# Benefits and Challenges in Adoption of Nano Urea Liquid, an Innovation for Sustainable Agriculture: A Review

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**ABSTRACT**

Nanotechnology has gained much attention in the field of agriculture for its potential to revolutionize traditional farming practices. It is the science of exploring nano particles to deliver the inputs to the crop resulting in increased efficiency. One remarkable development in this area is nanoscale urea, which is often referred to as "Nano Urea" or “Nano Urea Liquid.” This review article explores the introduction of the nano urea in modern agriculture, also shedding light on possible benefits and the challenges it faces in realizing its full potential. The main aim of the article is to deliver quality information about nano urea so that the students, scholars and farmers get the related content and use it for the better and efficient ecosystem..

## INTRODUCTION

The conventional nitrogenous fertilizer industry is continuously facing challenges due to low uptake of nitrogen by plants, in response requiring excessive doses of fertilizer application. To address this issue, Indian Farmers Fertilizer Cooperative Limited (IFFCO) launched Nano Urea, a liquid nitrogenous fertilizer developed

at its Nano Biotechnology Research Centre in Kalol, Gujarat. This innovation, aligned with the vision of 'Atmanirbhar Bharat' and 'Atmanirbhar Krishi,' which is aiming to reduce urea usage in soil. IFFCO is a major cooperative society which introduced Nano Urea on May 31, 2021 during its annual general body meeting with a ceremonial launch on June 5, 2021. This breakthrough represents a milestone in modern farming promising higher efficiency and lower environmental damage. Vice chairman of IFFCO, Shri Dilip Shangani emphasizes nano urea's importance in preserving the environment and ensuring food security. Use of traditional urea results in significant ecosystem harm, contributing to soil and water contamination, air pollution and indirectly global warming. It also causes ammonia emissions, soil acidification and water eutrophication. In long term, residues of urea harms soil health, delays crop maturity, reduces yield and increases vulnerability to pests and diseases as they also attract towards plenty of food. Nano Urea is able to addresses these challenges by offering higher nutrient use efficiency (NUE) and environmental sustainability which is crucial for well-being of future generation and food security (Kajal Kiran and Kailash Chandra Samal, 2021).

Like any other developing technology, it is essential to critically examine its benefits along with the challenges that need to be addressed for its successful placing into the mainstream agricultural practices. This article serves the purpose by introducing the nano urea followed by the mentioning its benefits and some of the challenges that must be overcome for the success of the new innovation.

Nano Urea Liquid is a best alternative to conventional urea and designed to enhance plant nitrogen uptake while reducing ill effects on the ecosystem. With 40,000 mg/l of nitrogen per 500 ml bottle, it equals the nutrient impact of one bag of traditional urea. It means one bottle of Nanu Urea Liquid is equal to the one bag of urea. Its effectiveness surpasses conventional urea, delivering over 80% nutrient efficiency compared to 30-40%. It is tested in around 11,000 farmer's fields across 94 crops and it demonstrates an average of 8% yield increase in crops like rice and wheat. This step promises to significantly reduce urea requirement along with boosting agricultural productivity and sustainability (Suman Kantwa and L. R. Yadav, 2022).

It is a revolutionary fertilizer produced by using nanotechnology, a word derived by the combination of "nano" (meaning extremely small) and "urea" (a nitrogen-rich fertilizer). This liquid fertilizer contains very minute nitrogen particles, about 10 to 50 nanometres in size, making it super-efficient in providing nutrients to plants. It is a water-soluble and easy to apply as a foliar spray, mixing 2 to 4 ml in a litre of water and spraying it on the leaves during vegetative stages. For optimal results, it is recommended to spray nano urea twice during the crop's growth cycle. The first spray should be done around 30 to 35 days after sowing or transplanting, and the second spray about 20 to 25 days later or before flowering. Because of its tiny size, nano urea easily enters plant cells through openings like stomata resulting its efficient absorption and minimal loss. Once inside, it travels through the plant's vascular system and delivers nitrogen where it is needed most. Any excess nitrogen is stored within the plant for later use, ensuring steady growth and development. Nano urea can be mixed with other water-soluble fertilizers and chemicals for convenience, but it is essential to check compatibility before mixing (D. Venkata Sri Akshay. 2022).

The excessive use of inorganic fertilizers, pesticides and herbicides in modern agriculture has led to environmental pollution, reduced input efficiency, soil degradation and

several health hazards to humans. One of the significant advantages of nano fertilizers is their controlled release mechanism, ensuring precise nutrient delivery to plants while minimizing losses to the environment. Moreover, nano particles can be tailored for specific crops and growth stages, optimizing nutrient uptake and utilization. Various studies have demonstrated the efficacy of nano fertilizers in promoting plant growth, seed germination, and yield enhancement across different crops. Nanotechnology holds immense potential to revolutionize agriculture by offering smart delivery systems, efficient nutrient management and environmentally sustainable solutions (M. Banotra *et al.*, 2017).

