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Effect of Nano Urea Liquid Fertilizer Application in Paddy under Different Agroclimatic Zones of Odisha, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

A field experiment was conducted in the three agroclimatic zones of Odisha located in East & South coastal plain regions (Jagatsinghpur), North Eastern coastal plain regions (Jajpur) & Western central table land regions (Bargarh) of Odisha to study the nano urea effect on transplanted rice by taking three treatments on 100 per cent NPK, 50 per cent N + 100 pec cent PK +Nano urea and 75 per cent N + 100 pec cent PK +Nano urea with seven replications in the RBD design. From the above experiment we conclude that the effect of nano urea increases the plant height at different stages of transplanted rice. The 75 per cent recommended N with 100 per cent PK and two sprays of nano urea @ 0.4 per cent at tillering & PI stages increases plant height at active tillering, panicle initiation, flowering, maturity stages in almost similar with application of 100 per cent NPK at Bargarh, Jagatsinghpur & Jajpur district of Odisha. Similarly the average yield was recorded almost nearer to similar in both the 100 per cent NPK with nano urea + 75 per cent N + 100 per cent PK. The farmer's net revenue per hectare is increased by applying nano urea twice with 75% less urea. This also reduces the 25% urea application, which is good for managing soil health. So, the nano urea application is better and can be recommended to the farmers to minimize the chemical urea application and efficient use of nitrogen to the paddy for better crop growth, development & increasing yield.

Keywords: Nano urea; plant height; yield; net income; urea and rice etc.

1. INTRODUCTION

Rice (*Oryza sativa* L.) belongs to Poaceae family; rice was initially assumed to be originating from South- East Asia. One of the major cereal crops of tropics and certain regions of the temperate world, Rice is grown in different types of agro ecologies, from irrigated uplands and rainfed lowlands to flood prone rice ecosystems. India ranks second to China in terms of area and production among the world's major rice producing nations. Rice plants require a lot of mineral nutrients, especially nitrogen, to grow, develop, and produce grains (Midde et al., 2022). Nitrogen is one of the important elements in plant owing to its major part in chlorophyll production, which is essential for the photosynthesis process. Whilst, nitrogen is part of different enzymatic proteins that catalyze and regulate plant development processes (Sinfield et al., 2010). Liquid nano fertilizer which is currently the best alternative to urea fertilizer (Bhargavi & Sundari, 2023). One bottle of nano urea (500 ml) is equivalent to a bag of urea fertilizer (45 kg), 10% lower than a bag of conventional urea. It may reduce the importing of urea fertilizer. One nano urea liquid particle of 30 nano meters in diameters has a surface area up to 10,000 times higher size than normal size of granular urea. Nano urea liquid applied through foliar by spraying at critical crop growth stages. It effectively meets the nitrogen requirement and leads to higher crop productivity and quality compared to traditional urea (Attri et al., 2022). Nano-urea has been designed and extensively tested by agricultural scientists and organizations. Researchers like Ramesh Chander Prasad and others (2020) have pointed out the enormous potential of nanotechnology for making fertilizers more effective. Nano-urea is one such product that comes in this category, having highly reactive nanoparticles that are bioavailable in nature.

The Indian Farmers Fertilizer Cooperative Limited (IFFCO) pioneered the development of liquid nano urea, extensively testing its performance across various crops. According to IFFCO (2021), nano urea reduces the need for conventional granular urea by up to 50%, significantly decreasing environmental and economic costs. Nano urea works by delivering nitrogen directly to plant leaves through foliar application. The nanosized particles directly penetrate the plant through stomata and cuticles, thereby entering metabolic pathways directly. This bypasses most of the soil-mediated nitrogen losses such as volatilization and leaching as commonly associated with traditional urea

fertilizers. The Rathore et al. (2022) have shown nano urea increases NUE by up to 80% while conventional urea raises it by 30-50%. Such efficiency further translates into better crop yields as well as reduced impacts on the environment. Nano urea strongly promotes NUE, meaning more application of nitrogen is utilized by the plant. A smaller amount of applied nitrogen is required for better crops, as demonstrated in Singh et al. (2021) field studies. Applications of nano urea enhanced the yield of rice, wheat, and maize, as determined by Kumar et al. (2021). These gains are as a result of the constant and efficient supply of nitrogen at the critical growth stages. However, researchers like Prasad et al. (2020) observe that nano urea is one of the latest innovations in fertilizer science. The future research direction should be the optimization of formulation, upscaling production, and linking nano urea with other sustainable farming practices.

2. MATERIALS AND METHODS

2.1 Study Area

The field experiment has been conducted in three districts of Odisha. i.e Bargarh, Jagatsinghpur and Jajpur etc. The details of agroclimatic zones are given below.

