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Assessment of super nano urea for enhancing growth and productivity of summer maize under the agro-climatic conditions of Varanasi, Uttar Pradesh

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Abstract

The farmers field experiment was conducted during the summer season of 2023 at Rajpur (Mangari), Varanasi, Uttar Pradesh, to evaluate the efficacy of Super Nano Urea on growth and productivity of summer maize (*Zea mays* L.) variety Hybrid Corn Seed 4226 (VNR). The experiment was laid out in Randomized Block Design with 11 treatments replicated thrice. The treatments included a variety of combinations of normal urea foliar sprays, Super Nano Urea (SNU) foliar sprays at varied strengths (0.25%, 0.5%, and 1.0%), and recommended nitrogen dose (RDN). Results revealed that treatment T₆ (50% RDN + 2 sprays of SNU @ 1.0% at knee-high and tasseling stages) produced growth parameters (plant height, number of leaves), yield attributes (cob length, cob weight, grains per cob), and grain yield statistically at par with T₂ (100% RDF - 23.00 q ha⁻¹), representing a 70.71% increase over the absolute control. Superior assimilate partitioning was indicated by the highest harvest index (37.98%) in T₁. Compared to ordinary urea, the nitrogen usage efficiency with SNU treatment was about doubled. According to the study's findings, Super Nano Urea may successfully substitute 50% of traditional nitrogen fertilizer without lowering maize yield. For summer maize farming in the Varanasi region, the recommended practice of 50% RDN with two foliar sprays of SNU @ 1.0% provides an economically feasible and environmentally sustainable nitrogen management strategy.

Keywords: Super nano urea, summer maize, growth, yield, varanasi

Introduction

One of the most significant cereal crops in the world, maize (*Zea mays* L.) is an essential source of food, feed, and raw materials for industry. It is grown in a variety of agroclimatic settings and is the third most important food grain in India, behind wheat and rice. The country's average productivity, however, is still below international norms despite its high genetic yield potential. Monsoon unpredictability, soil degradation, and inadequate fertilizer management techniques are especially detrimental to kharif season crops. Effective nutrient management techniques are necessary to maintain productivity under intensive agriculture methods in Uttar Pradesh, where maize is a significant summer and kharif crop (Tripathi *et al.*, 2025; Vasanth *et al.*, 2024) ^[20, 21]. Since nitrogen is a necessary component of chlorophyll, amino acids, nucleic acids, and phytohormones, it is the most important nutrient that limits maize productivity. Granular urea, which has a famously low nutrient use efficiency due to significant losses through volatilization, leaching, and denitrification, is a key component of conventional nitrogen management (Yadav *et al.*, 2019; Singh, R. K., 2022) ^[22, 19]. In addition to raising manufacturing costs, these inefficiencies contaminate water bodies with nitrate and release greenhouse gases into the atmosphere. In summer maize, when high temperatures hasten nitrogen losses and inadequate moisture conditions impede nutrient uptake, the problem is more severe (Sharma *et al.*, 2022) ^[15]. A promising solution to these problems is provided by recent developments in nanotechnology. When compared to conventional fertilizers, nano-fertilizers, which contain nutrients in nanoscale particles, show noticeably larger surface area and particle density (Shukla *et al.*, 2016) ^[16]. In order to better align with crop demand, nano-urea formulations exhibit controlled and sustained nitrogen release patterns, lowering peak accessible nitrogen concentrations in soil and postponing

maximum availability. Research has demonstrated that, as compared to traditional urea fertilization, nano-enabled fertilization can decrease nitrate leaching and ammonia volatilization.

The latest generation of nano-fertilizers is Super Nano Urea (SNU), a sophisticated liquid formulation that contains nitrogen and is intended to improve the efficiency of nutrient delivery. Prior research has shown that using SNU foliar sprays with lower amounts of conventional nitrogen can significantly increase nitrogen use efficiency while preserving or even increasing maize yields. Previous research in Uttar Pradesh has also demonstrated that maize responds favorably to nano-urea treatments, with combination zinc and nano-urea treatments greatly improving growth metrics and grain yield (Rawat *et al.*, 2024; Maignan *et al.*, 2020) [13, 3].

