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Influence of Nano urea and Nano DAP foliar Application on N, P and K uptake in tomato (*Solanum lycopersicum* L.)

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Abstract

Tomato (*Solanum lycopersicum* L.) is one of the important vegetable crops globally, but the low nutrient-use efficiency of conventional fertilizers often constrains its productivity. Traditional fertilisers have low nutrient use efficiency (NUE), leading to significant nutrient losses and environmental issues. Nano fertilizers are emerging as an eco-friendly alternative that can enhance nutrient use efficiency because their surface area and tiny size allow plants to absorb nutrients faster and more completely, while cutting down on waste from runoff or evaporation. In this study, we assessed how different nitrogen and phosphorus regimes affected the nutrient uptake (N, P, and K) in tomatoes when nano urea and nano DAP were combined with conventional fertilizers. At various growth phases, ten fertilizer treatments were evaluated, including full (100%), moderate (75%), low (50%), and very low (25%) recommended nitrogen and phosphorus (RNP), applied using traditional fertilizers as well as nano urea and nano DAP. The maximum nutrient absorption was continuously reported by treatment T₈, which included 75% RNP [(Nitrogen (N): 76.05 kg ha⁻¹, Phosphorus(P): 29.68 kg ha⁻¹, Potassium (K): 90.71 kg ha⁻¹)] as basal dose of soil application and 4 ml L⁻¹ nano urea and nano DAP foliar sprays at both 30 and 45 days after transplanting (DAT). While T₉ (75% RNP + 6 ml NUS + 6 ml NDS @ 30 & 45 DAT) with N:72.86 kg ha⁻¹ P: 26.92 kg ha⁻¹ K: 86.07 kg ha⁻¹ and T₁ (25% RNP + 2 ml NUS + 2 ml NDS @ 30 & 45 DAT) demonstrated less nutritional absorption compared to other treatments. The results demonstrate that using nano urea and nano DAP in conjunction with traditional fertilizer sources under ideal nitrogen and phosphorus regimes improves nutrient absorption. Although they could not completely replace traditional fertilizers, nano urea and nano DAP showed potential in partially correcting nutritional deficits under lower RNP. As a result, nano urea and nano DAP are effective complementing inputs in systems for sustainable nutrient management. Future studies should concentrate on its long-term impacts on soil health, crop yield, and field-based economic sustainability.

Keywords: Tomato, Nano urea, nutrient use efficiency and soil health

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops worldwide, valued for its nutritional and industrial significance. Farmers cultivate tomatoes on a commercial scale as a cash crop and on a small scale for domestic use in a variety of soil types. Because tomatoes are big yielders, they need enough fertilizer to thrive and produce [Pandey and Chandra (2013)]^[6]. A plant's ability to grow and develop typically depends on how well it is fed to meet its nutrient needs. Continuous application of excessive and unbalanced nutrients has resulted in a deterioration in nutrient-use efficiency, making fertilizer consumption unfeasible and creating health risks due to negative impacts on groundwater and the atmosphere. Chemical fertilizer's detrimental impacts on the environment and soil restrict its use in sustainable agriculture systems. Chemical fertilizers are being overdosed due to conventional application methods. As a primary food source for plants, nitrogen is a necessary component of chlorophyll, which facilitates photosynthesis, and protein, which is made up of amino acids and is involved in the catalysis of chemical reactions and electron transport. In several physiological functions, nitrogen is essential. It gives plants a dark green hue and encourages the growth and development of stems, leaves, and other vegetative parts. It regulates the general growth of the plant and promotes the uptake and utilization of other nutrients like potassium and phosphorus. In 2016, Leghari *et al.*^[5] Indian soils

are severely depleted because crops continually supply 20 mt of nutrients while continuously removing 30 mt, leaving a gap of 10 mt. Crop responsiveness to fertilizer has drastically decreased. Agricultural scientists are under tremendous pressure to develop solutions that address the complex concerns facing Indian agriculture due to socioeconomic factors such as laborers' inaccessibility, the departure of people from farming, and growing cultivation costs.

