Yield and yield attributes of wheat (*Triticum aestivum*) and soil physico-chemical properties under nano-urea application

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2022–23 at Dugurpur village Nuaon Block under On Farm Trial by Krishi Vigyan Kendra, Kaimur, to investigate the effect of nano-urea on yield, yield attributes soil physic chemical properties of wheat (*Triticum aestivum L.*). The experiment was tested in a randomized block design with 2-nano-urea based treatment,viz. farmers practice (100% RDF), 50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS), 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water. Results revealed that, yield attributes were significantly higher with 50% RDN& 100% PK along with nano urea. This treatment also resulted in 1.6 and 4.2% more grain yield with 100% RDF (33.14 q/ha).The effective tillers/m2 and number of grains/spike whichresulted in significantly higher grain yield. Thus, 50% RDN & 100% PK along with 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water are the more productive options for wheat-growingfarmers keeping view of the uprising cost and crisis of urea.

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Key words: IFFCO Nano-urea, Wheat, Yield attributes, Soil physico chemical properties

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world and the second most important crop in India. To keep pace with the annual population growth rate of India, i.e. 0.97%, and to meet the future wheat demand of India by 2050, i.e. 140 million tonnes, the productivity from present level of 3.3 t/ha to 4.7 t/ha and production of wheat by 46% have to be increased (Ramadas *et al.* 2019). The average annual wheat production in Bihar is approximately 4-4.5 million tonnes. Nitrogen is most important factors responsible for low productivity of wheat. Wheat (*Triticum aestivum* L.) is the most important and widely grown cereal crop of the globe which is grown since prehistoric times. It is referred to as the "king of cereals" and is the oldest cereal food crop belonging to the family Poaceae. Globally wheat (Triticum spp.) occupies an area of about 216.14 million hectares with an estimated annual production of 763.58 million tonnes with a productivity of 3.53 metric tonnes (USDA, 2020). In the world, the main wheat-producing countries are China, India, Russia, the USA, France, Canada, Ukraine, Pakistan, Germany, Argentina and Turkey (Anonymous, 2019). In India, wheat is farmed on around 31.76 million hectares, yielding 108.75 million tonnes with a productivity of 34.24 quintal ha^{-1} (Anonymous, 2021). In the state of Rajasthan, the wheat crop covers an area of 34.97 lakh hectares with an annual production of 10.92 million tonnes and average productivity of 3.5 tonnes ha^{-1}. Rajasthan state is in the fifth position in terms of wheat production after Uttar Pradesh, Punjab, Haryana and Madhya Pradesh (Anonymous, 2021).

After carbon, hydrogen and oxygen, nitrogen (N) is one of the important elements in plants because of its key part in chlorophyll production, which is basic for the photosynthesis process. Also, nitrogen is part of different enzymatic proteins that catalyze and regulate plant-development processes (Sinfieldet al., 2010). Besides, nitrogen contributes to the generation of chemical components that secure against parasites and plant diseases (Hofflandet al., 2000). At

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last, crop yield and biomass are profoundly affected by N fertilization (Tremblay et al., 2011). Plants absorb nitrogen as a mineral nutrient primarily from soil, and it can be may come in the form of ammonium (NH_4^+) and nitrate (NO_3^-) (Taiz and Zeiger 2010). Nonetheless, soil N supply is often limited (Vigneauet al.,2011), which forces farmers to increase the amount of N fertilizers in order to accomplish better crop yield. The conventional urea is less efficient and more harmful to the environment; however, recently developed nano-fertilizers like nano-urea enhanced the nutrient-use efficiency with very low rate of application, reduced input cost, environmentally safe and most importantly enhanced productivity and quality (Kiran and Samal, 2021; Kumar et al., 2021). Foliar application of nano-fertilizers significantly increased yield of the crop (Tarafdaret al.,2012).

Nano fertilizers which are environment-friendly or smart fertilizers with the potential to increase the application rates of fertilizers and reduce the loss of nutrients from it mainly phosphorous and nitrogen (Dimkpa and Bindraban 2018). However, 50–70% of nitrogenous fertilizers applied through conventional fertilization is either fixed in the soil or are lost to the environment due to volatilization, leaching and water runoff or they are incorporated as minerals in the soil through the action of microorganisms. Ironically, the unbalanced and haphazard use of inorganic fertilizers has a negative effect on the availability of nutrients to plants as well as on soil fertility and soil health resulting in lowering the productivity of crops and causing chronic diseases in human beings. Among the primary nutrients, nitrogen is the most crucial nutrient for crop productivity and it also plays a major role in agriculture.

