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Response of foliar application of urea and nano urea on growth, yield and quality of wheat under irrigated condition

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Abstract

Wheat (*Triticum aestivum* L.) is a crucial cereal crop globally, serving as a staple food for a vast population. Its productivity faces various challenges such as nutrient imbalance in India. To address this issue, a study was conducted during the *rabi* season of 2023-2024 at the Instructional Farm, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, with a view to study the “Response of foliar application of urea and nano urea on growth, yield and quality of wheat under irrigated condition”. The experiment was conducted in randomized block design and treatments were consisted of 12 levels of nutrient combination with 3 replications. Results revealed that treatment general recommended dose of fertilizers - 120:60:40 kg N:P₂O₅:K₂O ha⁻¹ + 10 t ha⁻¹ of FYM recorded the highest plant height (99.2 cm), number of total tillers (101.4), ear length (9.16 cm), number of spikelet ear⁻¹ (16.4), number of grains ear⁻¹ (44.6), weight of grains ear⁻¹ (1.7 g), test weight (40.9 g), grain yield (41.4 q ha⁻¹) and straw yield (52.1 q ha⁻¹) which was significantly superior over other treatments but was at par with treatments 75% RDN through soil + foliar spray of urea @ 6% as well as 75% RDN through soil + foliar spray of urea @ 4%.

Keywords: Plant height, number of tillers, test weight, grain yield, straw yield, protein content, nano urea and urea

Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop belongs to family “Poaceae” and genus “Triticum”. It is the world's most important cereal crop, accounting for 30% of all cereal food produced globally. It occupies around 220.7 million hectares of area across the world with the annual production of 783.43 million tones with the productivity of 3.55 metric tons per hectare (USDA, 2023) [8]. It has been under cultivation in the Indian subcontinent from pre-historic times and is an integral part of country's economy and food security. Wheat accounts for almost 55% of all carbohydrates and 20% of all dietary calories consumed globally (Graur and Breiman, 1995) [2]. Wheat is grown in India on 31.23 million hectares and produces of 112.92 million t with national average productivity of 3615 kg ha⁻¹ during 2023-24 (IIWBR, Karnal, 2023-24) [4].

Nitrogen is the universal deficient macro nutrient in Indian soil (Dey and Sekhon 2016) [1]. Wheat is highly responsive to nitrogen fertilization and is sensitive to insufficient nitrogen. Macro nutrients like N, P and K in sufficient quantity throughout the growing season are essential for optimum plant growth (Haque *et al.*, 2001) [3]. Nitrogen is fundamental part of protein and it is an essential part of chlorophyll molecule which helps in food production process called photosynthesis. Thus, nitrogen supply determines amount of protein, chlorophyll, protoplasm which ultimately determine leaf area and cell size. Growth of plants takes place with optimum rate with adequate supply of nitrogen and leaves remains dark green. However, under nitrogen deficiency light green leaves are observed and it results in reduced tillering, low protein synthesis and thus reduce the growth and yield of crop.

Materials and Methods

The field experiment entitled “Response of foliar application of urea and nano urea on growth, yield and quality of wheat under irrigated condition” was conducted at Post Graduate Institute Farm, MPKV, Rahuri during *rabi* 2023-24. The experiment consists of 12 treatments *viz.*, T₁: Absolute control; T₂: General recommended dose of fertilizers (120:60:40 N:P₂O₅:K₂O Kg ha⁻¹ + 10 t ha⁻¹ of FYM); T₃: 75% RDN through soil + foliar spray of nano urea @ 0.2%; T₄: 75% RDN through soil + foliar spray of urea @ 2%; T₅: 75% RDN through soil + foliar spray of nano urea @ 0.4%; T₆: 75% RDN through soil + foliar spray of urea @ 4%; T₇: 75% RDN through soil + foliar spray of nano urea @ 0.6%; T₈: 75% RDN through soil + foliar spray of urea @ 6%; and T₉: 50% RDN through soil + foliar spray of nano urea @ 0.4%; T₁₀: 50% RDN through soil + foliar spray of urea @ 4%; T₁₁: 50% RDN through soil + foliar spray of nano urea @ 0.6%; T₁₂: 50% RDN through soil + foliar spray of urea @ 6%. Potassium and Phosphorus will be applied through MoP and single super phosphate; P₂O₅ and K₂O applied as per the recommended dose of fertilizer for wheat except T₁.

