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Impact of nano urea and iron on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
The field experiment was on the Effect of Nano urea and Iron on growth and yield of wheat (*Triticum aestivum* L.) conducted at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India and was performed during Rabi season of 2024. Experimental plot was sandy loamy soil of nearly neutral soil reaction (pH 7.2), low in organic carbon (0.48 percent), placed in the Randomized Block Design, repeated three times, with ten treatments i.e. T_1: Nano urea 1.5 ml/l with Iron 0.25, T_2: Nano urea 2.5 ml/l with Iron 0.50, T_3: Nano urea 3.5 ml/l with Iron 0.75, T_4: Nano urea 1.5 ml/l with Iron 0.25%, T_5: Nano urea 2.5 ml/l with Iron 0.50%, T_6: Nano urea 3.5 ml/l with Iron 0.75%, T_7: Nano urea 1.5 ml/l with Iron 0.25%, T_8: Nano urea 2.5 ml/l with Iron 0.50%, T_9: Nano urea 3.5 ml/l with Iron 0.75% and T_{10}: Control (120:60:60 kg/ha).The maximum plant height (99.80), dry weight (26.71 g/plant), number of spikes/m^2 (211.33), number of grains/spike (47.27), grain yield (4.28 t/ha), straw yield (6.54 t/ha).

Keywords: Nano urea, iron, growth and yield, wheat (SW23)

Introduction
Wheat (*Triticum aestivum* L.) belongs to the family Gramineae or Poaceae. In India, it is an important crop because, it has a wide range of geographical adaptation, unique chemical composition, good nutritional values, functional health benefits and variety of end-uses (food, feed and non-edible). Wheat's 1st rank in the world among cereals in both area and production. Wheat is a grass that is commonly grown for its seed, a cereal grain that is a staple food all over the world. Wheat compares well with other important cereals in the nutritive value. It contains more protein than other cereals. The nutritive values of wheat are starch (60-68%), protein (8-15%), fat, sugar, cellulose, minerals, vitamins, etc. In India, wheat is predominantly rabi crop with 220.4 m ha of the total area under cultivation in the season. It is most important crop after rice in tropical and sub-tropical regions. In India, wheat crop is the second most after rice, so wheat is called as "King of cereals". Uttar Pradesh, Punjab, Madhya Pradesh, Haryana are leading states in area and production of wheat. Common bread wheat hexaploidy species mostly grown in India, occupying about 87% of wheat area, and are good for chapati making and bakery products. It is a C_3, long day plant hence, cool and moist weather period during vegetative growth is required whereas, warm and dry weather during grain formation is ideal Rani *et al*. (2024) [11].
Most of the world populations have wheat as a staple food in their diets and it is grown in 220 million hectares and yield 763.06 million tonnes. The highest is India with 14 percent of the world area, then Russia, China and the USA. The largest producer is China with an all-time record production of 136 million tonnes. Traditional countries of wheat-growing produce about 449 million tonnes (58%). Wheat is planted in Rabi in India, planted in the months of November and harvested in March to April. The national level of wheat cultivated area has grown by 1.5-million-hectare (5 percent) net gain. The Uttar Pradesh region owns the biggest portion, as 9.75 million hectares (32%). Other states that produce major wheat are Madhya Pradesh, Punjab, Rajasthan, Haryana and Bihar. The rise in minimum support price and government procurement has caused the growth in wheat farming. Wheat is also sensitive to the macro and micronutrients such that it yields better when supplemented with the requirement of less but vital nutrients such

as zinc, copper, iron, manganese, and chlorine.

