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Assessing the influence of different levels of nitrogen rates and foliar spray of urea and nano urea on growth, yield and economics of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted on medium black calcareous soil at Junagadh (Gujarat) during *rabi* season of 2022-23 to study the effect of different levels of nitrogen rates and foliar spray of urea and nano urea on growth, yield and economics of wheat (*Triticum aestivum* L.). The experiment was laid out in randomized block design with three replications and twelve treatments. The experimental results revealed that significantly higher values of growth parameters *viz.*, plant height, number of total tillers per m row length and dry matter production per plant and yield attributes *viz.*, number of effective tillers per m row length, length of spike, number of spikelets per spike, number of grains per spike, grain weight per spike, 1000-grain weight along with higher grain yield (5841 kg/ha) and straw yield (8273 kg/ha) were recorded with application of 75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS. However, higher net return (₹ 1,22,715/ha) and B:C ratio (4.28) were also realized with the application of 75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS. Based on the results, it could be concluded that higher production and net returns from wheat can be obtained by the application of 75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS.

Keywords: Wheat, nitrogen, foliar spray, urea, nano urea, yield attributes and yield

Introduction
Wheat (*Triticum aestivum* L.) is the most important and widely grown cereal crop of the globe which is grown since pre-historic times. It is also known as a king of cereals crop. Wheat plays a significant role in increasing the economic growth of the nation and ensuring food as well as nutrition security. In India, wheat is the second most important cereal crop next to rice. Wheat being an energy rich winter cereal contributes 35% to the food grain basket of the country. India had 318.7 lakh ha area, production 1105.5 lakh tons with national average productivity of 3.46 t/ha (Anon., 2023a) [1]. In Gujarat, it was cultivated in an area of 12.93 lakh ha with production of 41.04 lakh tons of grains with the average productivity of 3.174 t/ha (Anon., 2023b) [2].

Nitrogen is the most crucial nutrient for crop productivity and it also plays the major role in agriculture. Nitrogen being a major food for plants is an essential constituent of protein and chlorophyll present in major portions of the plant body. It plays a most important role in various physiological processes.

Among the different nitrogenous fertilizer, urea is the most important fertilizer. Urea contributes about 82% of the total fertilizer consumption in India and about 55% of the total fertilizer nitrogen consumed in the world. Around 30- 40% of nitrogen from urea is utilized by plants and the rest gets wasted due to quick chemical transformation as a result of leaching, volatilization, denitrification and run off, thereby low use efficiency. (Kannoj *et al.*, 2022) [6].

To overcome all these drawbacks, nano technology holds promise. Nano urea has high nitrogen use efficiency and also it is environment friendly. It has been developed at IFFCO Nano biotechnology Research center, Gujarat. Nano urea is a long-term solution for farmers who want to practice smart agriculture while also combating climate change. Because nano urea has a suitable particle size of 30-40 nm, higher surface area and higher number of particles it is bio-

available to plants as a fertilizer (Kumar *et al*., 2020b) [7]. This fertilizer is popularly known as "smart fertilizer" because it reduces the emission of nitrous oxide. Nano urea is gaining importance in Indian agriculture because it reduced the quantity of synthetic urea being applied by the farmers for supply nitrogen to their crops. This liquid nano urea, believed to supplement sufficient nitrogen to the crop, when it is applied as foliar spray at critical stages of crops.

Taking note of the facts highlighted above, a field experiment was conducted to study the influence of different levels of nitrogen rates and foliar spray of urea and nano urea on growth, yield and economics of wheat.

Materials and Methods

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) in *rabi* season of 2022-23. Geographically, Junagadh is situated at 21.5° N latitude and 70.5° E longitude with an altitude of 60 m above the mean sea level. The experiment took place on medium black calcareous soil with $pH_{2.5}$ 8.00 and $EC_{2.5}$ 0.34 dS/m, low in available nitrogen (242 kg/ha) and medium in available phosphorus (30.10 kg/ha) and potassium (235 kg/ha). The mean maximum and minimum temperature during the crop period ranged from 25.7 to 37.7 °C and 9.4 to 18.6 °C, respectively. During the crop period, the relative humidity was in the range of 39 to 78%. Bright sun shine hours, wind velocity and daily evaporation were 4.2 to 9.5 h/day, 2.3 to 7.6 km/h and 3.6 to 6.6 mm/ day, respectively.

