



Effect of Integrated Neem-coated Urea and Nano-urea Strategies on the Growth and Yield of Sesame (*Sesamum indicum* L.)

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ABSTRACT

The present field experiment was carried out during pre-*kharif* season (February to May) for two consecutive years of 2024 and 2025 at Baruipur Experimental Farm, University of Calcutta, West Bengal, India to evaluate the replacement potential of neem-coated prilled urea (NCPU) with nano-urea in sesame (var. Suprava, CUMS-17). The randomized block design included 10 nitrogen management treatments, combining varied proportions of soil-applied NCPU with foliar nano-urea (4% N) or 2% urea sprays. Growth, yield attributes, and seed yield were recorded and statistically analyzed. Results showed significant effects of nitrogen management on plant height, dry matter accumulation (DMA), crop growth rate (CGR, 30–60 DAS), capsules plant⁻¹, seeds capsule⁻¹, and seed yield. The highest plant height (143.71 cm), DMA (609.28 g m⁻²), CGR (8.28 g m⁻² day⁻¹), capsules plant⁻¹ (69.47), and seed yield (1.09 t ha⁻¹) were achieved with 100% RDN through split NCPU application. This was statistically at par with (75% NCPU+nano-urea spray at 45 DAS; yield: 1.07 t ha⁻¹), suggesting that partial soil-applied N replacement with nano-urea was feasible without yield loss. The study concluded that integrating 75% RDN via NCPU with a single nano-urea spray could sustain yields comparable to full NCPU application, offering a resource-efficient, sustainable nitrogen management option for sesame in West Bengal's pre-*kharif* season.

KEYWORDS: Suprava, nitrogen management, NCPU, resource-efficient, nano-urea

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the earliest domesticated oilseed crops, valued for its nutritional richness and ability to thrive in semi-arid environments, making it integral to both traditional and modern agriculture (Bedigian, 2010). Globally, sesame is cultivated on about 12.97 m ha (Sanni et al., 2024) and is often termed the “Queen of Oilseeds” for its exceptionally high oil content, up to 63%, which exceeds sunflower (45%), groundnut (45–56%), soybean (20%), and rapeseed (40%) (Teklu et al., 2021). Its seeds contain 19–25% protein, high levels of calcium, magnesium, phosphorus, zinc, and iron, and unique lignan antioxidants such as sesamin, sesamol, and sesamol that enhance oxidative stability and human health benefits (Mostashari and Mousavi Khaneghah, 2024; Langyan et al., 2022; Wan et al., 2023; Dossou et al., 2023). India remains the leading sesame producer, with major cultivation in West Bengal, Madhya Pradesh, Gujarat, and Uttar Pradesh. In 2022–23, production reached 8.02 lakh t, with West Bengal contributing 0.251 mt (31% of national output) (Anonymous, 2024). Apart from its edible oil value, sesame cake contains about 32% crude protein and 8–10% residual oil, making it a good livestock feed (Kabinda et al., 2022). Sesame is also linked to antihypertensive, anticancer, antioxidant, and lipid-lowering properties (Mili et al., 2021; Majdalawieh and Mansour, 2019). Yet, productivity in India remains low due to rainfed farming, indeterminate growth, capsule shattering, and poor adoption of improved practices (Kefale and Wang, 2022; Qureshi et al., 2022; Yadav et al., 2022). Nutrient management, particularly nitrogen, is a major constraint. Nitrogen strongly influences vegetative growth, dry matter accumulation, and seed yield, but its efficient use in sesame is limited by leaching and poor synchronization with crop demand (Maqsood et al., 2016; Rosolem et al., 2017). While conventional urea dominates, its low use efficiency causes environmental and economic concerns. Neem-coated prilled urea (NCPU) offers a slow-release alternative, ensuring better nutrient synchrony and reduced losses (Salam et al., 2020; Bellaloui et al., 2018). More recently, nano urea (4% N, 20–50 nm particles) has emerged as an innovative foliar fertilizer with reported uptake efficiencies above 80% (Anonymous, 2025). Field studies show nano urea integrated with conventional nitrogen increases wheat and black gram yields by 5–9% (Islam et al., 2023; Tripathi et al., 2025). In sesame, promising outcomes have been observed where nano urea sprays combined with soil-applied nitrogen sustained yields and improved profitability (Meena et al., 2024; Mandal et al., 2023; Kumar et al., 2023; Singh et al., 2023). Despite these advances, research on integrating nano urea with conventional nitrogen under sesame-based systems in eastern India is scarce. West Bengal, though a leading