The experiment was laid out in randomized block design (RBD) with three replications. Line sowing of wheat seeds was done on flat beds at spacing of 20 cm between rows. The soil was clay loam in texture, low in available nitrogen (191.6 kg ha⁻¹),

medium in available phosphorus (18.3 kg ha⁻¹) and high in potassium (436.6 kg ha⁻¹). The mean available nitrogen, phosphorus and potassium content in soil after harvest of wheat crop were 210.5, 45.4 and 418.2 kg ha⁻¹ respectively. The soil was slightly alkaline in reaction (pH 8.16) with medium in organic carbon content (0.57%). The pH is measured by Potentiometry and electrical conductivity measured by Conductometry method. The organic carbon estimated by Wet oxidation method Walkey and Black. The available Nitrogen, Phosphorus and potassium measured by Alkaline permanganate method, Olsen method 0.5 M NaHCO₃ (pH 8.5) and Flame photometry method respectively.

The recommended dose of fertilizer (120:60:40 N:P₂O₅:K₂O kg ha⁻¹ + 10 t ha⁻¹ of FYM) was applied 60:40 kg ha⁻¹ P₂O₅:K₂O as a basal through SSP and MOP in treatment T₂ to T₁₂. N applied as per treatments. Thereafter, foliar application of urea and nano urea was done at 20 and 35 days after sowing, respectively.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Plant height (cm)

Table 1: Effect of foliar application of urea and nano urea on periodical plant height of wheat

Sr. No.	Treatment Detail	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At Harvest
T ₁	Absolute control	33.5	56.9	72.3	73.0
T ₂	General recommended dose of fertilizers (120:60:40 N: P ₂ O ₅ :K ₂ O Kg ha ⁻¹ + 10 t ha ⁻¹ of FYM)	36.8	79.1	98.5	99.2
T ₃	75% RDN through soil + foliar spray of nano urea @ 0.2%	35.3	71.2	82.1	82.9
T ₄	75% RDN through soil + foliar spray of urea @ 2%	35.5	72.1	86.5	87.1
T ₅	75% RDN through soil + foliar spray of nano urea @ 0.4%	35.4	71.7	85.4	86.3
T ₆	75% RDN through soil + foliar spray of urea @ 4%	35.8	75.9	92.2	93.6
T ₇	75% RDN through soil + foliar spray of nano urea @ 0.6%	35.8	72.9	87.7	89.0
T ₈	75% RDN through soil + foliar spray of urea @ 6%	35.9	77.5	94.1	95.5
T ₉	50% RDN through soil + foliar spray of nano urea @ 0.4%	34.3	60.9	75.3	76.9
T ₁₀	50% RDN through soil + foliar spray of urea @ 4%	34.6	64.0	79.1	80.3
T ₁₁	50% RDN through soil + foliar spray of nano urea @ 0.6%	34.3	61.4	76.8	77.6
T ₁₂	50% RDN through soil + foliar spray of urea @ 6%	34.7	68.6	80.3	81.2
	S.E. m ±	0.66	1.30	3.63	2.93
	C.D. at 5%	NS	3.82	10.65	8.60
	General mean	35.1	69.4	84.2	85.2

The data in respect of plant height of wheat as influenced by different treatments during *rabi* season of 2023-2024 are presented in table 1. The mean plant height at 30, 60, 90 days after sowing as well as at harvest were 35.1, 69.4, 84.2 and 85.2 cm respectively.

Among the applied treatments, general recommended dose of fertilizer (120:60:40 N:P₂O₅:K₂O kg ha⁻¹ + 10 t ha⁻¹ of FYM) recorded significantly higher plant height at 30 (36.8 cm), 60 (79.1 cm) and 90 days after sowing (98.5 cm) as well as at harvest (99.2 cm) as compare to other treatments (Table 1). The significantly lowest plant height at 30 (33.5 cm), 60 (56.9 cm), 90 days after sowing (72.3 cm) and at harvest (73.0 cm) was observed in treatment absolute control.

The significant increase in plant height of wheat upto harvest was most favorably due to increased availability of nitrogen through foliar application of urea and nano urea. The improved N catalyzes N metabolism thus resulted in accelerated growth

which reflected in increased plant height. Besides N also improves P and K efficiency. Nitrogen plays important role in photosynthesis, formation of amino acids, building blocks of protein, cell division and boosts the production of carbohydrates. Phosphorus is also involved in photosynthesis, respiration, cell division, cell enlargement and promotes early root formation and growth. Potassium is essential for carbohydrate metabolism, translocation of starch and protein synthesis. It increases photosynthesis, quality of seeds and disease resistance. So, the foliar application of balanced nutrients resulted in increase in height of wheat.

The current experiment's results are consistent with those published by Surve and Bhosale (2015)^[7], Wagan *et al.* (2017)^[10], Vikas *et al.* (2019)^[9], Yadav *et al.* (2021)^[11], Rawate *et al.* (2022)^[6] and Ojha *et al.* (2023)^[5].

