



Effect of Nano Urea and Nano DAP on the Growth, Yield and Quality of Chilli (*Capsicum annum. L*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted at the Research Farm, MGM Nanasaheb Kadam College of Agriculture, Gandheli, Chhatrapati Sambhajnagar (M.S), India, during the *Kharif* season of 2023-24 with nine treatments replicated thrice in a randomized block design. Results that the growth, yield and quality parameters of chilli were significantly influenced by RDF with nano urea and DAP. The results revealed that, the highest plant height at 60, 90 and 120 DAT (54.97, 60.18 and 74.99 cm), number of leaves per plant at 60, 90 and 120 DAT (173.80, 245.33 and 291.67), fruit length of fruit at harvest (7.47 cm), average fruit girth of fruit at harvest (2.59 cm), average fruit weight per plant at harvest (6.57 g), number of fruit per plant at harvest (257.67 plant⁻¹), total chlorophyll content in fresh tissue (2.34 mg g⁻¹), green fruit yield of chilli (25.61 t ha⁻¹), total soluble solid (4.62 °Brix) and ascorbic acid content (139.41 mg/100 g) were observed with the application RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT.

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1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is a significant vegetable and spice crop in agriculture, widely used as both a vegetable and a spice and is commercially cultivated in tropical and subtropical regions. It belongs to the Solanaceae family and has a chromosome number of $2n=24$. The crop was first discovered by Christopher Columbus in Tropical America, with Mexico being the primary center of origin, while Guatemala and Bulgaria serve as secondary centers (Salvador et al., 2002). There are five major cultivated species within the genus *Capsicum* L.: *Capsicum annuum*, *Capsicum baccatum*, *Capsicum frutescens*, *Capsicum pubescens* and *Capsicum chinense*. Chilli is an annual shrub that can grow up to 1.5 meters in height and has a taproot system. Its flowers are pentamerous and protogynous. Although chilli is primarily a self-pollinated crop, cross-pollination rates of 7% to 36% have been observed under open pollination conditions (Davenport, 2004).

India has been a dominant force in the international chilli market, being the largest producer, consumer, and exporter of chillies worldwide. The country contributes 42% of the total spice export quantity, with major export destinations including China, Vietnam, Thailand, Sri Lanka, Indonesia, and Malaysia. Indian chillies are globally recognized for their exceptional commercial qualities, particularly in terms of color and pungency. Chilli cultivation in India spans approximately 2.29 lakh hectares, yielding around 10.78 lakh tonnes (NHB, 2022).

The application of Nano DAP and Nano Urea in chilli cultivation presents significant advantages over traditional fertilizers. Nano urea and DAP play crucial roles in chilli cultivation. DAP, rich in nitrogen and phosphorus, is essential during the early growth stage for strong root development, healthy seedlings, and better flowering. It is usually applied as a basal dose. Nano urea, a more efficient nitrogen source, enhances vegetative growth, improves leaf health, and boosts fruit setting with minimal environmental impact. It is used as a foliar spray during key growth stages. Together, they support balanced nutrition, improve yield quality and quantity, and reduce fertilizer waste, making chilli farming more productive and sustainable.

These nanotechnology-based fertilizers reduce the requirement for conventional urea by 50% or

more, making them an environmentally friendly alternative. They contribute to improved soil, air, and water quality, reduce input costs for farmers, and enhance farm profitability. Additionally, Nano DAP and Urea improve crop productivity, soil health, and the nutritional quality of produce. In light of these benefits, a study was conducted at the Research Farm of MGM Nanasaheb Kadam College of Agriculture, Gandheli, Chhatrapati Sambhajnagar (M.S), India, to assess their impact on chilli cultivation.

