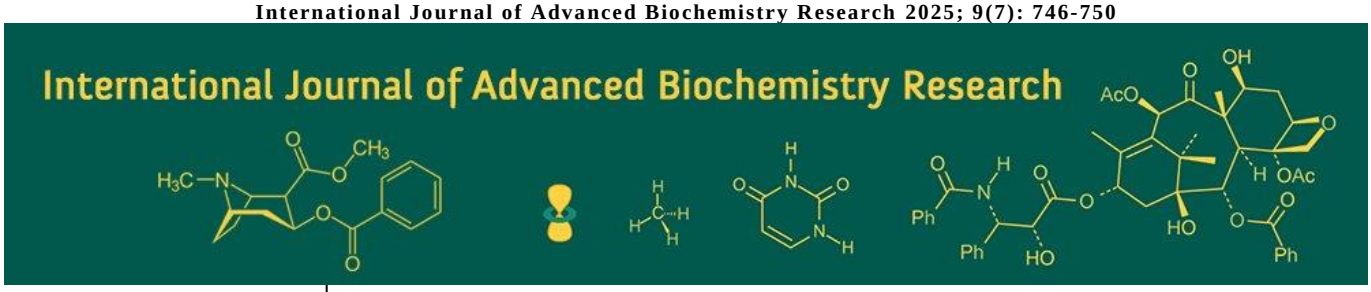

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Influence of the foliar application of integrated use of Nano urea and traditional fertilizers on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
The study was conducted during 2024-25 at the Agricultural Research Farm, Maharishi School of Science and Humanities, Lucknow, Uttar Pradesh, to evaluate the impact of Nano urea and different levels of recommended dose of fertilizers (RDF) on wheat. Results revealed that the application of 100% RDF + 4 ml/L Nano urea (two sprays at jointing and panicle initiation stages) significantly improved growth, yield attributes, and grain yield compared to other treatments. This treatment (T_4) showed the highest initial and final plant population, 1000 grain weight, grains per spike, and grain yield (q/ha), followed by 100% RDF + 4 ml/L Nano urea (one spray at panicle initiation), and 75% RDF + 4 ml/L Nano urea (three sprays at CRI, jointing, and panicle initiation). The control group consistently recorded the lowest values across all parameters. The findings indicate that Nano urea, when applied with full RDF at critical growth stages, enhances wheat performance significantly in terms of both growth and productivity.

Keywords: Growth stages, nutrient management, RDF

1. Introduction
Wheat (*Triticum aestivum* L.) is a member of the genus *Triticum* and the family Poaceae. This cereal crop is long-day, self-pollinating, and annual. As the primary staple food grain crop, it is a special gift from God to humanity. It is farmed on 215.9 million hectares of land in a variety of environments and produces 765.8 million metric tonnes year worldwide (FAO, 2020) [22]. Following rice as the most significant cereal crop in India, wheat comes in second. Abou T49% of food grain production is derived from winter cereals. 107.86 million Tonnes were produced on 31.45 million hectares of land in India, with a productivity of 3.42 tonnes per hectare (Pocket Book of Agricultural Statistics, 2020) [5]. Nano urea provides a more efficient method of delivering nitrogen to wheat plants. Since nitrogen is a key nutrient for wheat growth, its efficient uptake helps increase the crop's yield without excessive fertilizer application. Traditional urea tends to degrade and leach into the soil, contributing to environmental pollution. In contrast, nano urea has been shown to reduce the risk of nutrient runoff and leaching, thus improving soil health over time. Trials have shown that nano urea application in wheat crops can lead to higher yields and better-quality grains. The controlled release of nutrients ensures that plants receive a steady supply of nitrogen, which supports more robust growth and a stronger, healthier crop. (Yadav *et al*., 2025) [20] One of the major benefits of nano urea is its ability to reduce the total amount of fertilizer needed, which can significantly lower input costs for farmers in central Uttar Pradesh. By applying a smaller quantity of nano urea, farmers can achieve similar or even better results than with traditional urea. Reduced use of chemical fertilizers and improved nutrient uptake can lead to a decrease in soil degradation, reduced greenhouse gas emissions, and minimized water pollution. This aligns with the broader goal of sustainable agricultural practices in India. Despite the higher initial cost of nano urea, its ability to reduce the overall amount of fertilizer needed can make it a cost-effective solution for farmers in the long run, especially when considering the environmental savings and potential yield improvements. (Kumar *et al*., 2025) [20]

