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Effect of foliar application of nano urea under different fertility levels on the growth, yield attributes and yield of rice (*Oryza sativa* L.)

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Abstract

The experiment was carried out in Split Plot Design with 16 treatment combinations of fertility levels as main plot viz., N₁- Control, N₂- 50% RDF, N₃- 75% RDF and N₄- 100% RDF with foliar application of nano urea treatment as sub plot viz., S₁- Nano urea spray one time (20-25 DAT @ 5 ml L⁻¹ water), S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L⁻¹ water), S₃- Urea spray one time (20-25 DAT @ 20g L⁻¹ water) and S₄- Urea spray two times (20-25 DAT & 40-45 DAT @ 20g L⁻¹ water) were replicated thrice at DKS College of Agriculture and Research Station, Bhatapara, Chhattisgarh. The results of this experiment reveals that the values of growth attributing characters viz., plant height (cm), dry matter accumulation (g hill⁻¹) and yield attributes like number of tillers hill⁻¹, number of panicles hill⁻¹, number of grains panicle⁻¹, number of filled grains panicle⁻¹, test weight of 1000 grain (g), grain and straw yield (kg ha⁻¹) of rice were found significantly superior under treatment N₄- 100% RDF followed by N₃- 75% RDF. Among the foliar application of nano urea, parameters cited above were recorded significantly higher in treatment S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L⁻¹ water) followed by S₄- Urea spray two times (20-25 DAT & 40-45 DAT @ 20g L⁻¹ water).

Keywords: Rice (*Oryza sativa* L.), growth, yield

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops. It is a plant of South East Asia origin. It belongs to family Poaceae (Gramineae). The genus *Oryza* includes 24 species, of which 22 are wild and two species namely *Oryza sativa* and *Oryza glaberrima* are cultivated. All the varieties found in Asia, America and Europe belong to *Oryza sativa* and varieties found in West Africa belong to species *Oryza glaberrima*. Rice is primarily a high-energy or high calorie food. The protein content of milled rice is usually 6 to 7 per cent. Rice is enriched in the vitamin's thiamine, riboflavin and niacin. The amino acid profile of rice reveals that it is high in glutamic and aspartic acid (FAO, 2004) [5]. Rice contains 80% carbohydrates, 7-8% protein, 3% fat and 3% fiber. Globally, rice is cultivated in 165.25 million ha area with an annual production of around 787.30 million tonnes with yield of 4.76 tonnes ha⁻¹ [Anonymous. 2021(a)] [1]. In India, cultivated area about 45.07 million hectares with an annual production of about 122.27 million tonnes and productivity of 2713 kg ha⁻¹ [Anonymous. 2021(b)] [2]. In the Chhattisgarh state, Paddy cultivated area is 3.79 million hectares with production of 7.1 million tonnes and yield of paddy is 1889 kg ha⁻¹ [Anonymous. 2021(c)] [3]. For rice plants to grow, develop, and yield grains, they need a lot of mineral nutrients, particularly nitrogen. Furthermore, N is a component of several enzyme proteins that catalyse and control processes related to plant growth (Sinfield *et al.*, 2010) [10].

Although fertilizers are essential for agriculture to feed the growing population, the excessive use of large amounts of chemical fertilizers leads to environmental pollution. The application of nano-fertilizers (NFs) is an emerging research field in agriculture. These substances, which range in size from 1 to 100 nm, aid in the plants nutrition. As an alternative to traditional urea fertilizer, nano urea is a liquid formulation of urea based on nanotechnology that supplies

nitrogen to plants. Scientists at the Nano Biotechnology Research Centre in Kalol, Gujarat, affiliated with Indian Farmer Fertilizers Cooperative Limited (IFFCO), are responsible for its development. Its 40000 mg litre⁻¹ of nitrogen nano particle content is the same as the nitrogen nutrients found in a 45 kg bag of conventional urea fertilizer. According to IFFCO guidelines, a 500 ml bottle of nano urea is sufficient for one acre.

Foliar application of nano urea (Liquid) at critical crop growth stages of a plant effectively fulfils its nitrogen requirement and leads to higher crop productivity and quality in comparison to conventional urea. According to IFFCO (2021) nano urea liquid makes the crops stronger, healthier, and protects them from lodging effect. It is a sustainable solution for plant nutrition with higher nutrient use efficiency and reduces soil, water, and air pollution. It was also reported for substantial increase in farmers income.

