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RD Raut
M. Sc. Scholar, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

ST Shirale
Assistant Professor, AICRP on IFS, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

PH Vaidya
Professor and Head, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

SV Chikshe
Assistant Professor, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

RS Kuthumbare
M. Sc. Scholar, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

PS Aundhkar
M. Sc. Scholar, Department of Animal Husbandry and Dairy Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

SG Pawar
M. Sc. Scholar, Dept of agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
RD Raut
M. Sc. Scholar, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Effect of foliar application of nitrogenous fertilizers on growth attributes, soil properties, quality and productivity of wheat (*Triticum aestivum* L.)

RD Raut, ST Shirale, PH Vaidya, SV Chikshe, RS Kuthumbare, PS Aundhkar and SG Pawar

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Abstract
A field experiment was undertaken at AICRP on Integrated Farming System, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to assess the **"**Effect of foliar application of nitrogenous fertilizers on growth attributes, soil properties, quality and productivity of wheat (*Triticum aestivum* L.)" during *Rabi* season of 2023-2024. The experiment was conducted in randomized block design (RBD), replicated thrice with ten different treatment combinations were used in the experiment which includes T_1 – Absolute control, T_2 - RDF (120:60:60 kg NPK ha^{-1}), T_3 - 25% RDN + 100 % RDPK + Three foliar sprays of nano urea at 30, 45 and 60 DAS, T_4 - 50% RDN + 100 % RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS, T_5 - 75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS, T_6 - 25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS, T_7 - 50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS, T_8 - 75% RDF + One foliar spray of Nano Urea at 45 DAS, T_9 - Three foliar sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS and T_{10} - 100 % RDPK + Three foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS. The results emerged out indicated that plant height, number of tillers, leaf area, chlorophyll content, test weight, grain and straw yield also quality parameters such as protein and carbohydrate content of wheat was recorded highest with treatment of (75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS). Significantly higher value of soil available N, P and K were recorded after harvest in treatment receiving (75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS). The effect of foliar application of nitrogenous fertilizers on soil pH, EC, Organic Cardon and Calcium Carbonate and on DTPA extractable micronutrients in soil after harvest was found non-significant.

Keywords: Nitrogenous fertilizers**,** Nano urea, nitrate nitrogen, foliar spray, wheat

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 and it is a staple food for nearly 10 billion people in 43 nations. Plants need 17 nutrients for optimal growth and productivity; however, nitrogen(N) is the singularly most used nutrient. Nitrogen (N) is the nutrient that plants consume the most. Nitrogenous Fertilizers are essential for increasing food production in developing nations, particularly since high-yielding crop types that respond well to fertilizer have been introduced. but unfortunately, nitrogen that is applied by fertilizers is transformed by processes such volatilization, denitrification, and acidic and alkaline pH-dependent biological nitrogen fixation, humus mineralization, immobilization, and nitrification. Applying nitrogen through basal dose indiscriminately leads to soil and environmental contamination because a significant amount of the applied nitrogen can escape the soil-plant system and reach water bodies and the atmosphere. Because several potential channels for nitrogen loss connected with the administration of nitrogen to the soil are avoided, applying nitrogenous fertilizer to the leaves as a foliar spray is more efficient (Mosali *et al.*, 2006) [12]. In order to ensure food security through increased productivity and financial returns from using sustainable farming practices, foliar application of nitrogenous fertilizers can improve nutrient uptake and use efficiency, reduce losses from

leaching and gaseous emissions, and lower the risk of nutrient toxicity. Foliar application of nitrogen has more effects on yield and quality of wheat as it incurs minimum losses (Gosavi *et al*. (2017) [4]. Foliar nourishment of nitrogenous fertilizers guarantees the availability of nutrients to crops so that the higher yield can be obtained.