sesame-growing state, records yields below the global average, largely due to rainfed conditions and suboptimal nutrient use. Neem-coated urea is widely adopted, but its partial substitution with nano urea remains underexplored, especially during the pre-*kharif* season when nutrient leaching and climatic stresses are prevalent. This knowledge gap highlights the need for evaluating resource-efficient nitrogen strategies that sustain productivity while reducing fertilizer inputs. Therefore, this two-year field experiment was undertaken to assess the replacement potential of neem-coated prilled urea with nano urea sprays in sesame (var. Suprava, CUMS-17) under the pre-*kharif* season of West Bengal. The objective was to evaluate the effects of different nitrogen regimes on growth, yield attributes, and seed yield, aimed to identify sustainable nitrogen management practices that improve nitrogen use efficiency.

2. MATERIALS AND METHODS

2.1. Experimental period and location

The experiment was conducted during pre-*kharif* season (February to May) for two consecutive years of 2024 and 2025 at the Baruipur experimental farm of University of Calcutta, South 24 parganas, West Bengal (88°26'E; 22°22'N; 9 m altitude), to evaluate the suitable replacement of neem coated urea with nano urea. The temperature during the cropping period was in between 19°C to 36°C with an average rainfall of 0.7–120 mm and an average humidity of 72–88%. The soil of the experimental site was clay loam in texture having pH of 5.7, organic carbon 0.64%, available nitrogen 302 kg ha⁻¹, phosphate 24.9 kg ha⁻¹ and potassium 139.7 kg ha⁻¹.

2.2. Experimental design and treatment details

The experiment was laid out with 10 treatments replicated thrice in Randomized block design (RBD). A sesame variety Suprava ‘CUMS-17’ (85–90 days maturity) was sown in line by following a row to row spacing of 30 cm and plant to plant spacing of 10 cm. The treatments followed were T₁: Complete N through neem coated prilled urea (50% as basal+25% at 20 DAS+25% at early flowering); T₂: 50% recommended N through neem coated prilled urea as basal+4 ml l⁻¹ nano urea sprays at 30 DAS and 45 DAS; T₃: 50% recommended N through neem coated prilled urea as basal+2% urea sprays at 30 DAS and 45 DAS; T₄: N through nano urea only-2 sprays (4 ml l⁻¹ spray at 30 and 45 DAS); T₅: N through 2% urea spray only-2 sprays (30 DAS and 45 DAS); T₆: 75% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+4 ml l⁻¹ nano urea spray at 45 DAS; T₇: 75% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+2% urea spray at 45 DAS; T₈: 50% recommended N through neem coated prilled urea (50% N as basal+50%

N at 30 DAS)+4 ml l⁻¹ nano urea spray at 45 DAS; T₉: 50% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+2% urea spray at 45 DAS; T₁₀: Control (No N); N:Nitrogen; DAS: Days after sowing.

2.3. Package and practices

The recommended dose of fertilizer (RDF) was 60 kg Nitrogen ha⁻¹, 30 kg Phosphorus ha⁻¹ and 30 kg Potassium ha⁻¹. Fertilizer doses were applied as per treatment. Other recommended package of practices was followed to raise the crop.

2.4. Observations and procedure of data recorded

The biometric observations for different growth attributes, yield attributes and yield of sesame were recorded at regular interval. Plant height, Number of branches plant⁻¹ at harvest, dry matter accumulation, crop growth rate was measured and calculated. Whereas, at harvest, yield components like number of capsule plant⁻¹, number of seed capsule⁻¹, Test weight, seed yield, were measured and recorded for estimation of yield of sesame.

