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Effect of Foliar Spray of Nano urea with Various Doses of Nitrogen on Profitability of Rice in Verti Soils of Narmada Velley

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Abstract: Rice (*Oryza sativa* L.) is a vital staple food crop globally, serving as the primary source of calories for approximately 40% of the world's population. It plays a crucial role in the diets of many nations, especially in Asia, where most rice is produced and consumed. Still the nano urea a revolutionary invention in smart farming of sustainable and efficient crop production. Experiment was conducted during kharif seasons of 2022 and 2023 at Research Farm, Zonal Agricultural Research Station, Powarkheda, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. The experiment was carried out in split plot design with present experiment three replication treatment consisted of four doses of nitrogen taken as in main plots and four foliar sprays of nano urea four and control in sub plots. All the treatments were randomized and replicated three times during both the years of experiment treatments. Total treatments: 20 doses nitrogen 04 and 05 foliar spray of nano urea dose of nitrogen N1: 30 N kg ha^{-1}, N2: 60 N kg ha^{-1}, N3: 90 N kg ha^{-1}, N4: 120 N kg ha^{-1}Foliar spray of nano urea sub-plots: 05 T1: Control, T2: Foliar spray of nano urea at Tillering stage @4ml/litter of water, T3: Foliar spray of nano urea at panicle initiation @ 4ml /litter of water, T4: Foliar spray of nano urea at tillering and panicle initiation@4ml/litter of water, T5: Foliar spray of nano urea at tillering, panicle initiation and flowering @ 4ml/litter of water at each stage.

Keywords: *Crop production, Foliar Application, Nutrient Efficiency, Transplanted Rice.*

1. INTRODUCTION

India is one of the largest rice producers with cultivation spanning about 47.83 million hectares. The total rice production for the fiscal year 2022-23 is estimated at a record 135.76 million metric tons, reflecting an increase of 6.36 million metric tons compared to the previous year's production of 129.47 million metric tons (**Ministry of Agriculture and Farmer Welfare, 2023)**. India's position as the second-largest rice producer behind China, which produced around 197 million tons presents challenges in meeting the rising food demand driven by a growing population that increases at a rate of about 1.5% annually. In India, rice is cultivated from 8°N latitude to 35°N latitude, in areas that range from receiving 25 cm of annual rainfall in Rajasthan to 1250 cm in Assam, and across a variety of soil types, including sandy loams, black cotton soils, and saline-alkali soils (**Virdia and Mehta, 2009**). However, despite its adaptability, rice farming faces several challenges, including declining productivity, environmental degradation, and improper nutrient management, which hinder

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the achievement of sustainable production systems.

Nitrogen is a critical element in the fertilizer management practice for rice cultivation, as it plays a vital role in the growth, development, and yield of rice. It involved in photosynthesis, biomass production, and synthesis of amino acids and proteins. Nitrogen also influences physiological processes in rice, leaf area development and grain filling, which are essential for achieving high yields and good grain quality (**Bai, 2019**). During critical stages of rice development, such as early tillering, panicle initiation, booting, and grain ripening, nitrogen is required in larger quantities to support these growth phases. Research has shown that nitrogen fertilization, when applied within an optimal range, increases the net photosynthetic rate, contributing to higher biomass production and enhanced grain yield.

This high surface area enhances the absorption efficiency of the nitrogen by plants, leading to improved nutrient uptake and utilization. Nano urea also offers the advantage of foliar application, where the nutrient is delivered directly to the plant cells through the stomata, bypassing the soil. This mode of application ensures that nitrogen is absorbed quickly, which is particularly beneficial during periods of high nutrient demand, such as during the vegetative and reproductive growth phases of rice. The foliar application of nano urea has been shown to improve the availability of nitrogen to plants, enhance enzymatic activities related to nitrogen assimilation, and trigger biochemical pathways that support plant growth and development (**Kantwa & Yadav, 2022**).

