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

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Abstract
Recently, changes to agricultural practices have constituted a primary focal point for adaptation and change. A field experiment was conducted in the *Kharif* of 2022 at Agricultural Research Station, Vadgaon Maval, Dist: Pune, to "Study the effect of foliar sprays of nano-urea on growth and quality of transplanted paddy (*Oryza sativa* L.)". The experiment was set up using a randomized block design with thirteen treatments 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 recommended dose of fertilizers was 100:50:50 NPK kg/ha. The paddy variety *Phule Samruddhi* (VDN 99–29) was chosen for the field experiment. The result revealed that the application of foliar spray of nano-urea (liquid) spray with conventional fertilizer had a significant impact on primary growth parameters *viz*., plant height, tiller number, quality and chemical properties of soil of the field. Further, nano spray (N_{75}PK and N_{25} through nano-urea) was superior over the rest of the treatment which contributed to the growth parameters of the crop. Spraying of nano-urea can improve the growth contributing characteristics of the paddy and their bioavailability in soil.

Keywords: Nano-urea, paddy and foliar spray

Introduction
Paddy (*Oryza sativa* L.) is one of the most important food crops in India and plays an important role in national food security. Paddy is being cultivated under diverse agro-ecologies varying from irrigated, upland and rainfed lowland to flood-prone paddy ecosystems. Paddy was a source of energy for a major portion of the world's population and ranks second after maize concerning production. Therefore, sustainable rice 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; GOI 2022). India ranked second in the world in terms of production, accounting for about 23.3 per cent of the total area under cultivation.

To overcome the production vulnerabilities in paddy, there had to be developed many high yielding input responsive cultivars. Despite significant progress, the average productivity of paddy in India is low. 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 sprayed on 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

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 which ranges between 5-100 nm. 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. Foliar application of nano-urea liquid at the critical crop growth stage of a plant effectively fulfils its nitrogen requirement and leads to higher growth attributing characteristics and quality in comparison to conventional urea.

Materials and Methods

A field experiment was carried out to investigate the "Effect of foliar sprays of nano-urea on growth and 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 °C to 30.3 °C and 14.9 °C to 23.4 °C and mean relative humidity ranged from 88.7 per cent to 92 per cent in the morning and 66.9 per cent to 89.7 per cent 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). The soil of the experimental field was clay loam in texture, moderately alkaline in reaction (pH 7.8) with low available nitrogen (256.20 kg/ha), medium available phosphorus (13.60 kg/ha) and high available potassium (308.30 kg/ha).

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 per cent 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

Results and Discussion

Growth attributing character

The result of the growth parameters of paddy has been influenced periodically due to different combinations of conventional fertilizer and nano-urea are depicted in Table No. 2

Among the applied treatments, T_3: 75% nitrogen through urea and 25% nitrogen through two foliar sprays of IFFCO nano-urea recorded plant height attained at all observational stages (51.42, 69.61, 83.35, 94.62, 99.63 and 99.71 cm at 28 DAT, 42 DAT, 56 DAT, 70 DAT, 84 DAT and harvest) 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 significantly lowest plant height was observed in treatment T_1: absolute control. An increase in the supply of nitrogen application increased nitrogen availability to crops which might have enhanced cell division and cell elongation resulting in taller plants. Such a favourable effect of nitrogen on the increase in plant height of paddy has been reported (Meena *et al*., 2011; Prasad Rao *et al*., 2011) [5, 6].

The number of tillers per plant was significantly influenced by different levels of nitrogen with the combination of liquid nano urea. The treatment T_3: 75% nitrogen through urea + 25% nitrogen through two foliar sprays of IFFCO nano-urea (13.27 tiller per plant at 56 DAT) was significantly superior over the rest of all the treatments but it was at par with T_{13}: 75% nitrogen through urea+ two foliar

sprays of 2% urea, T_2: 100% nitrogen through urea, T_{11}: 75% nitrogen through urea + two foliar sprays of COAP nano-urea @ 12 ml / L and T_{10}: 75% nitrogen through urea + two foliar sprays of COAP nano-urea @ 6 ml / L were obtained with the application of liquid nano-urea. It might be because reducing particle size increased a fertilizer-specific surface area and number of particles per unit area, which opened up more opportunities for fertilizer interaction and increased penetration and nutrient uptake. This would then result in the best growth, as measured by the number of tillers for the plant. It may also be due to there was an increase in nitrogen availability in agricultural plants (Lin and Zing, 2007) [4].

3.2 Soil available nutrient status

In this experiment soil pH, EC, OC, available N, P and K were studied before sowing and after paddy harvest depicted in Table No. 3. The values concerning initial pH, EC, OC, available N, P and K were 7.80, 0.19, 0.44, 256.20, 13.60 and 308.31kg/ha respectively. There is no significant change due to different foliar spray treatments in soil pH, E.C. and organic carbon but application of conventional fertiliser (N_{100}PK) lowered the pH and increased the soil N content than foliar spray in combination with basal application of NPK (Subramani *et al*., 2023) [7].

