Assessing the Influence of Nano Urea on the Growthand Yield of Irrigated Wheat(*Triticum aestivum* L.)crop

Abstract

Wheat (*Triticum aestivum* L.) is one of the world's most essential cereal crops, serving as a staple food for a significant portion of the global population. In the pursuit of achieving higher yields in contemporary agriculture, the use of chemical fertilizers poses an increased environmental risk. However, the application of Nano urea offers a potential solution to mitigate this risk to a certain extent. To address this objective, a field experiment was conducted during the Rabi seasons of 2022-2023 at the A trial was executed in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh, during the Rabi season of 2022-23. The experimental design involved two main factors: Factor-1 Nitrogen (at 50%, 75%, and 100% levels) and Factor-2 Foliar Spray (at one time Nano urea andtwo time Nano urea, with 4 ml/l). A control group was included, and the experiment was laid out in a Randomized Block Design (RBD) with 13 treatments in three replications. The results indicated that the combination of 100% nitrogen along with a foliar spray of 4 ml/L Nano urea had a significant positive impact on growth, yield, and various yield parameters. Treatment 6 demonstrated the highest values for plant height (95.66 cm), Dry matter accumulation(1014.09 g m^{-2}), number of tillers m^{-2} (417.44), Leaf area index at 90 DAS (4.85), effective ear head per (m^{-2}) (282.66), grains per ear head (65.75), test weight (48.52 g), grain yield (46.15 quintals/ha), and straw yield (57.92 quintals/ha).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 in irrigated conditions.

Keywords:Growth, yield attributes and yield, wheat, Nano urea, foliar spray, RBD.

1. *Introduction*

Wheat marks its second cultivation cycle following maize; in the 2022-23 season, India's wheat production reached 110.55 million tonnes, securing the second position globally, trailing only behind China's production of 134.3 million tonnes (Anonymous 2023). Wheat is farmed across approximately 217 million hectares, yielding a remarkable output of 731 million tonnes. The largest wheat-growing regions include India (14%), Russia (12.43%), China (11.14%), and the USA (6.90%), collectively contributing to around 45% of the total global wheat cultivation area. Despite this, China emerges as the primary global wheat producer, achieving a record production of 136 million tonnes, followed by India (98.51 million tonnes), Russia (85 million tonnes), and the USA (47.35 million tonnes). Notably, traditional wheat-producing countries, such as China, India, Russia, the USA, Canada, Ukraine, and Pakistan, contribute approximately 58% of the total global wheat production, amounting to 449 million tonnes (USDA 2018). Wheat, boasting numerous advantages, underscores the importance of doubling its global crop yield by a significant margin by the year 2050 (Hunter et al. 2018). In India, where expanding crop acreage faces limitations and production threats and challenges are prevalent (Sharmaet al. 2013), a production target of 140 million tonnes has been set for the year 2050 (ICAR-IIWBR. Vision 2015)

Uttar Pradesh, India's wheat-producing state, has 9.85 million hectares dedicated to cultivation, contributing 35.50 million tonnes to the national output in 2020-21 (UPDES, 2022). Despite its largest land share at 35.1%, Uttar Pradesh's productivity remains the lowest at 2.7 tonnes/ha, making a significant contribution of 35.03% to national production. Challenges in wheat production include declining soil organic carbon, nutrient depletion, inconsistent fertilization, crop waste burning, and diminishing water table (Rizwana and Iyaqet, 2011). In recent times, the direct impact of climate change and global warming on crop yield and quality has become evident due to increased frequency and severity of various stresses. Wheat, rice, and maize, essential global staple crops providing a significant portion of daily calories and protein, are particularly susceptible (Kizilgeci et al., 2021). Environmental stressors, including salinity, can result in substantial production losses, accounting for approximately 50% (Acquaah, 2007). Moreover, the continuous growth in the global population poses a challenge to food security, as the world's food supply must increase by up to 70% by 2050 (FAO, 2009).

