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Nano Urea: The Smart Fertilizer Revolutionizing Modern Agriculture

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Cereals are a staple for over 80% of the global population, necessitating increased production to meet growing demands. Nitrogen, vital for crop growth, is often supplied through urea, which contains 46% nitrogen. However, excessive urea uses in India—where nitrogen deficiency is highest—can harm soil health. Nano-urea, a sustainable alternative, addresses these issues by enhancing nutrient delivery and nitrogen use efficiency (85–90%). It is eco-friendly, cost-effective, and has passed biosafety and toxicity tests. This innovative liquid fertilizer improves nutrient availability by ~80%, making it a promising step toward precise and sustainable agriculture.

Introduction

As the global population rises and food demand surges, agriculture continues to lean heavily on fertilizers, insecticides, and herbicides to meet yield expectations. While these chemical inputs have played a significant role in improving crop productivity, their excessive and often inefficient use has led to mounting environmental and economic concerns. From 1950 to 2020, global fertilizer consumption skyrocketed from 15 million tonnes to 194 million tonnes—a 13-fold increase—and is expected to reach 263 million tonnes by 2050. This over-dependence has resulted in soil degradation, nutrient depletion, poor food quality, declining profitability for farmers, and long-term ecological damage. More than half of the applied fertilizers fail to reach their intended targets, with 50–70% lost to leaching, runoff, volatilization, and microbial conversion (fig.1). These inefficiencies not only pollute soil, water, and air but also affect beneficial microorganisms and marine ecosystems through eutrophication. To counter these harmful consequences, agriculture must pivot toward more sustainable and efficient solutions—this is where nanotechnology steps in, particularly in the form of nano urea.

Why Nitrogen Matters—and It's Role

Nitrogen is one of the most vital nutrients for plant growth, involved in the formation of chlorophyll, enzymes, proteins, and nucleic acids. Among the nitrogen fertilizers, urea is the most widely used because of its high solubility, low toxicity, and affordability. However, its efficiency remains alarmingly low—only 30–40% of nitrogen from conventional urea is absorbed by crops. India stands as the second-largest consumer and third-largest producer of urea globally. The country consumes about 19.1 million tonnes of urea annually but produces only 13.68 million tonnes, bridging the gap through imports. Urea accounts for 82% of nitrogen fertilizers used in India, but the massive inefficiencies demand urgent solutions.

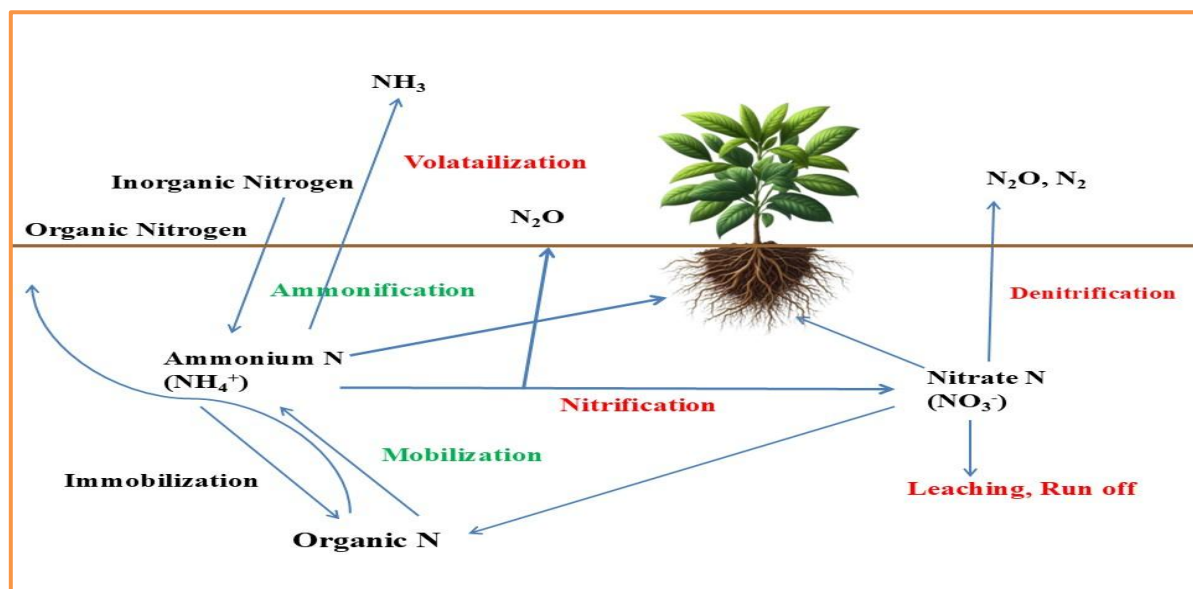


Fig 1: Soil nitrogen bio-chemical reactions that result in the loss of nitrogen fertilizers

What is Nano Urea?

Nano urea is an innovative nitrogen-based fertilizer developed using nanotechnology. These fertilizers contain nitrogen in nanoparticle form, typically ranging from 20 to 50 nano-meters in size. Produced using advanced technologies like spinning cone and nano-channel reactors, nano urea delivers nitrogen directly to plants through foliar application. Unlike conventional urea granules, which are applied to the soil, nano urea is sprayed on leaves. The tiny particles penetrate the stomata and are efficiently transported to nitrogen-deficient areas within the plant, enabling precise and timely nutrient delivery. One 500 ml bottle of nano urea can replace an entire 45 kg bag of conventional urea, reducing nitrogen application by up to 50%.

