.26	55.76	5.23	4.96	58.59	33.37	1.81	54.92	423.76	4.81	16.41
T_3	35.96	43.23	9.01	30.13	39.86	54.06	5.59	5.14	59.89	35.51	1.90	56.84	438.66	5.34	16.82
T_4	32.29	39.26	6.19	34.37	44.03	59.53	4.35	3.98	50.82	23.19	1.28	44.68	344.75	3.66	14.73
T_5	32.89	40.46	7.67	32.51	42.97	57.97	4.78	4.24	54.71	27.31	1.58	46.64	359.95	4.31	15.38
T_6	33.19	41.14	7.86	32.49	42.71	57.11	4.89	4.35	56.01	29.01	1.63	48.39	373.37	4.68	15.68
T_7	32.37	40.12	6.81	33.96	43.24	58.24	4.51	4.09	52.12	25.63	1.32	36.30	280.09	3.70	14.78
T_8	31.96	38.36	6.18	35.13	44.68	59.98	4.09	3.86	49.53	21.17	1.12	39.50	304.78	3.64	14.67
T_9	32.43	40.32	7.06	33.51	43.01	58.21	4.66	4.19	53.41	28.87	1.47	42.53	328.16	4.19	15.30
T_{10}	26.85	35.81	5.68	38.19	46.62	62.42	3.96	3.51	47.23	19.31	1.07	31.15	240.35	3.01	14.51
SE(m)±	1.04	1.20	0.22	0.99	1.34	1.69	0.15	0.13	1.87	0.81	0.05	1.60	12.34	0.12	0.44
CD (5%)	3.08	3.57	0.66	2.96	3.97	5.03	0.45	0.40	5.57	2.43	0.15	4.75	36.67	0.37	1.32
CV	5.52	5.19	5.25	5.17	5.38	5.05	5.60	5.51	6.02	5.17	6.10	6.10	6.10	5.20	5.00

Conclusion

Based on the study, it can be inferred that the combined application of 100% RDN + two sprays of nano urea @ 4 ml/litre at 30 and 50 DAT (T_3) was found significantly superior over all other treatments in terms of growth traits, yield attributes, yield and quality. Hence, it may be recommended for tomato farmers for higher returns from tomato crop under central plain zone of Uttar Pradesh.

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Effects of Nano Fertilizer on Yield, Yield Attributes and Economics in Tomato (*Solanum lycopersicum* L.). Int. J. Curr. Microbiol. App. Sci. 2020;9(05):2583-2591.
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