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EFFECT OF NANO FERTILIZER ON GROWTH, YIELD, NITROGEN UPTAKE AND ECONOMICS OF RICE IN ALLUVIAL SOILS OF GODAVARI ZONE OF ANDHRA PRADESH

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ABSTRACT

A field trial was conducted during the *Kharif* and *Rabi* seasons of 2023–24 to evaluate the efficacy of nano urea (NU) and super nano urea (SNU) on the growth, yield, nutrient uptake, and economics of rice. The experiment consisted of 11 treatments: T_1–Control (0% N; 100% P & K); T_2–Recommended Fertilizer Dose (RDF) representing 100% RDN (*Kharif*: 90-60-60 kg NPK ha^{-1}; *Rabi*: 180-90-60 kg NPK ha^{-1}); T_3–50% RDN; T_4- 50% RDN + two sprays of conventional urea @1.0% at active tillering (AT) and panicle initiation (PI) stages; T_5- 50% RDN + two sprays of NU @0.4% at A.T & PI; T_6- 50% RDN + three sprays of NU @0.4% at A.T, PI & heading; T_7- 50% RDN + two sprays of SNU @0.25% at A.T & PI; T_8- 50% RDN + two sprays of SNU @0.5% at A.T & PI; T_9- 50% RDN + two sprays of SNU @1.0% at A.T & PI; T_{10}- 33% RDN + three sprays of SNU @0.5% at A.T, PI & heading; and T_{11}- 66% RDN + one spray of SNU @0.5% at heading. The resultsrevealed that the application of 50% RDN with two foliar sprays of nano urea at the active tillering and panicle initiation stages (T_8) proved effective in enhancing rice growth, yield attributes, grain and straw yields, economic returns and nitrogen uptake. However, this treatment performed on par to the 100% RDN (T_2) across two consecutive seasons on alluvial soils of the Godavari zone.

Keywords: Grain yield, Nano urea,Nutrient uptake

INTRODUCTION

Rice (Oryza sativa L.) is important staple food crop for more than half of the global population. As a major source of carbohydrates, rice plays a vital role in meeting worldwide caloric requirements and supplying key micronutrients, including vitamins, minerals, and dietary fiber. The steady growth of the global population has strengthened the need to expand rice production to meet global food security. Beyond its nutritional value, rice has considerable economic, cultural, and religious significance across regions of the world.

In recent years, the agricultural sector has encountered a multitude of challenges that have posed significant threats to its stability and productivity. In response, the development of innovative technologies has been pivotal in overcoming these constraints and sustaining farm-level productivity. In this context, nanofertilizers have emerged as a promising component in crop nutrition, although their

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application is in the early stages of development. These advanced formulations hold considerable potential for promoting sustainable crop growth, with particular emphasis on nano nitrogen. Nanofertilizers enhance nutrient use efficiency in plants, reduce adverse effects on soil microorganisms, and alleviate stress associated with the overapplication of conventional fertilizers, thereby reducing the fertilizer requirements of crops (Kantwa and Yadav, 2022). Consequently, nanofertilizers may also serve as a viable and environmentally responsible alternative to conventional fertilization. Considering these factors, the present investigation was undertaken to evaluate the influence of nano-fertilizers on the yield performance, nitrogen uptake and economics of rice crops.

MATERIAL AND METHODS

A field trial was conducted during *kharif* and *rabi* seasons of 2023–24 at the Regional Agricultural Research Station, Maruteru, West Godavari district, to evaluate the effectiveness of nano urea (NU) and super nano urea (SNU) on the growth, yield, nitrogen uptake, and economic viability of rice. The Godavari zone is characterized by a tropical climate with hot summers and a dominant southwest monsoon from June to October, with an average rainfall ranging from 755 to 1500 mm. The experimental soil is alluvial.