**Table.1** Following are the main characteristics of the IFFCO nano urea and conventional urea (Jangir *et al.*, 2021)

| Characteristics | Nano urea | Conventional urea |
|---|---|---|
| **Invention** | *2021* | *1823* |
| **Technology** | *Nanotechnology* | *Conventional method* |
| **Particle size** | *32 nm* | *1 mm* |
| **Use efficiency** | *85-90 %* | *30 – 40 %* |
| **Price** | *Rs. 240/-* | *Rs. 266.50/-* |
| **Storage** | *Very less area* | *Very high area* |
| **Pollution** | *No* | *Air, water and soil* |
| **Vaporization** | *No* | *Yes* |
| **Soil residual** | *No* | *Yes* |
| **Effect on soil** | *Enhance quality* | *Acidifies soil* |
| **Availability in plants** | *Throughout the life cycle* | *3-4 days* |
| **Effect on crop maturity** | *Maturity on time* | *Early maturity* |
| **Intake medium** | *Direct through leaves* | *Through roots* |
| **Method of use** | *Spray* | *Top dressing* |

**Nano Urea: The Benefits**

The economic and agronomic benefits of nano urea liquid have been extensively studied, revealing its potential to enhance crop yield and nutrient efficiency while reducing environmental impact. Research indicates that while the application of nano spray includes additional costs compared to conventional fertilizers but the net returns are higher, especially when combined with a reduced rate of chemical fertilizer application. Studies showed that nano urea spray treatments result in higher grain yield and improved soil nutrient balance compared to conventional NPK application. Nano fertilizers facilitate better nutrient transport and utilization efficiency which leads to better crop growth. Foliar application at critical growth stages enhances better nitrogen use and decreased leaching & other losses. Furthermore, nano urea application improves carbon balance and accelerates plant growth reducing the dependency on chemical fertilizers and mitigating their harmful impacts. Higher concentrations of nano spray result in increased yield without impacting soil health, highlighting the effectiveness of nano urea in optimizing crop production while ensuring environmental sustainability.

To support the beneficial effects of nano urea, a field experiment was conducted on hybrid rice (Arize-6444 Gold) in West Bengal aimed to evaluate the impact of nano-urea spray on yield, nutrient uptake and economics. For the purpose, six treatments were compared, including different combinations of urea and nano urea spray, along with a controlled treatment. Notably, treatment T2 (100% N(Urea) + 2 foliar spray of nano-urea) exhibited superior growth parameters and yield attributes compared to other treatments. T2 resulted in the highest grain yield (7.15 t ha-1), harvest index (50.71%), and grain nutrient content. Despite the higher total cost, T2 showed the highest net return and benefit-cost ratio, indicating its economic viability. Overall, the application of 100% recommended dose of nitrogen along with nano-urea spray at specific growth stages proved effective in increasing hybrid rice productivity and profitability which suggests its potential for sustainable rice cultivation in lowland areas (Sreeja Namasharma *et al.*, 2023).

A similar experiment in support with the enhanced effect of using nano urea was concluded by a field experiment conducted at Rajasthan College of Agriculture, Udaipur. It was aimed to assess the impact of nitrogen sources along with the biofertilizers on nutrient uptake and economics of black wheat. For this, five levels of nitrogen sources, ranging from 100% urea to 100% nano urea liquid and four levels of biofertilizers including Azotobacter, PSB and their combination were examined. Talking about the results which indicated that a combination of 50% urea and 50% nano urea liquid (N3) maximized N, P, K, Fe, and Zn content and uptake in grain and straw, leading to the highest net return and benefit-cost ratio. Seed inoculation with Azotobacter + PSB mixture also significantly increased nutrient content and uptake showed improved economic returns. However, there was no significant differences in anthocyanin content among treatment combinations. In a nut shell, nano urea liquid application proved more efficient in enhancing nutrient uptake as well as economic returns of black wheat compared to urea. This successfully highlighted the practicality and efficacy of nano urea liquid in sustainable wheat cultivation (Kannoj *et al.*, 2022).

This product not only reduces environmental pollution but also improves nutrient assimilation and chlorophyll synthesis which leads to higher dry matter accumulation in the plants. Economically nano urea proves to be cost-effective, offering significant savings and with profit margins. Moreover, its production process is eco-friendly along with lower energy consumption and reduced carbon footprint compared to traditional urea manufacturing process. However, further research is needed to fully understand its long-term environmental impacts and optimize its application. Overall, it offers a sustainable approach for modern farming and minimizing harmful effects of urea while maximizing crop productivity and providing economic benefits.

**Nano Urea: The Challenges**

The adoption of nano urea in farming faces several challenges that hinder its widespread use. Firstly, cost is a significant barrier as the production process for nano urea is more complex and tedious process compared to the conventional urea. The expenses associated with raw materials, equipment, and processing contribute to its high price, making it unaffordable for many farmers, especially those with limited resources. Secondly, there is a lack of extensive research on the long-term effects of nano urea on soil health and plant growth. Most studies have been conducted in a controlled laboratory condition, leaving uncertainties about its performance in real-world farming conditions including various soil types and climates. Therefore, there must be more research in this area to evaluate its efficacy and possible impacts accurately. Moreover, safety concerns regarding nano urea creates another challenge as there are worries about its potential risks to human health, more precisely regarding inhalation or being in contact of the nanoparticles. The full extent of its environmental and health impact is not yet fully understood, emphasizing the need for comprehensive safety assessments. Also, the limited availability of nano urea further hampers its adoption. Only a few companies started producing nano urea and its distribution is restricted to specific regions making it challenging for farmers to access and apply it into their farming practices (Pooja L.R. *et al.*, 2023).

