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EFFECT OF REPLACING UREA TOP DRESSING BY NANO UREA ON GROWTH AND ECONOMICS OF DIRECT SEEDED RICE (*ORYZA SATIVA* L.) UNDER RAINFED CONDITION

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ABSTRACT

A field experiment was conducted on clay soils during *kharif* season 2023 at the research farm, College of Agriculture, Central Agricultural University, Iroisemba, Imphal to evaluate the study possibility of replacing urea top dressing by nano urea and its efficacy. The initial soil of the experimental field was acidic with pH 5.25. The study was replicated thrice and employed a randomized block design with seven treatments. To verify the objective observations on growth parameters and economics were recorded. The results indicated that replacing urea top dressing by nano urea had significant effect on the growth parameters and economics. Highest growth attributes and net returns were observed under Top Dress with Urea at Active Tillering + Foliar Spray with Nano Urea at Panicle Initiation + Foliar Spray with Nano Urea at Heading (T_6) while the lowest values were observed in Foliar Spray with Nano Urea at Active Tillering + Foliar Spray with Nano Urea at Panicle Initiation (T_2). With regards to nutrient uptake (NPK), the said treatment (T_6) was found the highest. On the basis of the 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.

Key words : Rice, Nitrogen, Urea, Nano urea, Foliar spray.

Introduction

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). Due to issues of water scarcity and expensive labour, direct seeded rice cultivation technology is becoming popular. 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 offers a very exhilarating opportunity to improve water and environmental sustainability (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. It plays a key role in photosynthetic activity, and crop yield and significantly increases agriculture production (50%), being a constituent of protein, it increases the food value as well. It plays a key role in photosynthetic activity, and crop yield and significantly increases agriculture production (50%), being a constituent of protein, it increases the food value as well. 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 (Shrestha *et al.*, 2020), as plants are not able to absorb the excess of N-fertilizer. 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).

Nanotechnology is the promising field with its extensive applications in biotechnology, pharmaceutical science, nano-medication and other research territories (Chandana *et al.*, 2021). Nano-Urea provide more surface area for different metabolic reactions in the plant which increase rate of photosynthesis and produce more dry matter and yield of the crop. It also helps in preventing plants from different biotic and abiotic stress (Baboo *et al.*, 2021). 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). 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 will be conducted at the Research Farm of College of Agriculture, Central Agricultural University, Imphal during kharif season, 2023 with the objective of to study the effect of replacing urea top dressing by nano urea on growth and soil parameters of direct seeded rice (*Oryza sativa* L.)

Materials and Methods

The experimental site is situated at 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). 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, P_2O_5 16.89 kg/ha and K_2O 276.32 kg/ha (Annexure-1). The study was replicated three times and employed a 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, in randomized block design replicated thrice. 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.

Annexure 1 : Chemical properties of the experimental soil (initial).

S. no.	Parameter	Value	Interpretation
1	pH	5.25	Acidic
2	Organic carbon (%)	1.43	High
3	Sand (%) Silt (%) Clay (%)	9.65 15.68 74.67	Clay soil
4	Available nitrogen (kg/ha)	275.34	Low
5	Available phosphorus (P_2O_5) (kg/ha)	16.89	Low
6	Available potassium (K_2O) (kg/ha)	276.32	Medium

The growth parameters namely, plant height (cm), number of leaves per hill, leaf area per hill, Leaf Area Index number of tillers per hill, fresh weight and dry weight of whole plant (g/plant) were recorded at 30, 60, 90 DAS and harvest stages. The economics (cost of cultivation, gross return, net return, benefit cost ratio) were observed. The texture of the soil is also determined before the start of the experiment. Initial and post-harvest soil parameters namely, pH, organic carbon (%), available N (kg/ha), available P_2O_5, available K_2O were also recorded.

Results and Discussion

Effects of top dressing of nano urea on the growth parameters

The results in Table 1 reveals that all the stages of the growth parameters except 30 DAS was found to be insignificant. At 60 DAS, T_1 treatment recorded to be highest in plant height (64.04 cm), number of leaves per hill (18.36), leaf area per hill (666.85 cm^2) and leaf area index (2.22) which was at par with the plot treated with T_6. At 90 DAS and harvest the maximum plant height (116.63 cm at 90 DAS; 115.87 cm at harvest), number of leaves per hill (33.40 at 90 DAS; 33.07 at harvest, leaf area per hill (1979.54 cm^2 at 90 DAS) and leaf area index (6.60 at 90 DAS) was found to be highest in the treatment T_6. The lowest growth parameters are reported

Table 1 : Plant height (cm), number of leaves per hill, leaf area per hill, leaf area index per hill as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition.

