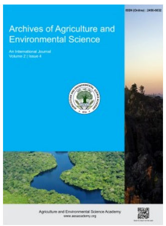
Archives of Agriculture and Environmental Science 10(4): 687-691 (2025)
https://doi.org/10.26832/24566632.2025.1004018

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE

CrossMark

Evaluation of Nano urea on growth and yield parameters of cowpea (*Vigna unguiculata*) in Chitwan, Nepal

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ARTICLE HISTORY

Received: 07 October 2025
Revised received: 14 December 2025
Accepted: 19 December 2025

Keywords

Granular urea
Nano urea
Nitrogen use efficiency
Yield characteristics

ABSTRACT

Granular urea has low nitrogen use efficiency and poses environmental risks. As a response, Nano urea is emerging as an innovative substitute. A field experiment conducted at Chitwan, Nepal to explored the effect of Nano urea on growth and yield parameters of cowpea, and its potential to substitute granular urea. The experiment was laid out in Randomized Block Design, with eight treatments and three replications: control, 100% recommended dose of nitrogen (RDN) through granular urea, single and double spray of Nano urea at 0.2% and 0.4%, and combination of 50% of RDN with 0.2% and 0.4% Nano urea. Various growth and yield parameters such as plant height, canopy diameter, leaf area index, number of primary branches, pod yield, pod length, pod diameter, pod per plant were recorded, which were found significantly affected by the treatments. Results revealed that 50% RDN granular urea + NU (0.2%) recorded the highest canopy diameter (97.43 cm), primary branches (5.92) leaf area index (0.38), pod yield (12.59), and pods per plant (30.6), with single spray of 0.2% of Nano urea at flowering stage being the most effective. Therefore, the study demonstrated that Nano urea has potential to substitute 50% of conventional granular urea, contributing to sustainable cowpea production.

Citation of this article: Nepal, S., Bhandari, S., Mainali, S., & Subedi, S. (2025). Evaluation of Nano urea on growth and yield parameters of cowpea (*Vigna unguiculata*) in Chitwan, Nepal. *Archives of Agriculture and Environmental Science*, *10*(4), 687-691, https://dx.doi.org/10.26832/24566632.2025.1004018

INTRODUCTION

Cowpea is warm-season leguminous crop, known for its nutritional benefits and improving soil fertility. It has an origin in Africa, and widely grown throughout tropical and subtropical regions (Aghora *et al.*, 2024; Herniter *et al.*, 2020). The average global productivity of cowpea is 0.643 tons/ha, while its productivity in Nepal is 0.61 t/ha (Pandey *et al.*,1970; FAO 2024). It is mostly cultivated in Terai -mid hills as an important summer season legume, particularly in marginal land with limited inputs (Dhakal, 2020). Ensuring sufficient nutrient supply is crucial for the maximum growth and yield of cowpea (Raja *et al.*, 2022). Nitrogen, an essential protein and chlorophyll component, must be provided to the crop on time (Dhakal *et al.*, 2019). Because, limited nitrogen in the soil slows down the *Rhizobium* bacteria, consequently hindering the vegetative growth, since the plants do not receive the necessary amount of nitrogen (Kaymak & Acar, 2021). Globally, nitrogen is mostly supplied through granular urea. This is evident by the fact that, in the last four decades, the global urea usage has increased more than hundred-folds, currently accounting for over half of worldwide nitrogenous fertilizer consumption (Glibert *et al.*, 2006).