Nanoparticles also carries a significant phytotoxicity risk to plants due to their ability to easy entrance to the plant tissues through surface adsorption or natural openings. Present research indicates that nanoparticles of sizes below 5 nm can readily penetrate cell walls while those up to 20 nm can move through

plasmodesmata. Even at lower concentrations small nanoparticles may cause harm by being easily taken up and translocated within the plant. Several studies show a range of effects including positive, negative and neutral impacts on plant systems showcasing the importance of size of the nanoparticles and concentration in determining phytotoxicity.

Also, producing nanomaterials in sufficient quantity with standardized sizes is costly and requires specialized infrastructure and skilled labour. Concerns arise regarding the accumulation of nanoparticles in the food chain creating risks for human health and ecosystem. The toxicity of nanomaterials during manufacturing, transportation and handling further complicates their adoption in farming. Inconsistent global regulations add to the uncertainty. To understand the benefits of nano urea liquid in agriculture there is a need for a robust research and efficient policies to ensure sustainable development while addressing safety concerns for both humans and the environment.

The particles of nano urea liquid are very tiny and highly reactive as it includes particles with an increased surface area allowing them to go through several reactions by reacting with many types of reactants. This high chemical reactivity can create various health problems for the workers who are exposed to this fertilizer. Farmers need a proper guidance and awareness to use them effectively and safely. However, currently there is a lack of clear regulations for nano fertilizers across the country which causes uncertainty about their safety. There are worries about nanomaterials entering the food chain which could affect the ecosystem. The long-term effects of nanomaterials in soil and water are not fully known raising concerns about their potential accumulation and negative ecological impact. Overall, there is a need for comprehensive safety assessments and better understanding of their environmental fate.

## CONCLUSION

The introduction of nano urea is representing a significant advancement in modern agricultural practices and promising for the increase in crop productivity along with the environmental sustainability. It offers various potential benefits over conventional urea which includes improved nutrient use efficiency (NUE), reduced environmental impact and increased profitability for the farmers. Also, with its higher nutrient use efficiency and a controlled release mechanism, it provides facility for addressing the key challenges faced by using conventional urea such as nitrogen wastage through leaching, soil degradation, and environmental pollution.

However, despite its greater positivity, the widespread adoption of nano urea faces several challenges that must be overcome. Meanwhile, cost remains a significant barrier as the production process is complex and costly making it unaffordable for marginal farmers & since Indian farmers are majorly marginal farmer holding around 1 ha of land, this poses a major challenge in the adoption process of nano urea. Additionally, there is a lack of extensive research on the long-term effects of nano urea on soil health, plant growth, and human health, raising uncertainties about its safety and efficacy in real-world farming conditions. Safety concerns regarding toxicity of nanoparticle further complicate its adoption, product must be checked for the risk it may have on human health and ecosystem in long run.

Despite some challenges, nano urea provides cutting edge solutions for current urea problems by increased crop production with sustainability allowing it to revolutionize agriculture. For these reasons & by further research, innovation and advertising, it can play a crucial role in creating the better future of agriculture and ensures global food security in a healthy manner as far as human as well as environmental health is concerned.

## REFERENCES

D.Venkata Sri Akshay. (2022). Current Research on Nano Urea Problems & Prospectus. Acharya N G Ranga Agricultural University Agricultural College, Bapatla. Department of Agronomy, Doctoral Seminar -II.

Jangir, N., Suman, Saxena, S., Yadav, S., and Nishikant, (2021). Nano Urea: environment friendly and better substitute for urea. *Just Agriculture*. 2. 34-37.

Kajal Kiran and Kailash Chandra Samal. (2021). 'Nano Urea Liquid' – A Boon for Indian Farmers and Mother Earth. *Biotica Research Today*. 03(06), 511-516.

Kannoj *et al.* (2022). Effect of Nano Urea vs Conventional Urea on the Nutrient Content, Uptake and Economics of Black Wheat (Triticum aestivum L.) along with Biofertilizers. *Biological Forum– An International Journal*. 14(2a), 499-504.

M. Banotra *et al.* (2017). Prospectus of use of Nanotechnology in Agriculture–A Review. *International Journal of Current Microbiology and Applied Sciences*. 6(12),1541-1551.

Pooja L.R. *et al.* (2023). Nanostructured Urea Fertilizer (Nano Urea): A Promising Approach to Sustainable Agriculture. *Food and Scientific Reports*. 04(05), 84-91.

Sreeja Namasharma *et al.* (2023). Impact of foliar applied nano-urea on growth, productivity and profitability of hybrid rice (Oryza sativa L.) *ORYZA- An International Journal on Rice.* 60(03), 464-472.

Suman Kantwa and L. R. Yadav. (2022). Nano Urea: Application and Significance. *Just Agriculture*. 01(07), 01-06.