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RESEARCH ARTICLE

Effect of nano urea foliar application on urea reduction, rice productivity and economic feasibility

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Abstract

Nano urea technology is gaining importance mainly due to improvement in crop yields besides reducing environmental issues. It is essential to study the effect of foliar application of nano urea on reduction of conventional urea, growth, grain productivity and net profit of rice. A field experiment was carried out at ADAC & RI, TNAU, Tiruchirappalli during *Rabi*, 2023. The treatments consisted of three levels of nitrogen (100, 75 and 50 %), nano urea (0.4 %) foliar application in twice (Active Tillering (AI) and Panicle Initiation (PI) stages) and thrice (AT, PI and Flowering stages) combined with 75 and 50 % N and control. Rice variety TRY 5 was used. The results showed that 100 % N application as conventional urea registered significantly increased growth, grain productivity (5200 kg/ha) of rice over lower levels of N and control. However, it was statistically comparable with 75 % N + nano urea (0.4 %) foliar application either two times (AT and PI stages) or three times (AT, PI and Flowering stages). Reducing 25 % N and substituting with nano urea spray twice or thrice showed comparable results with 100 % N. Nano urea spray either two or three times were comparable with each other, indicated that two sprays were sufficient. Economics of nitrogen application found that higher BCR (2.62) was obtained with application of conventional urea at 100 % N over other treatments. 75 % N application in soil + nano urea foliar application twice (AT and PI stages) and thrice (AT, PI and flowering period) gave similar BCR of 2.41.

Keywords: economics; foliar spray; growth; nano urea; rice; yield

Introduction

Rice (*Oryza sativa* L.) is a key and widely consumed staple crop around the world, feeding 50 % and above global population (1). Globally, 165.25 million hectares of rice cultivated, producing 516.7 million metric tonnes of rice annually (2), the sustainability of rice production is crucial for global food security. In India alone, rice is grown in 46 m. ha, making it the second-largest producer, contributing about 23.3% of the total cultivated area (3). In rice cultivation, conventional fertilization methods have posed significant challenges to environmental and agricultural sustainability. One major issue in modern agriculture is the excessive use of nitrogen-based fertilizers like urea, which has low nitrogen use efficiency (NUE). In rice farming, only about 30 % N is really utilized by crops, while the rest is lost through evaporation, leaching, or runoff (4). These losses cause pollution in groundwater and water bodies and contribute to greenhouse gas emissions (N_2O), worsening climate change. To address these challenges, nanotechnology product nano urea, offering an innovative approach to enhance NUE while minimizing environmental impacts. Nano-urea, a liquid formulation has been introduced as a sustainable alternative to conventional urea. Indian Farmers Fertilizer Cooperative (IFFCO) developed nano-urea consists of ultra-small nitrogen particles (20-50 nm) with significantly higher surface area compared to traditional urea. A single nano-urea liquid particle has surface area of 10000 times greater relative to its volume than that of conventional granular urea. This characteristic enhances the absorption and utilization of nitrogen by crops when applied as a foliar spray (5, 6). Unlike granular urea, which is broadcasted to the soil susceptible to significant losses, nano-urea is directly absorbed by plant leaves through stomatal uptake and surface absorption. This method allows for targeted nutrient delivery, reducing the dependency on excessive fertilizer application. The nano-sized particles penetrate plant cells efficiently, enhancing metabolic processes, meristematic activities and photosynthetic efficiency. As a result, nano-urea improves nitrogen assimilation in rice, contributing to increased grain yield and biomass production (7). Furthermore, nano-fertilizers offer a promising avenue for bio-fortification, increasing nutritional value of crops. Nano urea application in rice involves spraying the liquid formulation at important crop growth periods. The first spray is typically conducted at 5th week after germination or 3rd week after planting, 2nd spray before flowering. This targeted approach ensures optimal nitrogen uptake, reducing nutrient losses and improving crop growth and yield. Additionally, nano-urea supports sustainable farming practices by reducing transportation and storage costs, as well as minimizing the environmental footprint associated with traditional fertilizers. Studies have demonstrated that nano-urea application at important growth stages leads to enhanced photosynthesis, increased dry matter accumulation and improved grain filling. This translates into higher rice yield and quality, as the nutrient was effectively utilized by the plant without significant losses to the environment (8). Nano-urea application not only reduces dependence on chemical fertilizers but also mitigates their adverse effects on soil fertility and quality of water. Spraying of nano urea liquid during important growth periods successfully satisfies its nitrogen requirement which resulted in increased crop yield as compared to normal urea. However, literatures related to the effectiveness of nano urea on rice productivity and net profit are meagre. Hence, a field investigation was proposed to elucidate the effect of foliar application of nano urea on rice.