Materials and Methods

The present investigation was undertaken at AICRP on Integrated Farming System, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to assess the **"**Effect of foliar application of nitrogenous fertilizers on soil properties, quality and productivity of wheat (*Triticum aestivum* L.)" during *Rabi* season of 2023-2024. The experiment was conducted in randomized block design (RBD), replicated thrice with ten different treatment combinations were used in the experiment which includes T_1 – Absolute control, T_2 - RDF (120:60:60 kg NPK ha^{-1}), T_3 - 25% RDN + 100 % RDPK + Three foliar sprays of nano urea at 30, 45 and 60 DAS, T_4 - 50% RDN + 100 % RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS, T_5 - 75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS, T_6 - 25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS, T_7 - 50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS, T_8 - 75% RDF + One foliar spray of Nano Urea at 45 DAS, T_9 - Three foliar sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS and T_{10} - 100 % RDPK + Three foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS.

Biometric observations include plant height, number of tillers per hill, chlorophyll content, leaf area was recorded at different growth stages (30,60 and 90 DAS) of wheat. Plant height (cm) was measured with the help of meter scale from the base of the plant *i.e.*, from ground level to base of the terminal bud of main shoot. The total number of tillers per hill of observational plants were counted at 30, 60 and 90 DAS. The plant pigment total chlorophyll content (SPAD) in fresh wheat leaves is determined by electronic instrument called Pedometer which measures chlorophyll content with the help of radiation sensors. The leaf area (cm^2) was measured with the help of leaf area meter. The quality parameter such as protein content was calculated – (Nitrogen content in grain (%) was determined by micro Kjeldhal's method (AOAC, 1993) [2] which were multiplied by protein calculating factor 6.25 to get protein content value in grain) and the total carbohydrates were determined by difference according to AACC (2000) [1] method, with the following equation:

Total carbohydrate (%) = 100 – % (Moisture + Protein +Fat + Fiber + Ash)

Harvested bundles of wheat plants from each net plot were threshed and winnowed separately. After cleaning, the grain was dried plot wise and then the weight was recorded and consequently grain samples were taken from each plot to determine the moisture content with the help of moisture meter. Finally, the grain yield was calculated at 12 per cent moisture before being subjected to its statistical analysis. The net plot yield was then finally converted into kg/ha.

The plants were uprooted for dry matter study, excluding root system and were air dried under sunlight for eight days and subsequently dried in the oven at 64^0 C till they were completely dried. The final constant dry weight was recorded as total straw accumulation per plant and per hectare yield was calculated.

Soil samples were collected before sowing at harvest stage of crop at 0-20 cm depth from each treated plot. The sieved samples were stored in polythene bags with proper labelling for further analysis. Soil was air dried, ground with wooden mortar and pestle and sieved through 2 mm sieve. These soil samples are used to various chemical estimations as per the methods given below.

The chemical properties *viz.*, pH was determined in (1:2.5) soil water suspension using the digital pH meter described by Jackson (1973) [5]. Electrical conductivity was determined in (1:2.5) soil water suspension by using the conductivity bridge meter described by Jackson (1973) [5]. Organic carbon was determined by using the method described by Walkley and Black (1934) [20]. Calcium carbonate was determined by rapid titration method as suggested by (Jackson, 1973) [5]. Available N was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956) [18]. Available phosphorus was extracted from the soil with 0.5 M sodium bicarbonate (pH 8.5) as an extractant and measured with colorimeter by using 420 nm wave length as described by Olsen *et al.* (1954) [13]. Available potassium was determined by using neutral normal ammonium acetate as an extractant and was measured on flame photometer (Piper, 1966) [14]. The Fe, Mn, Zn, and Cu were determined by using DTPA extract as described by Lindsay and Norvell (1978) [11].

Results and Discussion

Growth attributes characters

Growth attributing characters *viz*., plant height, number of tillers per hill, leaf area and chlorophyll content were noted maximum under in treatment T_5 (75% RDN + 100% RDPK+ one foliar spray of Nano Urea at 45 DAS) over all other treatments except T_4, T_2, T_3 which were found at par with treatment T_5. Whereas the Lowest plant height, number of tillers hill per hill, leaf area and chlorophyll content were noted in treatment T_1 (absolute control). Similar results were found by (Sambita 2023) [16], (Kumar *et al.*, 2023) [8], (Upadhyay *et al.*, 2023) [19].