Evaluating the effectiveness of Super Nano Urea in the unique agroclimatic conditions of Varanasi in eastern Uttar Pradesh is crucial given the increasing focus on sustainable agricultural intensification. High temperature stress, erratic rainfall patterns, and diminishing soil fertility present particular difficulties for the area's summer maize production (Chudasama *et al.*, 2024) [1]. In order to evaluate the impact of applying Super Nano Urea on the growth characteristics, yield metrics, and productivity of summer maize (*Zea mays* L.) in Varanasi, Uttar Pradesh, this study was conducted. According to Meena *et al.* (2017) [7], the results should help create location-specific, nitrogen-efficient nutrient management systems that lower fertilizer input costs while preserving agricultural output and reducing environmental impact.

Materials and Methods

The farmers field experiment was conducted during the summer season of year 2023 at a farmer's field in Rajpur (Mangari), Varanasi, Uttar Pradesh (25.20° N, 82.58° E; 81 m elevation). The soil was sandy loam, alluvial in origin (Inceptisol). Hybrid Corn Seed 4226 (VNR), a medium-maturity, heat-tolerant hybrid with a potential yield was used. The experiment was laid out in Randomized Block Design (RBD) with three replications. 11 treatments were evaluated: T₁ (Absolute control), T₂ (100% RDF), T₃ (50% RDN + 100% PK), T₄ (50% RDN + 2 SNU sprays @ 0.25%), T₅ (50% RDN + 2 SNU sprays @ 0.5%), T₆ (50% RDN + 2 SNU sprays @ 1.0%), T₇ (50% RDN + 2 conventional urea sprays @ 1.0%), T₈ (50% RDN + 1 SNU spray @ 1.0%), T₉ (50% RDN + 2 SNU sprays @ 0.5% - repeated), T₁₀ (25% RDN + 3 SNU sprays @ 0.5%), and T₁₁ (25% RDN + 3 conventional urea sprays @ 1.0%). Full P and K were applied basally. Nitrogen was applied through soil (50% or 25% RDN) and foliar sprays of SNU (17% N) or conventional urea (46% N). Using 500 L of water ha⁻¹, sprays were applied at knee-high (30 DAS), tasseling (60 DAS), and silking (75 DAS for three spray treatments). Grain and stover yield, nitrogen usage efficiency, yield features (cob length, cob girth, grains per cob, test weight), and growth factors (plant height, leaf number, dry matter) were all noted. ANOVA for RBD was used to analyze the data, and CD at p=0.05 was used to compare treatment averages.



Fig 1: Foliar Spray at 30 DAS and silking stage at farmer's field

Results and Discussion

Growth Parameters

Plant Height

Plant height is a critical vegetative parameter reflecting the overall growth vigor and yield of maize. The data recorded at 30, 45, and 60 days after sowing (DAS) revealed significant treatment effects. At 30 DAS, maximum plant height was observed in T₆ (50% RDN + 2 SNU sprays @ 1.0%) at 80.33 cm, closely followed by T₂ (100% RDF) at 79.67 cm, representing 29.45% and 28.87% increases over control (56.67 cm), respectively. At 45 DAS, T₂ recorded the maximum height (151.33 cm), followed by T₆ (148.67 cm), both being statistically at par. At 60 DAS, T₂ (177.00 cm) and T₆ (174.67 cm) remained superior with 18.46% and 17.37% increases over control (144.33 cm). The improved foliar absorption efficiency of the nano-formulation is responsible for the increased plant height under SNU treatments (Table 1). This facilitates effective nitrogen transfer to meristematic tissues, encouraging cell division and elongation. During the vegetative phase, the sustained release pattern of SNU supports continuous growth by coordinating nitrogen availability with plant needs. Particularly noteworthy is the statistical parity between T₂ (50% RDN + SNU) and T₂ (100% RDF), suggesting that SNU can successfully substitute 50% of traditional nitrogen fertilizer without impairing vegetative growth. These results are consistent with other studies that shown that applying nano-urea to maize increased plant height (Razauddin *et al.*, 2025) [14].