The study focused on "Assessing the influence of different levels of nitrogen rates and foliar spray of urea and nano urea on growth, yield and economics of wheat (*Triticum aestivum* L.)". Employing a randomized block design (RBD), the experiment comprised twelve treatments replicated thrice. The treatments included various combinations of urea and nano urea: T_1 - Control (No fertilizer), T_2 -100% RDN (120 kg/ha) + Water spray at 35 and 55 DAS, T_3 -75% RDN + Foliar spray of 2% urea at 35 and 55 DAS, T_4 -75% RDN + Foliar spray of 3% urea at 35 and 55 DAS, T_5 -50% RDN + Foliar spray of 2% urea at 35 and 55 DAS, T_6 -50% RDN + Foliar spray of 3% urea at 35 and 55 DAS, T_7 -75% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS, T_8 -75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS, T_9 -75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS,T_{10} -50% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS,T_{11} -50% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS, T_{12} -50% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS. The recommended doses of phosphorus (60 kg/ha) and potassium (60 kg/ha) were applied during sowing using DAP and MOP, respectively. However, nitrogen was applied in the form of urea in three splits *i.e.* 50% at sowing, 25% at 35 DAS and 25% at 55 DAS and foliar spray of urea and nano urea as per treatment. In this study we have used IFFCO Nano urea (liquid). The wheat variety 'GJW 463' was sown on November 22, 2022 at row spacing of 22.5 cm using seed rate of 120 kg/ha. The gross and net plot size was 5.0 m x 2.7 m and 4.0 m x 1.8 m, respectively. The crop was raised as per the recommended package of practices. The crop was harvested at physiological maturity on March 09, 2023. The yield attributes were recorded from the five tagged plants in each plot. Grain and straw yield were recorded from the net plot area and converted into kilogram per hectare base.

The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of inputs *viz.*, seeds, fertilizers, herbicides, irrigation, etc. applied to each treatment was calculated on the basis of prevailing local charges. The gross realization in terms of rupees per hectare was worked out taking into consideration the grain and straw yields from each treatment and local market prices. Net return of each treatment was calculated by deducting the total cost of cultivation from the gross returns. The benefit: cost ratio (B:C) was calculated by dividing gross return with cost of cultivation. The data were subjected to statistical analysis by adopting appropriate analysis of variance as described by Gomez and Gomez (1984) [5]. Wherever the F values found significant at 5% level of probability, the critical difference (CD) values were computed for making comparison among the treatment means.

Results and Discussion

Growth Parameters

The results revealed that different treatments manifested significant influence on growth parameters of wheat (Table 1). The treatment T_8 (75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS) recorded significantly the highest plant height (84.21 cm), number of total tillers (89.00) and dry matter production per plant (16.52 g) at harvest, but it remained statistically at par with the treatments T_9 (75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS), T_4 (75% RDN + Foliar spray of 3% urea at 35 and 55 DAS), T_2 (100% RDN + Water spray at 35 and 55 DAS) and T_7 (75% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS). This might be due to fact that nano urea has a significant effect on the growth of the wheat crop because the micro size of nano urea results in better absorption of the nano nitrogen which effects the plant growth mechanism. The plots treated with nano urea positively influences the activity of chloroplast, anti-oxidant enzyme producing systems and nitrogen-reductase which are potential mechanisms for better plant growth. So that higher availability and absorption of nitrogen which facilitates better uptake from leaves, resulting in production of more phosynthesis and biomass required for healthy crops. These results are in conformity with the findings of Sheoran *et al.* (2021) [18], Gangwar *et al*. (2022) [4], Ojha *et al.* (2023) [9] and Singh *et al.* (2023) [20].