2. Materials and Methods

The present investigation was conducted at Instructional Farm, DKS College of Agriculture and Research Station, Bhatapara, Chhattisgarh during the *Kharif* season 2023 to find the effect of foliar application of nano urea under different fertility levels on rice (*Oryza sativa* L.). The typical climatic condition of Bhatapara is hot and humid and the soil texture at the field experiment site is clayey. The total rainfall received during crop growth period was 1339.4 mm. Relative humidity ranged between 92% to 83.1%. The mean weekly maximum and minimum temperature during the crop growth period ranged between 28.8 to 33.7°C and 11.8 to 25.7 °C respectively. Wind speed varied from 1 to 6.4 km hr⁻¹. The average and cumulative open pan evaporation during study period was 14.6 and 29.6 mm respectively. The bright sunshine varied from 0.8 to 9.2 hrs day⁻¹.

Sixteen treatment combinations comprising of four different fertility levels as main plot viz., N₁- Control, N₂- 50% RDF, N₃- 75% RDF and N₄- 100% RDF with foliar application of nano urea treatment as sub plot viz., S₁- Nano urea spray one time (20-25 DAT @ 5 ml L⁻¹ water), S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @5 ml L⁻¹ water), S₃- Urea spray one time (20-25 DAT @ 20g L⁻¹ water) and S₄- Urea spray two times (20-25 DAT & 40-45 DAT @20g L⁻¹ water) were replicated thrice in Split Plot Design taken under study to estimate response in growth and yield of rice.

The rice variety mahamaya were transplanted at spacing 20 cm × 10 cm (row × plant). The gross and net plot size was 4m × 4m and 3.2 m × 3.2 m, respectively. The Recommended dose (100 kg N + 60 kg P₂O₅ + 40 kg K₂O ha⁻¹) was provided as urea, diammonium phosphate and muriate of potash, in that order. Weed control practices were done by hand weeding at 30 DAT and 60 DAT. Although there were adequate amounts of rainfall during the testing period, the crop received two irrigations during the blossoming and grain filling stages. Throughout the trial, crop samples were taken from every plot in order to examine different crop characteristics. Characters of crop growth were recorded from every plot and appropriately tagged. The observations were made at four different time points: 30, 60, 90 DAT and the crop's harvesting stage. The data obtained on various observations for each treatment were subject to 'Analysis of variance'. Harvest index (HI) were worked out using the following formulas:

$$HI (\%) = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3. Result and Discussion

Growth parameters

Under present investigation, the growth parameters viz., plant height, total number of tillers hill⁻¹ and dry matter accumulation hill⁻¹ were recorded. The significant effect was found on all the stages of growth and parameters. The relevant data of growth parameters were presented in Table 1.

It is revealed from the data that plant height was significantly influenced by different fertility levels and foliar spray of nano urea. The maximum plant height, total number of tillers hill⁻¹ and dry matter accumulation hill⁻¹ were recorded on fertility level N₄- 100% RDF while minimum on N₁- Control.

Maximum plant height, total number of tillers hill⁻¹ and dry matter accumulation hill⁻¹ were recorded on S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L⁻¹ water) followed by S₄- Urea spray two times (20-25 DAT & 40-45 DAT @ 20g L⁻¹ water) while minimum on S₃- Urea spray one time (20-25 DAT @20 g L⁻¹ water). Because the plant can absorb the nano urea more effectively, it can absorb nutrients like nitrogen more effectively, which promotes improved plant development and the creation of dry matter. The increased deposition of dry matter could also have been attributed to the higher concentration and longer-lasting release of nutrients that the nano urea treatments offered. Similar result was also reported by Benzon *et al.* (2015)^[4] and Sharma *et al.* (2022)^[9].

Yield Attributes

The relevant data of yield attributes were presented in Table 2. Number of panicles hill⁻¹, and number of filled grains panicle⁻¹ were significantly influenced by fertility levels while number of grains panicle⁻¹, number of chaffy grains panicle⁻¹ and test weight (1000 seeds weight) had non-significant effect on it. The maximum number of panicles hill⁻¹, number of grains panicle⁻¹, number of filled grains panicle⁻¹ and test weight (1000 seeds weight) were recorded under fertility level N₄- 100% RDF while minimum on N₁- Control. This may be the result of applying nano urea foliar spray, which increases photosynthetic absorption and facilitates the transport of photosynthates from the source to the sink. In addition, timely nitrogen delivery accelerates beginning of grain production, contributing to the rise in grains panicle⁻¹. Nearly similar results were found by Jassim *et al.* (2019)^[6].