A significantly higher nitrogen (284.34 kg/ha) was recorded in treatment T_2: 100% nitrogen is supplied through urea which was found at par with treatment T_3: 75% nitrogen through urea + 25% nitrogen through two foliar sprays of IFFCO nano-urea was (278.02 kg/ha), T_{11}: 75% nitrogen through urea + two foliar sprays of COAP nano-urea @ 12 ml/ L was (278.4 kg/ha) and T_{13}: 75% nitrogen through urea + two foliar sprays of 2% urea has (276.43 kg/ha). In the case of available phosphorus and potassium in soil is found significantly superior in treatment T_2:100% nitrogen is supplied through urea was (P_2O_5 17.96 kg/ha) and (K_2O 327.94 kg/ha).

3.3 Protein content

The data concerning protein content (%) in a grain of transplanted paddy as influenced by different treatments are presented in Table No. 2.

The differences related to mean protein content were not found significant due to different treatments. However, the numerically higher value of protein content (12.06%) was found in the application of treatment T_3: 75% of nitrogen through conventional urea + 25% of nitrogen through IFFCO nano-urea as compared to the remaining treatments. It might be due to protein content being the genetic trait of the particular variety

Table 2: Effect of foliar spray of nano-urea on growth attribute and protein content

Treatment	Plant height (cm)						Number of tillers per plant				Protein %
	28 DAT	42 DAT	56 DAT	70 DAT	84 DAT	At Harvest	28 DAT	42 DAT	56 DAT	70 DAT to at harvest	
T_1	35.63	48.04	57.22	61.24	64.21	64.42	2.51	4.21	4.63	5.19	10.93
T_2	44.91	62.32	75.37	85.43	86.61	87.36	6.24	11.00	11.62	12.82	11.43
T_3	51.42	69.61	83.35	94.62	99.63	99.71	7.22	12.14	13.27	14.36	12.06
T_4	41.71	57.35	67.81	74.62	77.62	77.75	5.41	9.28	10.61	11.46	11.40
T_5	42.60	58.43	72.90	80.25	83.51	83.60	5.76	9.81	11.18	12.00	11.43
T_6	39.00	51.72	64.23	70.62	73.52	73.62	5.33	9.17	10.43	11.24	11.00
T_7	42.12	58.44	72.71	80.00	83.26	83.31	5.75	9.71	11.12	12.00	11.93
T_8	39.00	51.72	64.23	70.62	73.52	73.62	4.76	8.00	9.17	9.81	11.68
T_9	40.21	52.91	65.33	71.81	74.71	74.81	5.00	8.53	9.63	10.46	11.75
T_{10}	42.91	60.64	73.71	81.13	84.34	84.53	6.21	10.54	11.81	12.72	11.56
T_{11}	43.10	61.63	74.50	81.92	85.27	85.42	6.34	10.61	12.18	12.91	11.43
T_{12}	41.21	56.51	67.32	74.10	77.02	77.21	5.56	9.33	10.72	11.54	11.81
T_{13}	49.00	68.34	81.21	90.80	96.63	96.72	6.92	11.68	12.81	13.82	11.87
S.E. (m)±	2.83	3.70	3.40	4.56	5.12	5.21	0.36	0.52	0.62	0.70	0.03
C.D. at 5%	8.49	10.91	10.00	13.68	15.36	15.63	1.07	1.52	1.83	2.05	N.S.

Table 3: pH, EC, Organic carbon and available N, P and K in the soil after harvest of transplanted Paddy as influenced by different treatments

Treatment	pH	EC (ds/m)	Organic carbon (%)	Available nutrients (kg/ha)		
				Nitrogen	Phosphorus	Potassium
T_1	7.79	0.18	0.40	251.63	12.58	297.46
T_2	7.83	0.22	0.43	284.34	15.32	324.21
T_3	7.85	0.21	0.44	278.02	17.96	327.94
T_4	7.77	0.22	0.43	251.88	17.33	321.01
T_5	7.76	0.20	0.40	247.86	17.09	318.71
T_6	7.77	0.20	0.41	248.39	15.08	324.99
T_7	7.76	0.21	0.40	244.77	16.20	322.70
T_8	7.77	0.21	0.42	236.79	17.30	321.25
T_9	7.77	0.21	0.44	246.61	16.41	320.60
T_{10}	7.75	0.20	0.42	260.36	16.63	322.30
T_{11}	7.82	0.20	0.43	278.40	17.32	324.19
T_{12}	7.76	0.21	0.41	243.01	16.25	324.00
T_{13}	7.82	0.20	0.43	276.43	17.80	327.15
S.E. (m)±	0.03	0.01	0.01	3.44	1.47	3.61
C.D. at 5%	N.S.	N.S.	N.S.	10.06	4.29	10.54
Initial status	7.80	0.18	0.44	256.20	13.60	308.30

3. Conclusion

From the study, the application of a 75% recommended dose of nitrogen along with 25% nitrogen through nano-urea was found to be beneficial in improving the growth and quality of treatment. Foliar application of nano-urea at critical growth stages met nitrogen requirements effectively.

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