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Study on Effect of Replacing Urea Top Dressing by Nano Urea on Yield and Quality of Direct Seeded Rice (*Oryza sativa* L.) under Rainfed Condition

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Abstract: Field experiment on effect of replacing urea top dressing by nano urea on yield and quality of direct seeded rice (*Oryza sativa* L.) under rainfed condition was conducted on clay soils during *kharif* season, 2023 at Central Agricultural University, Iroisemba, Imphal to evaluate the possibility of replacing urea top dressing by nano urea and its efficacy. Initial soil of the experimental field was acidic (pH 5.25). Replacing urea top dressing by nano urea had significant effect on the yield attributing characters. Highest yield attributes were observed under top dress (urea) at active tillering + nano urea (foliar spray) at panicle initiation + nano urea (foliar spray) at heading (T_6). The nutrient uptake (NPK), in T_6 was the highest. On the basis of above findings, it can be inferred that foliar application of nano urea twice at panicle initiation and heading stages can effectively replace urea top dressing at panicle initiation stage of crop growth.

Keywords: Rice, Nitrogen, Urea, Nano urea, Foliar spray

Rice (*Oryza sativa* L.) is the main staple food for over half the population of the world producing highest next to wheat with a record of 520.5 mt produced in 2022 (Anonymous, 2022). In India rice is grown in an area of 43.79 million ha^{-1} producing 112.91 million tonnes with an average productivity of 2578 kg ha^{-1} (Singh et al., 2020). Direct seeded rice is a resource conservation technology and reduces water and labor use by 50%. Productivity of DSR is 5-10% more than the yield of transplanted rice. It is considered as prosperous provided that there is good crop establishment and adequate weed control methods by maintaining the crop free from weeds (Rao et al., 2007, Rao and Nagamani 2007). Methane gas emission is also lower in DSR than with conventionally tilled transplanted puddle rice giving better option in the era of climate change(Marasini et al., 2016).

Nitrogen continues to be the "kingpin" of the nutrient kingdom and its management is a critical issue to be addressed across the globe including in India. In recent years, the input of chemical fertilizer is rising rapidly and N and P have been overused in rice production, leading to not only environmental pollution but also an increase in production cost (Wang et al., 2020). Nevertheless, soil N supply is often limited (Kumar et al., 2017), which forces farmers to increase the amount of N fertilizers in order to accomplish better crop yield. However, farmers may provoke nitrogen over fertilization, which effect optimum plant productivity as plants are not able to absorb the excess of N-fertilizer(Shrestha et al., 2020). Since a major portion of added N got lost through leaching, volatilization, and denitrification, the N use efficiency of crops hardly exceeds 30-35% (Ladha et al., 2005). The primary target of nano fertilizers in field of agronomy is to increase the plant nutrient use efficiency and diminish losses of nutrients (Ingale et al., 2013) and slowly and steadily release nutrients to the crop as needed to boost crop output, enhance crop quality, and raise the overall sustainability of agricultural systems, (Tarafdar et al., 2014). Nano fertilizers also contribute to the health of the soil by increasing soil organic carbon, enhancing soil aggregation, and enhancing soil's capacity to store water, (Rai et al., 2012). Nano fertilizers are ecologically sound and were created with the same nutrient content and application rates as inorganic fertilizers (Liu and Lal 2015). Foliar application of nutrients can improve nutrient utilization and minimizes environment pollution by reducing the amount of fertilizers added to soil (Miah *et al*., 2017). It would be exceptionally useful if we use nano fertilizer in rice crops to limit the potential negative impacts realized by the broad utilization of synthetic fertilizers without bargaining production and nourishing advantages (Benzon et al., 2015). With this background in view the present research was conducted to study the effect of replacing urea top dressing by nano urea on yield and quality of direct seeded rice (*Oryza sativa* L.).

MATERIAL AND METHODS

Experiment site: The present research was conducted at the Research field of College of Agriculture, CAU, Imphal during *kharif* 2023 located in 24º45' N latitude and longitude of 93º54' E with an altitude of 774.5 m above mean sea level. The experimental area comes under the Eastern Himalayan

Region (II) and the agro climatic zone is Sub Tropical Zone (NEH-4) of Manipur (Experimental Agromet Advisory Service ICAR Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal).