The maximum number of panicles hill⁻¹, number of grains panicle⁻¹, number of filled grains panicle⁻¹ and test weight (1000 seeds weight) were recorded under S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L⁻¹ water) while minimum on S₃- Urea spray one time (20-25 DAT @20g L⁻¹ water). The highest number of panicles hill⁻¹ may have resulted from plants receiving enough nitrogen through nano urea at a critical stage, which would have maintained a continuous supply of nitrogen, stimulated cell elongation in plants, and meristematic activity. The results of Jassim *et al.* (2019)^[6] and Sahu *et al.* (2022)^[8] closely aligned with these findings.

Yield

The fertility levels and foliar application of nano urea both exerted significant effect on grain yield and straw yield. The results revealed that the maximum grain and straw yield was recorded under N₄- 100% RDF which was followed by N₃- 75% RDF > N₂- 50% RDF > N₁- Control. The control treatment yielded the lowest since it did not apply fertilizer. These results emphasise how important it is to apply fertilizer correctly in

order to maximise rice output. The results obtained in the present study are supported by the works of Valojai *et al.* (2021)^[11]. Also, the maximum grain and straw yield was recorded under S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @5 ml L⁻¹ water) followed by S₄- Urea spray two times (20-25 DAT & 40-45 DAT @20g L⁻¹ water) > S₁- Nano urea spray one time (20-25 DAT @ 5 ml L⁻¹ water) > S₃- Urea spray one time (20-25 DAT @ 20g L⁻¹ water). The findings highlight how crucial it is to apply nano urea for appropriate nutrient management in order to maximise rice yield and improve harvest quality. The finding of present study is in accordance with those of Midde and ferumal (2021)^[7] and Valojai *et al.* (2021)^[11].

Significantly, highest harvest index was recorded in treatment

N₄- 100% RDF followed by N₃- 75% RDF > N₂- 50% RDF > N₁- Control. Significant increases in yield parameters were also observed in treatment N₄- 100% RDF as compared to the Control treatment, emphasising the crucial importance of applying a sufficient amount of fertiliser. The research conducted by Valojai *et al.* (2021)^[11] provides support for the findings of the current investigation. Also, the maximum harvest index recorded under S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @5 ml L⁻¹ water) followed by S₄- Urea spray two times (20-25 DAT & 40-45 DAT @20g L⁻¹ water) > S₃- Urea spray one time (20-25 DAT @ 20g L⁻¹ water) > S₁- Nano urea spray one time (20-25 DAT @ 5 ml L⁻¹ water). The relevant data of grain yield, straw yield and harvest index were presented in Table 3.

Table 1: Plant height, dry matter accumulation hill⁻¹ and total no. of tillers hill⁻¹ influenced by fertility levels and foliar application of nano urea on rice

Treatments	Plant height (cm)				Dry matter accumulation hill ⁻¹				Total no. of tillers hill ⁻¹			
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
Fertility Levels												
N ₁ : Control	54.71	83.93	104.68	104.10	2.78	22.83	53.01	89.53	6.85	9.86	11.73	11.96
N ₂ : 50% RDF	59.83	87.71	109.58	108.67	3.19	26.53	58.62	95.74	7.61	11.74	12.85	13.08
N ₃ : 75% RDF	62.50	93.35	116.38	113.08	3.44	28.00	60.70	98.06	8.21	12.89	13.49	13.94
N ₄ : 100% RDF	62.39	95.79	120.65	117.44	3.55	29.73	63.70	101.96	8.91	13.80	14.53	14.98
S.E.m±	2.027	2.328	3.072	2.524	0.070	0.670	1.521	1.389	0.244	0.420	0.448	0.314
CD (0.05)	NS	8.055	10.631	8.735	NS	2.319	5.265	4.806	0.846	1.454	1.550	1.087
Foliar spray of nano urea												
S ₁ : Nano urea spray one time (20-25 DAT @ 5 ml L ⁻¹ water)	58.58	88.25	110.35	107.69	3.00	25.65	57.19	94.14	7.45	11.49	12.88	13.20
S ₂ : Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L ⁻¹ water)	62.87	94.43	117.21	117.38	3.62	30.26	63.80	102.17	8.37	13.04	14.59	14.84
S ₃ : Urea spray one time (20-25 DAT @ 20g L ⁻¹ water)	56.92	85.79	107.53	105.73	2.93	23.95	54.24	90.83	7.66	11.12	11.48	12.15
S ₄ : Urea spray two times (20-25 DAT & 40-45 DAT @ 20g L ⁻¹ water)	61.06	92.29	116.20	112.50	3.42	27.23	60.66	98.15	8.11	12.64	13.64	13.78
S.E.m±	1.385	1.529	2.293	2.301	0.070	0.724	1.168	1.538	0.242	0.344	0.292	0.215
CD (0.05)	NS	4.463	6.692	6.715	NS	2.112	3.410	4.490	NS	1.003	0.851	0.627
Interaction												
S.E.m±	2.770	3.058	4.585	4.601	0.140	1.447	2.336	3.077	0.485	0.687	0.583	0.429
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.253