In order to mitigate the challenges associated with soil-applied fertilizers, such as fixation, immobilization, volatilization, leaching, and runoff, we should consider using alternative technologies, like nanotechnology, to accurately detect and deliver the right amount of nutrients and other inputs needed by crops in a proportion that promotes productivity while maintaining environmental safety. Plant nutrients are encapsulated in nanomaterials, thinly coated with nanomaterials, and delivered as nano-sized emulsions to create nano fertilizers. Higher nutrient utilization efficiency (NUE) results from the uptake of nanomaterials and their deep penetration through stomatal apertures and nano-pores in plant leaves. Nanotechnology is gradually moving from the experimental stage to the operational and practical stage. This will lead to a more tangible presence of the technology in the agricultural sector (Baruah and Dutta, 2009) [1]. In this regard, using nano fertilizer

to control release of nutrients can be an effective step towards achieving sustainable agriculture and environment (Cui *et al.*, 2010) [2]. Farmers are using urea and DAP fertilizers for soil application to crops; however, the efficacy is lower. The present study was taken up to investigate the promotional or inhibitory influence of nano urea and nano DAP on uptake of primary nutrients in tomato.

Materials and Method

During Rabi 2022-2023, a field study was carried out at New-Orchard, MARS, Department of Horticulture, UAS, Raichur, Karnataka (16°15'N, 77°21'E, altitude 389 m). The experimental site's soil had a red sandy loam texture with 55.1% sand, 13.3% silt, and 30.8% clay. Three replications of the experiment were set up in a Randomized Complete Block Design (RCBD). Ten treatments (Presented in Table 1.) were administered at 30 and 45 days after transplanting (DAT) with varying dosages of nano urea and nano DAP (2, 4, & 6 ml l⁻¹) and RNP (three treatments with 25% RNP, three with 50% RNP, three with 75% RNP, and one with 100% RDF). On the other hand, every treatment received the recommended dosage of K. For the study, Arka Abhed was chosen. The healthy 30-day-old seedlings were placed in a paired row on raised beds at a distance of 90 cm by 45 cm.

Table 1: Experimental Treatment Details

Sl.No.	Treatment	Treatment Details
1.	T ₁	25% RNP + 2 ml NUS + 2 ml NDS @ 30 & 45 DAT
2.	T ₂	25% RNP + 4 ml NUS + 4 ml NDS @ 30 & 45 DAT
3.	T ₃	25% RNP + 6 ml NUS + 6 ml NDS @ 30 & 45 DAT
4.	T ₄	50% RNP + 2 ml NUS + 2 ml NDS @ 30 & 45 DAT
5.	T ₅	50% RNP + 4 ml NUS + 4 ml NDS @ 30 & 45 DAT
6.	T ₆	50% RNP + 6 ml NUS + 6 ml NDS @ 30 & 45 DAT
7.	T ₇	75% RNP + 2 ml NUS + 2 ml NDS @ 30 & 45 DAT
8.	T ₈	75% RNP + 4 ml NUS + 4 ml NDS @ 30 & 45 DAT
9.	T ₉	75% RNP + 6 ml NUS + 6 ml NDS @ 30 & 45 DAT
10.	T ₁₀	RDF (250:250:250 kg NPK ha ⁻¹) Acc.to UHS, Bagalkot POP

Plant sample Collection and analysis

Plant samples were collected at the final harvesting stage. Ten plants from each treatment, which were randomly selected, were collected by pulling out the entire plant. The plant samples were washed with tap water and later with distilled water to remove the adhering soil and dusts. Then they were air dried and later kept in the hot air oven at 78 °C overnight. The oven-dried samples were powdered with willey milling machine and stored in polythene bags. The primary nutrient concentration in the plant sample was thoroughly examined using many well-established techniques, including the use of Kjeldahl's digestion and distillation method to measure the percentage of total nitrogen, the Vanado-molybdo phosphoric acid yellow color method to measure the percentage of total phosphorus, and the flame photometric method to measure the percentage of total potassium using a Systronics flame photometer (Model 128), precisely as Jackson (1973) for P uptake and expressed in kg ha⁻¹.