The usage of nano-enabled fertilizers may improve nutrient delivery efficiency in plants (Chhipa, 2017). These nanoscale fertilizers reduce nutrient losses due to leaching, and chemical alterations can be avoided to enhance nutrient use efficiency and environmental quality (Raliya,

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2017). They are further characterized by their small size and large specific surface area, making them ideal materials in the manufacture of fertilizers called smart fertilizers after encapsulation with polymers or chelated to be slow release to suit the stages of a plant (Shang, 2019).

IFFCO has introduced nano urea (liquid) nitrogen to address low or declining use efficiency of nitrogen. Nano urea – liquid (Nano Nitrogen) utilises the dynamics of shape, size, surface area and better assimilation. Its application enhances plant metabolic processes, promotes meristematic activities; ensures higher apical growth and leaf photosynthetic area, triggers enzymes, and induces mechanisms/pathways inside the plant for achieving the desired N levels in amino acids/ protein content, chlorophyll content, nucleic acid, photosynthates, etc.

Precise and targeted application of nitrogen through foliar application of nano urea – liquid (nano nitrogen) reduces urea losses; increases nutrient uptake efficiency; and addresses environmental issues of soil, air and water pollution. It results in better crop harvest with lesser nitrogen application per unit area thus, leading to better farm economics. Spraying of nano urea – liquid (nano nitrogen) meets 100 ppm N requirement of crop at critical growth stages and triggers positive crop response, fulfils its nutritional requirement and also improves nutrient availability in the rhizosphere.

2. Materials & Methods

A field experiment of On-Farm Trial was conducted during winter (rabi) season of 2022-23, to investigate the Effect of nano-urea on yield, yield attributes and soil physico-chemical properties of wheat (*Triticum aestivum*)at the Village Dugurpur, Block- Nuaon, District Kaimur, Bihar. The experiment was conducted in randomized block design with 8 replicates and 3 treatments. The soil of the experimental site was sandy loam (sand 53.4%, silt 19.8% and clay 26.8%) with electrical conductivity of 0.12 dS/m and soil pH of 6.89. The organic carbon 3.5.,

available N 111 kg/ha, available P 13 kg/ha and available K 113 kg/ha. The treatments were tested in a randomized block design with 3 main plot treatments, viz. Farmers Practice (100% RDF), 50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS) and 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water. Wheat variety 'HD 2967' was shown on 25 November 2022 with a seed rate of 100 kg/ha, maintaining a row-to-row spacing of 22.5 cm along with basal dose of recommended dose of P and K, i.e. 60 kg P_2 O_5 and 40 kg K_2O/ha, applied uniformly technology option 01 and 02. 100% RDN, nitrogen was applied basal at 60 kg/ha and 2 equal splits of 30 kg/ha top-dressed at 25 DAS and at the maximum tillering, i.e. 60 DAS. In 50% RDN + 1 spray of nano-urea (at 35 DAS) treatment, nitrogen @ 30 kg/ha was applied basal, and rest 30 kg/ha top-dressed at 25 DAS as well as 1 spray of nano-urea was done at 35 DAS. In 50% RDN + 2 sprays of nano-urea (at 35 and 65 DAS) treatment, nitrogen was applied basal as 30 kg/ha, and rest 30 kg/ha as top-dressed at 25 DAS as well as 2 sprays of nano-urea was done at65 DAS. Nano-urea was applied by spraying @ 4 ml nano-urea/litre of water. Urea, Di ammonium phosphate and muriate of potash were used as a source of soil-applied N, P and K fertilizer respectively. At maturity, yield attributes and grain and straw yield of each plot recorded separately.

The soil samples were analysed for pH, EC, organic carbon, available N, P and K following standard methods. Available sulphur (0.15% $CaCl_2$-extractable) was estimated by turbidimetric method (Chesnin&Yien, 1951).