2. MATERIALS AND METHODS

The field experiment was conducted during the *Kharif* season of 2023. The present investigation was done to understand the "Effect of Nano Urea and Nano DAP on the growth, yield and quality of chilli (*Capsicum annuum* L.)" variety Prachi with spacing 6 x 1 ft. (R x P) which was carried out at Research Farm, MGM Nanasaheb Kadam College of Agriculture, Gandheli, Chhatrapati Sambhajnagar (M.S), India. The experiment was laid out in Randomized block design (RBD) with nine treatments and three replications. The treatments were comprises *viz.*, T₁: RDF, T₂: RDF + Nano urea @ 0.2% drenching at 30 DAT, T₃: RDF + Nano urea @ 0.4% drenching at 30 DAT, T₄: RDF + Nano DAP @ 0.2% drenching at 30 DAT, T₅: RDF + Nano DAP @ 0.4% drenching at 30 DAT, T₆: RDF + Nano urea @ 0.2% drenching at 30 DAT & 45 DAT, T₇: RDF + Nano urea @ 0.4% drenching at 30 DAT & 45 DAT, T₈: RDF + Nano DAP @ 0.2% drenching at 30 DAT & 45 DAT, T₉: RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT. The soils of the experimental site was belonged to order Inceptisol (*Vertic Haplustept*). The experimental soils were moderately alkaline in nature and low insoluble salts content. Medium in CaCO₃, low in organic carbon, available N, P and very high in K. The available Zn and Fe was deficient and available Mn and Cu were sufficient. The nutrients were applied through fertilizers (urea, single super phosphate, muriate of potash and diammonium phosphate). The recommended dose of fertilizer (RDF) applied to chilli was 100:50:50 kg N, P₂O₅ and K₂O ha⁻¹. Observations were recorded at different stages of growth periods and studied for growth parameters like plant height, number of leaves per plant, fruit length, fruit girth, average fruit weight, yield and quality parameters TSS and ascorbic acid content. The height of five randomly selected plants from each plot was measured in cm with

of a 100 cm meter scale from ground level to tip of the shoot at 60, 90 and 120 DAT stage. The results obtained were statistically analyzed and appropriately interpreted as per the methods described in "Statistical method for Agricultural Workers" by Panse and Sukhatme (1985). Appropriate standard error (S.E.) critical differences (C.D.) at 5 per cent levels were worked out for interpretation of results.

3. RESULT AND DISCUSION

3.1 Effect of Nano Urea and DAP on Growth Parameters

The growth parameters of green chilli viz., plant height, number of leaves per plant, fruit girth, fruit length, average fruit weight per plant, number of fruits per plant and total chlorophyll content were significantly influenced by application of nano urea and nano DAP (Table 1).

The application of RDF with nano DAP @ 0.4% drenching at 30 DAT & 45 DAT significantly increased plant height at 60, 90 and 120 DAT (54.97, 60.18 and 74.99 cm) in chilli. The lowest plant height at 60, 90 and 120 DAT (37, 43.51 and 47.19 cm) was recorded in the control (T₁). Increased plant height is attributed to an adequate supply of nitrogen and phosphorus, which enhance enzyme activity and auxin metabolism. This, in turn, promotes cell division and elongation, leading to taller plants. These results are in conformity with the results findings by, Ajirloo et al. (2015) in tomato, Gusain et al. (2015). Drostkar et al. (2016) in chickpea, Merghany et al. (2019) in cucumber, Al Jabri et al. (2020) in okra, Chauhan et al. (2023) in chilli and Rajeshwari neeruggi (2024) in chilli.

The application of RDF with nano DAP @ 0.4% drenching at 30 DAT & 45 DAT significantly increased the number of leaves per plant at 60, 90 and 120 DAT (173.80, 245.33 and 291.67) in chilli. The lowest number of leaves per plant at 60, 90 and 120 DAT was recorded (142.67, 178.73 and 236.33) in control (T₁). The increased number of leaves per plant is due to the nanosized particles' large surface area and smart delivery system, which enables a controlled release of nutrients, enhancing nutrient use efficiency. Additionally, the improved availability of nitrogen and phosphorus, essential components of chlorophyll and proteins, supports efficient photosynthesis, further promoting leaf growth. These results are in conformity with Ajirloo et al. (2015) in tomato, Gusain et al.