- Jagatsinghpur district is located in East & South coastal plain regions. The climate is hot & humid with mean annual rainfall 1577 mm. The men maximum summer temperature is 39^{o}C and mean minimum winter temperature is 11.5^{o}C. Broad soil groups in the district is saline, lateritic alluvial, red & mixed red and black etc.
- Jajpur district was located in North Eastern coastal plain regions. The climate is moist sub-humid with mean annual rainfall 1568 mm. The men maximum summer temperature is 36^{o}C and mean minimum winter temperature is 14.8^{o}C. Broad soil groups in the district is red, lateritic, deltaic alluvial, coastal alluvial and saline etc.
- Bargarh district was located in Western central table land regions. The climate is moist sub mid with mean annual rainfall 1514 mm. The men maximum summer temperature is 40^{o}C and mean minimum winter temperature is 12.4^{o}C. Broad soil groups in the district is red & yellow, red & black, black, brown forest and lateritic etc.

Nano urea: In this experiment we have utilized IFFCO nano urea (liquid) which is covered under the Fertilizer Control Order (FCO) issued by the Government of India. Nano nitrogen particle size ranges from 20-50 nm and it contains 4.0 % total nitrogen (w/v) evenly dispersed in water (IFFCO). When applied on leaves at critical crop growth stages, as reported, nano urea easily enters through stomata and other openings and is assimilated by the plant cells. It is the ability to easily distribute through phloem from source to sink inside the plant as per its need.

Field experiment: In order to evaluate the foliar application of nano urea (liquid) in transplanted rice, a field experiment was conducted during June-October, 2024. The experiment was conducted in RBD design with three treatments & seven replications. The details of treatments are given List 1.

Observations: Plant growth parameters like plant height, number of tillers, leaves, root length, and root mass shoot mass were recorded at active tillering and panicle initiation stages. Crop yield was taken after the harvest of rice. Before harvesting, soil samples were taken and after the experiment to take down the physicochemical properties of soil.

List 1. Treatment details

Treatments	Treatment details
FP	100 % N(25% basal + 50% tillering + 25% PI stage) + 100 % P & K
TO1	50 % recommended N + 100 % P and K as basal application and two sprays Nano urea @ 0.4 % tillering and PI stage
TO2	75 % recommended N + 100 %P and K as application and two sprays Nano urea @ 0.4 % at tillering and PI stage

3. RESULTS AND DISCUSSION

The effect of nano urea liquid fertilizer application on plant height of transplanted rice at different stages ie 30 DAS, 60 DAS, 90 DAS and 120 DAS has been presented in Table 1.

During active tillering stage the FP (100 % NPK) gives higher plant height at Bargarh district 39.7 cm followed by Jajpur district 39.2 cm followed by Jagatsinghpur 38.6 cm. Similar results found in the panicle initiation stage (Jagatsinghpur-71.6, Bargarh-70.8, Jajpur-70.2), flowering stage (Bargarh-86.9, Jajpur-86.2, Jagatsinghpur-85.3) and maturity stage (Jagatsinghpur-99.3, Jajpur-98.4, Bargarh-98.1). Among the three district the plant height was varies between 33.9 to 39.7 cm in active tillering stage, 65.7 to 71.6 cm in panicle initiation stage, 80.9 to 86.9 cm in flowering stage and 93.1 to 99.3 cm in maturity stage. The highest plant height was shown in the maturity stage at 120 days after showing.

The effect of nano urea liquid fertilizer application on yield of rice has been presented in the Table 2.

The field experiment of nano urea application in paddy resulted that the yield was varied between 43.7 to 47.6 q/ha in Jagatsinghpur district followed by 41.3 to 46.1 q/ha in Jajpur district followed by 42.3 to 44.8 q/ha in Bargarh district. Irrespective of the treatments in the experiment the Farmers practice (100 % NPK) gives higher result compare to the other treatments (TO1 & TO2). The record of higher yield in Bargarh district shown in FP (44.8 q/ha) followed by TO2 (44.3 q/ha) followed by TO1 (42.3 q/ha). Similar results found in Jagatsinghpur as FP (47.6 q/ha) followed by TO2 (44.5 q/ha) followed by TO1 (43.7 q/ha) and in Jajpur as FP (46.1 q/ha) followed by TO2(45.3 q/ha) followed by TO1 (41.3 q/ha) respectively. We found that almost nearer to the similar results found between application of 100 per cent NPK (FP) and 75 per cent N + 100 per cent P & K + two sprays of nano urea as 0.4 per cent (TO2). The TO2 treatment gives very less decrease in yield where -1.1 per cent in Bargarh, -6.5 per cent in Jagatsinghpur and -1.7 per cent in Jajpur in comparison with the FP.