The potential of nano fertilizers in improving rice productivity is not limited to nitrogen alone. Nano-fertilizers can be tailored to provide a wide range of nutrients, including phosphorus, potassium, and micronutrients, in a more efficient manner. Studies have shown that nano fertilizers can enhance nutrient uptake and availability, leading to improved growth, increased tiller count, and higher yields (**Subramani *et al.*, 2023**).

Nano urea, has demonstrated significant effects on growth and plant development in rice. Studies have also shown that the application of nano urea enhances nutrient absorption, which accelerates plant growth (**Bolashetti *et al.*, 2023**).

2. MARERIAL AND METHOD

2.1. Site Description

The field experiment was conducted during kharif seasons of 2022 and 2023 at Research Farm, Zonal Agricultural Research Station, Powarkheda, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. It lies between 21°50′ North latitude and 76°43′ East longitude as well as 229 meter above the mean sea level. The region experiences a semi-arid and subtropical climate with characteristics feature of hot dry summer and cool dry winter. According to agroclimatic condition, it comes under "Kymore plateau and Satpura hills" as per the norms of National Agriculture Research Project, New Delhi. As per the classification of National Bureau of Soil Science and Land use Planning (NBSS&LUP), Nagpur, Jabalpur comes under Argo-ecological region number 10, named as Central High Land (Malwa and Bundelkhand) sub region number 10.1 as hot sub-humid (dry) eco-region (Malwa plateau, Vindhyan Scarp land and Narmada Vally).

Soil of experimental field was clay loam deep black nature in pH (7.77) E (0.32 dsm^{-1}) medium in organic carbon (0.56%) available phosphorus (9.79kg ha^{-1}) and potassium (152 kg ha^{-1}) which lower in available nitrogen (120 kg ha^{-1}).

2.2. Experimental Description

Experiment was transplanted in main field with the help of manual laborers on 6th and 9th July in which 2021 and 2023 respectively and harvested on from 16th Oct to 19th October during both the years.

A total of 20 treatments consisted of 4 levels of nitrogen (N1: 30 kg N ha^{-1}, N2: 60 kg N ha^{-1}, N3: 90 N kg ha^{-1} and N4: 120 kg N ha^{-1}) put under main plots and five treatments of nano urea (T1: Control, T2: Foliar spray of nano urea at Tillering stage @4ml/litter of water,T3: Foliar spray of nano urea at panicle initiation @ 4ml /litter of water,T4: Foliar spray of nano urea at tillering and panicle initiation@4ml/ litter of water, and T5: Foliar spray of nano urea at tillering, panicle initiation and flowering @ 4ml/litter of water at each stage) taken under of sub plot. These treatments were arranged in a split plot design replicated theirs.

The Variety of Rice used for this experiment was **"JR 206"** which was released by JNKVV, Jabalpur in 2019. With the duration of 120-122 days Yield 50-60 q ha^{-1}. This is also resistant to bunt and blast diseases

3. RESULTS AND DISCUSSION

3.1. Grain, Straw yield & Harvest index (%)

Table 1: Effect of nitrogen doses and foliar spray of nano urea on grain and straw yields as well as harvest index

Treatments	*Grain yield (kg ha^{-1})*			*Straw yield (kg ha^{-1})*			*Harvest index (%)*		
	2022	*2023*	*Pooled*	*2022*	*2023*	*Pooled*	*2022*	*2023*	*Pooled*
Doses of nitrogen (kg ha^{-1})									
N1: 30	4927	4960	4943	8684	10070	9377	56.94	49.26	53.10
N2: 60	5158	5334	5246	10199	11346	10772	52.54	48.45	50.49
N3: 90	5381	5652	5516	10418	11553	10985	51.06	48.55	49.80
N4: 120	5567	5800	5683	11414	12535	11974	48.90	46.53	47.71
SEm (±)	113.54	60.24	86.89	202.01	239.35	220.68	3.08	2.01	2.56
CD at (0.05)	392.89	208.44	300.67	699.05	828.27	NS	NS	NS	NS
Foliar spray of nano urea									
T1: Control	4692	4998	4845	8638	9830	9234	54.51	50.90	52.70
T2: At tillering stage @4ml/litter of water	5096	5242	5169	9594	10792	10193	54.67	48.71	51.69
T3: At panicle initiation stage @4ml/litter of water	5215	5333	5274	9866	11156	10511	52.60	48.13	50.36
T4: At tiller and panicle initiation @ 4ml/litter of water at each stage	5481	5604	5543	10985	12164	18157	50.67	46.54	48.60
T5: At tillering, panicle initiation and flowering @4ml/litter of water at each stage	5805	6005	5905	11811	12938	12374	49.34	46.73	48.03
SEm (±)	70.78	50.18	60.48	179.01	185.35	182.18	2.72	2.81	2.75
CD at (0.05)	215.43	153.20	184.32	515.66	533.94	524.80	NS	NS	NS