3. Results and Discussion

Plant height did not differ significantly among application of 50% RDN along with 1 spray and 2 spray of nano urea (Table 1). Theeffective tillers no./m2 increased significantly,

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minimum being in the farmers practice and the maximum in 50% RDN along with 2 spray 35 and 65 DAS of nano urea, which was 32% higher over the farmers practice. Grain yield of wheat increased significantly (Table 1), the maximum was in 50% RDN + 2 spray of nano urea which yielded4, and 2% higher than farmers practice (100% RDF) and 50% RDN & 100% PK + 1soray of nano urea, respectively. The significantly higher spike length (Table 1) was recorded with application of 50% RDN along with 2 spray of nano urea (7.89 cm) followed by technology option 01 (50% RDN & 100% PK + 1soray of nano urea) which was 17% and 5% increase over farmers practice (100% RDF). Application of 50 % RDN and 100% PK along with 2 spray of nano urea (Tech. Op. 02) led to the production of maximum grains per spike (29.43), followed by50% RDN & 100% PK + 1spray of nano urea (27.63) which was 11% and 5% increased over farmers practice (26.41) show in table 2. Application of 50 % RDN and 100% PK along with 2 spray of nano urea resulted in highest test weight (36.70 g), which was closely followed by 50% RDN & 100% PK + 1spray of nano urea (35.94 g). Wheat grain yields recorded (Table 02& Fig 01) under 50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS) and 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water statistically similar. The straw yield (Table 02) was maximum in 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water which was about 4% higher than that in the farmers practice 100% RDF (100:40:20) kg/hawere reported by (Tamrabet et al., 2009).Among 50% RDF along with 100% PK along with nano urea, the highest net returns of Rs. 55,599 /ha coupled with broadest Benefit: cost (B:C) ratio of 2.59 was obtained owing to the 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water. (Ajithkumaret al., 2021) reported that the maximum weight of the cob was recorded under

treatment 50% N, 100% PK, 0% Zinc + 2 sprays of IFFCO nano N (4ml/l) mixed with IFFCO Sagarika (2 ml/l).

The available N content in post harvest wheat soil (Table 03) significantly with successive increase in foliar application of nano urea. The available phosphorus post harvest soil of wheat varied from 20.25 to 23.75 kg/ha. The maximum phosphorus content (23.75 kg/ha) was recorded with application of 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water followed by 50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS) (23.0 kg/ha) which was 17 and 13% increased over farmer practice (20.25 kg/ha). The potassium content in soil was varied from 137.88 to 157.88 kg/ha. Application of 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water recorded maximum sulphur content (7.81 to 8.84 mg/kg) and minimum in Farmer practice (7.81 mg/kg). The micronutrient content zinc in post harvest soil of wheat was recorded maximum in 0.23 mg/kg technology option 1 and technology option 02 and minimum in farmer practice (0.15 mg/kg).(Kumar et al., 2020) also reported that the application of nano urea resulted highest grain yield was recorded with application of IFFCO liquid nano urea.

Economics is the main parameter which finally decidesthe adoption levels at farming situations of any newly introduced technology by the farmers. It should be technically and economically viable. Therefore, the economicanalysis of the results is very important.The maximal net return (Rs. 55,599) and B:C ratio (2.59) were fetched under the crop treated with 50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water which was statistically comparable to 50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS)andfarmers practice 100% RDF (100:40:20) kg/ha (Table4). The increase of net return and B:C ratio with the application of 50% of RDN & 100% PK + 2 sprays

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of Nano Ureawas5 and 3 per cent over Farmer Practice. Nano fertilizers may boost crop development and yield characteristics as well as make active photosynthetic activities and source-sink relationships which directly affect yield. Reduced urea treatment and efficient foliar nano fertilizer application led to lower cultivation costs, which in turn increased grain and straw yield and ultimately net return. These results were consistent with the results(Manikandan et al., 2016) and (Kumar et al., 2020).

4. Conclusions

From the foregoing results it is concluded that IFFCO nanofertilizers in general, and Nano-N in particular, will successfully help in reducing the consumption of urea to 50% by applying 2 sprays of Nano-N. As N deficiency in Indian soils is universal and so is the response to applied nano-N. IFFCO Nano Urea liquid, based on nano technology, effectively fulfils crop nitrogen requirement when sprayed at critical crop growth stages. It is used in place of conventional urea and other nitrogenous fertilizers for better environment, soil health and farmers profitability. Nano urea contains 4% nitrogen by weight in its nano form.The soil chemical properties were also slightly increased in the soil. This study clearly suggests that, soil application of fertilizer can be replaced by nano nitrogen through foliar application which enhanced the growth and yield attributes of the crop. In addition the foliar application of nano nitrogen will also diminish the soil pollution and enhances soil fertility by improving the physical and chemical properties of the soil. Application of nano urea fertilizer in combination with 50% RDN shows a significant increase in yield attributes character and also nutrients content. It was also found beneficial and highly cost-effective for the farmers because of increased economic returns. This may be because it only chemical fertilizers release of nitrogen steadily for a longer time as per the requirement of the crop.

