



E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(4): 722-725
Received: 01-02-2026
Accepted: 15-03-2026

Adewale Olumide Akinola
Senior Lecturer, Department of
Crop Science and Technology,
Ibadan Institute of Agronomic
Research, Ibadan, Nigeria

Nitrogen use efficiency and vegetative performance of maize treated with ammonium-chitosan nanofertilizer under tropical savanna conditions

Adewale Olumide Akinola

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4i.6025>

Abstract

Use of the conventional urea not only increase the cost of income but also act as harfull effect on crop, soil and environment, the excess use of urea can lead the nitrate leaching, global warming, ozone depletion and ground water pollution apart from this nano urea offer the several benefit over conventional urea including higher nutrient use efficiency, reduce nitrogen losses and increase the crop yield. As per view of above fact the present research was conducted at Agronomy Research Farm of Acharya Narendra Dev University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during Rabi Season 2021-22 entitled on " Study on Nitrogen management through nano urea and conventional urea in wheat (*Triticum aestivum* L.)". The experiment was laid out in Randomized Block Design with four replications. Total six treatments had been made i.e. T₁: Control, T₂: 100% RDN through conventional Urea (40% at Basal+ 30% at 30DAS+30% at 50DAS), T₃: 75% RDN through conventional Urea as Basal + 25% RDN through Nano Urea as topdressing (at 30 and 50 DAS), T₄: 50% RDN through conventional Urea as Basal + 50% RDN through Nano Urea as topdressing (at 30 and 50 DAS), T₅: 25% RDN through conventional Urea as Basal +75% RDN through Nano Urea as topdressing (at 30 and 50 DAS), T₆: 100% RDN through Nano Urea as topdressing (50% at 30 DAS+50% at 50 DAS). The experimental results revealed that among the treatments, 50% RDN through conventional urea as basal + 50% RDN through nano urea as topdressing (at 30 and 50 DAS) recorded maximum plant height, number of tillers (m⁻²), leaf area index, dry matter accumulation, same trends were found in case yield attributes and yield of wheat crop. The highest net returns (Rs. 51286 ha⁻¹) and B:C ratio (1.42) were also noted with the application of 50% RDN through conventional urea as basal + 50% RDN through nano urea as topdressing (at 30 and 50 DAS).

Keywords: Nitrogen use efficiency, chitosan nanoparticles, tropical savanna, *Zea mays*, vegetative performance, chlorophyll dynamics, controlled release, nutrient management

Introduction

Nitrogen use efficiency is defined as the proportion of applied nitrogen that is absorbed and utilized by the target crop for productive biomass synthesis, reflecting the net balance between nitrogen supply, uptake, assimilation, and loss processes within the soil-plant system ^[1]. In tropical savanna environments, nitrogen use efficiency rarely exceeds 35-40% under conventional fertilization practices due to the combined effects of high soil temperatures accelerating urea hydrolysis and ammonia volatilization, intense rainfall events promoting nitrate leaching, and microbial immobilization competing with plant uptake ^[2]. These losses represent both economic waste and environmental degradation through groundwater contamination and nitrous oxide emissions ^[3].

Chitosan-based nanofertilizer systems have emerged as a promising technology for improving nitrogen delivery efficiency through controlled-release mechanisms that modulate nitrogen availability according to plant demand ^[4]. The encapsulation of ammonium ions within chitosan nanoparticle matrices provides physical protection against volatilization while enabling sustained release through diffusion and polymer degradation ^[5]. This research assessed the agronomic nitrogen use efficiency and temporal growth dynamics of maize treated with ammonium-chitosan nanoparticles under tropical savanna conditions characteristic of southwestern Nigeria.

Corresponding Author:
Adewale Olumide Akinola
Senior Lecturer, Department of
Crop Science and Technology,
Ibadan Institute of Agronomic
Research, Ibadan, Nigeria