3.2. Effect of nano urea on Grain Yield of transplanted Rice

Grain yield, straw yield and harvest index parameters were considered for evaluation

3.3. Effect of nitrogen and nano urea on grain yield

Grain yield of rice was recorded over two years showed comparatively higher yield in the second year than the first; however, treatment effects remained consistent across years.

Data presented in Table 2. Revealed significant variation in grain yield due to different nitrogen levels during both years and in pooled analysis. Application of nitrogen at 120 kg ha^{-1} produced the highest. Grain yield of 5567, 5800 and 5683 kg ha^{-1} during 2022, 2023 and pooled analysis, respectively which were significantly superior to lower nitrogen levels. Nitrogen doses of 90 kg ha^{-1} and 60 kg ha^{-1} were statistically at par during the first year but differed significantly during the second year and pooled data. The lowest values of grain yield (4927,4960 and 4943kg ha^{-1}) were recorded during 2022,2023 and pooled analysis, respectively.

Foliar application of nano urea significantly influenced grain yield across both years and pooled data. All nano urea spray treatments at tillering, panicle or their combination resulted

in higher yield than control. Three foliar sprays of nano urea at tillering, panicle initiation and flowering stages @ 4 ml^{-1} of water production the highest grain yield of 5805,6005 and 5905 kg ha^{-1} during 2022, 2023 and pooled data. Among spray schedules, combined application at tillering and panicle initiation was superior to single-stage application. Similar findings such that the application of nano urea as foliar spray along with the conventional urea resulted the better grain and straw yield by Attri et al., (2022)

3.4. Effect of nitrogen and nano urea on Straw Yield

Straw yield data recorded during both the year of study and their pooled analysis table 2 showed significant variation due to nitrogen levels. Application of nitrogen @ 120kg N ha^{-1} proved significantly higher straw yield of 11414, 12535 and 11974 kg ha^{-1}during 2022, 2023 and pooled analysis, respectively compared to other nitrogen levels. Nitrogen dose of 90 and 60 ha^{-1} significantly at par to each other significantly superior to the lowest doses of 30 kg N ha^{-1} which recorded the lowest straw yield 9377 kg ha^{-1}in fig 2.1.

The foliar spray of nano urea significantly influenced straw yield. All the nano urea treatments outperformed the control. Triple application of nano urea at tillering, panicle initiation and flowering stages @ 4 ml^{-1} of water stages resulted in the highest straw yield and was st statistically superior to other treatments. In pooled analysis single spray at panicle initiation and two sprays at tillering and panicle initiation were statistically at par, recording straw yields of 11811 and 12938 kg ha^{-1}respectively. Similar findings reported by Rosa et al., (2010) and Nair et al., (2010).

3.5. Harvest Index (HI)

It is the ratio economic yield to the biological yield and is expressed in percentage. It was calculated using the formula proposed by Synder and Carlson (1984).

HI= Economic yield / Biological yield*100

The data presented (Table -1) showed non-significant variations due to various treatments of nitrogen and foliar spray of nano urea. The harvest index (HI) recorded under different treatments of nitrogen application and foliar spray of nano urea during 2022 and 2023 and pooled over two years. The results indicate that neither doses of nitrogen nor foliar spray of nano urea influenced the harvest index across the two years of experimentations and pooled analysis. Among the various level of nitrogen over recorded 49.34 to 46.73% across treatments and years. The pooled data also followed the similar trend. The highest harvest index of 48.03% was recorded under120 kg N ha^{-1} through, the variations were not significant. Increasing number of sprays from one to three sprays numerical values were decreased from 51.69 to 48.03% through the variation were non-significant. The interaction for N x T (nitrogen and nano urea spray) was also found to be non-significant for harvest index during both the years and pooled study as well as in pooled analysis.