Despite its widespread use, only 30- 40 percent of nitrogen from granular urea is utilized by plants and remaining is subjected to leaching and volatilization loss consequently leading to low NUE, greenhouse gas emissions and water pollution which necessities exploring of alternative solution (Houlton *et al.*, 2019; Tripathi *et al.*, 2025). To combat this issue, nano urea -a liquid fertilizer with particle sizes ranging from 20-50 nm and a larger surface area, is emerging as an alternative substitute to conventional fertilizers (Hu & Xianyu, 2021). With the use of nanotechnology, it delivers nitrogen more efficiently to the target areas in the plant, reducing losses, and increasing efficiency (Mehta *et al*., 2024; Yarang *et al*., 2022). As it is applied directly on leaves, it easily enters through the stomata and gets assimilated through the plant cells and resulting about 25% higher nitrogen use efficiency as compared to conventional urea (Subramani *et al*., 2023). The use of nano-urea not only causes increased use efficiency but also minimize the toxicity resulting from over-application in the soil (Kumar, 2021). 500 ml of nano urea is claimed to be equivalent to one sack of 45 Kg urea (45 Kg) which reduce the production cost leading to higher profit for farmers, making nano urea more superior than granular urea on economic basis too (Sandeep *et al*., 2024). Despite the increasing use of Nano urea, existing studies provides limited evidence on its application rate, frequency, and its potentiality to fully or partially substitute granular urea. So, this study addresses this by evaluating the efficiency of nano urea as a substitute for granular urea in increasing cowpea productivity.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in spring season at Horticulture research farm of Institute of Agriculture and Animal Science (IAAS), Karahanl, Chitwan, Nepal which is located at the latitude: 27° 36' 26.34" N and at the Longitude: 84° 33' 52.29" E.

Experimental design

During the study, the experiment was conducted using a single-factor Randomized Complete Block Design (RCBD) and comprises eight treatments, each replicated thrice. The details of treatments are given in Table 1. The local bushy type cowpea variety-Prakash was selected to ensure local relevance. The distance between replications was 1 meter, while the distance between plots within a replication was 0.5 meters. In total, there were 24 plots. 1 m gap was maintained along the outer perimeter, and each plot measured 2.7.

Nutrient management

During field treatments, the recommended doses of FYM 8ton ha^{-1} phosphorus (40 kg P_2O_5 ha^{-1}) and potassium (20 kg K_2O ha^{-1}) through SSP and MOP respectively to all the treatments and granular urea was applied basally as per the treatment dose for the nitrogen supplement. Nano urea was sprayed using knack sap sprayer only once at 30 days after sowing (DAS) for the single spray treatments while at 30 DAS and 45 DAS for double spray treatments.

Table 1. Treatment details used in the study.

S. No.	Symbol	Treatment
1	T_1	Control nitrogen
2	T_2	100% *RDN through granular urea
3	T_3	Nano urea (NU) single spray (0.2%)
4	T_4	Nano urea (NU) double spray (0.2%)
5	T_5	Nano urea (NU) single spray (0.4%)
6	T_6	Nano urea (NU) double spray (0.4%)
7	T_7	50% RN through granular urea+ nano urea (NU) (0.2%)
8	T_8	50% RN through granular urea+ nano urea (NU) (0.4%)

Note*-RDN=Recommended dose of Nitrogen.

Data collection

Five randomly selected plants were taken and the data on plant height, canopy diameter, primary branch, LAI, pod length, pod diameter, marketable pod percentage, pod yield were taken. The vegetative parameters were recorded at maturity in all the plots. The height of the selected plant was measured from the ground surface to the tip of the plant using a measuring scale. The canopy diameter was measured following the standard procedure used in Wangyal, (2012). Each plant was observed to find longest and shortest horizontal spans and then those extreme ends were measured using measuring scale and averaged to calculate canopy diameter. Likewise, leaf area index (leaf area/ canopy diameter) and primary branches and plant height was measured following standard procedures. Likewise, marketable pod percentage was calculated visually by sorting the pods against its length, breadth, free of disease and insect infestation and acceptance on the market as per the method used by Beshir *et al.* (2015) and pod length and diameter was measured using measuring scale and Vernier caliper, respectively.

Statistical analysis

For this, MS EXCEL was used for data entry, construction of graphs, and tables. Simple statistical analysis was done through R-studio. ANOVA was used for the significance difference of each parameter at a 5% level of significance.