Treatments	Plant height (cm)				Number of leaves per hill				Leaf Area per hill (cm^2)			LAI		
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
T_1	30.87	64.04	113.90	113.11	9.57	18.36	30.61	30.28	64.74	666.85	1699.74	0.32	2.22	5.67
T_2	30.60	57.17	101.97	101.15	10.37	14.78	21.21	20.87	72.32	398.57	1010.33	0.36	1.33	3.37
T_3	31.03	59.73	110.90	109.63	10.63	15.40	27.58	27.24	71.68	492.31	1465.73	0.36	1.64	4.89
T_4	30.87	59.10	106.93	106.03	10.70	15.33	24.96	24.63	79.93	470.58	1281.11	0.40	1.57	4.27
T_5	30.50	57.15	104.77	103.93	10.53	15.18	23.60	23.60	78.29	421.54	1211.4	0.39	1.41	4.04
T_6	31.37	62.90	116.63	115.87	11.23	17.54	33.40	33.07	79.43	608.59	1979.54	0.40	2.01	6.60
T_7	30.73	61.87	114.12	113.21	10.43	16.29	30.75	30.42	74.85	563.42	1784.71	0.37	1.88	5.95
SEd (±)	**0.98**	**0.63**	**1.02**	**1.14**	**0.83**	**0.59**	**1.15**	**1.27**	**12.98**	**35.08**	**48.92**	**0.06**	**0.10**	**0.16**
C.D. 5%	**NS**	**1.38**	**2.22**	**2.48**	**NS**	**1.28**	**2.51**	**2.77**	**NS**	**76.42**	**106.60**	**NS**	**0.22**	**0.36**

to have in a plot treated with T_2 in all the stages of crops.

Growth parameters in Table 2 found that all the stages in growth parameters is significant except at 30 DAS. At 60 DAS, T_1 treatment recorded to be highest in number of tillers per hill (12.75), fresh weight of whole plant (54.40 g/hill) and dry weight of whole plant (19.69 g/hill) which was followed by the treatment T_6. At 90 DAS and harvest, T_6 treatment found to have maximum number of tillers per hill (19.33 at 90 DAS; 19.29 at harvest), fresh weight of whole plant (94.15 g/hill at 90 DAS; 126.22 g/hill at harvest) and dry weight of whole plant (28.71 g/hill at 90 DAS; 42.44 g/hill at harvest). T_2 treatment is found to have lowest growth parameters in all the stages of crops.

The effect of foliar application of nano urea on increased growth parameters might be due to the increase in availability and readily absorption of nano sized nitrogen particle which has more surface area for absorption. Unutilized nitrogen remains stored in plant vacuole which is slowly released for proper plant growth and development which eventually help in cell elongation and photosynthetic rate is increased. Exogenous application of nano particles can greatly boost plant growth resulting increase in number of leaves per plant, leaf area and LAI, number of tillers. It may be due to the fact that nano-fertilizers have high reactivity because of having features like higher specific surface area, more density of areas, or increased reactivity of these areas on the particle surfaces which eventually simplify their absorption in plants. The results were in conformity with the finding of Benzon *et al.* (2005), Kumar *et al.* (2017), Sahu *et al.* (2022).

Effects of top dressing of nano urea on soil parameters

In soil parameters *i.e.*, pH, organic carbon (%), available P_2O_5 (kg/ha), available K_2O (kg/ha) were found to be insignificant and soil parameter available nitrogen (kg/ha) was found to be significant (Table 3). Results on Soil pH is found to be highest in the plots treated with T_2 (5.19) and T_5 (5.19) where the lowest is under T_1 (5.13). Whereas, the plots treated with T_1 is found to have highest valued of Organic cardon (1.42), soil available N (245.25 kg/ha) and P_2O_5 (27.78 kg/ha) and minimum value is recorded under T_3 (organic carbon) and T_2 (soil available N and P_2O5). In case of soil available K_2O, highest was recorded in T_6 treatment (212.93 kg/ha), while lowest under T_2 treatment (195.96 kg/ha). In comparison to conventional fertilizers, the slow-release nature of nano fertilizers in rice reduces leaching and atmospheric losses, minimizing fixation and microbial conversion of soil