Soil status: The soil of the experimental field was clayey in texture with pH of 5.25, containing organic carbon 1.43 %, available N 275.34 kg ha^{-1}, P_2O_5 16.89 kg ha^{-1} and K_2O 276.32 kg ha^{-1} (Table 1).

Treatment details: The study was replicated three times in randomized block design with seven treatments viz., T_1: Top dress with urea at active tillering + top dress with urea at panicle initiation, T_2: Foliar spray with nano urea at active tillering + foliar spray with nano urea at panicle initiation, T_3: Top dress with urea at active tillering + foliar spray with nano urea at panicle initiation, T_4: Foliar spray with nano urea at active tillering + top dress with urea at panicle initiation, T_5: Foliar spray with nano urea at active tillering + foliar spray with nano urea at panicle initiation + foliar spray with nano urea at heading, T_6: Top dress with urea at active tillering + foliar spray with nano urea at panicle initiation + foliar spray with nano urea at heading, T_7: Foliar spray with nano urea at active tillering + top dress with urea at panicle initiation + foliar spray with nano urea at heading. All treatments are given equal basal dose of NPK (20:40:30 kg ha^{-1}), urea top dressing is given in two equal split doses at active tillering stage (35 DAS) and/or panicle initiation (50 DAS) @ 20kg N ha^{-1} each as per treatment and foliar spray of nano urea is given at the concentration of 0.4% as per treatment.

Yield attributes and parameters analysis

i. Number of effective tillers hill^{-1} was determined by counting panicle bearing tillers taken as effective tillers from each plot. The tillers of the representative samples were recorded in number and the values averaged for each treatment.
ii. Number of filled grains per panicle was determined after harvest of the crop by counting the number of filled grains from every ten panicles from five selected sample plants and recording the mean values as total filled grains for each treatment.
iii. Number of unfilled spikelets per panicle was determined after the harvest of the crop by counting the number of unfilled spikelets from every ten panicles from five selected sample plants and mean values were recorded as total filled grains from each treatment.
iv. Spikelet sterility percentage was calculated as a ratio between difference of total spikelets to filled grains and total spikelets multiplied by 100 to get the value in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economical Yield (q/ha)}}{\text{Biological Yield (q/ha)}} \times 100$$

v. Test weight was determined by taking the weight of 1000 randomly selected filled grains in gram after proper sun dry and recording for each plot.
vi. Grain yield (q/ha) was determined by weighing the cleaned seeds threshed dried at 14% moisture content after leaving the border rows in each plot. Grain yield for each net plot was recorded in kilogram and converted to quintal per hectare for statistical analysis.
vii. Straw yield (q/ha) in kilogram was recorded after proper sun drying of the straw separately for each plot, and converted to quintal per hectare.
viii. Harvest index (%) was calculated as a ratio between economic (grain) yield and biological yield (grain + straw) of the harvested plants which was introduced by Donald (1962).

$$\text{Spikelet sterility (\%)} = \frac{\text{Total number of spikelets- Number of filled grains}}{\text{Total number of spikelets}} \times 100$$

Quality parameters analysis: Plant samples were collected for nutrient content (NPK) at the harvest stage. Crop samples at harvest were used for nutrient analysis. These samples were dried and ground to a fine powder using a Willey mill and used for the analysis of the uptake of nutrients by crop.