2.5. Methods of statistical analysis

The data were analyzed by following Analysis of Variance (ANOVA) technique and mean difference were adjusted by the multiple comparison test (Gomez and Gomez, 1984). The significance of different source of variance was tested by error mean square of Fisher's 'F' test at Probability level 0.05. Fisher and Yate's tables were consulted for the determination of critical difference at $p=0.05$ level of significance. The value of standard error of mean (SEm±) and the critical difference (CD) to compare the difference between the treatment means.

3. RESULTS AND DISCUSSION

3.1. Effect of nitrogen management on growth attributes of sesame

The pooled analysis over two years revealed that nitrogen management significantly influenced sesame growth parameters such as plant height, dry matter accumulation, and crop growth rate (CGR), whereas number of branches plant⁻¹ remained statistically non-significant (Table 1).

The tallest plants at harvest were recorded in T₁ (143.71 cm), which was statistically at par with T₆ (136.94 cm), but significantly taller than all other treatments. The enhanced plant height under these treatments could be attributed to timely and adequate nitrogen supply, which promoted vegetative vigor and internodal elongation. Dry matter accumulation followed a parallel trend: T₁ (609.28 g m⁻²) and T₆ (597.90 g m⁻²) were statistically at par and superior to all other treatments. This might be attributed to increased canopy development, enhanced nitrogen assimilation, and improved sunlight interception, leading

to greater photosynthetic biomass production. Similarly, a Punjab-based experiment found that full soil-applied urea achieved the highest heights across multiple growth stages, though 25% nanourea foliar spray also significantly improved height over lower sprays and control Singh et al. (2025). These findings corroborate the current observation that split basal N, especially when coupled with foliar nano-urea, enhanced taller sesame plants. It was also emphasized that dry matter accumulation was positively influenced by synchronized nitrogen release aligned with critical crop stages, as nitrogen was integrated to chlorophyll biosynthesis and photosynthetic efficiency (Maqsood et al., 2016).

Regarding crop growth rate (30–60 DAS), the highest CGR was observed in T₁ (8.28 g m⁻² day⁻¹), which was statistically at par with T₆ (7.98 g m⁻² day⁻¹) and T₇ (7.67 g m⁻² day⁻¹). The improved CGR during this period was indicative of vigorous vegetative growth, a function of adequate nitrogen availability. CGR at this stage reflected biomass accumulation rate during canopy expansion a period when nitrogen uptake was typically maximal (Rosolem et al., 2017). The reduced CGR under T₄ and T₅, which relied solely on foliar sprays, suggested that exclusive foliar application might not satisfy the root-zone N demand during rapid biomass expansion, a point also mentioned by El-Sherif (2016) in Egyptian sesame systems. This also corresponded with Meena et al. (2024), where sesame received significant biomass gains from combined nano-fertilizer and conventional urea demonstrating increased dry matter accumulation and profitability. In contrast, CGR from 60 DAS to harvest showed, the highest value was found in T₆ (11.48 g m⁻² day⁻¹) and all other treatments remained statistically at par except the foliar only (T₄ and T₅) and control (T₀) treatments, suggesting that a combination of basal and later-stage nitrogen availability supported reproductive biomass production. This trend aligned with the findings of Damdar et al. (2015) and Gebremariam (2015), who emphasized the role of late-stage nitrogen in enhancing pod filling and seed development.

Branch production, while not statistically different across treatments, was numerically highest under T₁ (4.04) and T₆ (4.01). Gebremariam (2015) also reported that split application of nitrogen enhanced axillary meristem activity, which might contribute to better branching, a vital yield component in sesame.