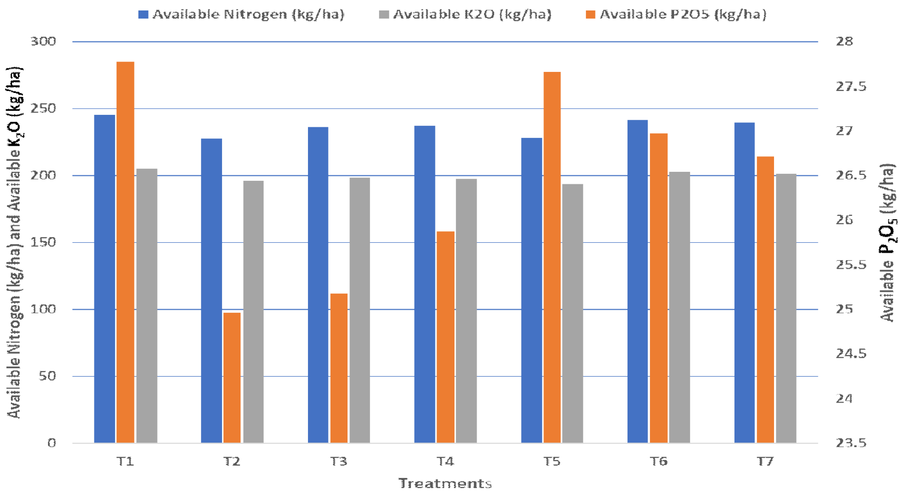

Fig. 1 : Soil available nitrogen (kg/ha), P_2O_5 (kg/ha) and K_2O (kg/ha) as influenced as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition.

Table 2 : Number of tillers per hill, fresh weight of whole plant (g/plant), dry weight of whole plant (g/plant) as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition.

Treatments	Number of tillers per hill				Fresh weight of whole plant (g/hill)				Dry Weight of whole plant (g/hill)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	5.80	12.75	18.09	18.07	9.97	54.40	91.52	122.86	3.07	19.69	26.25	38.96
T_2	5.77	9.46	15.07	15.04	9.53	47.02	84.46	115.18	2.90	14.77	19.72	31.30
T_3	5.97	10.52	17.11	17.03	9.83	49.41	89.19	120.17	3.00	16.08	24.28	36.29
T_4	6.00	10.39	16.15	16.01	9.00	49.32	86.58	117.45	2.97	16.04	21.82	33.62
T_5	6.03	9.49	16.04	15.96	9.80	47.47	87.20	118.08	3.07	15.10	22.25	34.07
T_6	6.10	12.10	19.33	19.29	9.17	53.17	94.15	126.22	3.13	17.87	28.71	42.44
T_7	5.97	11.56	18.39	18.26	9.50	52.36	91.81	123.44	3.10	17.57	26.63	39.55
SEd (±)	**0.31**	**0.36**	**0.33**	**0.38**	**1.23**	**0.83**	**0.89**	**0.92**	**0.22**	**0.83**	**0.83**	**0.86**
C.D 5%	**NS**	**0.79**	**0.73**	**0.82**	**NS**	**1.82**	**1.95**	**2.00**	**NS**	**1.82**	**1.80**	**1.87**

Table 3 : Soil pH, organic carbon, nitrogen, phosphorus, and potassium as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition.

Treatments	pH	Organic carbon (%)	Available Nitrogen (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
T_1	5.13	1.42	245.25	27.78	205.04
T_2	5.19	1.41	227.58	24.96	195.96
T_3	5.16	1.37	236.12	25.18	198.60
T_4	5.18	1.38	237.30	25.88	197.66
T_5	5.19	1.37	228.51	27.66	193.97
T_6	5.16	1.40	241.78	26.97	212.93
T_7	5.15	1.41	239.45	26.71	201.38
SEd (±)	**0.02**	**0.02**	**3.41**	**1.15**	**3.58**
C.D 5%	**NS**	**NS**	**7.42**	**NS**	**NS**

nutrients. Moreover, there is enhancement in some soil biochemical processes such as nitrification and which ultimately increases the available soil nitrogen. Similar findings were reported by Naderi and Danesh-Shahraki (2013), León-Silva *et al*. (2018), Thirunuvukkarasu and Subramanian (2021).