4. EFFECT OF NITROGEN AND NANO UREA ON PROFITABILITY

Adoption of any technology in modern agriculture can be accepted and adopted by farmers only if it is economically viable. The agricultural scientists related to production are trying to work out the optimal levels of various inputs used in production system. Hence, it helps the farmers to choose various crops to grow, how to minimize the cost, what type of inputs are to be selected and economize the sources. In the present investigation economic analysis of various treatments was carried out to studies on nitrogen management in transplanted rice under black soils of Madhya Pradesh.

The procedure for calculating the cost of cultivations, gross returns, net returns as well as benefit cost ratio of different treatments.

4.1. Cost of cultivation (Rs. ha^{-1})

Cost of cultivation for studies on nitrogen management in transplanted rice under black soils of Madhya Pradesh were calculated and presented in table -2 revealed that average cost of cultivation of rice under various doses of nitrogen and foliar spray of nano urea varied from Rs. 53430 ha^{-1} to 58251 ha^{-1} depending upon the treatments. Further, it was noted that doses of nitrogen and foliar spray of nano urea 4ml/litter of water computed higher amount cost ha^{-1} of cultivation as compared lowest doses of nitrogen with all foliar spray of nano urea. Hence, 30 kg ha^{-1} of nitrogen computed only Rs. 53430 ha^{-1}. The nitrogen 120 kg N ha^{-1} with their foliar spray of nano urea at tillering, panicle initiation and flowering @ 4ml/litter of water recorded the highest cost of cultivation Rs. 58251 ha^{-1} followed by Rs. 58051 ha^{-1} under 90 kg ha^{-1} with three foliar sprays of nano urea @ 4ml l^{-1} of water. The lowest cost of Rs. 53430 ha^{-1} was recorded under N1T1.

4.2. Gross monetary returns (Rs. ha^{-1})

Gross monetary returns computed for the years of 2022 and 2023 showed that the gross returns get during second year was higher over previous year in at almost all the treatments. On the basis of pooled values, it was revealed that 120 kg N ha^{-1} with three applications of nano urea at tillering, panicle initiation and followed by flowering registered higher gross returns of Rs. 158179 ha^{-1} gross returns followed by Rs. 150383 ha^{-1} under 120 kg N ha^{-1} with two sprays of nano urea at tillering followed by panicle initiation. The minimum gross returns of Rs. 111355 ha^{-1} were computed under 30 kg N ha^{-1} alone without nano urea.

4.3. Net monetary return (Rs ha^{-1})

The net monetary returns (Rs/ha) reveal that the treatment in which 120 kg N ha^{-1} was applied in three split doses along with foliar spray of nano urea in three stages registered highest NMR of Rs. 99928 ha^{-1} closely followed

Table 2: Cost of cultivation, Gross monetary returns, net monetary returns and B:C ratio of rice under different levels of nitrogen and foliar spray of nano urea