2. Materials and Methods

A field experiment was conducted at the agricultural research farm, Maharishi school of science and humanities, Lucknow; in *rabi* season of the year 2024-25 entitled "Evaluation of Foliar Application of Nano Urea on Growth and Yield of Wheat (*Triticum aestivum* L.)." The details of the materials used and the methods followed in the investigation are described in this chapter. The investigation was conducted at Maharishi school of science and humanities, Lucknow (U.P.) during the year 2024-25. The location of Lucknow is in the state of Uttar Pradesh in India. Situated on the northern Gangetic plains of India, Lucknow is the capital city of Uttar Pradesh. The geographical location of Lucknow is between 26.50° North and 80.50° East. Lucknow is located at an elevation of 123 meters above sea level. Lucknow has a warm humid subtropical climate with cool, dry winters from December to February and dry, hot summers from April to June. The rainy season is from mid-June to mid-September, when Lucknow gets an average rainfall of 1010 mm (40 in) mostly from the south-west monsoon winds. In winter the maximum temperature is around 25° Celsius and the minimum is in the 6° to 8° Celsius range. Fog is quite common from late December to late January. Summers are very hot with temperatures rising to the 40° to 45° Celsius range. The data related to weekly minimum and maximum temperature, relative humidity, rainfall (mm) and wind velocity (Km/hr) were recorded. In this experiment the observations *viz. initial* plant population ($m^{2)}$, final plant population ($m^{2)}$, Plant height at 30, 60,90 (DAS) and at harvest, Numbers of tiller per running meter at 30, 60, 90 (DAS), Numbers of effective tiller per running meter, Days to 50% flowering, No. of effective tiller per running meter, Spike length (cm) per plant, No. of Grains/spike,1000 seed weight (g), Grain yield (q/ha), Straw yield (q/ha), Biological yield (q/ha) were recorded.

3. Results and Discussion

3.1 Initial plant population

The application of different levels of RDF and Nano urea clearly had an impact on the initial plant population. The treatment application of 100% RDF + 4 ml/L Nano urea (2 spray at jointing stage and panicle initiation) was higher (52.67) than that of 75% RDF + 4 ml/L Nano urea (3spray at CRI stage, jointing stage, and panicle initiation), which was nearly equal to100% RDF + 4 ml/L Nano urea (1spray at panicle initiation). T_4 had the largest plant population, while control had the least initial plant population. The similar results have been also reported by Shamary and Ansari (2022) [23].

3.2 Final plant population

The data shows that applying different levels of RDF and Nano urea had a significant impacton the final plant population. The treatment application of 100% RDF + 4 ml/L Nano urea (2 spray at jointing stage and panicle initiation) had a higher final plant population (283.3), and it was nearly equal to 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation) at75% RDF + 4 ml/L Nano urea (3 spray at CRI stage, jointing stage, and panicle. The formation of the nano-urea environment factor may have contributed to the lowest final plant population seen in the control and the highest final plant population reported in T_4 Rawate *et al*. (2022) [24].

3.3 Plant height (cm)

The information on plant height at 30, 60, 90 days after sowing and at harvest is shown in the table is clear from the data that different levels of RDF and Nano urea had a significant impact on plant height (cm). The treatment application of 100% RDF + 4 ml/L Nano urea (2spray at jointing stage and panicle initiation) had a higher (23.47, 51.19, 91.65 and 103.29 respectively) recorded height than 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation), which was closely comparable to 75% RDF + 4 ml/L Nano urea (3spray at CRI stage, jointing stage, and panicle initiation). The control group had the lowest height population, while T_4 had the tallest plants. The similar results have been also reported by Neetam *et al*. (2020) [2].

3.4 No. of tillers per running meter

The information on the number of tillers per running meter at 30, 60, and 90 DAS and at harvest is shown in the table, the treatment application, 100% RDF + 4 ml/L Nano urea (2spray at jointing stage and panicle initiation) was closely comparable to 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation), and at 75% RDF + 4 ml/L Nano urea (3 spray at CRI stage, jointing stage, and panicle initiation), it was clear from the data that different levels of RDF and Nano urea had a significant impact on the number of tillers recorded. T_4 had the highest number of tillers (54.67, 279 and 271.67), while the control unit had the least number. The similar results have been also reported by Rathwa *et al*. (2018) [7].

3.5 No. of effective tillers per running meter

The data clearly shows that different levels of RDF and Nano urea had a significant impact on the number of effective tillers (278.33) recorded. The treatment application of100% RDF + 4 ml/L Nano urea (2spray at jointing stage and panicle initiation) was close to100% RDF + 4 ml/L Nano urea (1spray at panicle initiation), while 75% RDF + 4 ml/L Nano urea (3spray at CRI stage, jointing stage, and panicle initiation) was in close comparison. The control group had the least amount of effective tillers, while T_4 had the highest numbers (278.3).