RESULTS AND DISCUSSION

Biometric characteristics

In the study, the highest height (129.280 cm) was observed in the Nano Urea double spray (0.4%) which is statistically superior to other treatments whereas the lowest height (81.80 cm) was obtained in the control (Table 2). Previously, Subramani *et al.* (2023) also reported increased concentration of Nano spray (0.4%) has a significant impact on the plant height which is attributed to the availability of N. The increase in height at the double spray of nano urea might be due to the optimum nitrogen availability leading to the improved nutritional status of plants across different growth stages of cowpea. A similar result was observed by Ojha *et al.* (2023) in wheat. Similarly, the maximum number of primary branches were observed in 50% RN granular -urea+ NU (0.2%) which is statistically at par with 50%RN granular urea+ NU (0.4%). A similar effect was also observed in Borago officinalis L by Mahmoodi *et al.* (2018). In the same way, canopy diameter differed significantly for maximum (97.43 cm) in 50% RN granular urea+ NU (0.2%) which is statistically at par with 50%RN granular urea+ NU (0.4%) and Nano urea double spray (0.4%) (Table 2). The higher number of branches in this treatment could have been attributed to an increase in the canopy diameter. While the control treatment reached the minimum canopy diameter (59.40 cm). In addition, the combined, application of nano urea and granular urea gave the highest (0.038) Leaf Area Index which is at par with 100% RDN through granular urea (Table 2). Similar finding was reported in the previous study of Dhawne *et al.* (2023) where he stated, increased LAI in rice is due to the enhanced nutrient uptake by the plant cell which increase cell division and elongation. Nano fertilizers helps in increased production of plant hormones and carbon forming enzymes, thus accelerates the meristematic division, which is responsible for increased plant height, branches, LAI and diameter (Nofal *et al.*, 2024)

Yield and yield attributing characteristics

During the study, the highest pod length (14.90 cm) and pod diameter (0.76 cm) was obtained in 50%RN granular urea+ NU (0.2%) which contributed to the highest pod yield (12.59-ton ha-1) in the same treatment which is statistically at par 100% RDF through granular urea (Table 3). This finding is consistent with Subramani *et al.* (2023) in okra, Rawat *et al.* (2024) in maize, where they suggested that this may be due to the role of basal dose of granular in meeting initial nitrogen requirement along with the split application of nano urea releases slowly and fulfill the plant requirement during the reproductive stage. The application of 50%RN through granular urea+ nano urea (0.2%) gives a significantly higher (30.06) number of pods per plant followed by 100% RDN through granular urea (Table 3). The application of nano urea at 30 DAS might have been responsible for nutrient availability which reduces the flower drop, leading to the higher number of pods in this treatment. On the other hand, the lowest pod number (11.00) was reported in control. Our finding aligns with Kumari *et al.*(2024) in maize. Meanwhile, the control treatment gives the highest marketable pod percentage (84.37%) which is statistically at par with 50%RN granular urea+ NU (0.2%). In all treatments, farmyard manure (FYM) was applied, so although the control treatment yielded the fewest pods, it resulted in the highest percentage of marketable pods, even without granular and nano urea. On the other hand, the lowest marketable pod percent (49.97%) was obtained in nano urea double sprays (0.4%). The observed decline in the marketable pod percentage may have resulted from the lush vegetative growth caused by the nano urea double spray (0.4%), consequently increasing insect susceptibility and reducing the marketable quality of the pods (Table 3). Similar observations were made by Rahman (2022). Previously, Singh *et al.* (2023) also stated that when excessive fertilizer is applied to legumes, they lose their biological ability to fix atmospheric nitrogen, resulting in a decline in pod quality.

Table 2. Effect of nano-urea and granular urea on different biometric characteristics of cowpea at the time of harvest.

Treatments	Plant Height (cm)	Canopy diameter (cm)	Primary branches	Leaf area index
T_1: Control nitrogen	81.800^{d}	59.406^{c}	2.520^{f}	0.026^{b}
T_2: 100%RDN through granular urea	96.363^{cd}	72.356^{bc}	4.886^{bc}	0.038^{a}
T_3: NU single spray (0.2%)	100.280^{bcd}	70.863^{bc}	3.013^{ef}	0.033^{a}
T_4: NU double spray (0.2%)	103.910^{bc}	62.116^{c}	3.633^{de}	0.036^{a}
T_5: NU single spray (0.4%)	110.056^{bc}	82.200^{ab}	4.533^{bcd}	0.034^{a}
T_6: NU double spray (0.4%)	129.280^{a}	94.733^{a}	4.026^{cd}	0.035^{a}
T_7: 50%RN granular urea+ NU (0.2%)	121.656^{ab}	97.433^{a}	5.920^{a}	0.038^{a}
T_8: 50%RN granular urea+ NU (0.4%)	98.266^{cd}	84.053^{ab}	5.100^{ab}	0.032^{a}
Grand mean	105.201	77.895	4.204	0.034
SEM (±)	7.120	6.248	0.326	0.002
CV%	11.723	13.892	13.432	10.02
LSD	21.597	18.950	0.989	0.006
F-Test	**	**	***	*