Yield attributes

The data given in Table 2 showed that application of 75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS (T_8) recorded significantly the highest number of effective tillers per m row length (79.33), length of spike (9.43 cm), number of spikelets per spike (16.80), number of grains per spike (49.67), grain weight per spike (2.13 g) and 1000-grain weight (48.67 g) followed by the treatments T_9 (75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS), T_4 (75% RDN + Foliar spray of 3% urea at 35 and 55 DAS) and T_2 (100% RDN + Water spray at 35 and 55 DAS) in most of the cases. This result may be due to fact that the use of conventional urea in conjunction with nano urea had a substantial impact on yield attributes. The reason behind that nano urea has a harmonious effect on the practicality of conventional urea for enhanced nutrient fascination by plant cells resultant in optimal growth of plant parts and metabolic processes such as photosynthesis which accumulation and translocation higher photosynthates to the economically important plant parts. These results are in line with the findings of Rajput *et al*. (2022) [12], Samui *et al.* (2022) [16], Singh *et al*. (2022) [19], Pal *et al.* (2023) [10], Sarkar *et al.* (2023) [17] and Upapudi *et al.* (2023) [21].

Yield: A scrutiny of data (Table 3) revealed that significantly

the highest grain yield (5841 kg/ha) was recorded with the treatment T_8 (75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS) and it was found statistically equivalent to the treatments T_9 (75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS), T_4 (75% RDN + Foliar spray of 3% urea at 35 and 55 DAS) and T_2 (100% RDN + Water spray at 35 and 55 DAS). The magnitude of increase in grain yield with treatments T_8, T_9, T_4 and T_2 over T_1 (Control) was 57.74, 52.87, 48.44 and 48.08 percent, respectively. The data furnished in Table 3 further indicated that significantly the highest straw yield (8273 kg/ha) was registered under the treatment T_8 (75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS), and it was found statistically comparable to the treatments T_9 (75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS), T_4 (75% RDN + Foliar spray of 3% urea at 35 and 55 DAS), T_2 (100% RDN + Water spray at 35 and 55 DAS) and T_7 (75% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS). The extent of increase in straw yield with the treatments T_8, T_9, T_4 and T_2 was 60.70, 58.83, 56.92 and 55.86 percent, respectively over the treatment T_1 (Control). The increase in grain yield was attributed to remarkable improvement in almost all the growth and yield attributes under these treatments. It was also noticed that the addition of nano nitrogen increases the absorption area which contributes to optimal growth of plant parts and metabolic process such as photosynthesis leads to higher photosynthates accumulation and translocation to the economic parts of the plant, thus resulting in high yield which may be attributed to increased source (leaves) and sink (economic part) strength. These results are in conformity with those reported by Kumar *et al.* (2020a) [8], Rajesh *et al.* (2021) [11], Rathore *et al.* (2022) [13], Sahu *et al.* (2022) [14], Samanta *et al.* (2022) [15], Chavan *et al.* (2023) [3] and Upadhyay *et al.* (2023) [22].

Economics

An examination of data (Table 3) revealed that the maximum net return of ₹ 1,22,715/ha was accrued under the treatment T_8 (75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS) closely followed by the treatments T_9 (75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS) having net return of ₹ 1,16,909/ha. Whereas, the lowest net realization (₹ 73,546/ha) was observed with the treatment T_1 (Control). The data (Table 3) further indicated that the highest B:C ratio of 4.28 was realized with the treatment T_8 (75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS), followed by the treatments T_4 (75% RDN + Foliar spray of 3% urea at 35 and 55 DAS), with B:C ratio of 4.24. The treatment T_5 (50% RDN + Foliar spray of 2% urea at 35 and 55 DAS) registered the lowest B:C ratio of 3.50. The highest net return and B:C ratio gained in the treatment T_8 is mainly due to increased grain and straw yield over other treatments.

Table 1: Effect of different treatments on growth parameters of wheat

Tr. No.	Treatments	Plant height (cm)	Number of total tillers per m row length	Dry matter production (g/plant)
T_1	Control (No fertilizer)	69.35	64.67	10.74
T_2	100% RDN + Water spray at 35 and 55 DAS	80.68	84.33	15.59
T_3	75% RDN + Foliar spray of 2% urea at 35 and 55 DAS	74.75	77.00	14.53
T_4	75% RDN + Foliar spray of 3% urea at 35 and 55 DAS	80.72	85.33	15.98
T_5	50% RDN + Foliar spray of 2% urea at 35 and 55 DAS	70.26	69.00	12.07
T_6	50% RDN + Foliar spray of 3% urea at 35 and 55 DAS	71.12	71.33	13.86
T_7	75% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS	77.25	81.33	15.21
T_8	75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS	84.21	89.00	16.52
T_9	75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS	81.06	87.67	16.24
T_{10}	50% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS	70.14	70.00	13.23
T_{11}	50% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS	71.35	74.33	14.35
T_{12}	50% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS	74.40	75.00	14.47
	S.Em.±	3.23	3.33	0.67
	C.D. at 5%	9.46	9.76	1.95
	C.V.%	7.41	7.45	8.00