3.6 Days to 50%flowering

The application of different levels of RDF and Nano urea clearly had a significant impact on the number of days to 50% flowering. The treatment application of100% RDF + 4 ml/L Nano urea (2spray at jointing stage and panicle initiation) was nearly identical to that of 100% RDF + 4 ml/L Nano urea (1spray at panicle initiation), while75% RDF + 4 ml/L Nano urea (3spray at CRI stage, jointing stage, and panicle initiation). Maximum days to 50% flowering were noted in T_4 (85 DAS), while minimum days to 50%flowering were noted in the control. The similar results have been also reported by Iqbal *et al*. (2012) [25].

3.7 Spike length

The spike length data shows that different levels of RDF and Nano urea had a significant impact on spike length. The treatment application of 100% RDF + 4 ml/L Nano urea (2 spray at jointing stage and panicle initiation) had a higher spike length (10.93 cm) than 75% RDF + 4 ml/L Nano urea (3 spray at CRI stage, jointing stage, and panicle initiation), which was nearly equal to 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation). Control showed a minimum

spike length, while T_4 showed the maximum spike length. The similar results have been also reported by Kannoj *et al*. (2022) [4].

3.8 No. of Grain per spike

The data shows that different levels of RDF and Nano urea had a significant impact on the number of grains per spike. The treatment application of 100% RDF + 4 ml/L Nano urea (2 spray at jointing stage and panicle initiation) had a higher number of grains per spike (61) than 75% RDF + 4 ml/L Nano urea (3spray at CRI stage, jointing stage, and panicle initiation), which was closely comparable to 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation). Control showed the least amount of grain each spike, while T_4 showed the most grain per spike. The similar results have been also reported by Gangwar *et al*. (2022) [26].

Table 1: Presents growth parameters (plant population, height, and tillers) for different treatments at various growth stages, with statistical analysis (SE and CD).

Growth parameters												
Sr. No.	Treatment	Combination	Initial plant population per running meter	Final plant population per running meter	Plant height(cm)				Number of tiller per running meter (cm)			Number of effective tiller per running meter
					30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	
1	T_1	Control	43.33	174	19.02	46.1	84.42	89.62	45	198	194	184
2	T_2	100% Conventional	45.67	231.33	19.92	48.32	86.86	93.91	47.33	219.33	210.67	201.33
3	T_3	100% Conventional+4ml/L Nano urea (1 spray at Panicle Initiation)	52	260.67	23.33	50.15	91.08	101.05	54.33	273.67	267.33	260.33
4	T_4	100% Conventional+4ml/L Nano urea (2 spray at Jointing Stage and Panicle Initiation)	52.67	283.33	23.47	51.19	91.65	103.29	54.67	279	271.67	267.67
5	T_5	75% Conventional+4ml/L Nano urea (2 spray at Jointing Stage and Panicle Initiation)	48.67	248	21.19	48.03	88.44	100.68	51.33	262.33	254.33	249.33
6	T_6	75% Conventional+4ml/L Nano urea (3 spray at CRI Stage, Jointing Stage and Panicle Initiation)	50	250.67	22.33	49.13	90.04	100.57	52	268.33	261.33	254.33
7	T_7	50% Conventional+8ml/L Nano urea (2 spray at Jointing Stage and Panicle Initiation)	47.67	241.33	20.35	48.5	89.3	99.64	48.67	247.67	240.67	236.33
8	T_8	50% Conventional+8ml/L Nano urea (3 spray at CRI Stage, Jointing Stage and Panicle Initiation)	47	237.67	20.62	48.11	90.31	100.21	50	252.67	247	240
SE m±			0.98	5.38	0.3665	0.3097	0.3312	0.4904	1.03	0.53	0.36	0.47
CD at 5%			2.86	15.67	1.0657	0.9007	0.9632	1.4259	3	1.56	1.05	1.39

Table 2: Summarizes yield attributes under different treatments, including flowering time, spike length, grain yield, and straw yield