Results and Discussion

N uptake

The administration of graded amounts of nitrogen and different concentrations of nano urea and nano DAP in tomatoes was found to have a substantial impact on nitrogen uptake. At 30 and 45 DAT (T₈), foliar spraying 4 ml of nano urea and 4 ml of nano-

DAP after applying 75% RNP resulted in considerably better nitrogen uptake (76.05 kg ha⁻¹) compared to all other treatments. T₉ (75% RNP + 6 ml NUS & 6 ml NDS @ 30 & 45 DAT) came next with 72.86 kg ha⁻¹, which was comparable to T₇'s 69.24 kg ha⁻¹ (75% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT). Lowest nitrogen uptake (53.75 kg ha⁻¹) was recorded in T₁ (25% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT) compared to all other treatments (Results are presented in Table 2.).

P uptake

Phosphorous uptake was significantly influenced by the application graded levels of phosphorous and varied concentrations of nano urea and nano DAP in tomato were recorded in the study. Application of 75% RNP followed by foliar spray of 4 ml nano urea and 4 ml nano -DAP at 30 and 45 DAT (T₈) recorded significantly higher (29.68 kg ha⁻¹) phosphorous uptake over all other treatments. Followed by T₉ (75% RNP + 6 ml NUS & 6 ml NDS @ 30 & 45 DAT) with 26.92 kg ha⁻¹, which was on par with T₇ (75% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT), with 24.85 kg ha⁻¹. Lowest phosphorous uptake (10.25 kg ha⁻¹) was recorded in T₁ (25% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT) compared to all other treatments (Results are presented in Table 2.).

K uptake

Potassium uptake was significantly influenced by the application graded levels of nitrogen and phosphorous along with varied concentrations of nano urea and nano DAP in tomato were recorded in the study. Application of 75% RNP followed by foliar spray of 4 ml nano urea and 4 ml nano DAP at 30 and 45 DAT (T₈) recorded significantly higher (90.71 kg ha⁻¹) potassium uptake over all other treatments. Followed by T₉ (75% RNP + 6 ml NUS & 6 ml NDS @ 30 & 45 DAT) with 86.07 kg ha⁻¹, which was on par with T₇ (75% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT), with 83.18 kg ha⁻¹. Lowest potassium uptake (69.62 kg ha⁻¹) was recorded in T₁ (25% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT) compared to all other treatments (Results are presented in Table 2.).

Improved availability, aided by a baseline fertilizer dosage, was linked to plants' maximum uptake of NPK content. N fixation, P

solubilization, and K mobilization in the soil may be responsible for the rise in NPK reserve with increased nutrient availability. The enhanced absorption and utilization of nutrients like nitrogen and phosphorus by nano-sized particles, which have a large surface area and a smart system for delivery that is, a controlled release pattern of nutrients may be the cause of the increased nutrient uptake in treatments with nano urea and nano DAP throughout the cropping period. As demonstrated in this study with increased nutrient uptake in tomatoes, nano urea and nano DAP enhanced fertilizer efficacy and soil nutrient consumption in addition to aiding in the correction of mineral fertilization. The decreased NPK application in T₁ that reduced absorption may be the cause of T₁'s lower yield. The results were consistent with those of wheat, Saitheja *et al.* (2022) [9] for green gram, Sahu *et al.* (2022) [8] for rice, and Raliya *et al.* (2016) [6] for watermelon.