How Nano Fertilizers Work

Nano fertilizers are designed for controlled and targeted delivery of nutrients. Their small size and large surface area make them highly reactive and easily absorbed by plants. They offer (fig.2):

- Precise nutrient delivery to specific plant parts
- Lower application rates and reduced runoff
- Improved crop resilience and rooting depth
- Lower environmental impact

Nano urea, in particular, increases the efficiency of nitrogen uptake, reducing nutrient losses through leaching and volatilization. It also helps reduce nitrous oxide emissions, a major contributor to global warming.

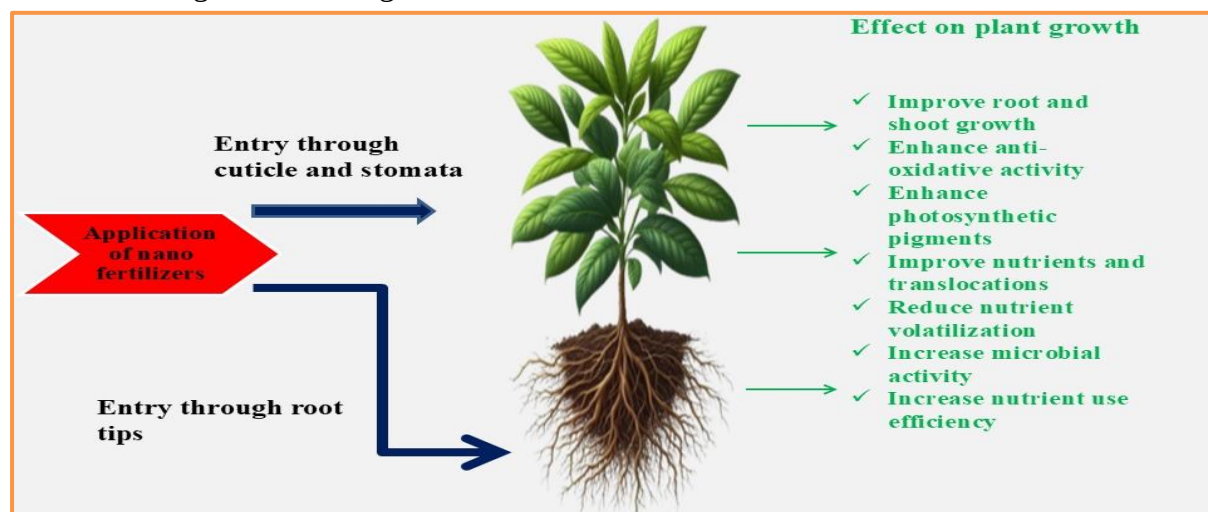


Fig 2: Impact of nano fertilizers on the growth and development of plants

Features and Benefits of Nano Urea

Nano urea has proven to be a game-changer with multiple advantages:

- Cost-effective: Cheaper than conventional urea.
- Eco-friendly: Reduces leaching, runoff, and gas emissions.
- Easy application: Mix 2–4 ml per litre of water and spray on leaves.
- Transport & storage friendly: Smaller quantities needed.
- Increased yield: Boosts crop output by up to 8%.
- Enhances crop quality: Improves nutritional value and shelf life.
- Drone-compatible: Suitable for modern precision farming methods.
- Reduces urea dependency: Contributes to India's self-reliance in fertilizer

Application Guidelines

- Use 2–4 ml per litre of water depending on crop type.
- Spray during early morning or late evening to avoid evaporation.
- For best results, apply twice during a crop's lifecycle.
- Use flat-fan or cut-type nozzles for uniform coverage.
- If rain occurs within 12 hours, reapply the spray.
- Always use gloves and face masks during application.

Impact on Cereals and Other Crops

Cereal crops like rice, wheat, maize, and sorghum are heavy nitrogen feeders. Traditional fertilizers often lead to inefficient nitrogen absorption, affecting yield and plant health. Nano urea's foliar application during critical growth phases enhances root growth, nutrient uptake, and enzymatic activity. A combination of 50% conventional nitrogen and 50% nano urea spray has shown superior results across crops.

Field Experience in West Bengal

At Bidhan Chandra Krishi Viswavidyalaya in West Bengal, a trial using 75% conventional nitrogen + 25% (fig 3) nano urea on French beans yielded 32.12% more produce and 19.41% higher dry biomass than the control. This demonstrated nano urea's effectiveness in real-world field conditions.



Fig 3: A field view of research work that received nano urea as treatment

Limitations and Considerations

While nano urea offers many benefits, certain limitations exist:

- Only foliar spray: Cannot replace basal soil applications entirely.

- Labour-intensive: Requires trained labour and timely spraying.
- Potential health risks: May cause eye irritation or skin itching; protective wear is essential.
- Limited long-term data: More research is needed to assess long-term soil health and yield impacts across diverse agro-climatic zones.

Conclusion

The integration of nanotechnology into agriculture is reshaping how we think about fertilizers. Nano urea stands as a landmark innovation, bridging the gap between high productivity and environmental sustainability. By increasing nitrogen use efficiency, reducing input costs, and limiting ecological damage, it aligns with global goals for sustainable development and climate resilience. While it's not a one-size-fits-all solution, the ongoing trials and field applications are promising. As more data emerges, nano urea could well become the future of nitrogen fertilization—empowering farmers, protecting the planet, and feeding the world more efficiently. In a world where every drop of fertilizer counts, nano urea is the smarter drop.

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