Materials and methods

Experimental site

An experiment was carried out at Anbil Dharmalingam Agricultural College and Research Institute (ADAC & RI), TNAU, Tiruchirappalli to investigate the influence nano urea foliar spray on growth, grain productivity and profitability of rice. The experimental field is situated at 10°45' N latitude, 78°36' E longitudes and 85 m above mean sea level altitude. The field soil was identified as sandy clay loam with a moderate drainage. It exhibited alkaline in nature, with 8.6 pH, EC of 0.31 dS m^{-1}, ESP of 22.5 %. The available N, P_2O_5 and K_2O of soil were 171.5, 14.1 and 224.5 kg/ha respectively.

Treatment details and crop husbandry

An experiment was carried out in RBD design with three replications and eight treatments (T_1- soil application of 100 % N as granular urea, T_2- soil application of 75 % N, T_3- 75 % N + foliar spray of nano-urea (0.4 %) at active tillering (AT) and panicle initiation stages, T_4-75 % N + nano urea foliar spray (0.4 %) at active tillering (AT), panicle initiation and flowering periods, T_5- recommended 50 % N, T_6-50 % N + foliar spray of nano urea (0.4 %) at AT and PI periods, T_7- 50 % N + foliar spray of nano urea (0.4 %) at active tillering (AT), panicle initiation and flowering stages and T_8- Control). Experiment was carried out during *Rabi*, 2023. Rice variety "TRY 5", short duration saline and sodic tolerant rice variety was used in this study. Prior to sowing, the experimental field was thoroughly puddled twice using a tractor-drawn cage wheel, followed by levelling using a levelling board. Manual transplanting was carried out at spacing of 20 x 10 cm using 24 days old seedlings in 2-3 seedlings per hill. The experimental plot was sprayed with a post-emergence herbicide bispyrinac sodium 10 % SL at 25 g ha^{-1} in 500 L/ha of spray fluid using a hand operated sprayer at 20 days after sowing (DAS), followed by manual weeding on 45th day for weed management. Fertilizer dose of 150:50:50 kg/ha NPK was adopted using urea, SSP and MOP fertilizers. Phosphorus was broadcasted entirely at planting, while nitrogen and potassium were applied during basal, AT, PI and flowering stages. Nano urea was sprayed at a concentration of 0.4 % using a hand-operated knapsack sprayer, with a spray volume of 500 L/ha (Fig. 1).

Fig. 1. Foliar spray of nano urea (0.4 %) at flowering stage.

Biometric observation

Biometric observation such as plant height (cm), dry matter production (kg/ha) and grain productivity were assessed before crop harvest. The number of tillers during the active tillering stage and panicles during harvesting stage were counted using four randomly selected quadrats measuring 0.25 m^2 each plot and expressed as numbers m^{-2}. The leaf chlorophyll was determined by using SPAD meter. Readings were taken from the uppermost fully expanded leaves in ten randomly chosen plants and the average values were calculated and expressed as SPAD readings. Ten panicles were randomly selected, threshed individually and the numbers of filled grains were counted to record filled grains/panicle. The crop was harvested when fully mature. The border rows on either side were harvested in each plot and removed from the field. The net plot was then harvested, threshed, winnowed and the grain was sun-dried to reach 14 % moisture. The cost of production was assessed according to the prevailing market rates and net profit was calculated by deducting the production costs from the gross income. To calculate the benefit-cost ratio, gross income was divided by the total production cost. Data recorded from the study were subjected to statistical analysis using AGRES software version 7.0 (9). To assess the significance between treatments, 5 % probability level critical difference value was used.

Results and Discussions

Growth parameters

Soil application of granular urea and nano urea foliar application statistically influenced the growth parameters of rice. Soil application of conventional urea at 100 % N level produced significantly taller plants (82.7 cm), more number tillers (606/m^2), dry matter production (12656 kg/ha), Leaf area index (4.78) and leaf chlorophyll (SPAD reading of 40.0) over 75 % and 50 % nitrogen as well as no nitrogen applied plot (Table 1). This was on par with 75 % N + spray of nano urea at AT and