Table 2: Influence of foliar sprays of nano urea and nano DAP on whole plant uptake of nitrogen, phosphorous and potassium in tomato

Treatment		Uptake of N (kg ha ⁻¹)	Uptake of P (kg ha ⁻¹)	Uptake of K (kg ha ⁻¹)
T ₁	25% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT	53.75	10.25	69.62
T ₂	25% RNP + 4 ml NUS & 4 ml NDS @ 30 & 45 DAT	55.92	11.09	71.29
T ₃	25% RNP + 6 ml NUS & 6 ml NDS @ 30 & 45 DAT	57.74	12.10	73.48
T ₄	50% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT	60.59	16.91	75.07
T ₅	50% RNP + 4 ml NUS & 4 ml NDS @ 30 & 45 DAT	63.82	19.69	78.92
T ₆	50% RNP + 6 ml NUS & 6 ml NDS @ 30 & 45 DAT	65.71	21.97	80.58
T ₇	75% RNP + 2 ml NUS & 2 ml NDS @ 30 & 45 DAT	69.24	24.85	83.18
T ₈	75% RNP + 4 ml NUS & 4 ml NDS @ 30 & 45 DAT	76.05	29.68	90.71
T ₉	75% RNP + 6 ml NUS & 6 ml NDS @ 30 & 45 DAT	72.86	26.92	86.07
T ₁₀	RDF (250:250:250 kg NPK ha ⁻¹)	58.76	14.83	73.65
Mean		63.44	18.83	78.26
S. Em. ±		1.04	0.26	1.08
CD at 5%		3.08	0.76	3.21

Note: RDF: Recommended dose of fertilizer.

RNP: Recommended dose of Nitrogen and Phosphorous.

NUS: Nano urea spray.

NDS: Nano DAP spray.

DAT: Days after transplanting.

Recommended K is common for all treatment.

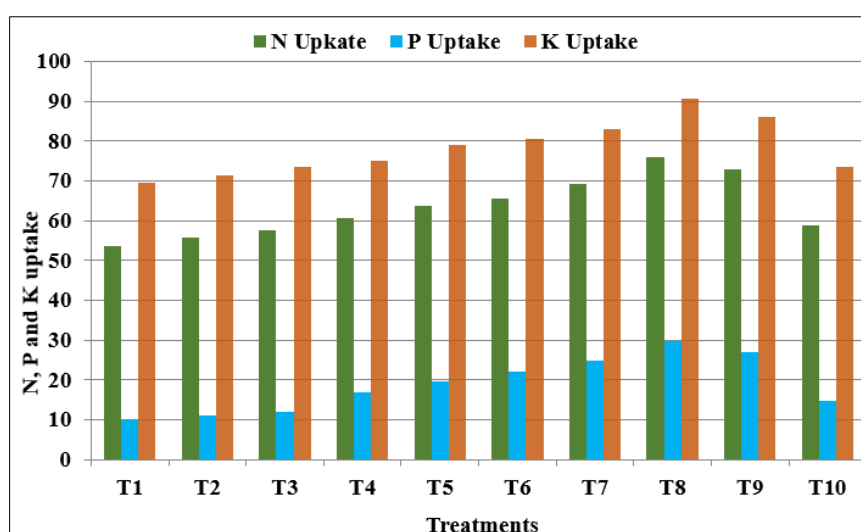


Fig 1: Influence of foliar sprays of nano urea and nano DAP on whole plant uptake of nitrogen (kg ha⁻¹), phosphorous (kg ha⁻¹) and potassium (kg ha⁻¹) in tomato

Conclusion

The present study indicated that foliar application of Nano Urea and Nano DAP in combination with reduced amounts of prescribed nitrogen and phosphorus fertilization greatly altered N,

P and K uptake in tomato. Among the treatments, 75% prescribed N and P fertilizer supplemented with 4 ml L⁻¹ each of Nano Urea and Nano DAP at 30 and 45 days after transplanting (T₈) reported the maximum uptake of N (76.05 kg ha⁻¹), P (29.68 kg ha⁻¹) and

K (90.71 kg ha^{-1}). Nutrient uptake did not improve further when the nano-fertilizer concentration was increased from 4 to 6 ml L^{-1} , suggesting that the 4 ml L^{-1} concentration was more effective in the current study. According to the research, foliar Nano Urea and Nano DAP may enhance tomato nitrogen uptake by acting as complementary nutrient sources with lower basal N and P fertilization. To confirm the constancy of these reactions and evaluate their effects on yield, soil health, nutrient-use efficiency, and economic sustainability, more multi-season and multi-location research is necessary.

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