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The Effect of Foliar Application of Nano Urea (Liquid) on Rice (*Oryza sativa* L)

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Abstract

In recent times rice production has experienced fluctuation and stagnation due to uncertain climatic factors and lowering soil fertility. Thus a field experiment was conducted to assess the effect of Nano urea (liquid) on the growth and yield of rice under island conditions. The treatments combinations consist of basal application of RDF and two sprays of liquid urea with two concentrations (0.2% and 0.4% concentrations) at critical stages. The results showed that nano spray resulted in higher rice yield (15-21%) than NPK addition through chemical fertilizers. While increased concentration of nano spray (0.4%) had significant impact on the plant growth and yield parameters due to increased availability of N within the plant system. The total cost for nano spray was higher than NPK addition but recorded 12-16% higher yield over RDF addition resulting in additional monetary benefit (Rs. 7,937 to 10,082). Further, the increased efficiency of nano urea resulted in saving of nitrogen fertilizer to the extent of 25-34%. At the same time nano urea had no significant negative impact on soil properties and soil-root micro environment by the accumulation of excess mineral N.

Key words: *Nano-fertilizers, nutrient use, fertilizer efficiency, crop growth, yield*

Introduction

Use of modern agricultural inputs during the second half of the 20th century, in general, has greatly enhanced the agricultural production in most of the countries. At the same time agricultural production has been confronted with new challenges. Nevertheless the world has witnessed the development of new technologies to address the production constraints and sustain the farm production. In this context, nanotechnology has a greater role in crop production with a strong promise to affect the current status of fertilizer use with environmental safety, ecological sustainability, and economic stability (Anjuman et al., 2017; Davarpanath et al. 2017)). Due to the growing challenges in Indian agriculture, interest in nanotechnology has been increased with the goals to increase crop production and to increase resource use efficiency. Researchers have developed nano particles that have a high surface area, high activity, better catalytic surface, rapid chemical reaction, rapid dispersibility and higher water adsorbtion capacity. The products of nanotechnology, the nano particles can be utilized in the entire agriculture production system value chain (Tarafdar *et al*., 2012).

More importantly the nano formulated nutrient elements hold great promise for application in plant nourishment because of the size-dependent qualities, high surface-volume ratio, and unique optical properties. Because of high surface area to volume ratio, the effectiveness of nano-fertilizers may surpass the most innovative polymer-coated conventional fertilizers, which have seen little improvement in the past ten years (Naderi and Danesh-Shahraki, 2013). Nano-fertilizers with nano formulated particles can directly supply essential plant nutrients and can be delivered at time and dose required by crops to the rhizosphere (Subramanian and Tarafdar, 2011). This ultimately results in input used efficiency and lesser harm to the environment than conventional fertilizer materials.

India is one the largest producer and consumer of rice in the world. Over the last 15 years (2005- 2020), rice production in India increased from around 80.0 million tonnes in 2005 to around 121 million tonnes in 2020 (Economic survey 2005-2020). It was made possible mostly by increased inputs use besides exploitation of genetic resources. However, in recent years the input response or factor productivity is reported to be declining in major rice growing states. In other words there is a growing compulsion to address the issue of stagnant input response and growing environmental concerns. In India, besides climatic factors, deterioration of soil fertility has been widely reported to be the major cause for stagnating rice productivity. For this reason efforts to pursue national food self-sufficiency, especially rice, have become the main concern of most of the Asian countries. Therefore, going forward, increasing rice production requires increased productivity and efficiency.

In this context, the use of nano urea is expected to improve the input efficiency and enhance the productivity of rice and reduce the environmental concerns. The development of nano urea (liquid) by IFFCO for agricultural use has a pretty good prospect to be able to answer the challenge of precisely providing nutrients for plants through a more efficient nutrient delivery system. At the same time it is essential to understand its efficiency and advantage over conventional fertilizer materials. This is essential to minimise the chemical fertilizer use and increase the nano urea without compromising crop yield particularly in the island ecosystem. Thus in the present study a field experiment was carried out to study the effect of nano urea (liquid) in reducing the application of conventional urea and increasing rice productivity and profitability in tropical island conditions.

Materials and Methods

Study area

The Andaman Group of Islands is located 1200 km south-east of the mainland India in the Bay of Bengal. This Islands experience tropical to humid tropical climate with distinct dry and wet season. The islands receive copious amount of annual rainfall averaging 2900 to 3100 mm with the mean maximum and mean minimum temperature of 32°C and 22°C, respectively. The relative humidity varies from 68 to 86%. The wet season (June to November) is characterized by monsoonal rainfall associated with deep depressions and tropical cyclones. Low input rainfed agriculture is the major occupation and in general crop yields are low as compared to the mainland India. In the coastal lowlands, rice is the only crop grown during wet season, while pulses and vegetables are commonly grown after harvesting of rice in few places.