Table 1. Effect of nano urea foliar spray on growth parameters of rice

Treatments	Plant height (cm)	Tillers (No./m²)	DMP (kg/ha)	LAI	Leaf Chlorophyll (SPAD value)
T_1- 100 % N	82.7	606	12656	4.78	40.0
T_2- 75 % N	77.3	546	11725	4.37	37.4
T_3- 75 % N + Nano urea spray (0.4 %) at AT and PI stages	80.5	576	13345	4.64	38.7
T_4-75 % N + Nano urea spray (0.4%) at AT, PI and Flowering stages	82.4	581	12645	4.73	39.1
T_5- 50 % N	73.0	488	10235	4.05	35.5
T_6-50 % N + Nano urea spray (0.4 %) at AT and PI stages	75.7	528	10976	4.31	36.6
T_7- 50 % N + Nano urea spray (0.4 %) at AT, PI and flowering stages	78.1	534	11435	4.45	37.1
T_8- Control	69.0	444	9478	3.46	33.7
Mean	77.3	538	11562	4.3	37.3
SEd	2.0	15	404	0.14	0.7
CD (P=0.05)	4.3	32	867	0.30	1.6

AT- Active Tillering; **PI** - Panicle Initiation

PI period (twice) as well as 75 % N + spray of nano urea at AT, PI and flowering period (Thrice) (Fig. 2). Combination of soil application and nano urea foliar application during critical periods showed significant variation in growth parameters over soil applied 50 % and 75 % N alone. Nano urea foliar application enhanced nitrogen absorption through the stomata, leading to increased cell division, meristematic activity and cell elongation in plants. This, in turn, contributed to greater plant height and more tillers (10). Further, nitrogen is a vital nutrient required to produce amino acid tryptophan, directly influenced the growth attributes of rice crop and the findings also supported by previous studies (11). Foliar application of nano urea produced taller plants over without the nano nitrogen spray (12). Nano urea contributes to better assimilation of nutrients and improves metabolic processes within the plant due to its unique shape, size and enhanced surface area. By promoting meristematic activity, nano urea stimulates terminal growth and an increased leaf area, induces the activity of key enzymes and mechanisms inside the plant, helping to achieve optimal nitrogen levels. This, in turn, boosts amino acid and protein content, chlorophyll concentration, nucleic acids and photosynthates, ultimately enhancing overall growth characters of rice. Soil application normal urea at 75 % N + nano urea foliar application at AT, PI and flowering periods registered next best treatment. Reducing N dose to 50 % recorded significantly lesser growth parameters over 100 % N application. Control plot exhibited significantly lower growth parameters of rice. Reducing the N dose to 50 % significantly affected the rice growth parameters.

Fig. 2. 75 % N + Nano urea spray (0.4 %) at AT, PI & flowering stages.

Yield attributes and yield

Application of 100 % N as conventional urea in four equal splits during critical periods registered significantly a greater number of panicles (576/m²), panicle length (20.7 cm) filled grains/ panicle (117.3), grain yield (5200 kg/ha), straw yield (7644 kg/ ha) and harvest index (0.40) than lower level of N (75 and 50 % N) (Table 2) (Fig. 3). Nitrogen split application during critical growth stages maintained continuous supply of N as well as met up the N requirement by the crop, delayed leaf aging and maintenance of active leaves during grain filling period caused more grain filling and reduced chaffy grains which ultimately increased the grain yield (13). Foliar spray of nano urea either twice or thrice during critical growth stages along with soil application of 75 % N showed on par with 100 % N application.

Table 2. Effect of nano urea foliar spray on yield parameters and yield of rice

Treatments	Panicles (Nos./m²)	Panicle length (cm)	Filled grains/ Panicle	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index
T_1- 100 % N	576	20.7	123.0	5200	7644	0.40
T_2- 75 % N	448	18.6	98.7	4610	7159	0.39
T_3- 75 % N + Nano urea spray (0.4 %) at AT and PI stages	516	19.6	113.7	4990	7535	0.40
T_4-75 % N + Nano urea spray (0.4 %) at AT, PI and Flowering stages	536	20.4	117.3	5120	7680	0.40
T_5- 50 % N	412	17.5	86.0	4130	6402	0.39
T_6-50 % N + Nano urea spray (0.4 %) at AT and PI stages	460	18.1	96.3	4410	6615	0.40
T_7- 50 % N + Nano urea spray (0.4 %) at AT, PI and flowering stages	484	18.8	101.3	4630	7005	0.40
T_8- Control	368	16.1	61.3	3760	5828	0.39
Mean	473	18.7	99.8	4606	6983	0.40
SEd	13	0.35	2.3	133	244	0.014
CD (P=0.05)	28	0.75	5.0	286	524	0.030

AT- Active Tillering; **PI** - Panicle Initiation

Fig. 3. Soil application of 100 % N as conventional urea.