I. Nitrogen content (%) in the grain and stover were assessed by the micro Kjeldhal method (Jackson, 1967) using a Kelplus N analyzer after digesting the samples with H_2SO_4 and H_2O_2.
ii. To analyse phosphorus content (%), one gram of plant sample and 10 ml of di-acid mixture was digested over a sand bath till a clear colourless solution was obtained. Then a known volume of the digested samples was taken for total phosphorus content determination by adopting the Vanado molybdophosphoric yellow color method as

Table 1. Chemical properties of the experimental soil (initial)

Parameter	Value	Interpretation
pH	5.25	Acidic
Organic carbon (%)	1.43	High
Sand (%)	9.65	Clay soil
Silt (%)	15.68	
Clay (%)	74.67	
Available nitrogen (kg ha^{-1})	275.34	Low
Available phosphorus (P_2O_5) (kg ha^{-1})	16.89	Low
Available potassium (K_2O) (kg ha^{-1})	276.32	Medium

described by Jackson (1973).

iii. For analysis of potassium content (%) one gram of plant sample was digested with di-acid to determine the amount of potassium in plant samples. Following this, 10 ml of the digested material was taken in a volumetric flask and make up volume up to 50 ml od distilled water. The total potassium content was estimated by atomizing the diluted digest to a calibrated flame photometer under suitable measuring conditions as described by Jackson (1973).

iv. For calculation of nutrient uptake (kg/ha) in grain and stover, the respective percent content of nitrogen in grain and stover were analyzed separately and the uptake of nutrient by rice was worked out for different treatments by multiplying the nutrient content and dry matter yield of the rice as given in the following formula.

Nutrient uptake (kg ha^{-1}) = Nutrient concentration (%) X Dry matter Yield (kg/ha)

RESULTS AND DISCUSSION

Effects of top dressing of nano urea on the yield attributes and parameters: The replacing urea top dressing by nano urea at different stages of crop growth had a significant effect on the yield attributes and parameters (Table 2). However, there was no significant effect of the treatments on test weight (g) and harvest index (%). T_6 produced highest number of effective tillers $hill^{-1}$ (16.83), no. of filled grains $panicle^{-1}$ (168.78), grain yield (46.80 q ha^{-1}) and stover yield (66.88 q ha^{-1}). Consequently, T_6 recorded the minimum number of unfilled spikelets $panicle^{-1}$ (17.11) and spikelet sterility (9.22 %) over other treatments. This might be due to combined application of conventional fertilizer as basal dose and split dosage application of Nano urea at panicle initiation and heading stage of rice had synergistic effects which leads to slow release of nitrogen resulting in higher nitrogen use efficiency, minimized loss and storage of remaining nitrogen in plant cells that can prevent the plant biotic and abiotic stress produces number of effective tillers per hill. Foliar application of nano urea resulted in more photosynthates accumulation and translocation of nitrogen and abundant availability and timely supply of nitrogen stimulated initiation and development of grain formation resulting in more number of filled grains per panicle, lesser number of unfilled spikelet per panicle and consequently lower spikelet sterility (%) in rice. Synergetic effect of conventional fertilizers as basal dose and split dose application of foliar nano urea improving nitrogen uptake by the plant through slow release mechanism that can prevent the plant from biotic and abiotic stress and increasing grain and stover yield. Similar findings were reported in earlier studies(Benzon et al., 2015, Yadav et al., 2021, Attri et al., 2022), Kothari et al. (2023).

Effects of top dressing of nano urea on quality parameters: P content in stover (%) and K content in grain (%), K content in stover (%) were not significantly influenced by replacing urea top dressing by nano urea in direct seeded rice under rainfed condition (Table 3). However, N content in grain (%), N content in stover (%) was significantly influenced by replacing urea top dressing by nano urea in direct seeded rice under rainfed condition . The T_6 recorded the maximum N content (1.49% in grain; 0.97% in stover) and T_2 recorded minimum N content (1.41% in grain; 0.91% in stover). Nutrient uptake (kg ha^{-1}) by grain and stover was significantly influenced by replacing urea top dressing by nano urea in rice (Table 2). Maximum N uptake by grain (kg ha^{-1}) and stover was recorded under T_6 (59.71 kg ha^{-1} for grain; 35.71 kg ha^{-1} for stover). This was followed by T_7 , , T_3 , , T_4, and T_5 .Minimum nitrogen uptake was observed under T_2 (41.59 kg ha^{-1} for

Table 2. Yield attributes and parameters as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition

Treatments	No. of effective tillers per panicle	No. of filled grains per panicle	No. of unfilled spikelets per panicle	Spikelet sterility (%)	Test weight (g)	Grain yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
T_1	14.99	150.47	20.05	11.77	27.13	44.19	64.14	0.79
T_2	10.37	106.36	26.39	19.89	26.27	38.69	58.32	39.88
T_3	13.48	135.96	22.38	14.13	26.03	42.46	62.75	40.36
T_4	11.94	121.14	24.04	16.86	25.33	40.72	61.30	39.92
T_5	11.87	120.68	24.47	16.58	28.18	40.18	60.44	39.93
T_6	16.83	168.78	17.11	9.22	28.33	46.80	66.88	41.17
T_7	15.18	153.72	19.62	11.32	29.00	44.84	64.90	40.86
CD (p=0.05)	1.40	14.07	1.49	0.96	NS	1.51	1.21	NS

Table 3. Quality parameters (both grain and stover) as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition

Treatments	N Content (%)		P Content (%)		K Content (%)		N Uptake (kg ha^{-1})		P Uptake (kg ha^{-1})		K Uptake (kg ha^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1	1.45	0.94	0.26	0.21	1.05	2.06	54.37	32.95	9.65	7.25	39.46	72.10
T_2	1.41	0.91	0.24	0.19	1.03	2.04	41.59	27.45	7.06	5.63	30.21	61.43
T_3	1.44	0.93	0.25	0.20	1.04	2.05	49.77	31.07	8.54	6.59	36.03	68.72
T_4	1.43	0.92	0.24	0.18	1.04	2.06	46.61	29.05	8.21	5.98	33.56	65.05
T_5	1.42	0.91	0.25	0.19	1.02	2.03	45.75	29.05	7.55	5.66	33.09	64.82
T_6	1.49	0.97	0.28	0.22	1.06	2.09	59.71	35.71	11.06	8.10	42.38	76.95
T_7	1.47	0.94	0.27	0.20	1.06	2.07	56.20	33.66	10.45	7.25	40.65	73.73
CD (p=0.05)	0.06	0.02	NS	NS	NS	NS	0.56	0.87	1.10	0.87	1.24	2.78

grain; 27.45 kg ha^{-1} for stover). Maximum P uptake by grain (kg ha^{-1}) and stover was in T_6 (11.06 kg ha^{-1} for grain; 8.10 kg ha^{-1} for stover) followed by T_7, T_1, T_3, T_4 and T_5 Minimum P uptake was observed under T_2 (7.06 kg ha^{-1} for grain; 5.63 kg ha^{-1} for stover. Maximum K uptake by grain (kg ha^{-1}) and stover was in T_6 (42.38 kg ha^{-1} for grain; 76.95 kg ha^{-1} for stover) followed by T_7, T_1, T_3, T_4, T_5. Minimum nitrogen uptake was observed under T_2 (30.21 kg ha^{-1} for grain; 61.43 kg ha^{-1} for stover). The positive influence of foliar nano urea application in panicle initiation and heading stages in rice might be due to improved nitrogen availability and absorption in both the root zone and plant system. The increased availability and accumulation of nutrients again leads to more metabolic activity at cellular level which in turn increased nutrient uptake resulting in greater translocation of nutrients to reproductive organs of the crop and ultimately increased the nitrogen contents in both grain and stover. Moreover, the nano particles have more specific surface area and number of particles per unit area of a fertilizer and can easily penetrate into the plants from applied surface and improve uptake and nutrient use efficiency of rice. The findings were in close agreement with the findings of Bora and Pandey (2018), Burhan and AL-Hassan (2019) and Mehta and Bharat (2019), Yadav et al. (2021), Sahu et al. (2022) and Sharma et al. (2022).

CONCLUSION

The treatment Foliar spray with nano urea at active tillering + top dress with urea at panicle initiation + foliar spray with nano urea at heading was the best treatment on replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition with highest yield attributes and quality parameters of both grain and stover. Therefore, foliar application of nano urea twice at the panicle initiation and heading stages of rice growth can effectively replace urea top dressing at panicle initiation stage.

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