Yield attributes and quality parameters

The yield attributing characters and quality parameters of wheat such as number of grains per spike, test weight, protein and carbohydrate content was noted maximum under in treatment T_5 (75% RDN + 100% RDPK+1 foliar spray of Nano Urea at 45 DAS) over all other treatments except T_2, T_4, T_3 and T_8 which were found at par with treatment T_5. Similar results were also recorded by (Singh *et al*., 2023) [17], (Kannoj *et al*., 2022) [6] and (Farooqi *et al*., 2019) [3].

Grain yield and straw yield

The Grain yield and straw yield was influenced by the foliar spray of nitrogenous fertilizer's application treatments The highest grain yield (3135.76 kg ha^{-1}) and straw yield (4286.36 kg ha^{-1}) was found under treatment T_5 (75% RDN + 100% RDPK+ one foliar spray of Nano Urea at 45 DAS) over all other treatments except T_2, T_3, T_4 and T_8 which were found at par with treatment T_5. The lowest grain and straw yield were recorded in T_1 (absolute control). Similar result was also reported by (Khaled *et al.*, 2021) [7].

Table 1: Effect of foliar application of nitrogenous fertilizers on growth attributing characters of wheat.

Tr. No.	Treatments detail	Plant height (cm) at 90 DAS	Number of tillers hill^{-1} at 90 DAS	Leaf area (cm^2) at 90 DAS	Chlorophyll content at 90 DAS (SPAD)
T_1	Control (without fertilizers)	51.30	4.50	1954.33	15.83
T_2	RDF (120:60:60 NPK kg ha^{-1})	62.78	7.00	2640.00	20.10
T_3	25% RDN + 100 % RDPK + Three Foliar sprays of nano urea at 30, 45 and 60 DAS.	58.09	6.60	2610.50	21.07
T_4	50% RDN +100% RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS	60.13	6.90	2630.20	23.07
T_5	75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS	64.41	7.60	2780.00	21.27
T_6	25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS	57.32	6.20	2270.00	20.87
T_7	50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS	54.25	6.10	2180.00	21.00
T_8	75% RDF + One foliar spray of Nano Urea at 45 DAS	56.76	6.30	2260.30	22.17
T_9	Three foliar sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS	53.42	5.20	1960.00	16.27
T_{10}	100 % RDPK + Three Foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS	55.03	6.30	2284.50	19.97
	SE (±)	2.17	0.41	150.56	0.54
	CD at 5%	6.45	1.22	447.35	1.61
	CV	6.56	11.35	11.06	4.65
	GM	57.35	6.27	2340.48	20.16

Table 2: Effect of foliar application of nitrogenous fertilizers on Yield attributes and quality parameters of wheat.

Tr. No.	Treatments detail	Grain spike^{-1}	Test weight (g)	Protein (%)	Carbo-hydrate (%)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Control (without fertilizers)	32.00	44.22	11.13	69.45	2026.31	2873.21
T_2	RDF (120:60:60 NPK kg ha^{-1})	43.20	45.69	12.21	70.32	3081.44	4164.55
T_3	25% RDN + 100 % RDPK + Three Foliar sprays of nano urea at 30, 45 and 60 DAS.	41.70	45.06	12.31	69.98	2844.81	3926.94
T_4	50% RDN +100% RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS	42.24	44.52	12.65	71.24	2909.02	4020.86
T_5	75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS	45.50	46.14	12.83	71.40	3135.76	4286.36
T_6	25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS	38.45	44.33	11.42	70.08	2596.67	3529.58
T_7	50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS	39.37	45.67	11.73	70.66	2618.07	3762.91
T_8	75% RDF + One foliar spray of Nano Urea at 45 DAS	40.20	45.34	12.38	71.05	2824.80	3919.37
T_9	Three foliar sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS	34.00	46.02	11.27	69.72	2301.20	3081.44
T_{10}	100 % RDPK + Three Foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS	36.65	45.40	12.10	70.66	2427.95	3368.27
	SE (±)	2.00	1.44	0.16	0.20	110.83	138.58
	CD at 5 %	5.93	NS	0.49	0.60	329.30	411.75
	CV	8.79	5.51	2.37	0.50	7.17	6.50
	GM	39.33	45.24	11.99	70.40	2654.72	3665.24