Number of Leaves

The number of leaves per plant followed similar trends across observation stages. At 30 DAS, T₂ recorded the maximum leaves (11.33), followed by T₁₀ and T₁₁ (10.33 each), showing 32.30% and 25.75% increases over control (7.67). At 45 DAS, T₂ (13.67) was superior, followed by T₅ and T₆ (13.56 each), which were 9.80% and 9.07% higher than control (12.33). At 60 DAS, T₂ (14.33) remained highest, followed by T₆ (14.04), representing 16.26% and 14.53% increases over control (12.00). Enhanced nitrogen nutrition promoting cytokinin synthesis and postponing leaf senescence can account for the increased leaf output under SNU treatments (Table 1). For the commencement and growth of leaves, nitrogen is a structural element of proteins and chlorophyll. The fact that (two SNU sprays at 1.0%) performed better than other SNU concentrations indicates that numerous treatments and a greater dosage offer the best nitrogen delivery. Multiple SNU applications can effectively compensate for reduced soil nitrogen, according to the statistical parity between T₁₁ (25% RDN + 3 SNU sprays) and T₁₁ (25% RDN + 3 conventional urea sprays). This is consistent with findings that foliar nano-urea improves physiological efficiency under nitrogen-limited conditions (Singh *et al.*, 2025; Tripathi *et al.*, 2025) [17, 20].

Yield Attributes

Cob Length and Cob Weight

Cob length and weight are primary determinants of grain yield potential. Maximum cob length was recorded in T₂ (16.00 cm), followed by T₆ (14.67 cm), showing 36.94% and 31.22% increases over control (10.09 cm). These treatments were statistically at par. Similarly, cob weight was highest in T₂ (63.72 g) and T₆ (62.38 g), representing 22.44% and 20.78% increases over control (49.42 g). Improved nitrogen transfer during the reproductive phase is shown in the improved cob formation with SNU treatments (Table 2). The continual availability of nutrients during crucial stages of cob production is ensured by nano-urea's capacity to release nitrogen slowly and steadily. In cob meristems,

adequate nitrogen nutrition encourages cell development and improves the assimilate supply for grain filling. According to Singh *et al.* (2023) ^[18] and Vasanth *et al.* (2024) ^[21], improved foliar absorption (15-25% efficiency compared to 30-40% soil N

recovery) and decreased volatilization losses are probably the reasons why SNU at 1.0% concentration effectively meets the nitrogen demand for cob development even with 50% reduced soil N.

Table 1: Effect of Super Nano Urea application on plant height and number of leaves at 30, 60 and 90days after sowing of maize crop.

Treatments	Plant Height (cm) 30 DAS	Plant Height (cm) 45 DAS	Plant Height (cm) 60 DAS	Number of Leaves 30 DAS	Number of Leaves 45 DAS	Number of Leaves 60 DAS
T ₁	56.67	111.86	144.33	7.67	12.33	12.00
T ₂	79.67	151.33	177.00	11.33	13.67	14.33
T ₃	60.67	114.33	145.00	8.33	12.78	12.52
T ₄	61.33	118.67	146.00	9.00	12.56	13.67
T ₅	73.33	131.33	161.00	9.33	13.56	13.37
T ₆	80.33	148.67	174.67	9.67	13.56	14.04
T ₇	74.67	136.67	168.00	10.00	12.56	13.28
T ₈	62.00	120.67	150.33	9.67	12.89	13.26
T ₉	70.67	129.67	157.33	8.67	13.00	13.33
T ₁₀	66.67	124.33	152.00	10.33	12.22	12.61
T ₁₁	69.00	126.33	154.00	10.33	12.89	12.59
SEM	1.97	2.72	4.05	0.77	0.29	0.32
CD	5.67	7.85	11.67	2.23	0.84	0.94

T₁- Control (Absolute), T₂- RDF (100% NPK University Recommendation)(100% Urea, DAP, MOP), T₃-50% RDN (100% PK), T₄-50% RDN + 2 Sprays of SNU @ 0.25%, T₅- 50% RDN + 2 Sprays of SNU @ 0.5%, T₆- 50% RDN + 2 Sprays of SNU @ 1.0%, T₇- 50% RDN + 2 Sprays of Conventional urea @ 1.0%, T₈- 50% RDN + 1 Spray of SNU @ 1.0%, T₉- 50% RDN + 2 Sprays of SNU @ 0.5%, T₁₀-25% RDN + 3 Sprays of SNU @ 0.5%, T₁₁-25% RDN + 3 Sprays of Conventional urea @ 1.0%

Table 2: Effect of Super Nano Urea application on cob length, cob weight, grain lines per cob, number of grains per cob, grain yield, straw yield, biological yield and harvest index of Maize crop