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Table1Effect of nano-urea-based nitrogen management on growth attributing characters of wheat

Treatments	Plant Height (cm)				Effective tillers (no./m^2)	Spike length (cm)
	30 DAS	60 DAS	90DAS	At harvest	At harvest	At harvest
Farmers Practice (RDF: 100:40:20) kg/ha	16.90	38.53	70.67	72.50	234	6.76
50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS)	17.76	42.45	80.17	85.37	255	7.48
50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water	18.23	43.09	88.29	87.62	308	7.89
SEm±	0.0152	0.245	0.773	1.031	0.337	0.072
CD (P=0.05)	0.46	0.745	2.344	3.129	1.02	0.219

*RDF, Recommended dose of fertilizers, *RDN, Recommended dose of nitrogen, *DAS, Days after sowing

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Table 2Effect of nano-urea-based nitrogen management on yield attributing characters of wheat

Treatments	Grains per Spike	Test wt. (gm)/ 1000 grains wt.	Grain yield (q/ha)	Straw yield (q/ha)
Farmers Practice (RDF: 100:40:20) kg/ha	26.41	34.38	33.14	51.70
50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS)	27.63	35.94	34.02	52.92
50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water	29.43	36.70	34.54	53.60
SEm±	0.135	0.136	0.193	0.959
CD (P=0.05)	0.410	0.412	0.587	2.909

*RDF, Recommended dose of fertilizers, *RDN, Recommended dose of nitrogen, *DAS, Days after sowing

Table 3Effect of nano-urea-based nitrogen management on post harvest soil of wheat

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Treatments	pH	EC (dS^{-m})	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (mg/kg)	Zn (mg/kg)
Initial Soil	6.89	0.12	0.35	111	13	113	9	0.14
Farmers Practice (RDF: 100:40:20) kg/ha	7.52	0.17	0.36	172.63	20.25	137.88	7.81	0.15
50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS)	7.88	0.21	0.38	177.38	23.00	147.00	8.17	0.23
50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water	8.21	0.17	0.41	179.25	23.75	157.88	8.84	0.23
SEm±	0.19	0.022	0.005	0.90	0.520	0.475	0.105	0.009
CD (P=0.05)	NS	NS	0.015	2.731	1.579	1.439	0.318	0.028

*RDF, Recommended dose of fertilizers, *RDN, Recommended dose of nitrogen, *DAS, Days after sowing

Table 4Effect of nano-urea-based nitrogen management on economics of wheat

Treatments	Grain Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross Return (Rs./ha)	Net Return (Rs./ha)	B:C Ratio
Farmers Practice (RDF: 100:40:20) kg/ha	33.14	34108	86960	52852	2.54
50% of RDN & 100% PK + nano urea @4ml/lt. water (Single spray at 35 DAS)	34.02	34792	89208	54416	2.56
50% of RDN & 100% PK + 2 sprays of Nano Urea at (35 DAS) and (60-65DAS) @ 4 ml/lt water	34.54	34921	90520	55599	2.59

*RDF, Recommended dose of fertilizers, *RDN, Recommended dose of nitrogen, *DAS, Days after sowing

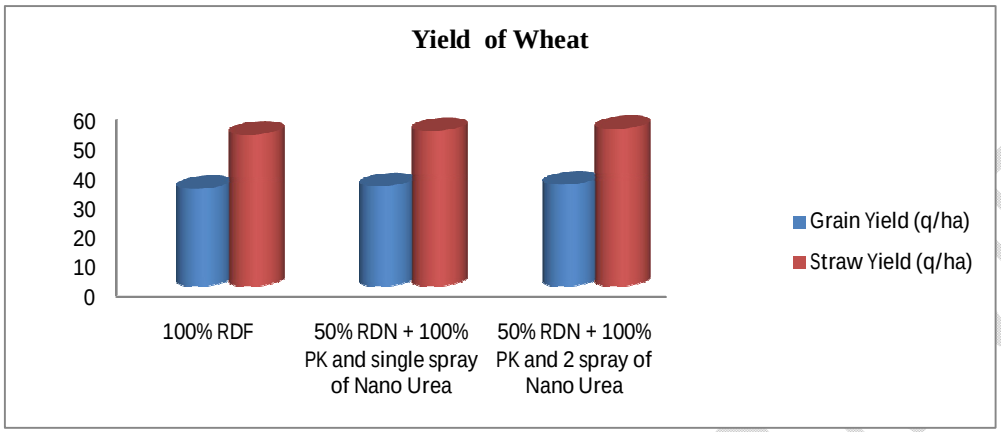

Fig. 1. Effect of nano urea on grain and straw yield of wheat