Nano urea, a modified form of traditional fertilizers based on nanotechnology, addresses challenges in traditional agriculture due to population growth, soil nutrient depletion, limited land resources, and climate change. Nano-fertilizers utilize nanotechnology's unique properties, such as reduced molecular size and modified interactions between molecules, to enhance bioavailability, bioactivity, and adherence effects. This innovative approach addresses the negative impacts of high doses of chemical fertilizers on soil ecosystems and contributes to environmental conservationdiscussed by Gutierrez et al. in 2011. These specialized fertilizers aim to address gaps in both traditional and innovative fertilizer markets. Nano-fertilizers, with their nano-sized particles, offer enhanced nutrient use efficiency and profitability. 40–70% Nitrogen loss through processes like nitrate leaching, de-nitrification, and ammonia volatilization is reduced with the use of Nano urea. (TrenkelME 2010 and Solanki et al. 2015). This is crucial in mitigating economic losses, environmental pollution, and the release of greenhouse gases contributing to global warming. Nano urea adheres to the 4R principles, promoting more photosynthesis, biomass production, and fulfilling crop nutrient requirements.

Lower transportation and application costs of nano urea are compared to conventional fertilizers, offering advantages such as reduced input requirements, slow release mechanism, and minimal salt accumulation in soil. These nano fertilizers enhance growth parameters, increase dry matter and chlorophyll production, and improve photosynthesis rate as discussed by Ali and Al-Juthery in 2017 and Singh et al. in 2017.Nano fertilizers regulate urea nutrient release in a suitable proportion, ensuring safety and productivity while maintaining environmental safety.Utilizing foliar applications technique, urea is effectively applied to plant leaves, enhancing nutrient absorption and yield, thereby boosting farmers' revenue. (Rahman et al., 2014). Nano urea also improves crop quality, nutritional content, and protein levels, reducing the need for chemical use(Gosavi et al., 2017). The liquid-based foliar application of Nano urea offers logistical and warehousing advantages, making it economically sound for farmers. Overall, nano urea emerges as a promising input in agriculture, aligning with the principles of sustainability and efficiency in the face of contemporary agricultural challengesCrista et al., 2012; Abdel-Aziz et al., 2016).

The utilization of nanotechnology in agriculture has emerged as a promising avenue for enhancing crop productivity and mitigating the environmental impact of traditional farming practices. In this context, the assessment of Nano Urea's influence on the growth, yield, and nitrogen use efficiency in irrigated wheat represents a crucial exploration at the intersection of technology and sustainable agriculture. The article's primary focus is to investigate the impact of foliar feeding with Nano-fertilizers SMP and tri, di combinations of N, P, and K, comparing them with a control group and traditional fertilizers, on various parameters of wheat growth and yield.

2. Materials and methods

A research was conducted in Research farm of the Faculty of agriculture & Allied industries in Rama University Kanpur, during the Rabi season of 2022-23. The experiment took place on silty loam soil with a pH of 7.65, electrical conductivity (EC) of 0.26 dSm-1, organic carbon content of 0.42%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 221.0, 19.7, and 147.30 kg ha-1, respectively. Uttar Pradesh. The study focused on the "Assessing the Influence of Nano Urea on the Growth, Yield, and Nitrogen Use Efficiency in Irrigated Wheat". Employing a Randomized Block Design (RBD), the experiment comprised ten treatments replicated thrice. With the wheat variety HD-2967. The crop was sown in first week of December. The treatments included various combinations of urea and Nano urea in foliarapplication: **T1:**100 % RDN (Recommended Doses of Nitrogen) + One foliar spray of Nano urea @ 4ml/ L, **T2**:100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L, **T3:**100 % RDN +One spray of urea @ 4%, **T4:**100 % RDN + Two spray of urea @ 4%, **T5:**75 % RDN + One foliar spray of Nano-urea @ 4ml/ L, **T6:**75 % RDN+ Two foliar spray of Nano urea @ 4ml/ L, **T7:**75 % RDN +One spray of urea @ 4%, **T8:**75 % RDN + Two spray of urea @ 4%, **T9**:50 % RDN + One foliar spray of Nano urea @ 4ml/ L, **T10**:50 % RDN+ Two foliar spray of Nano urea @ 4ml/ L, **T11**:50 % RDN +One spray of urea @ 4%, **T12**:50 % RDN + Two spray of urea @ 4%, **T13**:Control (120:60:40 Kg/ha). The recommended doses of phosphorus (60 kg/ha) and potassium (40 kg/ha) were applied during sowing using SSP and MOP, respectively. Nitrogen, applied as urea, was split into doses according to treatments throughout the crop period. Nano urea and foliar spray of urea were applied foliarly at 25 and 55 days after sowing. Sowing involved healthy seeds spaced at 20 cm from row to row. Cultural operations adhered to recommended practices. Observations were recorded from five random plants per treatment, focusing on various aspects of the crop, including growth, yield, and yield parameters.