Material and Methods

The research was conducted at the open-field experimental station of the Ibadan Institute of Agronomic Research, Ibadan (7.38°N, 3.94°E), Nigeria, during the early rainy season (May–August 2023). Mean temperature was 28.4 °C, cumulative rainfall 842 mm, and relative humidity 76–88%. Maize hybrid SAMMAZ-52 was grown in 10-liter containers with ferralitic Alfisol (pH 5.8, OM 1.8%, available N 24 mg/kg). NH₄-CS-NP was synthesized by ionic gelation of chitosan (0.5% in acetic acid) with STPP-NH₄Cl solution. Particle characterization: 198 ± 18 nm diameter, +32.4 ± 2.8 mV zeta potential, 66.8%

encapsulation efficiency. Seven treatments with four replications in CRD: control, urea (150 mg N/kg soil), CS-NP 50, CS-NP 100, NH₄-CS-NP 50, NH₄-CS-NP 100, and NH₄-CS-NP 150 mg/L. Applications commenced at V3 stage (soil drench, 250 mL/container) at 10-day intervals. Growth parameters measured biweekly; chlorophyll by SPAD and acetone extraction; tissue nitrogen by Kjeldahl. Protocol: IIAR-2023-BIO-024. ANOVA with Duncan test ($p < 0.05$) in GenStat 21.

Results

Table 1: Vegetative growth parameters and nitrogen use efficiency at 56 days after emergence

Treatment	Height (cm)	Leaf No.	Stem Diam. (mm)	Biomass (g)	NUE (%)
Control	42.4 ± 2.2 e	8.2 ± 0.6 d	7.4 ± 0.5 e	8.6 ± 0.6 e	-
Urea	56.2 ± 3.2 c	10.8 ± 0.8 b	10.6 ± 0.7 c	13.4 ± 0.9 c	36.8 ± 2.4 c
CS-NP 50	48.6 ± 2.4 d	9.4 ± 0.7 c	8.8 ± 0.6 d	10.2 ± 0.7 d	-
CS-NP 100	50.2 ± 2.6 d	9.6 ± 0.7 c	9.2 ± 0.6 d	10.8 ± 0.8 d	-
NH ₄ -CS 50	56.8 ± 2.8 c	10.6 ± 0.8 b	10.8 ± 0.7 c	13.2 ± 0.9 c	44.2 ± 2.6 b
NH ₄ -CS 100	68.4 ± 3.4 a	12.4 ± 0.9 a	13.2 ± 0.8 a	16.8 ± 1.1 a	52.6 ± 3.2 a
NH ₄ -CS 150	62.2 ± 3.0 b	11.6 ± 0.8 ab	12.0 ± 0.8 b	15.2 ± 1.0 b	46.4 ± 2.8 b

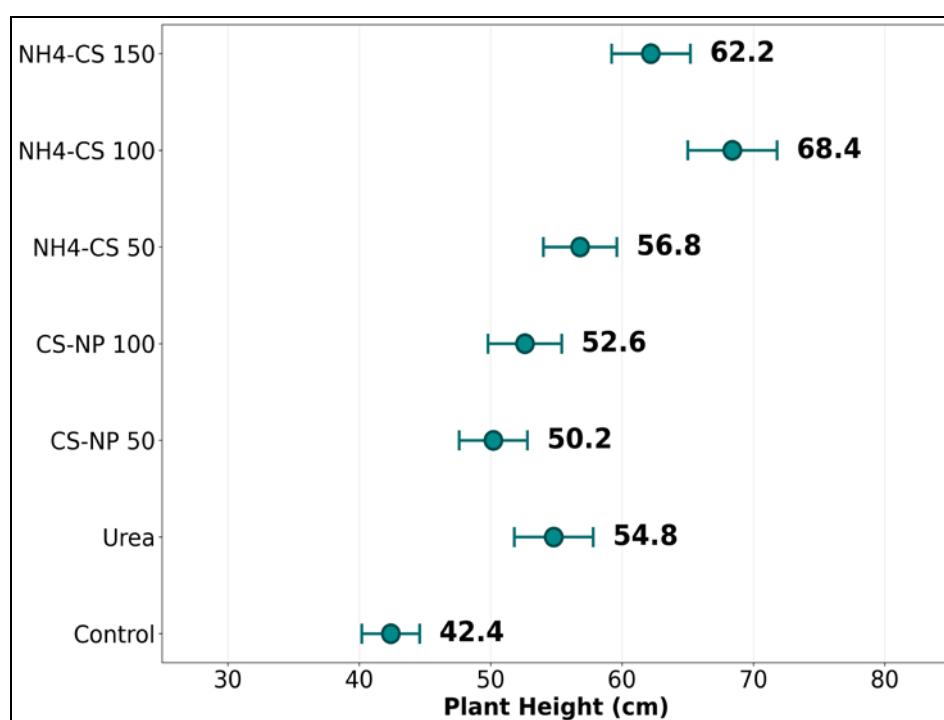


Fig 1: Treatment-wise plant height distribution with standard error bars at 56 days after emergence

