International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(6): 152-154
Received: 16-03-2024
Accepted: 27-04-2024

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Effect of foliar sprays of nano-urea on yield and nutrient quality of transplanted paddy (*Oryza sativa* L.)

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6c.823

Abstract
Nitrogen is one of the most limiting nutrients for paddy production. However, 60-70% of applied nitrogen is lost from the paddy ecosystem in the form of reactive nitrogen species such as ammonia (NH_3), nitrous oxide (N_2O), nitric oxide (NO), nitrogen dioxide (NO_2) and nitrate (NO_3) through various processes. Hence enhancing nitrogen efficiency through improved nitrogen management is of greater importance for ensuring food security and environmental sustainability. A field experiment was conducted at Agricultural Research Station, Vadgaon Maval, Dist. Pune to "Study the effect of foliar sprays of nano-urea on yield and nutrient quality of transplanted paddy (*Oryza sativa* L.)" during *Kharif* in 2022 (July to November 2022) under puddled transplanted condition, involving thirteen treatments in a randomized block design (RBD) replicated thrice. The treatments included foliar sprays of 2% urea, IFFCO nano-urea and COAP nano-urea at 75% and 50% of the recommended nitrogen doses through conventional urea. The basal dose was applied through conventional fertilizers. The result revealed that different treatments considerably affected the yield contributing characters *viz*., number of spikes per plant, number of grains per spike, grain and straw yield and improved the nutrient (N, P and K) content and total uptake by paddy crop were also ensured under treatment T_3: 75% of recommended nitrogen through urea + 25% nitrogen through two foliar sprays of IFFCO nano-urea (AT and PI). Spraying of nano-urea can increase crop yield by increasing the nutrient uptake by plants.

Keywords: Nano-urea, paddy, yield, nitrogen etc.

Introduction

Paddy (*Oryza sativa* L.) is one of the most popular field crops among other cereals in the world. Belong to the genus "Oryzae" and the family Gramineae. India and Burma should be recognized as the origins of cultivated paddy. At present, paddy is a stable food for more people than other cereals and 90 percent of total paddy production is grown and consumed in Asia. Paddy was a source of energy for a major portion of the world's population and ranks second after maize concerning production. Therefore, sustainable paddy production is necessary to overcome food scarcity throughout the globe. According to FAO (2021-22) statistics, 165.25 million hectares of paddy are planted worldwide and 516.7 million metric tonnes of paddy are produced each year. With approximately 46 million hectares of land dedicated to paddy farming, (Statista Research Department, 16, 2022).

Two important resource management strategies that can help us enhance the production scenario for paddy agriculture are the cultivation of improved high-yielding varieties and balanced nutrition. Nitrogen is the essential nutrient element for paddy growth and metabolic processes. Urea is the source of nitrogen in India. Every year, 188 million metric tonnes of urea are applied to crops globally. Increased pest-disease problems due to succulence, lodging of crops, distorted soil NPK balance, deterioration of soil health and most importantly, environmental problems are brought on by excessive urea application. One kilogram of NO_3 emission is equivalent to 298 kilogrammes of carbon dioxide and urea use results in this emission to replace or reduce the negative effects of the current urea application situation.

In addition to the expanding issues facing Indian agriculture, nano fertilizer has garnered particular attention for plant nutrition. Researchers have created nanoparticles with a large surface area, high activity, a better catalytic surface, a quick chemical reaction, quick dispersibility and a high water adsorption capacity. Any product that uses nanotechnology or nanoparticles to increase the effectiveness of nutrient utilisation in the form of fertilizers is referred to as a "nano fertilizer". However, the world has seen the creation of new technologies to overcome production limitations and maintain farm production. Application of fertilizer nutrients through the foliar application is always superior to soil application but foliar-applied fertilizer nutrients face several structural barriers because the nutrients are salt-based (cation and anion) which may struggle to penetrate the plant tissue cells. This is because of the pore size of the cell wall that ranges between 5-100 nm (Schwab *et al*., 2015). Hence, nanoparticle aggregate with a diameter less than the pore size of the plant cell wall can easily enter through the cell wall and reach up to the plasma membrane (Navarro *et al*., 2008).

2. Materials and Methods

A field experiment was carried out to investigate the "Effect of foliar sprays of nano-urea on yield and nutrient quality of transplanted paddy (*Oryza sativa* L.)", at Agricultural Research Station (ARS) Vadgaon Maval, Pune during the *Kharif* season of 2022. The experiment was set up using a randomized block design with thirteen treatments depicted in Table No. 1 and three replications. The treatments included sprays of 2% urea, IFFCO nano- urea and COAP nano-urea at 75% and 50% of the recommended nitrogen doses through conventional urea. The basal dose was applied through conventional fertilizers. The recommended dose (100: 50: 50 kg/ha of N, P_2O_5 and K_2O) was applied with split doses of nitrogen *viz*., 50% at the time of sowing and the remaining 50% nitrogen was applied as per treatments. The full dose of phosphorus and potassium was applied at the time of transplanting to each plot. The spray volume for spraying Nano-urea and foliar urea was taken as 500 L/ha.

