Effects of different nitrogen levels and nano urea sprays on growth, yield and economics of wheat (*Triticum aestivum* L.): A Review

# Abstract

*Triticum aestivum*, commonly referred to as wheat, is the main component of the human diet. After rice, it is considered the second most important cereal crop in India. Wheat is the most consumed cereal in the world, with about one-third of the world's population depending on it as a staple diet. Growth, yield, and the economic output of a crop are all significantly influenced by nutrients. The growth, yield, and economic yield responses of wheat crops to varying nitrogen levels and foliar nano-urea application are compiled in this review. An essential ingredient for boosting wheat productivity is nitrogen. Therefore, the administration of nitrogen in the form of chemical fertilizer is necessary to increase crop output. It is well recognized that nitrogen fertilizer has an impact on the number of tillers per square meter, spikelet spikes per spike, spike length, and spike number. Crops only use 20–50% of the nitrogen fertilizer that is directly given to the soil; the remaining nitrogen is lost through leaching and denitrification. It takes some effort to minimize these losses because crops only use 20–50% of the nitrogen fertilizer that is physically given to the soil; the remaining nitrogen is lost through denitrification and leaching. Liquid fertilizer is easily applied and is widely accessible. Compared to solid fertilizers, plants receive nutrients sooner when nutrients are applied in liquid form. One effective technique for making nitrogen more accessible to crops is foliar spraying. Nitrogen foliar spraying is also a great way to increase growth and output. The tests' goals were to evaluate how foliar application of nano urea and its combination affected wheat growth, yield, and yield characteristics. Higher nitrogen treatment doses were found to maximize growth characteristics, including plant height, number of tillers per plant, number of spikelet’s, spike length, and yield. The growth and yield factor are greatly impacted by the foliar application of nano urea at various stages.

**Key words:** Nano Urea, conventional urea, fertilizer wheat, yield, growth, liquid fertilizer, nitrogen.

# Introduction

In India, wheat (*Triticum aestivum* L.) is the most common cereal crop grown during the rabi season. A hexaploid (6n = 42) annual crop in the Poaceae or Gramineae family, it provides 20% of the daily protein and calorie intake of almost 4.5 billion people, making it essential to their survival. After rice, it is considered the second most important cereal crop in India. Wheat is the most consumed cereal in the world, with about one-third of the world's population depending on it as a staple diet. Wheat provides around 20% of daily protein and food calories to 4.5 billion people, making it the second most important staple, after rice. Every 100 gm of wheat contains 72 gm carbohydrates, 13.2 gm proteins, 10.7 gm fibres, 2.5 gm fat, 0.4 gm sugar, along with 11% water and provides about 340 calories of energy (Sendhil et al., 2022). Around 225.62 million hectares (m ha) of wheat are grown worldwide, producing 685.60 million tons (m ton) with a production rate of 3039 kg ha-1 (Shingne *et al*. 2017). The Indian states, namely, Uttar Pradesh, Haryana, Punjab, and Rajasthan, are the main producers of wheat. The most productive states are Punjab, Haryana, and Uttar Pradesh (Maurya *et al*., 2021). With a productivity rate of 2626 kg ha-1 and an area of 2.25 m ha under cultivation, Bihar ranks sixth in terms of wheat output, yielding 5.90 m tons (Directorate of Economics and Statistics, 2022). On the other hand, nano fertilizers are an important source of nutrients for agriculture, improving crop quality, productivity, and growth (Pohshna & Mailapalli, 2021). They seem to be very successful in precision agriculture for accurate nutrient management since they increase nutrient usage efficiency and lower cultivation expenses (Chawla & Balasaheb, 2023).

One of the essential elements for plants, nitrogen, is lacking in the majority of Indian soils, especially the light-textured ones. Plants require more nitrogen than any other nutrients, but only a small fraction of soil nitrogen is accessible to plants, because about 98% of organic forms cannot be absorbed by plant roots (Mahboob et al., 2023). Proteins, nucleic acids, growth hormones, vitamins, and chlorophyll all need nitrogen for their synthesis (Khose & Mailapalli, 2024). According to Qureshi *et al*. (2018), nano fertilizers enhance the surface area available for several metabolic processes in plants, which raises photosynthesis rates and, in turn, increases crop yield and dry matter production. Notably, the nation's agriculture could undergo a transformation because of nano urea, which is manufactured by a variety of sectors. By starting the commercial production of Nano urea, India has gained the lead globally and is now the world's second-largest customer.