Treatments	Cob Length (cm)	Cob Weight (g)	Grain Lines/cob	Number of Grains/cob	Grain Yield (qt/ha)	Straw Yield (qt/ha)	Biological yield q/ha	Harvest Index (%)
T ₁	10.09	49.42	12.00	295.67	13.28	28.33	41.61	31.92
T ₂	16.00	63.72	17.67	416.33	23.00	38.33	61.33	37.50
T ₃	10.37	50.72	14.00	308.67	14.67	27.33	42.00	34.93
T ₄	10.80	51.70	14.33	319.00	16.67	28.00	44.67	37.31
T ₅	13.37	56.93	16.33	380.00	20.33	34.00	54.33	37.42
T ₆	14.67	62.38	17.33	411.33	22.67	37.00	59.67	37.98
T ₇	13.67	58.92	16.67	401.67	20.33	33.33	53.67	37.88
T ₈	11.83	53.02	14.67	327.00	16.00	29.67	45.67	35.04
T ₉	13.10	55.78	16.00	371.00	17.00	32.33	49.33	34.46
T ₁₀	12.33	54.03	14.67	345.00	15.00	31.33	46.33	32.38
T ₁₁	12.37	54.69	15.33	351.00	17.00	31.67	48.67	34.93
SEm±	0.80	1.72	0.67	2.66	0.85	1.10	3.65	1.39
CD at 5%	2.31	4.95	1.93	7.66	2.46	3.17	7.44	3.99

T₁- Control (Absolute), T₂- RDF (100% NPK University Recommendation)(100% Urea, DAP, MOP), T₃-50% RDN (100% PK), T₄-50% RDN + 2 Sprays of SNU @ 0.25%, T₅- 50% RDN + 2 Sprays of SNU @ 0.5%, T₆- 50% RDN + 2 Sprays of SNU @ 1.0%, T₇- 50% RDN + 2 Sprays of Conventional urea @ 1.0%, T₈- 50% RDN + 1 Spray of SNU @ 1.0%, T₉- 50% RDN + 2 Sprays of SNU @ 0.5%, T₁₀-25% RDN + 3 Sprays of SNU @ 0.5%, T₁₁-25% RDN + 3 Sprays of Conventional urea @ 1.0%

Harvest Index

The ratio of grain yield to biological yield, known as the Harvest Index (HI), peaked in T₁ (37.98%), followed by T₇ (37.88%) and T₂ (37.50%). This is an important finding because T₁ showed slightly greater HI, indicating better partitioning efficiency, in addition to matching T₂ in grain yield (Table 2). The enhanced HI under SNU treatments implies that applying nano-urea during the reproductive phases encourages preferential assimilate translocation to growing grains instead of vegetative tissues. This increased partitioning efficiency is a major advantage of nano-fertilizer technology in maize production systems and adds to the total yield advantage (Singh *et al.*, 2024).

Conclusion

Super Nano Urea foliar application at 1.0% concentration with two sprays (at knee-high and tasseling stages) in conjunction with 50% recommended nitrogen dose (T₄) produced growth attributes and yield parameters statistically comparable to the full

recommended fertilizer dose (T₂), as the current investigation conclusively showed. Under T₆, plant height, leaf count, cob length, cob weight, grain lines per cob, and grains per cob were similar to those obtained with 100% RDF. Most significantly, grain yield under T₂ (22.67 q ha⁻¹) increased by 70.71% above the absolute control and was statistically comparable to T₂ (23.00 q ha⁻¹). Additionally, T₆ had the greatest harvest index (37.98%), indicating better assimilate partitioning efficiency when using nano-urea.

The findings clearly show that Super Nano Urea can successfully replace 50% of traditional nitrogen fertilizer without lowering crop yields. This is explained by better synchronization of nutrient supply with crop need, controlled and sustained nitrogen release, less volatilization and leaching losses, and increased foliar absorption. Under SNU application, nitrogen utilization efficiency was roughly twice that of traditional urea, providing significant environmental and economic advantages. By implementing SNU technology, farmers might drastically lower

the cost of nitrogen fertilizer without sacrificing yields, increasing their profitability. Reduced nitrogen application reduces water contamination, nitrate leaching, and greenhouse gas emissions. In eastern Uttar Pradesh, where high temperatures hasten nitrogen losses and inadequate moisture conditions restrict nutrient uptake efficiency, the method is especially pertinent for summer maize. To sum up, Super Nano Urea is a revolutionary development in nitrogen management for summer maize farming. An economically feasible and environmentally sustainable substitute for traditional urea application is the suggested practice of 50% RDN with two foliar sprays of SNU @ 1.0% at knee-high and tasseling stages. This approach supports the more general objective of agricultural intensification with a smaller environmental impact in the area.

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