Nano urea

In this study we have used IFFCO nano urea (liquid) which is included in the Fertilizer Control Order (FCO) issued by the Government of India. Nano nitrogen particle size varies from 20-50 nm and it contains 4.0 % total nitrogen (w/v) evenly dispersed in water (IFFCO). When sprayed on leaves at critical crop growth stages, as reported, nano urea easily enters through stomata and other openings and is assimilated by the plant cells. It is easily distributed through the phloem from source to sink inside the plant as per its need.

Field experiments

In order to evaluate the effect of nano urea (liquid) a field experiment was conducted during June-December, 2021 in a RBD design at Bloomsdale Research Farm, ICAR-CIARI, Port Blair and two farmers field one each at South Andaman and Middle Andaman, India. There were 8 treatments at Bloomsdale research farm *viz*., N_0PK, N_{100} PK, N_{50}PK , N_{66}PK, T3 + nano 0.2 %, T3 + nano 0.4 %, T4 + nano 0.2 % and T4 + nano 0.4 %. Similarly at farmers field there were 5 treatments viz., N0PK, N100PK, N50PK + Nano Urea (2 sprays), N75PK + Nano Urea (2 sprays), N50PK + Nano Urea (2 sprays) and N75PK + Nano Urea (2 sprays). The recommended dose of fertilizers was 90:60:60 NPK. 4.0 ml of Nano urea in one litre of water was mixed and sprayed on crop leaves at active tillering and panicle initiation stages.

Observations

Plant growth parameters like plant height, number of leaves, number of tillers, root length, root mass and shoot mass were recorded at active tillering and panicle initiation stages. Crop yield was recorded after the harvest of rice. Soil samples were also collected before and after the experiment to record the soil physico-chemical properties.

Statistical analysis

The analysis of variance (ANOVA) was used to determine the effects of treatments on the generated data. Least significant difference (LSD) was used to test the difference between means at probability < 0.05 using SAS software package.

Results

The results indicated that application of nano urea (liquid) did not significantly affect the soil properties (pH, EC and OC) as compared to 100% NPK in the form of chemical fertilizers. All the treatments were at par, but inorganic (100 NPK) application lowered the pH and increased the soil N content than foliar spray in combination with basal application of NPK. This indicated that foliar spray has not negatively affected the soil-root micro environment by the accumulation of excess mineral N applied through chemical fertilizers as it is used in the plant system. This is mainly due to controlled release of nano nitrogen (Kashyap *et al.,* 2015)

Studies on nano urea reported that the unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant. The results have shown that application of mineral fertilizers (NPK) at 100% RDF (T2) tends to increase the height, shoot and root length of rice plants compared to no N application (T1) (table 1). At the same time, the application of nano urea (spray) with fertilization (NPK) had significant impact on the growth parameters particularly at critical periods. Thereby nano spray contributes to the increased plant yield (15-21%) than only NPK addition through chemical fertilizers. Similarly increased concentration of nano spray (0.4%) had significant impact on the plant growth parameters due to increased availability of N within the plant system.

Table 1: Effect of nano urea spray on rice growth parameters

Treatments	Plant height (cm)	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)
T1	105	98	7.6	25.2	7.2
T2	147	137	10.1	26.6	6.9
T3	126	115	11.2	20.5	7.8
T4	129	118	11.3	30.1	7.4
T5	142	132	10.2	28.9	6.8
T6	135	120	14.1	26.4	7.6
T7	125	113	11.2	29.3	6.6
T8	151*	139*	12.4*	30.5*	7.5*
CD (0.05)	1.83	1.62	0.41	0.87	0.32

The experiment also indicated that plant structure in terms of root and shoot length was highest for 0.4% nano spray along with N66+PK (T8) although the total shoot length was highest for 100% NPK. This showed that nano spray was effective for increasing nitrogen use in different parts of the plant and helped to establish good root growth. Consequently nano spray helped the rice plant to develop stronger root system, use the nutrient efficiently and enhance the yield besides withstanding adverse situations (Fig. 1). But, decrease in plant growth due to reduced mineral fertilization (N0 and N50) can be compensated with the increased concentration of nano spray at critical stages. This provided scope for saving of conventional mineral N fertilizers.