3. Results and Discussion

3.1 Effect on Growth Parameters

3.1.1. Plant height (cm)

A noticeable rise in plant height was observed as the growth advanced, as indicated in (Table 1). The highest plant height (95.66 cm) was recorded in treatment **T2** (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) fallowed by **T4:**100 % RDN + Two spray of urea @ 4%, and **T1:**100 % RDN + One foliar spray of Nano urea @ 4ml/ L, as compare to other treatment in terms of statistical significance.

The application of 100% nitrogen resulted in increased plant height, emphasizing the crucial role of nitrogen as an essential nutrient effective for enhancing crop growth. Numerous prior studies have consistently demonstrated that nitrogen application contributes to increased crop height (Guo et al. 2019) This observation aligns with findings reported by Rawat et al. and Iqtidar et al., Ojha et al. 2023). The varying nitrogen levels significantly influenced plant height. The additional increase in plant height was attributed to the foliar spray of nano urea, which, as indicated by previous research, enhances Nitrogen Use Efficiency (NUE) by up to 45%, directly contributing to heightened plant stature. Importantly, the application of nano urea helps prevent nitrogen losses through processes like nitrate leaching, de-nitrification, and ammonia volatilization, ensuring direct availability to plants without losses.

3.1.2. No. of tillers (m^{-2})

The highest number of tillersm^{-2} (417.44) was observed in treatment **T2** (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment fallowed by **T4:**100 % RDN + Two spray of urea @ 4%, and. **T1:**100 % RDN + One foliar spray of Nano urea @ 4ml/l Demonstrated statistically comparable results to treatment T2.Tiller abundance is positively associated with leaf nitrogen accumulation. The application of Nano urea, known for its higher absorption rate and utilization efficacy, further enhanced the growth of tillers in this context similar results also found by Ojha et al. 2023 and Al-Juthery, et al. 2018.

3.1.3 Leaf area index (LAI)

The maximum number of Leaf area index at 90 DAS (4.85) was observed in treatment **T2** (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment fallowed by **T4:**100 % RDN + Two spray of urea @ 4%, and. **T1:**100 % RDN + One foliar spray of Nano urea @ 4ml/l Demonstrated statistically comparable results to treatment T2. Leaf area were increased by increasing in nitrogen content, biomass and photosynthetic rate is positively associated with leaf nitrogen accumulation. The application of Nano urea, known for its higher absorption rate and utilization efficacy, further enhanced the Leaf area indexin this context similar results also found by Al-Juthery, et al. 2018.

3.1.4 Dry matter accumulation (g m^{-2})

As the crop progressed in growth, there was a concurrent increase in the weight of plant dry matter, as depicted in (Table 1). A significant and maximum Dry matter accumulation(1014.09 g m^{-2}) was noted in treatment **T2** (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment fallowed by **T4:**100 % RDN + Two spray of urea @ 4%, and.exhibited statistically comparable results to treatment **T2.**

The impact of escalating nitrogen levels up to 100% was found to be significant in influencing plant dry weight. Nitrogen played a pivotal role in increasing the photosynthetic rate and expanding leaf area, leading to a higher accumulation of total dry matter. This finding aligns with similar observations reported by Ojha et al. 2023 and Al-Juthery, et al. 2018, Rahman et al. 2014. Nitrogen, being a critical element for plant growth, directly influences factors such as leaf area, leaf emergence rate, photosynthetic capacity, and radiation interception. The further increase in plant dry weight is attributed to the application of Nano urea.

3.1.5 Crop growth rate (g/day/plant)

As the crop progressed in growth, there was a concurrent increase in the Dry matter accumulationof with increases CGR, as depicted in (Table 1). A significant and maximum CGR (11.33 g/day/plant) was noted in treatment **T2** (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment fallowed by **T4:**100 % RDN + Two spray of urea @ 4%, and.exhibited statistically comparable results to treatment **T2.** The CGR is in line withdry matter accumulation. Ojha et al. 2023, Al-Juthery, et al. 2018 and Rahman et al. 2014**.**

3.2. Yield Attributes and Yields

3.2.1 Number of effective ear head per (m^{-2})

A noteworthy and highest count of effective ear head per (m^{-2}) (282.66) was noted (Table 2) in treatment T2 (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment fallowed by T4:100 % RDN + Two spray of urea @ 4%, and T1,T3 T13. exhibited statistically comparable results to treatment T2 similar observations reported by Al-Juthery, et al. 2018.