2. Chemical properties

2.1 Effect of foliar application of Nitrogenous fertilizers on physico- chemical properties of soil after harvest of wheat

The data about soil pH, EC, Organic Cardon and Calcium Carbonate was influenced by the foliar application of nitrogenous fertilizers to wheat are presented in Table 2.1. However, results of foliar application of nitrogenous fertilizers on soil pH, EC, Organic Carbon and Calcium Carbonate was found statistically non-significant. These results are agreements with (Kumar *et al.*, 2021) [10] application of Nano fertilizer did not change the electrical conductivity, pH, organic carbon and calcium carbonate.

2.2 Effect of foliar application of Nitrogenous fertilizers on nutrient availability in soil after harvest of wheat

The effect of foliar application of nitrogenous fertilizers was found significant on the available nitrogen, Phosphorous and potassium status of soil after harvest of wheat. The initially available nitrogen, phosphorous and potassium content in the soil was (159.23 kg ha^{-1}), (14.13 kg ha^{-1}), and (504.30 kg ha^{-1}) respectively. The maximum nitrogen (165.77 kg ha^{-1}), phosphorous (15.40 kg ha^{-1}) and potassium (521.33 kg ha^{-1}) availability was recorded with T_5 (75% RDN + 100% RDPK+ one foliar spray of Nano Urea at 45 DAS) over the all-other treatments. But, treatment T_2, T_4, which were found at par with treatment T_5. Lowest value of available nitrogen, phosphorous and potassium content in soil after harvest was recorded in T_1 (absolute control). The results were also similar with the finding of (Sambita 2023) [16] in case of available nitrogen, (Kumar *et al.*, 2024) [9] in case of available phosphorous and (Rathore *et al.*, 2022) [15] in case of available potassium in soil.

Table 3: Effect of foliar application of Nitrogenous fertilizers on physico- chemical properties of soil after harvest of wheat

Tr. No.	Treatments detail	Soil Properties			
		pH	EC (dsm^{-1})	OC (%)	$CaCO_3$ (%)
T_1	Control (without fertilizers)	7.68	0.18	0.34	4.46
T_2	RDF (120:60:60 NPK kg ha^{-1})	7.73	0.17	0.37	4.65
T_3	25% RDN + 100 % RDPK + Three foliar sprays of nano urea at 30, 45 and 60 DAS.	7.78	0.18	0.35	4.49
T_4	50% RDN +100% RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS	7.75	0.17	0.36	4.50
T_5	75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS	7.71	0.19	0.38	4.65
T_6	25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS	7.74	0.18	0.36	4.47
T_7	50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS	7.67	0.18	0.35	4.50
T_8	75% RDF + One foliar spray of Nano Urea at 45 DAS	7.70	0.19	0.36	4.50
T_9	Three sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS	7.79	0.17	0.37	4.58
T_{10}	100 % RDPK + Three Foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS	7.75	0.18	0.35	4.48
	SE (±)	0.120	0.010	0.010	0.080
	CD at 5 %	NS	NS	NS	NS
	CV	2.70	7.13	3.96	3.00
	GM	7.73	0.18	0.36	4.53
	Initial	7.74	0.19	0.37	4.54

Table 3: Effect of foliar application of Nitrogenous fertilizers on major nutrients availability in soil after harvest of wheat (kg ha^{-1})