Application of 75 % nitrogen in soil + foliar application of nano urea thrice produced higher number of panicles (536/m^2), panicle length (20.4 cm) filled grains/panicle (128.0), grain yield (5120 kg/ha) and harvest index (0.40) over soil application of 75 % N. This increment in yield is mainly due to, foliar application of nano-urea improved the N uptake and better trans-location caused higher yield through promotion of metabolic processes like photosynthesis as well as accumulation and movement of more photosynthates to grains ensured more yield (8, 14). Additionally, increased reproductive tillers were greatly influenced by the application of conventional urea in combination of nano-fertilizers also reported (15). Reducing 25 % N and substituting with nano urea spray twice or thrice showed comparable results with 100 % N. Between nano urea sprays, both twice and thrice were comparable statistically with each other's indicates that two spray was sufficient. Two times foliar spray with nano urea + 75 % N application registered 4.0 % reduction in grain yield over 100 % N, which needs attention. Reducing N doses to 25 and 50 % curtailed the rice grain yield to the tune of 11.3 and 20.5 % respectively. Significantly higher straw yield (7680 kg/ha) was noticed under 75 % N soil application + nano urea foliar applied thrice at active tillering, PI and flowering periods over other treatments. The higher straw yield observed in nano urea-treated plots can be attributed to more active meristematic growth, leading to better overall plant development and greater straw production. The treatment which received no nitrogen showed significantly lesser yield characters and grain yield (27.7 %) over 100 % N application.

Economics

Regarding economics of nano urea application, higher cost of cultivation (Rs. 54028/- per ha) was incurred under nano urea application thrice along with 75 % nitrogen than other N management practices (Table 3). Under nano urea spray, charges towards spraying were the reason for increased cost of cultivation. But, increased gross returns (Rs. 131612/- per ha), net profit (Rs. 81374/- per ha) and BCR (2.62) was obtained with 100 % N as conventional urea over other treatments. The results corroborate with previous findings (16). Reducing 25% N and substituting with nano urea foliar spray twice reduced the net returns to the tune of Rs. 7056/- per ha in relation to 100 % N soil application mainly due to reduced grain yield as well as additional spraying cost. Soil application of 75 % + nano urea foliar application twice at AT and PI periods (T_3) and 75 % N + nano urea foliar application thrice at AT, PI and flowering periods (T_4) gave similar BCR of 2.41. Reducing N at 50 % and substituting with nano urea showed drastic reduction in gross income, net profit and benefit cost ratio.

Conclusion

Nitrogen is a crucial nutrient in rice cultivation, as it supports rapid plant growth and development. Nitrogen management needs immediate attention to reduce the environmental pollution as well as improve the NUE. To address these issues, use of nano urea is considered as an option. From the experiment, application of conventional urea at 100 % N in four equal splits during critical stages registered significantly more panicles (576/m^2), filled grains/panicle (128.0) and grain yield (5200 kg/ha) and economics than lower level of N (75 and 50 % N). Soil application of 75 % N+ nano urea (0.4 %) foliar application twice at active tillering and PI periods (T_3) and 75 % N + nano urea foliar application thrice at active tillering, PI and flowering periods (T_4) were comparable with 100 % N indicates that there was 25 % saving of N noticed when nano urea sprayed twice or thrice (Fig. 4). Between two and three numbers of foliar spray, there was no significant difference noticed, indicating that two sprays were sufficient. Thus, soil application of 75 % N + nano-urea foliar application twice at AT and PI periods (T_3) is recommended for enhanced growth and productivity of rice. However, the long-term impact of nano urea on soil nitrogen depletion, as well as the economic viability of its foliar application, requires comprehensive study.

Table 3. Effect of nano urea foliar spray on economics of rice

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	Benefit cost ratio
T_1- 100 % N	50238	131612	81374	2.62
T_2- 75 % N	49678	117827	68149	2.37
T_3- 75 % N + Nano urea spray (0.4 %) at AT and PI stages	52578	126895.7	74318	2.41
T_4-75 % N + Nano urea spray (0.4 %) at AT, PI and Flowering stages	54028	130048	76020	2.41
T_5- 50 % N	49119	105521.5	56403	2.15
T_6-50 % N + Nano urea spray (0.4 %) at AT and PI stages	52019	112014	59995	2.15
T_7- 50 % N + Nano urea spray (0.4 %) at AT, PI and flowering stages	53469	117782.6	64314	2.20
T_8- Control	46000	96068	50068	2.09

Data not statistically analysed. **AT**- Active Tillering; **PI** - Panicle Initiation

Fig. 4. General view of experimental field.