3.2.2 Number of grains per ear head

A substantial and increased count of grains per ear head(65.75) was noted in treatment ear headexhibited statistically equivalent results to treatment T2 (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment at par T4:100 % RDN + Two spray of urea @ 4%, and T1,and significantly superior over other treatments. Wheat grain exhibited a positive quadratic relationship with the nitrogen application rate. Our findings align with those reported in Ojha et al. 2023.

3.2.3 Test weight (g)

The results indicate that the maximum test weight (45.22) was observed in treatment 6 (100% nitrogen + foliar spray of 4ml/L Nano urea). Nevertheless, treatment T2 (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment at par T4:100 % RDN + Two spray of urea @ 4%, and T1 compare to the other treatments.

3.2.4 Spike length (cm)

The results indicate that the maximum Spike length (10.84 cm) was observed in treatment T2 (100% nitrogen + foliar spray of 4ml/L Nano urea). Nevertheless, treatment T2 (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment at par T4:100 % RDN + Two spray of urea @ 4%, and T1 compare to the other treatments.

3.2.5 Grain yield (kg ha^{-1})

A substantial and increased grain yield (46.15 quintals/ha) was observed in treatment T2 (100% nitrogen + foliar spray of 4ml/L Nano urea). Nevertheless, treatment T2 (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment at par T4:100 % RDN + Two spray of urea @ 4%, and T1 and significantly superior over rest treatments. Nitrogen was found to have a significant impact on grain yield. According to reports, the synergistic effect of nano-fertilizers enhances the efficacy of conventional fertilizers, leading to optimal nutrient absorption by plant cells, thereby promoting optimal growth and metabolic processes like photosynthesis. This, in turn, results in higher photosynthesis accumulation and translocation to the economic parts of the plant, contributing to a higher yield attributed to increased source (leaves) and sink (economic part) strength Ojha et al. 2023. The foliar application of nano-fertilizers has been reported to significantly increase crop yield. As mentioned earlier, Nano fertilizers may have influenced these processes through their nutrient transportation capabilities, facilitating the penetration and movement of a wide range of nutrients from root uptake to foliage penetration and movement within the plant. This finding aligns with similar observations reported by Ojha et al. 2023 and Al-Juthery, et al. 2018, Rahman et al. 2014.

3.2.6 Straw yield (kg ha^{-1})

The results indicated that a greater straw yield (57.92 quintals/ha) was observed in treatment T2 (100% nitrogen + foliar spray of 4ml/L Nano urea). Nevertheless, treatment T2 (100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L) Nevertheless, treatment at par T4:100 % RDN + Two spray of urea @ 4%, and T1. In contrast, the lowest straw yield was recorded in treatment T12 (50 % RDN + Two spray of urea @ 4%) Ojha et al. 2023.

4. Conclusion

In summary, the optimal fertilizer treatment for growth, yield, nutrient uptake, and fertilizer productivity was determined to be the foliar application of Nano fertilizer at a rate of 100% nitrogen + foliar spray of 4ml/L Nano urea In light of the aforementioned results, it can be concluded that treatment T2. Involving the application of 100% nitrogen along with a 100% nitrogen + foliar spray of 4ml/L Nano urea at 25 and 55 days after sowing, demonstrates positive effects on the growth parameters, yield, and yield attributes of wheat. It's important to note that these conclusions are based on a single season, and further trials may be necessary for additional confirmation. 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 in irrigated conditions.

Conference disclaimer:

Some part of this manuscript was previously presented in the conference: "International Conference on Emerging Trends in Agriculture & Allied Sector for Sustainable Developments" organized by Faculty of Agricultural Sciences & Allied Industries, Rama University, Kanpur Nagar, U.P., India on 8th and 9th December, 2023. Web Link of the proceeding: https://www.ramauniversity.ac.in/news-rama-university-hosts-successful-international-conference-on-emerging-trends-in-agriculture-12-49-5706

Table. 1: Influence of Nano Urea on the Growth in Irrigated Wheat crop.