Total Number of Tillers m⁻¹

Table 2: Effect of foliar application of urea and nano urea on periodical number of tillers of wheat

Sr. No.	Treatment Detail	Number of tiller (m ⁻¹ length)			
		30 DAS	60 DAS	90 DAS	At Harvest
T ₁	Absolute control	60.4	68.2	75.8	75.8
T ₂	General recommended dose of fertilizers (120:60:40 N: P ₂ O ₅ :K ₂ O Kg ha ⁻¹ + 10 t ha ⁻¹ of FYM)	65.2	91.9	101.4	101.4
T ₃	75% RDN through soil + foliar spray of nano urea @ 0.2%	63.3	78.7	85.5	85.5
T ₄	75% RDN through soil + foliar spray of urea @ 2%	63.9	81.5	91.7	91.7
T ₅	75% RDN through soil + foliar spray of nano urea @ 0.4%	63.6	80.0	87.2	87.2
T ₆	75% RDN through soil + foliar spray of urea @ 4%	64.4	86.5	98.1	98.1
T ₇	75% RDN through soil + foliar spray of nano urea @ 0.6%	64.1	83.5	93.3	93.3
T ₈	75% RDN through soil + foliar spray of urea @ 6%	64.9	87.5	99.7	99.7
T ₉	50% RDN through soil + foliar spray of nano urea @ 0.4%	61.9	70.8	77.9	77.9
T ₁₀	50% RDN through soil + foliar spray of urea @ 4%	62.2	74.3	80.9	80.9
T ₁₁	50% RDN through soil + foliar spray of nano urea @ 0.6%	62.0	72.6	78.3	78.3
T ₁₂	50% RDN through soil + foliar spray of urea @ 6%	62.8	76.4	83.0	83.0
	S.E. m ±	0.96	2.16	2.51	2.51
	C.D. at 5%	NS	7.68	7.38	7.38
	General mean	63.2	79.3	87.7	87.7

The data in respect of total number of tillers of wheat as influenced by different treatments during *rabi* season of 2023-2024 are presented in table 2. The mean total number of tillers at 60, 90 DAS and at harvest (79.3 cm, 87.7 and 87.7 m⁻¹, respectively) of wheat were obtained during investigation.

Among all the treatments, at 60, 90 DAS and at harvest, wheat crop applied with treatment general recommended dose of fertilizers (120:60:40 kg N: P₂O₅:K₂O ha⁻¹ + 10 t ha⁻¹ of FYM) at 60 DAS, 90 DAS and at harvest showed significantly maximum total number of tiller (91.9, 101.4 and 101.4 respectively) at 60, 90 DAS and at harvest respectively. However, the treatment absolute control produced significantly minimum total number of tillers (68.2, 75.8 and 75.8,

respectively) at 60, 90 DAS and at harvest respectively.

The highest total number of tillers found in wheat crop might be due to addition of general recommended dose of fertilizers and their uptake by wheat crop. It results in increased availability of all nutrients to plants and enhanced meristematic activity, cell division, enlargement and elongation of cells resulting in higher plant height and total number of tillers. These results are similar with the results reported by Vikas *et al.* (2019)^[9], Yadav *et al.* (2021)^[11], Surve and Bhosale (2015)^[7], Wagan *et al.* (2017)^[10], Rawate *et al.* (2022)^[6] and Ojha *et al.* (2023)^[5].

Yield Attributing Characters

Table 3: Effect of foliar application of urea and nano urea on yield contributing characters of wheat

Sr. No.	Treatment Detail	Length of ear (cm)	Number of spikelet ear ⁻¹	Number of grains ear ⁻¹	Weight of grains ear ⁻¹ (g)	Test weight g (1000 seed)
T ₁	Absolute control	6.9	11.7	32.8	1.23	36.7
T ₂	General recommended dose of fertilizers (120:60:40 N: P ₂ O ₅ : K ₂ O Kg ha ⁻¹ + 10 t ha ⁻¹ of FYM)	9.2	16.4	44.6	1.66	40.9
T ₃	75% RDN through soil + foliar spray of nano urea @ 0.2%	7.5	13.7	36.8	1.42	38.2
T ₄	75% RDN through soil + foliar spray of urea @ 2%	7.9	14.3	39.7	1.48	39.5
T ₅	75% RDN through soil + foliar spray of nano urea @ 0.4%	7.7	14.0	37.0	1.45	38.8
T ₆	75% RDN through soil + foliar spray of urea @ 4%	8.5	15.0	42.0	1.58	40.4
T ₇	75% RDN through soil + foliar spray of nano urea @ 0.6%	8.1	14.8	41.1	1.50	39.8
T ₈	75% RDN through soil + foliar spray of urea @ 6%	8.8	15.1	43.0	1.61	40.6
T ₉	50% RDN through soil + foliar spray of nano urea @ 0.4%	7.1	12.2	34.1	1.28	37.7
T ₁₀	50% RDN through soil + foliar spray of urea @ 4%	7.3	12.8	35.9	1.36	38.1
T ₁₁	50% RDN through soil + foliar spray of nano urea @ 0.6%	7.2	12.4	34.8	1.33	36.9
T ₁₂	50% RDN through soil + foliar spray of urea @ 6%	7.5	13.1	36.1	1.40	38.2
	S.Em ±	0.3	0.5	1.3	0.05	1.8
	C.D. at 5%	0.9	1.5	2.6	0.15	NS
	General mean	7.8	13.8	38.1	1.44	38.8