Table 2: Yield attributes of rice influenced by fertility levels and foliar application of nano urea

Treatments	No. of panicles hill ⁻¹	No. of grains panicle ⁻¹	No. of filled grains panicle ⁻¹	No. of chaffy grains panicle ⁻¹	Test weight (g)
Fertility Levels					
N ₁ : Control	8.55	129.92	111.67	18.25	29.25
N ₂ : 50% RDF	10.51	144.75	129.75	15.00	29.65
N ₃ : 75% RDF	11.60	149.21	135.25	13.96	29.92
N ₄ : 100% RDF	12.40	153.50	140.58	12.92	30.08
S.E.m±	0.320	5.082	5.068	2.182	0.183
CD (0.05)	1.106	NS	17.536	NS	NS
Foliar spray of nano urea					
S ₁ : Nano urea spray one time (20-25 DAT @ 5 ml L ⁻¹ water)	10.33	139.21	124.17	15.04	29.65
S ₂ : Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L ⁻¹ water)	11.73	157.50	143.83	13.67	30.41
S ₃ : Urea spray one time (20-25 DAT @ 20g L ⁻¹ water)	9.42	130.33	113.83	16.50	28.85
S ₄ : Urea spray two times (20-25 DAT & 40-45 DAT @ 20 g L ⁻¹ water)	11.58	150.33	135.42	14.92	30.00
S.E.m±	0.202	2.512	2.403	2.163	0.142
CD (0.05)	0.591	7.333	7.013	NS	0.416
Interaction					
S.E.m±	0.405	5.025	4.805	4.327	0.285
CD (0.05)	1.181	NS	NS	NS	NS

Table 3: Grain yield, straw yield and harvest index of rice as influenced by fertility levels and foliar spray of nano urea

Treatments	Grain yield (Kg ha ⁻¹)	Straw yield (Kg ha ⁻¹)	Harvest index (%)
Fertility Levels			
N ₁ : Control	3368	4733	41.6
N ₂ : 50% RDF	4933	6142	44.5
N ₃ : 75% RDF	5396	6453	45.5
N ₄ : 100% RDF	5722	6783	45.7
S.E.m±	111	160	1.01
CD (0.05)	383	553	3.50
Foliar spray of nano urea			
S ₁ : Nano urea spray one time (20-25 DAT @ 5 ml L ⁻¹ water)	4595	5798	44.0
S ₂ : Nano urea spray two times (20-25 DAT & 40-45 DAT @5 ml L ⁻¹ water)	5260	6366	44.8
S ₃ : Urea spray one time (20-25 DAT @ 20g L ⁻¹ water)	4461	5619	44.2
S ₄ : Urea spray two times (20-25 DAT & 40-45 DAT @20g L ⁻¹ water)	5101	6328	44.4
S.E.m±	75	77	0.55
CD (0.05)	218	225	NS
Interaction			
S.E.m±	149	154	1.10
CD (0.05)	436	450	NS

4. Conclusion

The higher growth characters like, plant height, number of tillers and dry matter accumulation was obtained in treatment N₄-100% RDF + S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L⁻¹ water) and also yield attributing characters like number of panicles, number of grains panicle⁻¹, number of filled grains panicle⁻¹ and test weight was obtained in treatment N₄- 100% RDF + S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @ 5 ml L⁻¹ water).

Grain yield, straw yield and harvest index was obtained in treatment N₄- 100% RDF + S₂- Nano urea spray two times (20-25 DAT & 40-45 DAT @5 ml L⁻¹ water).

Hence, it can be concluded that 100% fertilizer application + Nano urea spray two times (20-25 DAT & 40-45 DAT @5 ml L⁻¹ water) and 100% fertilizer application + Urea spray two times (20-25 DAT & 40-45 DAT @20g L⁻¹ water) is beneficial for higher rice productions.

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