The climate of Vadgaon Maval is classified as sub-humid. The experimental site was located 602.0 meters above mean sea level and is part of Maharashtra Agro-climatic Zone VIII (central plateau and hills). It is located between latitudes 18° 73' N and longitude 73° 65' E. The station received 1260 mm of precipitation in total per year. The total Rainfall received during the crop-growing season was 1,507 mm in 69 rainy days. The highest mean amount of Rainfall (511.2 mm) was recorded during the 28th Metrological week. The mean monthly maximum and minimum temperature during the cropping period ranged from 24.0 ^{0}C to 30.3 ^{0}C and 14.9 ^{0}C to 23.4 ^{0}C and mean relative humidity ranged from 88.7 percent to 92 percent in the morning and 66.9 percent to 89.7 percent in the evening. The recommended spacing (20 cm x 15 cm), Gross plot size (4.0 cm x 3.0 cm) and Net plot size (3.60 cm x 2.70 cm).

Observations on various parameters entailing yield and nutrient quality of paddy were recorded. The results were statistically analysed using the ANOVA technique and critical difference (C.D.) values were computed and inferences were drawn at a 5 percent level of significance.

Table 1: Treatment details along with symbols used

Tr. No.	Treatments
T_1	Absolute control
T_2	100% RDF (100: 50: 50 NPK kg ha^{-1})
T_3	75% N through urea + 25% N through two foliar sprays of IFFCO nano-urea
T_4	50% N through urea + 50% N through two foliar sprays of IFFCO nano-urea
T_5	50% N through urea + 50% N through four foliar sprays of IFFCO nano-urea
T_6	50% N through urea + Two foliar sprays of IFFCO nano-urea @ 2 ml / L
T_7	50% N through urea + Two foliar spray of IFFCO nano-urea @ 4 ml / L
T_8	50% N through urea + Two foliar spray of COAP nano-urea @ 6 ml / L
T_9	50% N through urea + Two foliar spray of COAP nano-urea @ 12 ml / L
T_{10}	75% N through urea + Two foliar spray of COAP nano-urea @ 6 ml / L
T_{11}	75% N through urea + Two foliar spray of COAP nano-urea @ 12 ml / L
T_{12}	50% N through urea + Two foliar sprays of 2% urea
T_{13}	75% N through urea + Two foliar sprays of 2% urea

3. Results and Discussion

3.1 Yield attributes and Yield

The application of nano-urea fertilizers had a significant effect on yield attributes and yield (q/ha). Among the applied treatments, highest number of spike per plant (14.00), the total number of grains per spike (256.02) and length of spike (26.32 cm) were recorded under treatment T_3: 75% nitrogen through urea + 25% nitrogen through two foliar sprays of IFFCO nano-urea (AT and PI) which was at par with treatment T_{13}: 75% nitrogen through urea + two foliar application of 2% urea, T_2: 100% nitrogen through urea (50% at basal, 25% at tillering and 25% at panicle initiation; T_{11}: 75% nitrogen through urea + two foliar application of COAP nano-urea @ 12 ml/L and T_{10}: 75% nitrogen through urea + two foliar application of COAP nano-urea @ 6 ml/L. The highest number of spikes per plant may be the consequence of continuous nitrogen delivery by nano-urea at critical growth stages, which would have stimulated cell elongation and meristematic activity in plants, resulting in a larger number of spikes per plant. These result findings were in close agreement with the findings of Jassim *et al*., (2019) [5]. The total number of grains per spike might be caused by the foliar spray of nano-urea, which increases photosynthate assimilation and translocation of photosynthates from source to sink. In addition, a timely nitrogen supply stimulates the onset of grain formation, which helps to increase the number of grains per spike. Nearly similar results were found by Algym *et al*., (2020) [1]. The longest length of the spike could be due to an improvement in apical growth and an increase in meristematic activity. Similar findings were in direct line with Rawate *et al*., (2022) [9]. Data about yield attribute and yield is recorded and presented in Table No. 2. Among the other treatments, T_3: 75% nitrogen through urea + 25% nitrogen through two foliar sprays of IFFCO nano-urea (AT and PI) observed significantly higher paddy grain yield (58.08 q/ha) and straw yield (63.31 q/ha) it might be due to increased rate of photosynthesis, higher dry matter produce, photosynthate accumulate and translocation to the economic part of the plant. A similar result was observed by Apoorva *et al*., (2017) [2] and Khaled *et al*., (2021) [6].