Yield attributing parameters											
Sr. No.	Treatment	Combination	Days to 50% flowering	Length of spike (cm)	Number of grains per spike	Seed Index	Grain yield (kg/plot)	Grain yield (q/ha)	Straw yield (kg/plot)	Straw yield (q/ha)	Biological yield (kg/plot)
1	T_1	Control	75.67	6.73	39.33	38.18	0.74	12.37	0.63	11.14	1.47
2	T_2	100% Conventional	77.67	8.47	50	40.66	3.33	50.78	3.22	50.78	6.66
3	T_3	100% Conventional+4ml/L Nano urea (1 spray at Panicle Initiation)	84	10.3	58.67	42.4	4.01	63.52	4.35	66.69	8.4
4	T_4	100% Conventional+4ml/L Nano urea (2 spray at Jointing Stage and Panicle Initiation)	85	10.93	61.33	42.67	4.23	66.45	4.7	73.08	9.04
5	T_5	75% Conventional+4ml/L Nano urea (2 spray at Jointing Stage and Panicle Initiation)	81.33	9.7	55.33	41.78	3.74	57.77	3.86	60.65	7.73
6	T_6	75% Conventional+4ml/L Nano urea (3 spray at CRI Stage, Jointing Stage and Panicle Initiation)	83	10.13	57	41.92	3.88	60.68	4.35	66.75	8.29
7	T_7	50% Conventional+8ml/L Nano urea (2 spray at Jointing Stage and Panicle Initiation)	80	9.53	54	41.53	3.32	52.57	3.44	55.29	6.96
8	T_8	50% Conventional+8ml/L Nano urea (3 spray at CRI Stage, Jointing Stage and Panicle Initiation)	80.67	10.43	55.33	42.5	3.44	54.62	3.8	60.06	7.4
SE m±			0.45	0.18	0.43	0.35	0.0331	0.159	0.3854	0.1522	0.0315

3.9 1000 seed weight
In the treatment application, 100% RDF + 4 ml/L Nano urea (2 spray at jointing stage and panicle initiation) nearly equaled 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation), and at75% RDF + 4 ml/L Nano urea (3 spray at CRI stage, jointing stage, and panicle initiation), it is clear from the data that different levels of RDF and Nano urea had a significant impact on the1000 grain weight recorded higher. T_4 recorded its highest Seed Index, while the control group showed the minimum.

3.10 Grain yield (q/ha)
Results for grain yield (q/ha) shows that applying different levels of RDF and Nano urea had a significant impact on grain yield (66.45q/ha). The treatment application of 100% RDF + 4 ml/L Nano urea (2 spray at jointing stage and panicle initiation) recorded a higher grain yield (q/ha) than 75% RDF + 4 ml/L Nanourea (3spray at CRI stage, jointing stage, and panicle initiation), which was closely comparable to 100% RDF + 4 ml/L Nano urea (1spray at panicle initiation). The control had the lowest grain production, while T_4 had the highest grain yield. The similar results have been also reported by Sahu *et al*. (2022) [16].

3.11 Straw yield (q/ha)
The data clearly shows that applying different levels of RDF and Nano urea had a significant impact on straw yield (q/ha). The treatment application of 100% RDF + 4 ml/L Nano urea (2spray at jointing stage and panicle initiation) recorded a higher yield (73.08), which was comparable to100% RDF + 4 ml/L Nano urea (1spray at panicle initiation) at 75% RDF + 4 ml/L Nano urea (3spray at CRI stage, jointing stage, and panicle initiation). The control had a minimum straw yield, while T_4 had a maximum straw yield. The similar results have been also reported by Patidar *et al*. (2022) [4].

3.12 Biological yield (q/ha)
The information on biological yield (q/ha) shows that applying different levels of RDF and Nano urea had a significant impact on biological yield (q/ha). The treatment application of 100% RDF + 4 ml/L Nano urea (2spray at jointing stage and panicle initiation) recorded a higher biological yield (139.45 q/ha) than 75% RDF + 4 ml/L Nano urea (3 spray at CRI stage, jointing stage, and panicle initiation), which was closely comparable to 100% RDF + 4 ml/L Nano urea (1 spray at panicle initiation). The control had the lowest biological yield, while T_4 showed the highest biological yield. The similar results have been also reported by Choudhary *et al*. (2023) [27]

4. Conclusion
The study clearly demonstrates the beneficial impact of integrating Nano urea with varying levels of recommended dose of fertilizers (RDF) on wheat growth and productivity. Among all the treatments evaluated, the application of 100% RDF combined with two foliar sprays of Nano urea at the jointing and panicle initiation stages (T_4) significantly outperformed other treatments across all measured parameters. This treatment resulted in the highest initial and final plant populations, 1000-grain weight, grains per spike, and overall grain yield (q/ha), highlighting the importance of synchronizing nutrient application with critical crop growth stages. The superior performance of T_4 was followed by treatments involving either one or three Nano urea sprays in combination with full or reduced RDF, respectively. In contrast, the control group consistently showed the poorest results, underlining the essential role of nutrient supplementation in wheat cultivation. The findings suggest that Nano urea, when strategically applied along with a full dose of conventional fertilizers, can significantly boost wheat performance, making it a viable option for enhancing productivity and ensuring sustainable agricultural practices.

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