The experiment consisted of 11 treatments arranged in a randomized block design with three replications: T_1–control (0% N; 100% P & K); T_2–recommended fertilizer dose (RDF) representing 100% RDN (*Kharif*: 90-60-60 kg NPK ha^{-1}; *Rabi*: 180-90-60 kg NPK ha^{-1}); T_3–50% RDN; T_4–50% RDN + two sprays of conventional urea @1.0% at active tillering (AT) and panicle initiation (PI) stages; T_5–50% RDN + two sprays of NU @0.4% at AT and & PI; T_6 50% RDN + three sprays of NU @0.4% at AT, PI and & heading; T_7 50% RDN + two sprays of SNU @ 0.25% at AT & PI; T_8 50% RDN + two sprays of SNU @0.5% at AT & PI; T_9 50% RDN + two sprays of SNU @1.0% at AT & PI; T_{10} 33% RDN + three sprays of SNU @0.5% at AT, PI & heading; and T_{11} 66% RDN + one spray of SNU @0.5% at heading.

IFFCO nano Urea (liquid), with a particle size ranging from 20 to 50 nm and containing 4.0% total nitrogen (w/v) uniformly dispersed in water, was utilized in this study. This product is officially listed under the Fertilizer Control Order (FCO), as notified by the Government of India. Both Nano Urea and Super Nano Urea are recognized as advanced formulations relative to conventional fertilizers owing to their superior efficacy. While both nano urea plus and nano urea are liquid fertilizers developed using nanotechnology (<100 nm), Nano urea plus is further distinguished by a higher nitrogen content (20% N), incorporation of improved bio-polymers, and enhanced nutrient absorption capacity attributes to improved crop performance.The recommended nutrients were applied in the form of urea, SSP, and MOP under transplantation conditions.The prescribed doses of P_2O_5 and K_2O were uniformly applied across all treatments.MTU 1061 and MTU 1121 were the test varieties used during the *Kharif* and *Rabi* seasons, respectively.

Plant samples were collected and assessed for nitrogen content using standard analytical procedures and nutrient uptake values were subsequently computed. The data were statistically analysed using Fisher's method of analysis of variance and interpreted following Gomez and Gomez (1984).An economic analysis was performed based on the prevailing market prices of inputs and the minimum support price for grain to compute the cost of cultivation, gross returns, net returns, and benefit-cost ratio.

RESULTS AND DISCUSSION

Growth and Yield Attributes

As presented in Tables 1 and 2, plant height showed a positive response with application of Super Nano Urea in combination with 50% of the recommended nitrogen dose during the active tillering and panicle initiation stages (T_8) during both *Kharif* and *Rabi* seasons. The significant enhancement in plant height may be attributed to enhanced seedling vigour, which promotes more active cell division and elongation (Nithya *et al.*, 2018).

Data regarding the yield attributing parameters, *viz.,* number of panicles m^{-2}, panicle weight^{-1}, panicle length, number of grains panicle^{-1}, and 1000-grain weight are furnished in Tables 1 and 2. During the *Kharif* season, reducing the nitrogen dose to 50% did not significantly reduce yield attributes compared to full 100% nitrogen application. Similarly, the supplementation of nano urea and super urea sprays with 50% RDN produced results comparable to both 50% N and 100% N treatments, suggesting a limited response to nitrogen inputs during the *Kharif* season. In the *Rabi* season, substitution of nano urea with a reduced nitrogen dose produced comparable yield attributes.However, a more severe reduction to 33% nitrogen led to a decline in yield-contributing parameters.

Grain Yield

During the *Kharif* season (Table 1), the 100% RDN recorded the highest grain yield (5150 kg/ha), closely followed by T_9 (50% RDN + two sprays of SNU @1.0% at AT and PI stages). The latter was comparable to other reduced nitrogen as well as those supplemented with nano-urea or super-nano-urea. The lowest grain yield (3971 kg/ha) was observed with the control. In the *Rabi* season, the same treatment, that is, 100% RDN, recorded the highest grain yield (6183 kg/ha) and was comparable to T_8 (50% RDN + two sprays of SNU @ 0.5%; 5260 kg/ha) and T_9 (50% RDN + two sprays of SNU @1.0%; 5350 kg/ha) applied at AT and PI stages.The lowest yield of 3347 kg/ha was recorded under 0% N, that is,the control.The comparable grain yield obtained with 50% RDN with two nano-urea sprays to the 100% recommended dose of nitrogen may be attributed to the timely and efficient delivery of nitrogen during the critical growth stages of the crop. This targeted approach adequately nourished the crop and enhanced yield attributes through a precise nutrient delivery mechanism, thereby maximizing nutrient uptake and utilization efficiency. Benzon *et al.* (2015) reported a synergistic relationship between nano-fertilizers and conventional fertilizers, resulting in superior nutrient absorption by plant cells when applied at critical crop stages, such as tillering and panicle initiation. These nano-fertilizers have been shown to increase tiller numbers and chlorophyll content, thereby supporting optimal metabolic processes, including photosynthesis, and ultimately promoting greater photosynthate accumulation and translocation to economic plant parts. These findings were correlated with the findings of Upadhyay *et al.* (2023).