3.2 Nutrient content and uptake

The data about nutrient content% and uptake (kg/ha) at the harvest stage of paddy were depicted in Table No. 3 respectively. Demonstrate that there was a significant improvement in the nitrogen content in grain and straw of paddy (1.91% and 0.47%) and the highest total uptake of N, P and K in grain and straw was 108.75 kg/ha, 36.46 kg/ha and 213.16 kg/ha respectively, under the treatment T_3: 75% nitrogen through urea + 25% nitrogen through two foliar sprays of IFFCO nano-urea. It might be due to nano fertilizers having a large surface area and particle size smaller than the pore size of plant leaves, allowing for greater penetration into plant tissues from the applied surface and improved absorption and nutrient use efficiency, which causes to increase the nutrient uptake and improve the nutrient content of grain and straw. Also, a similar result was found by Bora and Pandey (2018) [3].

Table 2: Yield contributing characters of paddy as influenced by different treatments

Treatment	Number of spike per plant	Length of Spike (cm)	Number of grains per spike	Grain yield (q/ha)	Straw yield (q/ha)
T_1	4.51	15.12	123.36	21.19	23.31
T_2	12.03	23.24	238.86	55.15	59.57
T_3	14.00	26.32	256.02	58.08	63.31
T_4	10.43	20.45	200.06	46.50	50.22
T_5	10.19	21.26	211.73	48.84	52.90
T_6	10.13	20.01	196.83	45.53	49.17
T_7	10.90	21.26	210.46	48.74	52.75
T_8	8.09	18.32	176.78	40.03	43.23
T_9	9.25	19.33	186.60	42.38	45.77
T_{10}	11.85	23.72	229.73	52.69	57.43
T_{11}	11.38	23.25	232.57	53.35	58.16
T_{12}	10.14	20.67	206.86	46.84	50.58
T_{13}	12.16	25.61	247.23	56.09	61.14
S.E.(m)+	0.91	1.50	13.56	2.74	2.98
C.D. at 5%	2.40	4.50	39.56	7.99	8.72

Table 3: N, P and K content in grain and straw and its total uptake by paddy crop as influenced

Treatment	NPK content (%)						Total Uptake (kg/ha)		
	Grain			Straw					
	N	P	K	N	P	K	Nitrogen	Phosphorus	Potassium
T_1	1.75	0.37	0.29	0.35	0.09	1.98	55.89	12.71	165.06
T_2	1.83	0.41	0.48	0.44	0.13	2.21	85.32	29.66	193.21
T_3	1.91	0.42	0.46	0.47	0.16	2.20	108.75	36.46	213.16
T_4	1.83	0.40	0.44	0.42	0.14	2.16	83.43	27.62	185.96
T_5	1.83	0.41	0.42	0.42	0.14	2.13	79.46	26.91	177.90
T_6	1.76	0.41	0.44	0.42	0.16	2.16	70.72	26.07	178.54
T_7	1.87	0.43	0.40	0.43	0.15	2.14	80.87	19.88	182.87
T_8	1.93	0.41	0.44	0.41	0.15	2.13	59.23	17.56	174.43
T_9	1.88	0.42	0.43	0.42	0.14	2.17	73.34	25.12	180.42
T_{10}	1.85	0.40	0.40	0.43	0.17	2.19	84.09	25.96	191.73
T_{11}	1.83	0.43	0.44	0.45	0.16	2.23	87.41	29.45	202.64
T_{12}	1.89	0.41	0.40	0.43	0.17	2.15	81.31	27.35	193.74
T_{13}	1.90	0.44	0.45	0.45	0.15	2.25	93.11	31.43	202.90
S.E. (m)+	0.00	0.01	0.01	0.005	0.00	0.01	5.51	1.68	3.53
C.D.at 5%	0.01	N.S.	N.S.	0.01	N.S.	N.S.	16.53	5.04	10.59

4. Conclusion

Spraying of liquid nanomaterial can increase crop yield by increasing nutrient uptake by plants and its bioavailability. The highest number of yield attributing character, straw and grain yield, nutrient uptake and nutrient content in grain and straw was recorded under treatment where 75% nitrogen through urea and 25% nitrogen through two foliar sprays of IFFCO nano-urea (AT and PI). The lowest number of yield attributing character, straw and grain yield, nutrient uptake and nutrient content in grain and straw was recorded in absolute control.

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