It was observed that T₁₀ (control) consistently recorded the lowest values across all growth attributes. This clearly highlighted the necessity of nitrogen in sesame for promoting vegetative and early reproductive growth that without any N, vegetative growth remained minimal, with shorter and sparser plants correlating researches of Salam et al. (2020); Bellaloui et al. (2018) Foliar-only treatments

Table 1: Effect of nitrogen management on growth, yield attributes and seed yield of sesame at different growth stages (Pooled data)

Treat- ment	Plant height at harvest (cm)	No. of branches plant ⁻¹ at harvest	Dry matter accumulation at harvest (g m ⁻²)	Crop growth rate at 30–60 DAS (g m ⁻² day ⁻¹)	Crop growth rate at 60 DAS-at harvest (g m ⁻² day ⁻¹)	Capsule plant ⁻¹	Seed capsule ⁻¹	Test weight (g)	Seed yield (t ha ⁻¹)
T ₁	143.71	4.04	609.28	8.28	11.32	69.47	53.50	2.92	1.09
T ₂	127.49	3.96	495.35	5.64	10.38	63.28	50.41	2.81	0.93
T ₃	127.07	3.98	489.37	5.41	10.43	62.07	50.27	2.80	0.90
T ₄	99.77	4.00	399.88	4.24	8.73	56.78	44.72	2.66	0.71
T ₅	106.30	3.98	364.36	4.04	7.83	52.90	49.36	2.76	0.68
T ₆	136.94	4.01	597.90	7.98	11.48	66.12	53.45	2.89	1.07
T ₇	133.61	3.97	550.72	7.67	10.23	63.68	51.64	2.80	1.00
T ₈	121.61	3.66	484.04	5.15	10.55	59.42	51.66	2.86	0.88
T ₉	121.57	3.29	480.83	5.07	10.56	57.70	51.15	2.80	0.86
T ₁₀	95.04	3.66	291.51	3.80	5.59	49.82	47.67	2.49	0.55
SEm±	3.24	0.40	14.61	0.22	0.49	1.35	1.03	0.03	0.03
CD (<i>p</i> =0.05)	9.31	NS	41.91	0.63	1.41	3.88	2.96	0.09	0.07

T₁: Complete N through neem coated prilled urea (50% as basal+25% at 20 DAS+25% at early flowering); T₂: 50% recommended N through neem coated prilled urea as basal+4 ml l⁻¹ nano urea sprays at 30 DAS and 45 DAS; T₃: 50% recommended N through neem coated prilled urea as basal+2% urea sprays at 30 DAS and 45 DAS; T₄: N through nano urea only-2 sprays (4 ml l⁻¹ spray at 30 and 45 DAS); T₅: N through 2% urea spray only-2 sprays (30 DAS and 45 DAS); T₆: 75% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+4 ml l⁻¹ nano urea spray at 45 DAS; T₇: 75% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+2% urea spray at 45 DAS; T₈: 50% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+4 ml l⁻¹ nano urea spray at 45 DAS; T₉: 50% recommended N through neem coated prilled urea (50% N as basal+50% N at 30 DAS)+2% urea spray at 45 DAS; T₁₀: Control (No N); N:Nitrogen; DAS: Days after sowing

(T₄ and T₅) recorded lower performance across parameters, reinforcing the idea that foliar nitrogen alone, particularly nano urea or 2% conventional urea, cannot totally substitute for a full soil-applied nitrogen regime.

3.2. Effect of nitrogen management on yield attributes of sesame

The pooled data over two years showed that nitrogen management treatments had a significant effect on key yield attributes of sesame, number of capsules plant⁻¹ and seeds capsule⁻¹, test weight (Table 1).