The effect of nano urea liquid fertilizer application on average economic study has been presented in the Table 3.

The average economic study was recorded between the three districts. We found that the highest net return was recorded in the FP (Rs. 54,880/ha) followed by TO2 (Rs. 54,530/ha) followed by TO1 (Rs. 49,630/ha) respectively. Similarly, the average B: C ratio found highest in FP (1.65) followed by TO2 (1.64) followed by TO1 (1.60). Irrespective of the treatments the FP (100 % NPK) gives higher net return and B : C ratio in comparison with the other treatments (TO1 & TO2). The application of nano urea (0.4 %) with 75 per cent N & 100 per cent P, K gives similar results (net return and B : C ratio) with application of 100 % NPK. The average net return in TO1 was -9.6 per cent decrease over FP and TO2 was -0.6 per cent over FP. Similarly the average B : C ratio in TO1 was -3.0 per cent decrease over FP and TO2 was -0.6 per cent over FP respectively.

Table 1. Effect of nano urea on plant height (cm) of transplanted rice at different stages

Treatments	Active tillering (30 DAS)			Panicle Initiation (60 DAS)			Flowering (90 DAS)			Maturity (120 DAS)		
	BR	JG	JJ	BR	JG	JJ	BR	JG	JJ	BR	JG	JJ
FP	39.7	38.6	39.2	70.8	71.6	70.2	86.9	85.3	86.2	98.1	99.3	98.4
TO1	35.1	34.3	33.9	63.2	64.8	65.7	81.3	80.9	81.4	94.2	93.1	93.6
TO2	38.4	38.2	37.5	68.6	69.1	69.4	85.8	84.8	85.3	96.5	98.8	97.3

**BR = Bargarh, JG = Jagatsinghpur, JJ = Jajpur*

Table 2. Effect of nano urea on yield of rice

	Bargarh		Jagatsinghpur		Jajpur	
Treatments	**Yield (q/ha)**	**% increase in yield**	**Yield (q/ha)**	**% increase in yield**	**Yield (q/ha)**	**% increase in yield**
FP	44.8	-	47.6	-	46.1	-
TO1	42.3	-5.6	43.7	-8.1	41.3	-10.4
TO2	44.3	-1.1	44.5	-6.5	45.3	-1.7

Table 3. Effect of nano urea on average economic study

Treatments	Gross cost (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B : C ratio
FP	84,000	1,38,880	54,880	1.65
TO1	81,500	1,31,130	49,630	1.60
TO2	82,800	1,37,330	54,530	1.64

Table 4. Effect of nano urea on post harvest properties of soil

		pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	B (ppm)	Zn (ppm)
Bargarh	**Post harvest**	5.7	0.37	242	13	117	0.41	0.52
	Initial	5.9	0.43	253	19	123	0.46	0.57
Jagatsinghpur	**Post harvest**	5.8	0.38	208	12	102	0.42	0.51
	Initial	6.1	0.41	216	18	110	0.47	0.58
Jajpur	**Post harvest**	6.0	0.40	212	11	111	0.41	0.49
	Initial	6.3	0.43	229	14	115	0.48	0.54

The effect of nano urea liquid fertilizer application on post harvest properties of soil has been presented in the Table 4.

In this field experiment of nano urea application in paddy, there was no effect in soil. In the three district of experimental area the pH was varied between 5.7 to 6.3, OC between 0.37 to 0.43 %, N between 212 to 253 kg/ha, P between 11 to 19 kg/ha, K between 102 to 123 kg/ha, B between 0.41 to 0.48 ppm and 0.49 to 0.58 ppm. We found that the pH was acidic in nature and OC, N, P, K, B, Zn shown low status in post harvest soil. The post harvest soil properties shown low in status in comparison with initial soil properties due to crop uptake.

4. CONCLUSION

From the above experiment we conclude that the effect of nano urea increases the plant height at different stages of transplanted rice. The 75 per cent recommended N with 100 per cent PK and two sprays of nano urea @ 0.4 per cent at tillering & PI stages increases plant height at active tillering, panicle initiation, flowering, maturity stages in almost similar with application of 100 per cent NPK at Bargarh, Jagatsinghpur & Jajpur district of Odisha. Similarly the average yield was recorded almost nearer to similar in both the 100 per cent NPK with nano urea + 75 per cent N + 100 per cent PK. The nano urea application two times with 75 per cent less urea increases the net income of the farmer per hacter as well as reduce the 25 per cent urea application which is beneficial for soil health management. So, the nano urea application is best and can be recommended to the farmers to minimize the chemical urea application and efficient use of nitrogen to the paddy for better crop growth, development & increasing yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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