(2015). Drostkar et al. (2016) in chickpea, Merghany et al. (2019) in cucumber, Al Jabri et al. (2020) in okra and Mishra et al. (2020) in tomato.

The maximum average fruit length of fruit at harvest (7.47 cm) was observed with treatment T₉. The minimum average fruit length at harvest (6.07 cm) was observed in T₁. The maximum average fruit girth of fruit at harvest (2.59 cm) was observed with treatment T₉. The minimum average fruit girth at harvest (2.14 cm) was observed in T₁. The maximum average fruit weight per plant at harvest (6.57 g) was observed with treatment T₉. Minimum average fruit weight per plant at harvest (3.82 g) was observed in T₁. The maximum number of fruits per plant at harvest (257.67 plant⁻¹) was observed with treatment T₉. The minimum number of fruit per plant at harvest (171.33 plant⁻¹) was observed in T₁. Nano fertilizers significantly enhance fruit length and girth in chili crops. Their small particle size ensures efficient nutrient absorption and uptake, supplying essential elements for fruit development. By improving nutrient availability, nano fertilizers promote better fruit growth and quality, ultimately boosting overall yield potential. These results are in close conformity with the findings of Parani and Nanthini (2021), Rather et al (2022) and Chauhan et al. (2023) in chilli.

Total chlorophyll content in fresh tissue of chilli crop showed significantly the highest response to soil application of RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT (2.34 mg g⁻¹) and statistically on par with soil application of RDF + Nano DAP @ 0.2% drenching at 30 DAT & 45 DAT (2.30 mg g⁻¹) at flowering stage. Significantly lowest chlorophyll content of leaves was recorded in control (1.47 mg g⁻¹). This may be due to the enhanced absorption and utilization of nutrients like nitrogen and phosphorus by nanosized particles, which have a large surface area and a smart delivery system. Their controlled nutrient release improves nutrient use efficiency in crops, leading to better growth and development as concluded by Ajirloo et al. (2015) in tomato, Merghany et al. (2019) in cucumber, Al Jabri et al. (2020) in okra, AL-Kaby et al. (2021) in okra, Rajeshwari neeruggi (2024) in chilli and Sunil et al. (2024) in chilli.

3.2 Effect of Nano Urea and DAP on Yield

The treatment, soil application (Table 2) of RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45, DAT recorded significantly higher green fruit yield

Table 1. Effect of nano urea and nano DAP on growth parameters of chilli

Treatment	Plant height (cm)			Number of leaves plant ⁻¹			Fruit girth (cm)	Fruit length (cm)	Average fruit weight plant ⁻¹	Number of fruit plant ⁻¹	Total chlorophyll content (mg g ⁻¹ fr. wt.)
	60 DAT	90 DAT	120 DAT	60 DAT	90 DAT	120 DAT					
T ₁	37.00	43.51	47.19	142.67	178.73	236.33	2.14	6.07	3.82	171.33	1.47
T ₂	41.23	48.94	54.75	156.73	198.00	252.67	2.19	7.09	4.21	179.67	1.80
T ₃	41.95	55.43	59.86	158.73	206.33	256.00	2.24	7.14	4.40	188.33	1.88
T ₄	46.61	57.51	67.28	169.60	224.00	278.00	2.41	7.34	5.41	213.33	2.09
T ₅	48.09	59.25	69.15	172.00	235.33	282.33	2.47	7.38	5.79	221.67	2.21
T ₆	43.26	56.35	64.25	164.90	218.33	256.67	2.28	7.25	4.75	197.33	1.97
T ₇	44.49	56.53	65.46	166.87	210.33	267.67	2.33	7.29	5.10	207.33	2.06
T ₈	51.78	60.08	72.11	171.87	240.33	289.33	2.50	7.44	6.29	250.00	2.30
T ₉	54.97	60.18	74.99	173.80	245.33	291.67	2.59	7.47	6.57	257.67	2.34
S. Em (±)	1.55	0.54	1.37	0.79	1.95	0.99	0.03	0.02	0.07	2.49	0.01
CD at 5%	4.67	1.16	4.14	2.38	5.87	2.98	0.09	0.06	0.23	7.49	0.05