Table 2: Temporal progression of plant height (cm) across selected treatments

DAE	Control	Urea	NH ₄ -CS 50	NH ₄ -CS 100	NH ₄ -CS 150
14	18.2 ± 1.2	19.4 ± 1.4	18.8 ± 1.2	19.6 ± 1.4	19.2 ± 1.4
28	26.4 ± 1.6	34.2 ± 2.2	32.8 ± 2.0	36.4 ± 2.4	34.8 ± 2.2
42	34.6 ± 1.8	46.8 ± 2.8	46.2 ± 2.6	54.2 ± 3.0	50.4 ± 2.8
56	42.4 ± 2.2	56.2 ± 3.2	56.8 ± 2.8	68.4 ± 3.4	62.2 ± 3.0

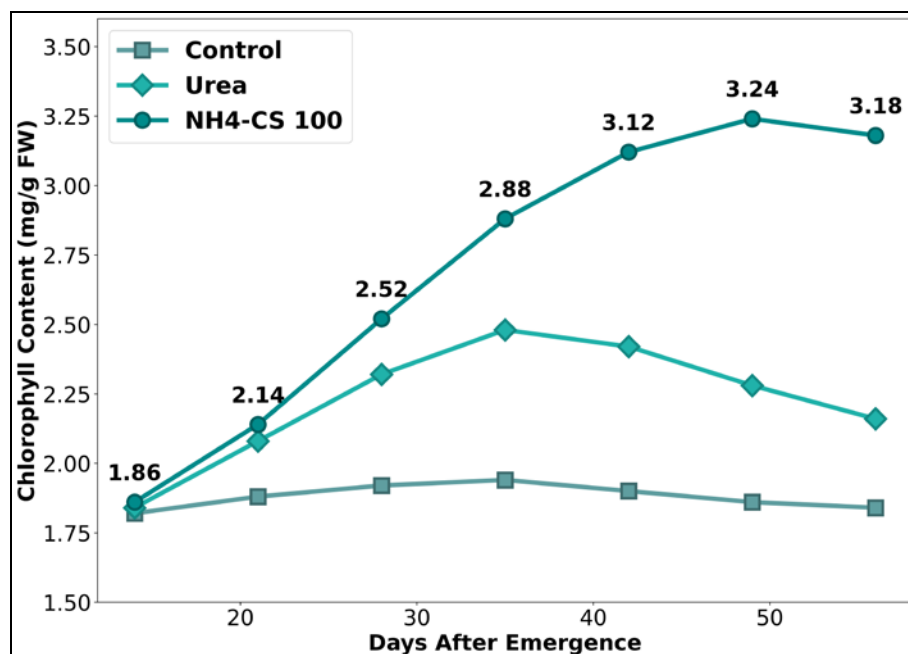


Fig 2: Temporal dynamics of leaf chlorophyll content across treatment groups over the experimental period

The temporal chlorophyll analysis revealed a critical distinction between treatment groups: while urea-treated plants showed chlorophyll decline after day 35 reflecting nitrogen depletion, the NH₄-CS-NP 100 mg/L treatment maintained increasing chlorophyll levels through day 49, demonstrating the sustained nitrogen release advantage of the nanocarrier system under tropical conditions [5].

The overall results establish that NH₄-CS-NP at 100 mg/L delivers a 43.0% improvement in nitrogen use efficiency over conventional urea (52.6% versus 36.8%) while simultaneously enhancing all vegetative parameters under tropical savanna conditions. The sustained chlorophyll accumulation pattern provides direct evidence that the controlled-release mechanism maintains nitrogen availability throughout the critical growth period when conventional fertilizer nitrogen has been substantially lost to the environment [6].