Fig. 1. A glimpse of nano urea experimental field & effects of nano spray on rice plant growth

The primary reason for better performance of rice receiving two nano spray was due to nano-pores and stomatal openings in plant leaves which facilitated nano material uptake and their penetration deep inside leaves leading to higher nutrient use efficiency (NUE). Precisely nano fertilizers have higher transport and delivery of nutrients through plasmodesmata, which are nano sized (50–60 nm) channels between cells (Mahanta et al., 2019).

A summary of effect of conventional and nano urea spray on N use, additional yield and N saving in rice is given in table 2. The table indicated that total cost in nano sprayed plots were higher than conventional NPK addition at all the three places where rice trial was conducted. It is estimated that Rs. 249, 339 and 339 respectively were incurred as additional cost on account of application of nano spray. However, at all the three places the grain yield was significantly higher in nano urea sprayed treatments than 100% NPK. This varied from 12-16% higher yield over RDF addition resulting in additional monetary benefit of Rs. 10082 (research farm), 11679 and 7937 (farmers field). Further, the increased efficiency of nano urea resulted in saving of mineral urea to the extent of 34% at experimental conditions and 25% at farmers field.

Conclusions

Spraying of liquid nano materials can increase crop yield by increasing nutrient uptake by plants and its bioavailability in soil. Spraying of nano urea is proved to be beneficial particularly under low input rainfed conditions of Andaman islands. This also led to saving of mineral N in the form of nitrogen fertilizer thereby decreased the accumulation of N in the surroundings. Further formulations of nano fertilizers (liquid) can provide required nutrition for crops particularly at critical stages of growth cycle, which in turn improves crop production.

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Conflict of interest

The authors declare that there is no conflict of interest in publishing this paper.

Table 2. Summary of effect of conventional and nano urea spray on N use, additional yield and N saving in rice

S. N	Crops	Location	Season	Treatments	Nitrogen Dose Applied per Plot (Kg)	Equivalent Top dressed Urea Qty per Plot	Urea Top dressing Cost (Avg. 3 Top dressed splits @ Rs 507 / split)	Nano Appn. Cost . (Bottle + Foliar labour) #	Subsidised Urea Cost (@ Rs 266.50 / Bag)	Total Cost (Urea cost + Nano Urea)	Add^{n} cost in Nano Plot	Grain Yield *	Mandi Price of the produce	Addn. Yield over RDF	% Inc over RDF	Addn. Return	Overall Economic Benefit	Nitrogen Saving in Top Dressed Nitrogen Only	
						kg /ha	Rs / ha	Rs /ha	Rs / ha	Rs	Rs / ha	kg /ha	Rs / kg	kg	%	Rs / ha	Rs / ha	kg S (Frdf - Fnano)	%
A	B	C	D	E	F	G	H	I	J (G x 266.5)/ 45	K (H+I+J)	L	M	N	O (M-Mrdf)	P (O/ Mrdf* 100)	Q (OxN)	R (Q-L)		T (S/Frdf X 100)
1	Rice (CIARI Dhan-3 Medium duration)	ICAR- CIARI, Bloomsdale Research Farm, Port Blair	Kharif 2021	T2 RDN ((90 Kg N /ha)	90.0	196	1521	0	1043	2564	-	3593	19.5						
				T8 RDF with 66 % N & 2 Sprays of Nano N @ 4ml / litre at AT & PI	59.4	130	507	1614	692	2813	249	4110	19.5	517	14.4	10082	9833	30.6	34
2	Rice (CIARI Dhan 2 Medium duration)	Farmer-1 Guptapara KVK, S. Andaman	Kharif 2021	T2 RDN ((90 Kg N /ha)	90.0	196	1521	0	1043	2564	-	3611	19.5						
				T6 RDF with 75 % N & 2 Sprays of Nano N @ 4ml / litre at AT & PI	67.5	147	507	1614	782	2903	339	4213	19.5	602	16.7	11679	11340	22.5	25
3	Rice (ANR 40)	Farmer-2 Basantipur (KVK, Nimbudera) N. Andaman	Kharif 2021	T2 RDN ((90 Kg N /ha)	90.0	196	1521	0	1043	2564	-	3373	19.5						
				T6 RDF with 75 % N & 2 Sprays of Nano N @ 4ml / litre at AT & PI	67.5	147	507	1614	782	2903	339	3780	19.5	407	12.1	7937	7598	22.5	25

Rice RDF for Island condition (Zone 15) = 90:60:60 NPK

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