The data in respect of length of ear, number of spikelet ear⁻¹, number of grains ear⁻¹, weight of grains ear⁻¹ and test weight of wheat as influenced by different treatments during *rabi* season of 2023-2024 are presented in table 3. The mean length of ear, number of spikelet ear⁻¹, number of grains ear⁻¹, weight of grains ear⁻¹ and test weight were (7.8 cm, 13.8, 38.1, 1.44 g and 38.8 g, respectively) of wheat were obtained during investigation.

The wheat crop applied with general recommended dose of fertilizers (120:60:40 kg N: P₂O₅:K₂O ha⁻¹ + 10 t ha⁻¹ of FYM) produced significantly higher length of ear, number of spikelet ear⁻¹, number of grains ear⁻¹, weight of grains ear⁻¹ and test

weight of wheat (9.2 cm, 16.4, 44.6, 1.66 g and 40.9 g, respectively) as compared to rest of the nutrient management treatments. Whereas the minimum length of ear, number of spikelet ear⁻¹, number of grains ear⁻¹, weight of grains ear⁻¹ and test weight of wheat (6.9 cm, 11.7, 32.8, 1.23 g and 36.7 g, respectively) were recorded in the treatment absolute control, where no fertilizers were applied during the experimentation. These results are in collaboration with findings of Wagan *et al.* (2017)^[10], Vikas *et al.* (2019)^[9], Yadav *et al.* (2021)^[11], Rawate *et al.* (2022)^[6] and Ojha *et al.* (2023)^[5].

Yield Studies (q ha⁻¹)**Table 4:** Effect of foliar application of urea and nano urea on grain, straw, biological yield and harvest index of wheat

Sr. No.	Treatments	Yield (q ha ⁻¹)			Harvest index (%)	Yield increase over control (%)
		Grain yield	Straw yield	Biological yield		
T ₁	Absolute control	21.3	37.1	58.4	36.5	-
T ₂	General recommended dose of fertilizers (120:60:40 N: P ₂ O ₅ :K ₂ O Kg ha ⁻¹ + 10 t ha ⁻¹ of FYM)	41.4	52.1	93.5	44.3	94.2
T ₃	75% RDN through soil + foliar spray of nano urea @ 0.2%	34.8	43.1	77.9	44.7	63.1
T ₄	75% RDN through soil + foliar spray of urea @ 2%	37.8	46.4	84.2	45.0	77.2
T ₅	75% RDN through soil + foliar spray of nano urea @ 0.4%	35.8	44.2	80.0	44.7	67.7
T ₆	75% RDN through soil + foliar spray of urea @ 4%	40.2	48.6	88.8	45.3	88.7
T ₇	75% RDN through soil + foliar spray of nano urea @ 0.6%	38.9	47.7	86.5	44.9	82.2
T ₈	75% RDN through soil + foliar spray of urea @ 6%	40.9	50.7	91.6	44.7	91.9
T ₉	50% RDN through soil + foliar spray of nano urea @ 0.4%	27.7	40.1	67.8	40.9	30.0
T ₁₀	50% RDN through soil + foliar spray of urea @ 4%	31.9	42.1	74.0	43.1	49.5
T ₁₁	50% RDN through soil + foliar spray of nano urea @ 0.6%	29.3	41.7	71.1	41.3	37.5
T ₁₂	50% RDN through soil + foliar spray of urea @ 6%	32.7	42.8	75.4	43.3	53.1
	S.Em ±	0.8	1.2	2.2	-	-
	C.D. at 5%	2.3	3.6	6.4	-	-
	General mean	34.4	44.7	79.1	43.2	-

The data in respect of grain, straw and biological yield of wheat as influenced by different treatments during *rabi* season of 2023-2024 are presented in table 4. The mean grain, straw and biological yield of wheat (34.4, 44.7 and 79.1 q ha⁻¹, respectively) were obtained during investigation.