Table 2. Effect of nano urea and nano DAP on yield and quality parameters of chilli

Treatment	Green fruit yield Ton ha ⁻¹	TSS (°Brix)	Ascorbic acid content (mg/100 g)
T ₁	20.14	3.04	116.84
T ₂	20.85	4.09	122.41
T ₃	21.94	4.20	125.41
T ₄	23.42	4.41	132.08
T ₅	23.62	4.46	133.81
T ₆	22.23	4.25	127.47
T ₇	22.61	4.33	130.33
T ₈	24.63	4.57	137.40
T ₉	25.61	4.62	139.41
S. Em (±)	0.35	0.01	0.67
CD at 5%	1.05	0.05	2.02

of chilli (25.61 t ha⁻¹) and the per cent increase was 5.15 per cent over RDF. It was on par with soil application of RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT recorded significantly higher green fruit yield of chilli (24.63 t ha⁻¹). The lowest green fruit yield was recorded in T₁ control (20.14 t ha⁻¹). Increases in fruit yield per hectare in treatment T₉: RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT followed by T₈: RDF + Nano DAP @ 0.2% drenching at 30 DAT & 45 DAT might be due to increase in the number of flowers per plant may, in turn, lead to higher fruit production. The application of an adequate and optimal dose of nitrogen and phosphorus enables the crop to reach its full growth potential by improving nutrient availability, uptake, and use efficiency throughout the cropping period. This may have enhanced the translocation of photosynthates from source to sink, promoting greater flower production and, consequently, more fruits. Additionally, nitrogen, a key macronutrient, may have supported beneficial microbial activity, further contributing to increased flower production. This ultimately results in a higher number of fruits per plant, maximizing harvest yield per square meter and boosting overall fruit production. Ajirloo et al. (2015) in tomato, Merghany et al. (2019) in cucumber. Panda et al. (2020), Mishra et al. (2020) in tomato and Rajeshwari neeruggi (2024) in chilli.

3.3 Effect of Nano Urea and DAP on Quality Parameters

The significantly highest total soluble solid (4.62 °Brix) was recorded in soil application (Table 2) of RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT and statistically on par with soil application of RDF + Nano DAP @ 0.2% drenching at 30 DAT & 45 DAT (4.57 °Brix). The lowest total soluble solid was observed in control

T₁ (3.04 ° Brix). This might be due to nano fertilizers, with their small particle size, which ensure efficient nutrient uptake and utilization, providing essential elements for metabolic processes. Balanced application in nano form improves nutrient availability, leading to increased TSS content in chilli fruits. This enhancement in TSS contributes to improved fruit quality and overall market value of chilli crops. Similar inferences were also concluded by Mishra et al. (2020) in chilli and Chauhan et al. (2023) in chilli.

The ascorbic acid content in chilli crop showed significantly the highest response to soil application of RDF + Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT (139.41 mg/100 g) and statistically on par with soil application of RDF + Nano DAP @ 0.2% drenching at 30 DAT & 45 DAT (137.40 mg/100 g). The lowest ascorbic acid content was observed in control T₁ (116.84 mg/100 g). The quality parameter of chilli is ascorbic acid, which acts as a natural protector of pigment stability. The application of nano fertilizer increases the availability and utilization of the available plant nutrients. The application of nano fertilizer has a significant effect on ascorbic acid, which acts as an antioxidant and also a natural protector. Al-juthery et al. (2020) in potato and Chauhan et al. (2023) in chilli.

4. CONCLUSION

The present study concluded that the recommended dose of fertilizer with application of Nano DAP @ 0.4% drenching at 30 DAT & 45 DAT was significantly superior to the control concerning growth, yield and quality parameters. The application of Nano DAP and Nano Urea in chilli cultivation presents significant advantages over traditional fertilizers. Nano urea and DAP play crucial roles in chilli cultivation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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