Economic analysis of different nitrogen levels and foliar spray of nano urea in rice												
Treatments	*Cost of Cultivation (Rs ha^{-1})*			*Gross monetary returns (Rs ha^{-1})*			*Net monetary returns (Rs ha^{-1})*			*B:C ratio*		
	2022	*2023*	*Pooled*	*2022*	*2023*	*Pooled*	*2022*	*2023*	*Pooled*	*2022*	*2023*	*Pooled*
N1T1	53430	53430	**53430**	105736	116974	**111355**	52306	63544	**57925**	1.9	2.1	**2.0**
N1T2	54687	54687	**54687**	113284	122547	**117915**	58597	67860	**63228**	2.0	2.2	**2.1**
N1T3	54687	54687	**54687**	115288	126153	**120720**	60601	71466	**66033**	2.1	2.3	**2.2**
N1T4	55944	55944	**55944**	123982	131812	**127897**	68038	75868	**71953**	2.2	2.3	**2.2**
N1T5	57201	57201	**57201**	131106	144554	**137830**	73905	87353	**80629**	2.2	2.5	**2.3**
N2T1	53780	53780	**53780**	111530	124395	**117962**	57750	70615	**64182**	2.0	2.3	**2.1**
N2T2	55037	55037	**55037**	118360	133713	**126036**	63323	78676	**70999**	2.1	2.4	**2.2**
N2T3	55037	55037	**55037**	124188	135914	**130051**	69151	80877	**75014**	2.2	2.4	**2.3**
N2T4	56294	56294	**56294**	131636	143257	**137446**	75342	86963	**81152**	2.3	2.5	**2.4**
N2T5	57551	57551	**57551**	141770	155565	**148667**	84219	98014	**91116**	2.4	2.7	**2.5**
N3T1	54280	54280	**54280**	115760	134799	**125279**	61480	80519	**70999**	2.1	2.4	**2.2**
N3T2	55537	55537	**55537**	126482	141102	**133792**	70945	85565	**78255**	2.2	2.5	**2.3**
N3T3	55537	55537	**55537**	127658	100996	**114327**	72121	45459	**58790**	2.2	1.8	**2.0**
N3T4	56794	56794	**56794**	138830	153579	**146204**	82036	96785	**89410**	2.4	2.7	**2.5**
N3T5	58051	58051	**58051**	145850	163139	**154494**	87799	105088	**96443**	2.5	2.8	**2.6**
N4T1	54480	54480	**54480**	119009	138922	**128965**	64529	84442	**74485**	2.1	2.5	**2.3**
N4T2	55737	55737	**55737**	133332	146379	**139855**	77595	90642	**84118**	2.3	2.6	**2.4**
N4T3	55737	55737	**55737**	137958	151219	**144588**	82221	95482	**88851**	2.4	2.7	**2.5**
N4T4	56994	56994	**56994**	142716	158051	**150383**	85722	101057	**93389**	2.5	2.7	**2.6**
N4T5	58251	58251	**58251**	149518	166840	**158179**	91267	108589	**99928**	2.5	2.8	2.6

by Rs. 93389 ha^{-1} under 120 kg N ha^{-1} along with two sprays of nano urea at tillering and panicle initiation, Whereas, the lowest net monetary returns of Rs. 57925 ha^{-1} was recorded under 30kg N+ without foliar spray of nano urea.

These finding shows that the foliar spray of nano urea proved beneficial to obtain higher net returns over without foliar spray of nano urea.

4.4. Benefit cost ratio (BCR)

Benefit cost ratio refers the monetary returns per rupee invested as invested by the farmer in the cultivation of crop. It is evident from the data that increasing level of nitrogen and foliar spray of nano urea increased the B:C ratio. The highest B:C ratio of 2.6 under 120 kg N ha^{-1} with their foliar spray which was almost equal to 90 kg N x 2 spray of nano urea and 120 kg N x 2 spray of nano urea and registered 2.6 B:C ratio. Treatment in which 30 kg/ha N x without nano urea fetched Rs 2.0 per rupee investment. However, lowest dose of nitrogen with foliar spray increases the B:C ratio from 2.0 to 2.2. These findings are consistent with earlier studies suggesting that judicious use of nano urea can reduce input costs while maintaining or enhancing yield (Singh et al., 2021). The nanoscale properties ultra-small size and high surface area of nano urea enhance nitrogen use efficiency, limiting losses from leaching and volatilization (Prasad et al., 2020). Moreover, foliar applications at strategic stages improve nutrient uptake and utilization, translating into better economic outcome

CONCLUSION

Results of study carried out for two years reveal that 120 kg of N ha^{-1} along with three sprays of nano urea at tillering panicle initiation followed by flowering fetched highest NMR of Rs. 99938 ha^{-1} with benefit cast ratio of 2.6. Thus, this management practice of nitrogen in transplanted rice of Verti soils is recommended.

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