Nano urea is a low concentration; liquid fertilizer created through nanotechnology which aims at fertilizing plants in an efficient and sustainable manner. It gives a better substitute to conventional urea by enhancing efficiency of nitrogen use, environmental impact and probably crop yields. On the other hand, nano fertilizers form a substantial quantity of nutrient in agriculture, which improves the crop growth, crop yield and quality indices. They enhance the efficiency of nutrient utilization and minimize the cost of cultivation and are very successful in precision agriculture of having fine control of nutrients. Nano fertilizers provide added surface area on which plants can react to different metabolic processes, increasing the photosynthesis rate, and, thus, dry matter production and crop yield (Qureshi *et al.* 2018) [10]. Nano urea is one of the products that have revolutionized agriculture in the country through its production by different industries. India has gone a step further to become the second-largest consumer in the world by rolling out commercial production of Nano urea. The only nano fertilizer is nano urea approved by the Government of India and covered under the Fertilizer Control Order, 1985. Rani *et al.* (2024) [11] reported that the nano-fertilizer formulations of nitrogen could reduce the loss of nitrogen in the form of leaching, emission and soil microbial immobilization. Micronutrients are crucial in growth and development of plant and occupy a significant share by virtue of their significance in enhancing crop yields. Actually, the role that they play in plant nutrition and enhancing soil productivity is paramount and hence all the more important. Abbas *et al.* (2020) [1] reported high levels of incidence of micronutrient deficiencies in view of intensive crop farming with high yielding varieties and the use of high analysis major and secondary nutrient fertilizer.

Iron (Fe) is a vital micro-nutrient to the growth and yield of wheat. Iron is important in the process of chlorophyll production essential in photosynthesis. High levels of iron may result in greater growth parameters such as plant height, the number of tillers and grain yield and better grain quality. The nutritional worth of the wheat grains can also be enhanced with iron fertilization resulting in the rise of iron and protein content. This is especially the case where iron deficiency is a common occurrence in the human diet. It is an important constituent of chlorophyll which is the pigment that enables plants to change sunlight into energy. The outcome of iron deficiency may be chlorosis (yellowing of the leaves) and decrease of the photosynthetic ability and growth. Healthy green leaves and healthy growth on the other are conducive with sufficient iron. Iron fertilizer can be defined as substances with iron that are applied to eliminate iron deficiency in plants to ensure good growth. Iron is an important micronutrient to plant development, as it is essential in the process of chlorophyll formation as well as activation of enzymes. There are different types of iron fertilizers, such as iron sulphate, iron chelates, and organic sources such as Morganite, all with particular use and advantage Gul *et al*. (2023) [3].

Material and Methods

An experiment field experiment was conducted during Rabi season 2024 at Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) to study the "Effect of Nano urea and Iron on growth and yield of Wheat (*Triticum aestivum* L.)." The soil of the experimental field was sandy loam in texture, with soil pH 7.1, low level of organic carbon (0.48 %), available N (87.0 Kg/ha), available P (20.5 Kg/ha) and available K (225.0 Kg/ha). The experiment was laid out in Randomized Block Design with ten treatments and three replications. The treatment combinations are., T_1: Nano urea 1.5 ml/l with Iron 0.25,T_2: Nano urea 2.5 ml/l with Iron 0.50, T_3: Nano urea 3.5 ml/l with Iron 0.75, T_4: Nano urea 1.5 ml/l with Iron 0.25%, T_5: Nano urea 2.5 ml/l with Iron 0.50%, T_6: Nano urea 3.5 ml/l with Iron 0.75%, T_7: Nano urea 1.5 ml/l with Iron 0.25%, T_8: Nano urea 2.5 ml/l with Iron 0.50%, T_9: Nano urea 3.5 ml/l with Iron 0.75% and T_{10}: Control (120:60:60 kg/ha).

Chemical analysis of soil

To establish the initial soil characteristics, a composite soil sample was obtained before the experiment was laid out. The soil sample was taken from a depth of 0-15 cm, dried in the shade, pulverised using a wooden pestel and motor, passed through a 2 mm filter, and utilised for analysis. Available organic carbon and black technique by (Jackson 1973) [5], available nitrogen by alkaline permanganate method by Subbaih and Asija (1956) [14], available phosphorus by Olsen's colorimeter method as outlined by Olsen *et al*., (1954) [9], and available potassium by flame photometer method by Jackson (1973; Toth and Prince, (1949) [5, 15].

Statistical analysis:

Experimental data collected was subjected to statistical analysis of variance (ANOVA) as outline by Gamez and Gomez (2010). Critical Difference (CD) values were calculated the 'F' test was found significant at 5% level.