Table 2: Effect of different treatments on yield attributes of wheat

Tr. No.	Treatments	Number of effective tillers per m row length	Length of spike (cm)	Number of spikelets per spike	Number of grains per spike	Grain weight per spike (g)	1000 grain weight (g)
T_1	Control (No fertilizer)	57.00	6.57	11.72	30.73	1.49	39.67
T_2	100% RDN + Water spray at 35 and 55 DAS	76.67	8.59	16.05	46.96	2.03	45.22
T_3	75% RDN + Foliar spray of 2% urea at 35 and 55 DAS	70.67	8.33	14.75	41.32	1.88	44.26
T_4	75% RDN + Foliar spray of 3% urea at 35 and 55 DAS	75.00	8.63	16.35	46.00	2.06	45.23
T_5	50% RDN + Foliar spray of 2% urea at 35 and 55 DAS	60.33	7.13	12.27	32.82	1.57	41.05
T_6	50% RDN + Foliar spray of 3% urea at 35 and 55 DAS	64.67	7.50	13.45	40.07	1.84	43.21
T_7	75% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS	73.33	8.39	14.84	44.45	1.95	44.38
T_8	75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS	79.33	9.43	16.80	49.67	2.13	48.67
T_9	75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS	76.00	8.67	16.65	47.46	2.11	46.26
T_{10}	50% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS	61.00	7.44	12.33	36.82	1.68	43.66
T_{11}	50% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS	65.33	8.00	13.70	41.10	1.84	43.76
T_{12}	50% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS	67.67	8.12	14.72	40.24	1.85	44.14
	S.Em.±	3.88	0.35	0.66	2.73	0.09	1.46
	C.D. at 5%	11.39	1.04	1.95	8.02	0.27	4.29
	C.V.%	9.76	7.61	7.94	11.42	8.69	5.73

Table 3: Effect of different treatments on yields and economics of wheat

Tr. No.	Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Net return (₹/ha)	B:C Ratio
T_1	Control (No fertilizer)	3703	5148	73546	3.64
T_2	100% RDN + Water spray at 35 and 55 DAS	5483	8024	114743	4.20
T_3	75% RDN + Foliar spray of 2% urea at 35 and 55 DAS	5047	7218	102937	3.90
T_4	75% RDN + Foliar spray of 3% urea at 35 and 55 DAS	5496	8079	115404	4.24
T_5	50% RDN + Foliar spray of 2% urea at 35 and 55 DAS	4480	6046	87508	3.50
T_6	50% RDN + Foliar spray of 3% urea at 35 and 55 DAS	4707	6693	93992	3.68
T_7	75% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS	5104	7430	103765	3.85
T_8	75% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS	5841	8273	122715	4.28
T_9	75% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS	5661	8177	116909	4.04
T_{10}	50% RDN + Foliar spray of 0.2% nano urea at 35 and 55 DAS	4661	6397	91687	3.55
T_{11}	50% RDN + Foliar spray of 0.4% nano urea at 35 and 55 DAS	4893	6945	97225	3.63
T_{12}	50% RDN + Foliar spray of 0.6% nano urea at 35 and 55 DAS	4981	7067	98623	3.60
	S.Em.±	251	335	-	-
	C.D. at 5%	736	982	-	-
	C.V.%	8.68	8.14	-	-

Conclusion

On the basis of the results obtained from one year field study, it seems quite logical to conclude that significantly higher production and net realization from wheat (cv. GJW 463) can be achieved by application of 75% RDN + foliar spray of 0.4% nano urea at 35 and 55 DAS on medium black calcareous soil under South Saurashtra Agro-climatic Zone. The study's results demonstrated a generally positive effect of combined nano urea with traditional NPK nutrient supply on the growth and yield parameters of wheat.

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