**Nano Urea:**

With a particle size of 20 to 50 nm, nano urea is a novel agricultural input based on nanotechnology that offers a much greater surface area than traditional urea prills (Raliya *et al.*, 2017; Mahapatra *et al*., 2022). Under the Fertilizer (Inorganic, Organic or Mixed) (Control) Order 1985, the Indian government formally recognizes the liquid nano urea produced by the Indian Farmers Fertilizer Cooperative (IFFCO). It has a shelf life of roughly two years, contains 4% nitrogen (N), and has particles smaller than 100 nm (Madhavi *et al*., 2022). It stands out with nanometer-sized particles, prolonged shelf-life, and reduced environmental impact. Its adoption holds promise for sustainable agriculture, reducing agrochemical use and enhancing soil health (Kumar et al., 2023). Depending on crop nitrogen requirements, canopy growth, and water needs, 2-4 mL of liquid nano urea is sprayed at a rate of 2-4 mL per liter of water (Lakshman *et al*., 2022). The liquid nano urea has a zeta potential larger than 30 for stability.

On June 5, 2021, IFFCO created a new nano fertilizer dubbed "nano urea" with the goal of replacing or lessening the negative impacts of urea. According to Kiran and Samal (2021) and Kumar *et al.* (2021), nano fertilizers are any products that contain nanoparticles or that use nanotechnology to improve nutrient efficiency in the form of fertilizers. In the crop production sector, they increase productivity and quality while requiring less input, lowering input costs, and being environmentally safe. Wheat, one of the most important and principal food crops on the eastern plains, is crucial to preserving the nation's food security.

The secret to improving the wheat growing production scenario is balanced nutrition. Once more, the use of NDVI sensors, leaf color charts, and decision support tools like Nutrient Expert which are becoming more and more popular for scheduling nitrogen to wheat crops—are essential to precision nitrogen management for wheat (Mitra *et al*., 2019; Singha and Mitra, 2020; Mitra *et al*., 2023a). Because wheat takes longer to develop, growing it requires more expensive labor (Zhang *et al*., 2018). But in soil, urea is hydrolyzed to produce ammonia and carbon dioxide; when the urease enzyme is present, this process is accelerated by 8 × 107 times (Rana *et al*., 2021).

# The activities of protein synthesis, carbon absorption, photosynthesis, and chlorophyll biosynthesis in terrestrial plants all depend on nitrogen (N), one of the fundamental main macronutrients (Leghari *et al*., 2016). Urea is the most frequently used source of nitrogen, contributing to about 50% of global nitrogen consumption due to its high N content (46%), water solubility, and convenience of use (Motasim *et al*., 2021; Tanan *et al*., 2021). The foliar application of urea is another efficient fertilization technique that boosts the availability of nutrients, especially nitrogen (Khan *et al*., 2009). A new technique in the field of fertilizer management is nano urea, which is also sprayed on the leaves as a foliar solution.

# Table 1: Specifications of IFFCO Nano Urea (Liquid) (FCO, 1985)

# Conventional Urea

# The most used solid nitrogen fertilizer in the world, urea, is vital for giving plants the nitrogen they need to flourish. Urea is created by carefully regulating the interactions between ammonia gas and carbon dioxide at high temperatures and pressures. It is then molten and either hardened into prills or molded into spheres (Hignett, TP. 1985). It is efficient for transportation and application due to its 46% nitrogen concentration, affordability, and quick conversion to nitrogen that plants can use. With its many uses, urea can be used as a broadcast, top-dress, starter, or component of both liquid and dry fertilizer mixtures. Over 82% of nitrogenous fertilizers in India are conventional granular urea, and the government addresses subsidy concerns to ensure affordability for farmers, as evidenced by the Union Budget 2022–2023's significant budget allocation of Rs. 67,187 lakh crores (Lakshman *et al*., 2022).

# Table 2: Differences between Liquid Nano Urea and Conventional Urea

# Plant height

An experiment with four nitrogen levels and foliar spraying of nano urea (@ 3 ml per liter of water) at three different phases was carried out by Bala *et al*. (2024). The study found that N4 (100% RDN) produced the tallest plants, whereas F3 (at the jointing stage) produced the tallest plants when treated with nano urea spray. Additionally, Biswas *et al*. (2024) conducted an experiment using varying concentrations of foliar nano urea at various phases. In comparison to 100% RDN + 2 sprays of 5% urea at tillering and jointing (T4) and 100% RDN + single spray of nano urea at tillering (T2) treatments, the highest plant height (96.8 cm) was attained with 100% RDN + 2 sprays of nano urea at tillering and jointing (T3). In their experiment, Kumar *et al*. (2023) found that the highest nitrogen dosage (175 kg N) resulted in the highest plant height, whereas the lowest nitrogen dose (0 KG N) produced the lowest plant height. With rising nitrogen levels, wheat's growth characteristics, plant height, leaf area index, and dry matter accumulation, rose noticeably. At every stage, the nitrogen content of 160 kg N/ha yielded the highest values of all growth parameters (Gurjar *et al*., 2024).