Result and Discussion

Growth and Yield attributes

Plant height (cm)

Significant differences were recorded among the treatments. Observations on the effect of Nano urea and Iron on wheat plant was observed to rise gradually with the age of the crop that peaked at harvest. There were no significant differences in treatments at 20 DAS, but the highest (9.83 cm) was with the Nano urea 2.5 ml/l with Iron 0.50% (T_5), and lowest (8.14 cm) with the control (T_{10}). At 40 DAS (Nano urea 3.5 ml/l with 0.75% Iron) and onwards, Nano urea and Iron treatments produced significant effects, the highest plant height could be observed at Nano urea 3.5 ml/l with Iron 0.75% (T_9), amounting to 33.03 cm, 56.21 cm, 84.72 cm, and 99.80 cm at 40 DAS, 60 DAS, 80 DAS and 100 DAS, T_7 (Nano urea 1.5 ml/l with Iron 0.25%) and T_8 (Nano urea 2.5 ml/l with Iron 0.50%) were statistically the same as T_9 in terms of growth stage. The vast growth of plant height due to the addition of Nano urea: 3.5 ml/l with Iron 0.75% could be explained by the high absorption of nitrogen, protein synthesis, cell division, elongation, and the facilitating effect of iron in enzymatic processes and the formation of chlorophyll. The same results were documented by Kumar *et al.* (2021) [6].

Plant dry weight (g)

In the given research, the dry weight of planted and grown wheat had a gradual growth between 20 and 100 DAS, whereas there were significant variations in the treatments after 40 DAS. There was no significant difference at 20 DAS, but the maximum dry weight was 0.35 g in Nano urea 3.5 ml/l with Iron 0.75% (T_9), and the minimum (0.24 g) was in (T_5). Since 40 DAS, T_9 showed the greatest dry weight (7.16 g at 40 DAS, 11.16 g at 60 DAS, 13.82 g at 80 DAS, and 26.71 g at 100 DAS), T_7 (Nano urea 1.5 ml/l with Iron 0.25%) and T_8 (Nano urea 2.5 ml/l with Iron 0.50%) could not be statistically differentiated at any point. The high growth in the dry weight of Nano urea 3.5 ml/l with Iron 0.75% was explained by the greater nitrogen supply, which ameliorated morphological characteristics, photosynthetic, and nutrient uptake, which accelerated the accumulation of dry matter. Production of biomass was also supported by the role of iron in chlorophyll and enzyme activity. These findings are consistent with the findings by Saurabh *et al.* (2019) [12] and Kumar *et al.* (2021) [6].

Number of Spike/m^2

The highest number of Spike/m^2 was recorded in the T_9 (211.33) with the application of Nano urea 3.5 ml/l with Iron 0.75 %. However, T_5 application of Nano urea 2.5 ml/l with Iron 0.50 %, T_6 application of Nano urea 3.5 ml/l with Iron 0.75 %, T_7 application of Nano urea 1.5 ml/l with Iron 0.25 % and T_8 application of Nano urea 2.5 ml/l with Iron 0.50 % which were found to be statistically at par with T_9 application of Nano urea 3.5 ml/l with Iron 0.75%. Maximum number of number of Spike/m^2 be due to sufficient supply of nitrogen which helps in better root development and more nutrient absorption. Iron application also helps in promoting growth enzymes responsible for tiller initiation. Similar findings were also reported by Dubey *et al.* (2018) [2].

Number of Grains/spikes

Significant and maximum number of grains/spike (47.27) was recorded with the application of Nano urea 3.5 ml/l with Iron 0.75 % which was superior over all other treatments. Higher grains/spike may be attributed to better nitrogen uptake and effective photosynthate translocation to the spike during grain filling stage. Similar findings were also reported by Narayan *et al.* (2017) [8] and Dubey *et al.* (2018) [2].

Test Weight: There is no significant highest test weight (38.71g) was recorded with was recorded with (T_9) application of Nano urea 3.5 ml/l with Iron 0.75% which was superior over all other treatments. These treatments were found to be non-significant. Higher test weight might be due to zinc-enhanced enzymatic activities involved in grain filling and accumulation of starch and protein. Similar results were also reported by Muhammad *et al.* (2017) [7].