The application of treatment general recommended dose of fertilizers (120:60:40 N: P₂O₅: K₂O kg ha⁻¹ + 10 t ha⁻¹ of FYM) produced significantly the highest grain, straw and biological yield (41.4, 52.1 and 93.5 q ha⁻¹, respectively) of wheat among all treatments. The significantly lowest grain, straw and biological yield in wheat (21.3, 37.1 and 58.4 q ha⁻¹, respectively) was obtained with the application of treatment absolute control.

This significant difference in grain, straw and biological yield of

wheat may be due to involvement of sprayed nutrient i.e. nitrogen in chlorophyll synthesis, enzyme activity, stomata regulation, starch translocation and assimilation into grains. It may result in increasing number and weight of wheat grains as well as physiological performance of wheat. Rapid and efficient response is given by the nutrients applied through general recommended dose of fertilizers. There was cumulative effect in the more accumulation of photosynthates and its translocation from sink to reproductive part like grain of wheat. These results are similar with the results reported by Wagan *et al.* (2017)^[10], Vikas *et al.* (2019)^[9], Yadav *et al.* (2021)^[11], Rawate *et al.* (2022)^[6] and Ojha *et al.* (2023)^[5].

Protein Yield (kg ha⁻¹)**Table 5:** Effect of foliar application of urea and nano urea on protein content of wheat

Tr. No.	Treatments	Protein content (%)	Protein yield (kg ha ⁻¹)
T ₁	Absolute control	10.34	220.56
T ₂	General recommended dose of fertilizers (120:60:40 N: P ₂ O ₅ :K ₂ O Kg ha ⁻¹ + 10 t ha ⁻¹ of FYM)	10.79	446.52
T ₃	75% RDN through soil + foliar spray of nano urea @ 0.2%	10.58	367.64
T ₄	75% RDN through soil + foliar spray of urea @ 2%	10.65	403.20
T ₅	75% RDN through soil + foliar spray of nano urea @ 0.4%	10.61	378.79
T ₆	75% RDN through soil + foliar spray of urea @ 4%	10.72	431.59
T ₇	75% RDN through soil + foliar spray of nano urea @ 0.6%	10.69	415.25
T ₈	75% RDN through soil + foliar spray of urea @ 6%	10.75	441.04
T ₉	50% RDN through soil + foliar spray of nano urea @ 0.4%	10.42	288.85
T ₁₀	50% RDN through soil + foliar spray of urea @ 4%	10.52	334.24
T ₁₁	50% RDN through soil + foliar spray of nano urea @ 0.6%	10.48	308.20
T ₁₂	50% RDN through soil + foliar spray of urea @ 6%	10.55	345.60
	S.E. m ±	0.26	6.10
	C.D. at 5%	NS	17.91
	General mean	10.59	365.12

The data in respect of protein content of wheat as influenced by different treatments during *rabi* season of 2023-2024 are presented in table 5. The mean protein yield of wheat was 365.12 kg ha⁻¹ (79.3 cm, 87.7 and 87.7 m⁻¹, respectively) during investigation. The data in respect protein yield in wheat were influenced significantly due to different nutrient management treatments.

The wheat fertilized with general recommended dose of

fertilizers (120:60:40 N: P₂O₅:K₂O kg ha⁻¹ + 10 t ha⁻¹ of FYM) produced significantly maximum protein yield (446.5 kg ha⁻¹) as compared to rest of the nutrient management treatments during investigation. While the minimum protein yield ha⁻¹ (220.56 kg ha⁻¹) was observed in the treatment absolute control. These results are in collaboration with findings of Wagan *et al.* (2017)^[10], Vikas *et al.* (2019)^[9], Yadav *et al.* (2021)^[11], Rawate *et al.* (2022)^[6] and Ojha *et al.* (2023)^[5].

Conclusion

The application of application of general recommended dose of fertilizers (120:60:40 N: P₂O₅: K₂O kg ha⁻¹ + 10 t ha⁻¹ of FYM) to wheat found beneficial for increase in yield attributing characters, uptake of nutrients, yield and monetary returns of wheat grown in medium deep soil. However, the treatments of 75% RDN through soil and foliar spray of urea @ 4% and 6% at crown root initiation (CRI) and tillering stage were at par with treatment general recommended dose of fertilizers which showed saving of 25% N to wheat crop.

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Conflict of Interest

The authors declare there are no conflict of interest relevant to this article.

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