Tr. No.	Treatments detail	Available nitrogen	Available phosphorus	Available potassium
T_1	Control (without fertilizers)	147.00	12.04	495.07
T_2	RDF (120:60:60 NPK kg ha^{-1})	167.56	15.11	516.55
T_3	25% RDN + 100 % RDPK + Three Foliar sprays of nano urea at 30, 45 and 60 DAS.	154.33	14.30	511.00
T_4	50% RDN +100% RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS	160.07	14.94	514.33
T_5	75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS	165.77	15.40	521.33
T_6	25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS	152.00	12.88	504.16
T_7	50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS	161.67	13.10	509.38
T_8	75% RDF + One foliar spray of Nano Urea at 45 DAS	163.96	13.50	513.33
T_9	Three sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS	148.61	12.10	504.00
T_{10}	100 % RDPK + Three Foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS	154.67	14.50	518.67
	SE (±)	3.81	0.34	7.56
	CD at 5%	11.31	1.01	22.46
	CV	4.18	4.28	2.56
	GM	157.56	13.79	511.53
	Initial	159.23	14.13	504.30

The effect of foliar application of nitrogenous fertilizers on DTPA extractable Fe, Mn, Zn and copper in soil after harvest of wheat was slightly influence by foliar application of nitrogenous fertilizers but, the effect of foliar application of nitrogenous fertilizers on DTPA extractable Fe, Mn, Zn and copper in soil after harvest of wheat was found non- significant.

Table 4: Effect of foliar application of Nitrogenous fertilizers on DTPA extractable micronutrients in soil after harvest of wheat (mg kg^{-1})

Tr. No.	Treatments detail	DTPA Extractable Micro Nutrients (mg kg^{-1})			
		Fe	Mn	Zn	Cu
T_1	Control (without fertilizers)	4.97	12.37	0.48	2.24
T_2	RDF (120:60:60 NPK kg ha^{-1})	5.48	13.63	0.59	2.26
T_3	25% RDN + 100 % RDPK + Three Foliar sprays of nano urea at 30, 45 and 60 DAS.	5.55	12.96	0.59	2.32
T_4	50% RDN +100% RDPK + Two foliar sprays of Nano Urea at 45 and 60 DAS	5.80	13.86	0.54	2.38
T_5	75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS	5.86	13.30	0.63	2.33
T_6	25% RDF + Three foliar sprays of Nano Urea at 30, 45, and 60 DAS	5.59	13.13	0.59	2.37
T_7	50% RDF + Two foliar sprays of Nano Urea at 45 and 60 DAS	5.77	13.10	0.55	2.24
T_8	75% RDF + One foliar spray of Nano Urea at 45 DAS	6.11	13.49	0.50	2.25
T_9	Three sprays of 19:19:19 NPK liquid fertilizer at 30, 45 and 60 DAS	5.08	13.31	0.49	2.29
T_{10}	100 % RDPK + Three Foliar sprays of Nitrate Nitrogen at 30, 45 and 60 DAS	5.47	13.78	0.57	2.39
	SE (±)	0.23	0.40	0.01	0.05
	CD at 5%	NS	NS	NS	NS
	CV	5.47	5.24	3.26	4.13
	GM	5.57	13.29	0.55	2.31
	Initial	5.10	13.51	0.54	2.24

Conclusion

- The treatment with (75% RDF + one foliar spray of Nano Urea at 45 DAS) was shows better effect on all growth and yield attributing characters such as plant height, number of tillers, leaf area, chlorophyll content, number of grains per spike. Quality parameter like protein content and

carbohydrate content were also enhanced.

- Significant effect of foliar application of nitrogenous fertilizers along with application of variation in basal doses of RDF was better effect on grain yield and straw yield. The highest grain yield and straw yield was found under treatment T_5 (75% RDN + 100% RDPK+ one foliar spray of Nano Urea at 45 DAS) over all other treatments except T_2, T_3, T_4 and T_8 which were found at par with this treatment.
- The nutrient availability in soil was found to be significant by foliar application of nitrogenous fertilizers. The highest availability of nitrogen, phosphorous and potassium were noted in (75% RDN + 100 % RDPK + One foliar spray of Nano Urea at 45 DAS).
- Effect of foliar application of nitrogenous fertilizers on soil physio-chemical properties like pH, EC, organic carbon, calcium carbonate and DTPA extractable micronutrients in soil were found to be non-significant.

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