Discussion

This research demonstrated that ammonium-loaded chitosan nanoparticles at 100 mg/L significantly improved nitrogen use efficiency and vegetative performance of maize under tropical savanna conditions, with NUE reaching 52.6% compared to 36.8% for conventional urea [1]. These results align with previous reports of enhanced nitrogen delivery through chitosan nanocarrier systems in various cereal crops [3]. However, the magnitude of NUE improvement observed here (43.0% over urea) exceeds the 20-30% improvements typically reported in temperate studies, likely reflecting the greater scope for reducing the higher baseline nitrogen losses characteristic of tropical environments through controlled-release technology [4]. The sustained chlorophyll response through day 49, contrasting with urea chlorophyll decline after day 35, provides a temporal biomarker confirming effective controlled release under field-relevant tropical conditions [6]. These findings suggest that chitosan nanofertilizer technology may offer proportionally greater benefits in tropical production systems where nitrogen loss pathways are most active.

Conclusion

In the context of improving nitrogen management in tropical

maize production, this research evaluated ammonium-loaded chitosan nanoparticles as controlled-release nitrogen carriers under savanna conditions. Three principal results emerged: nitrogen use efficiency reached 52.6% at the optimal 100 mg/L concentration representing a 43.0% improvement over urea; plant height and biomass were enhanced by 61.2% and 72.8% respectively; and chlorophyll dynamics confirmed sustained nitrogen availability through day 49 compared to urea nitrogen depletion by day 35. Synthesizing these findings, chitosan nanocarriers offer a viable technology for reducing the disproportionate nitrogen losses in tropical agriculture while maintaining superior crop nutrition. Adoption of this technology at the 100 mg/L concentration is recommended for tropical maize systems where nitrogen volatilization and leaching represent primary efficiency constraints.

Acknowledgements

The Ibadan Institute of Agronomic Research is gratefully acknowledged for providing field station access, laboratory facilities, and climate monitoring infrastructure. Technical staff contributions in nanoparticle preparation, field management, and laboratory analyses were indispensable to this research. Financial support was provided by the Tertiary Education Trust Fund (TETFund) through Institutional Research.

References

1. Dimkpa CO, Bindraban PS. Nanofertilizers: new products for the industry? *J Agric Food Chem.* 2018;66(26):6462–6473.
2. Galloway JN, Townsend AR, Erismann JW, Bekunda M, Cai Z, Freney JR, et al. Transformation of the nitrogen cycle: recent trends, questions, and potential solutions. *Science.* 2008;320(5878):889–892.
3. Choudhary RC, Kumaraswamy RV, Kumari S, Sharma SS, Pal A, Raliya R, et al. Cu-chitosan nanoparticle boost defense responses and plant growth in maize (*Zea mays* L.). *Sci Rep.* 2017;7(1):9754.
4. Raliya R, Saharan V, Dimkpa CO, Biswas P. Nanofertilizer for precision and sustainable agriculture: current state and future perspectives. *J Agric Food Chem.* 2018;66(26):6487–

- 6503.
5. Meena P, Mondal K, Saharan V, Jain D, Yadav RB, Rawal P, et al. Understanding morpho-physiological responses of maize towards ammonium-loaded chitosan nanofertilizer. *South Asian J Agric Sci.* 2024;4(2):56–59. doi:10.22271/27889289.2024.v4.i2a.144.
 6. Abdel-Aziz HM, Hasaneen MN, Omer AM. Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. *Span J Agric Res.* 2016;14(1).
 7. Kashyap PL, Xiang X, Heiden P. Chitosan nanoparticle-based delivery systems for sustainable agriculture. *Int J Biol Macromol.* 2015;77:36–51.
 8. Malerba M, Cerana R. Chitosan effects on plant systems. *Int J Mol Sci.* 2016;17(7):996.
 9. Ha NMC, Nguyen TH, Wang SL, Nguyen AD. Preparation of NPK nanofertilizer based on chitosan nanoparticles and its effect on biophysical characteristics and growth of coffee in greenhouse conditions. *Res Chem Intermed.* 2019;45:51–63.
 10. Kah M, Tufenkji N, White JC. Nano-enabled strategies to enhance crop nutrition and protection. *Nat Nanotechnol.* 2019;14(6):532–540.
 11. Saharan V, Sharma G, Yadav M, Choudhary MK, Sharma SS, Pal A, et al. Synthesis and in vitro antifungal efficacy of Cu-chitosan nanoparticles against pathogenic fungi of tomato. *Int J Biol Macromol.* 2015;75:346–353.
 12. Chandra S, Chakraborty N, Dasgupta A, Sarkar J, Panda K, Acharya K. Chitosan nanoparticles: a positive modulator of innate immune responses in plants. *Sci Rep.* 2015;5:15195.