# Number of Spikelets

# Kumar *et al*. (2021) report that treatment T6 (150% Nitrogen (RDF) with mulch) had the highest number of grain spike, with a higher nitrogen dose of 56.80. In contrast, the control group had the fewest amount of grains spike-1 (45.17). Because nitrogen encourages the start of spikelets, there are more grains spike-1. According to Kumar *et al*. (2023), the number of spikelets or spikes varied considerably between treatments where no nitrogen was applied (T1) and greater dose nitrogen delivery (T6; 125 kg N+RDF-P&K).

# Spike length (cm)

According to Kumar *et al*. (2021), wheat spike length rose as nitrogen levels rose relative to the control. In comparison to the control and other treatments, the longest spike length occurred in treatment T6, which received the highest nitrogen dosage (11.8 cm). The application of (N4) 100% RDN resulted in the longest spike length (15.24 cm), while (N1) Control produced the shortest spike length (14.59 cm).

# The application of (F2) foliar spray of nano urea at the tillering stage produced the longest spike length (15.07 cm) among the foliar spray of nano urea, while the treatment of (F1) foliar spray of nano urea at the CRI stage produced the shortest spike length (14.77 cm) (Bala et al., 2024). While working on wheat, Singh *et al*. (2022) found that the progressive and sustained release of nutrients through the use of nano fertilizers is responsible for the increased growth metrics shown when applied in conjunction with RDF.

# Number of effective tillers

The most crucial factor affecting yield is the number of tillers per unit area. The yield will increase with the quantity of tillers, particularly the fruitful tillers. The experiment's higher number of tillers per square meter may be the result of increased nitrogen availability, which is essential for cell division (Chaturvedi *et al*., 2005). According to the results of Yoshida *et al*. (1972), the number of tillers per square meter rises as the crop absorbs more nitrogen.

# Different nano treatments also had a substantial impact on the quantity of effective tillers (m²). Comparing the treatment (Recommended N + two sprays of urea (5%) at tillering and jointing to the control, where only recommended nitrogen was sprayed, revealed a significantly increased number of effective tillers (m2) at harvest (477) (Dabhi *et al*., 2025).

# Grain yield

The impact of foliar application of nano urea at varying concentrations and growth stages on the nutrient uptake, yield, and production economics of wheat (*Triticum aestivum* L) cv. "Phule samadhan" under normal field and saline-sodic field during two seasons, *Rabi* 2021 and 2022, was assessed in a field experiment. Different nitrogen levels also greatly boosted wheat grain yield. The treatment that provided a higher dose of nitrogen (125 kg N+RDF-P&K) produced the highest grain yield (12.46 q), while the treatment that applied no nitrogen produced the lowest grain yield (10.29 q). These findings are consistent with those of Roy *et al*. (2021), who also noted that nitrogen production rises with rising nitrogen levels. According to Kumar *et al*. (2023), using the recommended dose of N+ two urea (5%) sprays at tillering and jointing resulted in a noticeably higher grain yield (54.08 q ha-1).



Figure 1: Benefits of Nano Fertilizers

**Economic yield**

The crop's benefit-cost ratio is greatly impacted by split nitrogen application. In an experiment, Akthar *et al*. (2017) found that the split nitrogen application in (50-25-25) had the highest benefit-cost ratio. According to data from an experiment by Kumar *et al*. (2021), of the various treatments, 75% N was applied through urea (soil application) and 25% N was applied through two foliar sprays of nano urea, 40% at 30 DAS (tillering) and 60% at 60 DAS (flowering). This combination was found to be advantageous for increasing yield, contributing characteristics. Maximum gross returns, net returns, and benefit-cost ratios were noted in an experiment with varying levels of nano urea and nitrogen. The nano urea was treated with 12 milliliters of nano urea per liter of water at 25-30 DAT, and then with 8 milliliters of nano urea per liter of water at 25-30 DAT.

# Ahire *et al*. (2024) found that among the various nitrogen application levels, the application of 75% RDN in three split doses (25% basal + 25% at tillering stage + 25% at booting stage) significantly increased grain yield, straw yield, and biological yield. It also described the maximum gross returns, net returns, and benefit-cost ratio. The application of 100% RDN in three split doses (50% basal + 25% at tillering stage + 25% at booting stage) was significantly comparable.

# Table 3: Effect of Liquid Nano Urea Fertilizer on Crops

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# Source: Kumar *et al*., 2023

# Conclusion

# Chemical fertilizers are easily applied and widely accessible. Chemical fertilizers are readily available to farmers from nearby agricultural supply stores, and they may be applied to crops with standard machinery. Based on the results of this study, it can be said that nitrogen is crucial for crop growth and output. According to the reviewed study, crop growth and output are impacted as nitrogen levels rise. Higher nitrogen treatment doses were found to maximize growth characteristics, including plant height, number of tillers per plant, number of spikelets, spike length, and yield. The growth and yield factor are greatly impacted by the foliar application of nano-urea at various stages.

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# Reference

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