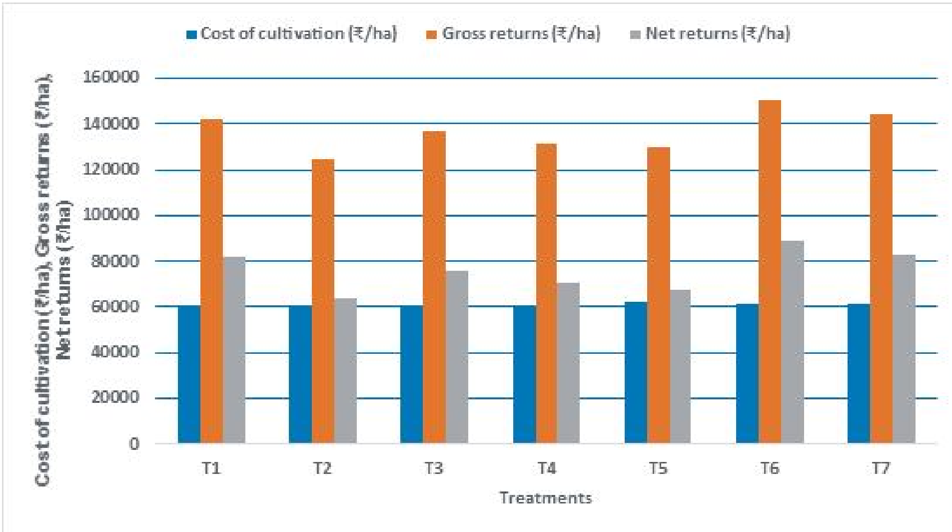

Fig. 2 : Economics as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition.

Table 4 : Economics as influenced by replacing urea top dressing by nano urea in direct seeded rice (*Oryza sativa* L.) under rainfed condition.

Treatments	Cost of cultivation (` /ha)	Gross returns (` /ha)	Net returns (` /ha)	Benefit Cost Ratio (BCR)
T_1	60209.16	142201.00	81991.84	1.36
T_2	60701.64	124807.50	64105.86	1.06
T_3	60455.52	136782.00	76326.48	1.26
T_4	60455.52	131364.50	70908.98	1.17
T_5	61893.64	129606.50	67712.86	1.09
T_6	61647.52	150442.50	88794.98	1.44
T_7	61647.52	144245.50	82597.98	1.34

Effects of top dressing of nano urea on economics

Data pertaining to economics was presented in Table 4. Lowest cost of cultivation was recorded with T_1 (60209.16 ` /ha). Higher cost of cultivation was noticed under $T_5$ (61893.64 ` /ha). Maximum gross return (150442.50 ` /ha), net return $T_6$ (88794.98 ` /ha) and B:C ratio T_6 (1.44) were noticed under T_6 and the minimum gross return (124807.50 ` /ha), net return (64105.86 ` /ha) and B:C ratio (1.06) were recorded under T_2. Highest net return was recorded from the treatment T_6, which is due to higher grain and straw yield from the said treatment. Lowest net returns were recorded in T_2, which may be attributed to lower grain and straw yield recorded by the treatment. This might be due to which was the significant difference in grain and straw yield of rice crop and cost of fertilizers incurred at different treatments. The results were in conformity with the findings of Rahman *et al*. (2017), Velmurugan *et al*. (2021), Velmurugan *et al*. (2021), Yadav *et al*. (2021), Attri *et al*. (2022), Sahu *et al*. (2022).

Benefit cost ratio of T_6 was highest that could be due to higher net returns. Lowest benefit cost ratio was found on T_2 which may be due to higher cost of cultivation and low yield of crop. Similar results were reported by Kumar *et al*. (2014), Rahman *et al*. (2017), Yadav *et al*. (2021), Attri *et al*. (2022), Sahu *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 (T_6) was found to be the best treatment on replacing urea top dressing by nano urea in Direct Seeded Rice (*Oryza sativa* L.) under rainfed condition as it achieved highest values with regard to growth parameters and economics (gross return, net return, B:C ratio). Therefore, it can be inferred that 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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