Grain Yield

The maximum grain yield was observed in T_9 (4.28 t/ha) with the application of Nano urea 3.5 ml/l with Iron 0.75%. However, T_8 (4.28 t/ha) with the application of Nano urea 2.5 ml/l with Iron 0.50 % which were found to be statistically at par with (T_9) application of Nano urea 3.5 ml/l with Iron 0.75%. Adequate nitrogen levels create a larger, photosynthetically active canopy, which increases the amount of energy the plant can produce to support grain development Singh *et al*., (2005) [13].

Straw Yield

Significantly higher straw yield T_9 (6.54 t/ha) was recorded with application of Nano urea 3.5 ml/l with Iron 0.75%. However, T_8 (5.67 t/ha) with the application of Nano urea 2.5 ml/l with Iron 0.50 % which were found to be statistically at par with T_9 application of Nano urea 3.5 ml/l with Iron 0.75%.

Harvest Index

Maximum harvest index (46.14 %) was observed with T_4 application of Nano urea 1.5 ml/l with Iron 0.25% which was superior over all other treatments. These treatments were found to be non-significant. This might be due to efficient partitioning of dry matter towards reproductive structures.

Table 1: Influence of Nano urea and Iron on growth attributes of Wheat.

S. No.	Treatment combination	Pre Harvest Observation	
		Plant Height (cm)	Plant Dry weight (g)
1.	Nano urea 1.5 ml/l+ Iron 0.25%	91.37	20.70
2.	Nano urea 2.5 ml/l + Iron 0.50 %	89.77	21.42
3.	Nano urea 3.5 ml/l + Iron 0.75 %	94.86	20.48
4.	Nano urea 1.5 ml/l+ Iron 0.25%	96.85	21.56
5.	Nano urea 2.5 ml/l + Iron 0.50 %	92.05	20.86
6.	Nano urea 3.5 ml/l + Iron 0.75 %	93.66	22.03
7.	Nano urea 1.5 ml/l+ Iron 0.25%	93.40	21.64
8.	Nano urea 2.5 ml/l+ Iron 0.50 %	94.60	22.95
9.	Nano urea 3.5 ml/l+ Iron 0.75 %	99.80	26.71
10.	Control (120:60:60 NPK kg/ha)	91.68	20.43
	F - Test	S	S
	S.Em (±)	1.82	0.52
	CD (p = 0.05)	5.40	1.50

Table 2: Influence of Nano urea and Iron on growth and yield attributes of wheat.

S. No.	Treatment Combination	Post - Harvest Observations					
		No. of spikes/m^2	No. of grains/ Spike	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1.	Nano urea 1.5 ml/l+ Iron 0.25%	187.00	46.47	32.24	3.72	4.52	45.12
2.	Nano urea 2.5 ml/l + Iron 0.50 %	199.00	46.60	35.06	3.83	4.57	45.58
3.	Nano urea 3.5 ml/l + Iron 0.75 %	197.00	46.73	32.76	3.90	4.84	44.64
4.	Nano urea 1.5 ml/l+ Iron 0.25%	193.67	46.53	35.42	3.86	4.51	46.14
5.	Nano urea 2.5 ml/l + Iron 0.50 %	202.00	45.87	33.56	3.84	4.64	45.26
6.	Nano urea 3.5 ml/l + Iron 0.75 %	206.00	46.80	35.85	3.99	5.54	41.86
7.	Nano urea 1.5 ml/l+ Iron 0.25%	202.33	46.13	35.81	3.95	5.22	44.19
8.	Nano urea 2.5 ml/l+ Iron 0.50 %	201.33	46.86	36.53	4.01	5.67	43.59
9.	Nano urea 3.5 ml/l+ Iron 0.75 %	211.33	47.27	38.71	4.28	6.54	40.12
10.	CONTROL (120:60:60 NPK kg/ha)	198.67	46.53	32.41	3.26	4.19	43.76
F - Test		S	S	NS	S	S	NS
S.Em (±)		3.72	0.22	1.39	0.08	0.10	0.65
CD (p = 0.05)		11.06	0.69	-	0.29	0.92	-

Conclusion

It is concluded that the application of Nano urea 3.5 ml/l with Iron 0.75% recorded highest plant height, plant dry weight, number of spikes per square meter, number of grains per spike per square meter, grain yield and straw yield for wheat.

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