Treatments		Plant height (cm) At harvesting stage	No. of tillers (m-2) At harvesting stage	Leaf area index (LAI)	Dry matter accumulation (g m^{-2}) At harvesting stage	Crop growth rate (g/day/plant) 90 DAS to At harvesting stage
T_1	100 % RDN + One foliar spray of Nano urea @ 4ml/ L	94.20	405.23	4.75	893.14	10.08
T_2	100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L	95.66	417.44	4.85	1014.09	11.33
T_3	100 % RDN +One spray of urea @ 4%	89.78	377.11	4.13	854.92	9.95
T_4	100 % RDN + Two spray of urea @ 4%	95.59	421.35	5.23	992.07	10.95
T_5	75 % RDN + One foliar spray of Nano-urea @ 4ml/ L	85.97	367.94	3.96	835.04	9.79
T_6	75 % RDN+ Two foliar spray of Nano urea @ 4ml/ L	93.73	402.78	4.61	884.32	10.21
T_7	75 % RDN +One spray of urea @ 4%	84.15	346.44	3.76	654.94	7.83
T_8	75 % RDN + Two spray of urea @ 4%	91.83	374.34	4.29	856.84	9.58
T_9	50 % RDN + One foliar spray of Nano urea @ 4ml/ L	81.78	331.61	3.58	623.74	8.25
T_{10}	50 % RDN+ Two foliar spray of Nano urea @ 4ml/ L	83.60	341.27	3.73	648.73	7.77
T_{11}	50 % RDN +One spray of urea @ 4%	77.45	305.45	3.15	571.66	7.46
T_{12}	50 % RDN + Two spray of urea @ 4%	83.06	332.48	3.66	642.35	8.05
T_{13}	Control (120:60:40 Kg/ha)	90.46	372.33	4.12	849.77	9.63
SEm (±)		3.27	17.26	0.17	32.57	0.38
Critical Difference at 5%		9.54	50.38	0.49	95.07	1.10
Ftest		S	S	S	S	S

Table. 2: Influence of Nano Urea on the Yield in Irrigated Wheat crop.

Treatments		Number of effectiveear head per (m^{-2})	Number of grains per ear head	Test weight (g)	Spike length (cm)	Grain yield (quintal ha^{-1})	Straw yield (quintal ha^{-1})
T_1	100 % RDN + One foliar spray of Nano urea @ 4ml/ L	279.46	61.07	44.27	10.17	44.27	56.67
T_2	100 % RDN+ Two foliar spray of Nano urea @ 4ml/ L	282.66	65.75	45.22	10.84	46.15	57.92
T_3	100 % RDN +One spray of urea @ 4%	273.38	57.74	42.91	9.41	42.44	52.36
T_4	100 % RDN + Two spray of urea @ 4%	280.50	63.40	45.15	10.41	44.96	57.43
T_5	75 % RDN + One foliar spray of Nano-urea @ 4ml/ L	268.06	54.39	41.79	8.94	39.31	50.38
T_6	75 % RDN+ Two foliar spray of Nano urea @ 4ml/ L	276.50	60.74	43.71	9.78	42.14	56.84
T_7	75 % RDN +One spray of urea @ 4%	256.23	50.39	41.41	7.34	34.72	46.12
T_8	75 % RDN + Two spray of urea @ 4%	272.05	56.40	42.84	9.18	40.27	51.28
T_9	50 % RDN + One foliar spray of Nano urea @ 4ml/ L	248.78	48.39	40.39	6.51	32.58	42.49
T_{10}	50 % RDN+ Two foliar spray of Nano urea @ 4ml/ L	254.29	50.06	41.14	7.18	34.47	45.38
T_{11}	50 % RDN +One spray of urea @ 4%	244.62	42.38	34.66	6.01	29.41	38.13
T_{12}	50 % RDN + Two spray of urea @ 4%	253.41	48.73	40.76	7.01	33.95	44.98
T_{13}	Control (120:60:40 Kg/ha)	269.39	55.07	42.26	9.01	41.02	51.66
SEm (±)		7.28	1.78	1.15	0.24	1.07	1.38
Critical Difference at 5%		21.25	5.21	3.36	0.70	3.13	4.03
Ftest		S	S	S	S	S	S

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