Note: * Significant at the 0.05 probability level; ** Significant- at the 0.01 probability level; *** Significant at the 0.001 probability level: NS, not significant. Means followed by common letter do not significantly differ at 5% level of significance.

Table 3. Effects of nano-urea and conventional urea on yield attributing characters of cowpea at the time of harvest.

Treatment	Yield (Ton ha^{-1})	Pod length (cm)	Pod diameter (cm)	Marketable pod (%)	Pod/Plant
T_1: Control nitrogen	8.56^{d}	11.55^{b}	0.60^{d}	84.37^{a}	11.00^{d}
T_2: 100%RDF granular urea	11.97^{a}	14.61^{a}	0.67^{bcd}	82.34^{ab}	21.80^{b}
T_3: NU single spray (0.2%)	11.00^{abc}	13.19^{ab}	0.72^{abc}	75.89^{abc}	11.80^{d}
T_4: NU double spray (0.2%)	10.95^{abc}	13.50^{a}	0.70^{abc}	74.38^{abcd}	20.93^{b}
T_5: NU single spray (0.4%)	11.64 ^{ab}	14.27^{a}	0.65^{cd}	58.57^{cde}	18.80^{bc}
T_6: NU double spray (0.4%)	9.14^{cd}	14.50^{a}	0.61^{d}	49.97^{e}	14.40^{cd}
T_7: 50%RN granular urea+ NU (0.2%)	12.59^{a}	14.90^{a}	0.76^{a}	74.38^{abcd}	30.06^{a}
T_8: 50%RN granular urea+ NU (0.4%)	9.78^{bcd}	13.62^{a}	0.74^{ab}	65.66^{bcde}	21.60^{b}
Grand Mean	10.70	13.77	0.68	68.42	18.72
SEM (±)	0.712	0.59	0.02	6.08	1.95
CV%	11.51	7.51	6.15	15.41	18.03
LSD	2.15	1.81	0.74	18.46	5.91
F-Test	*	*	**	**	***

Note: * Significant at the 0.05 probability level; ** Significant- at the 0.01 probability level; *** Significant at the 0.001 probability level: NS, not significant. Means followed by common letters do not significantly differ at 5% level of significance.

Conclusion

Therefore, based on our research findings, it can be concluded that the combination of granular urea and nano urea particularly 50% RDN granular urea + NU (0.2%) performed best in terms of growth and yield attributes of cowpea. Nano urea, because of its nanoparticle size, sustained nutrients release and enhances nutrient availability, especially during the reproductive stages, and has the potential to substitute 50% of granular urea. Furthermore, single spray of 0.2% nano urea at flowering stage was the most effective. The synergetic effect of granular urea and nano urea not only optimizes nitrogen uptake but also highlights the potential of nano urea to replace up to 50% of the conventional granular urea, thereby improving nitrogen use efficiency and productivity. Moving forward, future studies should explore the cost-benefit analysis and integration of nano urea with organic amendments for more sustainable cowpea production.

ACKNOWLEDGEMENTS

We express our gratitude to IAAS Rampur Campus for providing us research materials and constant guidance. We are also grateful to our parents and friends for both physical and mental support during the research period.

DECLARATIONS

Authors contribution statement: Conceptualization, methodology: S.N. and S.B.; Software, validation: S.N. and S.M.; Investigation: S.N. and S.B.; Data curation: S.N.; formal analysis, S.N; Writing -original draft preparation: S.N. and S.M.; Writing-review and editing: S.N.; Supervision: S.S. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare no conflict of interest.

Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.
Consent for publication: All co-authors gave their consent to publish.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: No supplementary data is available for the paper.

Funding statement: Not applicable.

Additional information: No additional information is available for this paper.

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