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Authors' contributions

TR and SA did conceptualization and methodology of the experiment. TR and SR carried out the field experiment and data analysis and prepared the manuscript. SN and SM helped in laboratory analysis. SAS did the data collection and drafting the manuscript. TR and SR did the final revision of the manuscript. All authors read and approved the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. Siddiq EA. Yawning productivity gaps. The Hindu Survey of Indian Agriculture. 2000;39–44.
2. Food and Agriculture Organization (FAO). The state of world fisheries and aquaculture 2022: towards blue transformation. Rome: FAO; 2022. https://openknowledge.fao.org/items/11a4abd8-4e09-4bef-9c12-900fb4605a02
3. Agricultural Statistics Directorate. The production of paddy and sunflower for the year 2022. Report of the Central Bureau of Statistics - Ministry of Planning. https://desagri.gov.in/wp-content/uploads/2023/05/Agricultural-Statistics-at-a-Glance-2022.pdf
4. Manikandan A, Subramainan KS, Arulmozhiselvan K, Natarajan N, Amanullah M, Deshmukh R, Blaise D. Nano-nitrogen formulation for enhancing use efficiency. Agropedology. 2022;32(1):13–32. https://doi.org/10.47114/j.agroped.2022.jun2
5. Valojai STS, Niknejad Y, Fallah H, Tari DB. Effect of nitrogen, phosphorus and potassium nano-fertilizers on growth and seed of two rice (*Oryza sativa* L.) cultivars. Journal of Crop Ecophysiology. 2021;15(1):37–56. https://doi.org/10.30495/jcep.2021.681005
6. Midde SK, Perumal MS, Murugan G, Sudhagar R, Mattepally VS, Bada MR. Evaluation of nano urea on growth and yield attributes of rice (*Oryza sativa* L.). Chem Sci Rev Lett. 2022;11(42):211–4. https://www.researchgate.net/publication/361579077
7. Kumar Y, Singh T, Raliya R, Tiwari KN. Nano fertilizers for sustainable crop production, higher nutrient use efficiency and enhanced profitability. Indian J Fert. 2021;17(11):1206–14. https://www.researchgate.net/publication/356406533
8. Mehta S, Bharat R. Effect of integrated use of nano and non-nano fertilizers on yield and yield attributes of wheat (*Triticum aestivum* L.). Int J Curr Microbiol App Sci. 2019;8(12):598–606. https://doi.org/10.20546/ijcmas.2019.812.078
9. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New Delhi: Wiley India Pvt Ltd; 2010.
10. Ranjan P, Kumar B, Mala A, Priyadarshi S, Aditya S, Babu L, et al. Effect of foliar spray of nano urea on yield and economics of rice. Pharma Innov J. 2023;12(1):3030–3. https://doi.org/10.22271/tpi.2023.v12.i1ai.19419
11. Velmurugan A, Subramani T, Bommayasamy N, Kumar M, Swarnam TP, Ramakrishna. The effect of foliar application of nano urea (liquid) on rice (*Oryza sativa* L.). J Andaman Sci Assoc. 2021;26(2):76–81. https://www.researchgate.net/publication/360438800
12. Kothari SK, Saha S, Mallick P. Evaluation of foliar application of nano-fertilizers (nitrogen, zinc, copper) on growth and yield of rice (*Oryza sativa* L.) in Kharif season. Pharma Innov J. 2023;12(6):247–50. https://www.thepharmajournal.com/archives/?year=2023&vol=12&issue=6&ArticleId=20511
13. Kamruzzaman M, Kayum MA, Hasan MM, Hasan MM, Silva JATD. Effect of split application of nitrogen fertilizer on yield and yield attributes of transplanted Aman rice (*Oryza sativa* L.). Bangladesh J Agric Res. 2014;38(4):579–87. https://doi.org/10.3329/bjar.v38i4.18886
14. Sahu TK, Kumar M, Kumar N, Chandrakar T, Singh DP. Effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.) under midland situation of Bastar region. Pharma Innov J. 2022;11(6):185–7.
15. Benzon HRL, Rubenecia MRU, Ultra Jr VU, Lee SC. Nano-fertilizer affects the growth, development and chemical properties of rice. Int J Agron Agril Res. 2015;7(1):105–17. https://www.researchgate.net/publication/281387862
16. Acharya SM, Bhakare BD, Nakhate PR, Durgude AG, Thakare R. Effect of foliar application of nano urea on yield and production economics of wheat crop under normal and saline-sodic soils. Int J Chem Stud. 2024;8(1):49–53. https://doi.org/10.61080/CA/V41/i1/2024/22-27

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