Straw Yield

During the *Kharif* season, straw yield was not enhanced by either nano-urea or super-nano-urea combinations (Table 1). In contrast, during the *Rabi* season (Table 2), the application of 50% recommended nitrogen with nano-urea or super-nano-urea resulted in straw yields comparable to those achieved with 100% RDN. The improvement in straw yield with foliar nano-urea application may be attributed to its rapid uptake and efficient translocation within the plant, which facilitated faster photosynthesis and greater dry matter accumulation, ultimately contributing to a higher straw yield.

Table 1. Influence of Nanofertilizer application on performance of rice during *Kharif* season

	Treatment	Plant Height at Harvest (cm)	No of Tillers at Harvest (m^{-2})	No of Panicles m^{-2}	Panicles Weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1	Control (0% N; 100% P&K)	105.87	234	259	4.15	5294	6855
T_2	Recommended Dose of Fertilizer (RDF) (90-60-60 kg NPK/ha)	117.43	251	269	5.12	6866	7115
T_3	50 % RDN	113.37	235	259	4.34	6150	7920
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 % at AT& PI	116.33	226	244	4.32	6194	7871
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	115.97	240	259	4.26	6011	7479
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT, PI & Heading stage	116.73	239	265	4.38	5638	7174
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	117.63	234	239	4.59	6438	8151
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	119.93	261	270	4.64	6550	8017
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	118.00	236	265	4.48	6472	7915
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	112.87	224	255	4.03	6027	7579
T_{11}	66 % RDN + 1 spray of SNU @ 0.5 % at Heading stage	122.73	233	242	4.05	6294	8571
	CD at 0.05	**11.40**	**39.05**	**19.97**	**0.81**	**1286**	**2796**
	CV (%)	**5.76**	**9.65**	**4.56**	**10.91**	**12.22**	**21.33**

Table. 2. Influence of Nano fertilizer application on performance of rice during *Rabi* season

	Treatment	Plant Height at Harvest (cm)	No of Tillers at Harvest (m^{-2})	No of Panicles m^{-2}	Panicles Weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1	Control (0% N; 100% P&K)	85.7	188	163	3.24	3347	4817
T_2	Recommended Dose of Fertilizer (RDF) (180-90-60 kg NPK/ha)	103.9	317	296	4.28	5247	6763
T_3	50 % RDN	97.0	264	233	3.95	4527	5710
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 %at AT& PI	100.6	269	247	4.01	4740	6260
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	96.5	278	234	3.82	4673	6277
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT , PI & Heading stage	101.5	288	263	3.88	4843	6597
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	102.6	315	297	4.00	5367	6827
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	105.3	335	314	4.26	5793	7330
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	101.1	318	292	3.86	4883	6277
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	93.6	231	210	3.65	4280	5793
T_{11}	66 % RDN + 1 spray of SNU @ 0.5 % at Heading stage	102.5	292	273	3.90	4617	6170
	CD at 0.05	**8.70**	**66.25**	**60.85**	**0.53**	**1009**	**1075**
	CV (%)	**5.27**	**14.16**	**14.26**	**8.15**	**12.8**	**10.3**

Table: 3. Influence of Nano fertilizer application on Economics of rice during *Kharif* and *Rabi* seasons