Across these parameters, T₁ Complete N through neem coated prilled urea (50% as basal+25% at 20 DAS+25% at early flowering) consistently recorded the highest values 69.47 capsules plant⁻¹, 53.50 seeds capsule⁻¹, and 2.92 g test weight, all significantly superior to most treatments. T₆ ranked next, with values statistically at par with T₁ for 53.45 seeds capsule⁻¹, 2.89 g test weight and 66.12 capsules plant⁻¹. Enhanced capsule setting in T₁ and T₆ could be attributed to balanced and timely nitrogen availability

during flowering, promoting axillary bud differentiation, flower development, and pod retention. This aligned with Salam et al. (2020), who reported higher capsules plant⁻¹ with increased nitrogen, enhancing photosynthate production and allocation to reproductive sinks. For seeds capsule⁻¹, superior treatments supplied nitrogen during critical flowering and seed development stages, improving pollen fertility, fertilization, and seed set, consistent with El-Sherif (2016), Gebremariam (2015), and Hassan et al. (2018), who emphasized the role of reproductive-phase nitrogen in seed filling and seed count.

The test weight, though numerically highest under T₁ (2.92 g) and T₆ (2.89 g), but not differed too much with all other treatments. This indicated that genotypic factors also have an influence with nitrogen levels, primarily control seed mass in sesame. A conclusion by Khan et al. (2016), who also observed linear increase in test weight with relation to increasing level of nitrogen.

Overall, the superior performance of T_1 highlighted the importance of synchronizing nitrogen supply with crop demand. The results also confirm that T_6 , which integrated 75% neem-coated prilled urea with a nano urea spray at 45 DAS, was equally effective in enhancing yield attributes, providing a potential strategy for partial nitrogen substitution without yield penalty. In contrast, treatments relying exclusively on foliar nutrition (T_4 and T_5) or reduced soil-applied nitrogen (T_8 and T_9) demonstrated moderate to poor performance. The control treatment T_{10} consistently produced the lowest values across all yield parameters, reinforcing nitrogen's vital role in reproductive development, reflecting that foliar N alone did not satisfy the nitrogen demand during capsule initiation and seed growth stages. (Sarkar et al., 2025); (Khan et al., 2016).

3.3. Effect of nitrogen management on seed yield of sesame

Seed yield differed significantly among treatments confirming that nitrogen management markedly impacts economic output in sesame (Table 1). Treatment T_1 , which received 100% recommended dose of neem-coated prilled urea in split soil application, produced the highest pooled yield of 1.09 t ha^{-1} . Treatment T_6 , combining 75% soil-applied N with a nano-urea foliar spray, statistically at par at 1.07 t ha^{-1} , indicating that strategic foliar supplementation could nearly match full-dose soil application. This outcome corroborated field trial by Singh et al. (2023), that incremental nitrogen rates significantly boost sesame seed yield, especially when split applied to match crop demand across growth stages.

These treatments performed better than foliar-only (T_4 , T_5 : $0.71\text{--}0.68 \text{ t ha}^{-1}$) or no nitrogen (T_{10} : 0.55 t ha^{-1}) treatments, underscoring that a minimum soil-applied N component was essential for achieving appreciable yields. Soil-applied nitrogen played a vital role in supporting early vegetative growth and capsule formation, which foliar application alone could not sustain. Adequate soil N ensured continuous nutrient uptake and promoted photosynthetic activity, assimilate translocation, and efficient seed filling, ultimately leading to superior yield fulfillment in sesame. Adisu et al. (2020) concluded that the combined effect of nitrogen and phosphorus fertilization significantly enhanced the final yield and critical yield components of sesame, underscoring that optimizing the soil nutrient matrix was essential for maximizing biological efficiency. Bellaloui et al. (2018) specifically found that increasing soil nitrogen application rates positively correlated with a substantial increase in overall sesame seed yield, affirming the direct link between sustained N supply and maximized harvestable output. Furthermore, Salam et al. (2020) demonstrated that varying levels of soil-applied nitrogen obtained beneficial effects on the vegetative growth characteristics and the final yield metrics.

4. CONCLUSION

Substituting 25% of the recommended nitrogen dose from neem-coated prilled urea (NCPU) with a single foliar spray of nano-urea at 45 DAS maintained sesame yields comparable to full NCPU application. The integrated treatment significantly improved plant growth, dry matter accumulation, and yield attributes. This strategy had improved nitrogen use efficiency through an appropriate partial substitution of soil-applied nitrogen.

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