	Treatment	Gross Returns (Rs/ha)		Cost of Cultivation (Rs/ha)		Net Returns (Rs/ha)		B:C Ratio	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	Control (0% N; 100% P&K)	86687	73065	74425	78117	12262	-5052	1.16	0.94
T_2	Recommended Dose of Fertilizer (RDF) (180-90-60 kg NPK/ha)	112425	134975	75602	80469	36823	54506	1.49	1.68
T_3	50 % RDN	100702	98824	75013	79293	25689	19531	1.34	1.25
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 % at AT& PI	105963	103474	81513	85793	24450	17681	1.30	1.21
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	98410	102012	78813	83093	19597	18919	1.25	1.23
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT , PI & Heading stage	92319	105723	80713	84993	11606	20730	1.14	1.24
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	105417	106596	78138	82418	27279	24178	1.35	1.29
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	101422	114826	79263	83543	22159	31283	1.28	1.37
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	107251	116791	81513	85793	25738	30998	1.32	1.36
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	98693	93432	81188	85268	17505	8164	1.22	1.10
T_{11}	66 % RDN + 1 spray of SNU @ 0.5% at Heading stage	103059	100789	77326	81794	25733	18995	1.33	1.23

Table: 4. Nitrogen content and uptake as influenced by Nano fertilizer application in Paddy

	Treatment	Grain N Uptake (kg/ha)		Straw N Uptake (kg/ha)	
		Kharif	*Rabi*	*Kharif*	*Rabi*
T_1	Control (0% N; 100% P&K)	34.6	30.5	22.9	20
T_2	Recommended Dose of Fertilizer (RDF) (180-90-60 kg NPK/ha)	48.2	57.8	25.8	33.4
T_3	50 % RDN	48.6	47.8	30.9	31.1
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 % at AT& PI	52.3	51.0	33.4	34.9
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	44.8	46.6	30.1	33.3
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT, PI & Heading stage	45.4	51.8	31.0	36.9
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	54.0	49.3	34.6	40.7
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	42.8	48.4	27.7	31.1
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	53.3	54.9	34.2	35.6
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	44.3	42.0	29.9	30.5
T_{11}	66 % RDN + 1 spray of SNU @ 0.5 % at Heading stage	49.0	47.7	31.3	37.8
	CD at 0.05%	**9.0**	**11.1**	**7.5**	**6.0**
	CV (%)	**11.2**	**13.5**	**14.6**	**10.6**

These findings are in agreement with those reported by Anushka *et al.* (2023) and Upadhyay *et al.* (2023).

Economic Analysis

An economic analysis of the data (Table 3) revealed that a higher B:C ratio of 1.49 was attained with the 100% RDN, followed by 50% RDN + two sprays of SNU @0.25% at the active tillering and panicle initiation stages (1.35)during *the Kharif season*. However, during the *rabi* season, the 100% RDN treatment achieved a higher B:C ratio of 1.68, followed by 50% RDN + two sprays of SNU @0.5% at the AT and PI stages (1.37).

Nitrogen Uptake

During both the *kharif* and *rabi* seasons,nitrogen uptake was analysed separately for grain and straw are presented in Table 4.During the *kharif* season, the highest grain N uptake (53.3 kg/ha) was recorded under T_9 (50% RDN + two sprays of SNU @1.0% at active tillering and panicle initiation stages), which was statistically comparable to all remaining treatments except the control.In the *rabi* season, grain N uptake was highest under the 100% RDN treatment (57.8 kg/ha), performing on par with all 50% N treatments supplemented with nano urea.

Straw N uptake was greatest under T_7 (50% RDN + two sprays of SNU @0.25% at AT and PI) during both *kharif* (34.6 kg/ha) and *rabi* (40.7 kg/ha), highlighting the contribution of SNU to straw N content. The increase in nitrogen uptake associated with nano urea may be due to its immediate absorption and efficient translocation within the plant (Abdel-Aziz *et al.*, 2018). Nano fertilizers possess a large surface area and smaller particle size, which facilitates deeper penetration into plant tissues and improves overall nutrient uptake and use efficiency (Qureshi *et al.*, 2018). Furthermore, the foliar route enables rapid nutrient absorption during fast-growing crop stages, particularly when soil nutrient availability is limited (Wojtkowiak *et al.*, 2014).

CONCLUSION

Based on these findings, it can be stated that the application of 50% of the recommended dose of nitrogen (RDN) in combination with two foliar sprays of nano urea at the active tillering and panicle initiation stages was an effective treatment for improving rice growth, yield attributes, grain and straw yields, economic returns, and nutrient uptake. Importantly, this treatment performed comparably to the full 100% RDN application across two consecutive cropping seasons on alluvial soils in the Godavari zone.

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