

# *Nano-Fertilizers and their Impact on Precision Nutrient Delivery*

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## **Keywords**

Nanotechnology, Nano fertilizers, Nutrient use efficiency, Crop production, Sustainable agriculture

### *How to cite this article:*

Bajya, N., Manuja, S., Sharma, G. D. and Shivalika. 2025. Nano-Fertilizers and their Impact on Precision Nutrient Delivery. *Vigyan Varta* 6(4): 191-194.

## **ABSTRACT**

The global population is rapidly increasing and is projected to reach 10 billion by 2050. To meet the demand for food security in the world we need to focus on the new technologies to reduce the hunger and poverty. Chemical fertilizers are considered an indispensable source of plant nutrition to improve the crop production. However, only about half of the fertilizer applied is use by crop and the rest, which is supposed to be absorbed by the plant, remains in the soil and might make matters worse by contaminating water, settling in the soil, or seeping into it. The major macronutrients that are applied to the soil (nitrogen, phosphorus and potassium) are observed to be lost at rapid rate. Nanotechnology can precisely identify and provide a certain amount of nutrients to a crop, thereby improving resource use efficiency besides keeping safety into consideration. This also reduces the adverse impact of fertilizer applicants on soil. Besides these advantages, the use of nano fertilizers minimizes the potential negative effects associated with over dosage and reduce the frequency of the application.

## INTRODUCTION

At present, agriculture is facing many challenges such as low nutrient use efficiency, excessive use of chemical fertilizers is increasing environmental pollution, deterioration in soil health as well as reduction in good organisms in the soil. All these challenges can be controlled through nanotechnology. Due to the continuous use of chemical fertilizers, agricultural production has become stagnant, and hence new technologies are needed to give it a new impetus also the environment is being harmed due to the continuous use of chemical fertilizers, and this calls for development of practices that can result in sustainable crop production. Nano-fertilizers improve soil health and reduce greenhouse gas emissions. Nano-fertilizers are efficiently absorbed by plants due to their extremely high absorption properties and high surface-to-volume ratio (Elemike et al.2019). Nano-fertilizers play an essential role in sustainable agriculture because of their smaller size (1-100 nm) and larger surface area (Raguraj et al. 2020). Nano fertilizers increase nutrient use efficiency and promote clean production with less impact on environment. Compared to conventional fertilizers, nano fertilizers increase nutrient use efficiency by 30%, increase crop yield by 20% and reduce conventional fertilizer use by 50% (Saurabh et al. 2024).

Along with all these benefits, the use of nano-fertilizers can reduce soil toxicity. Nano-fertilizers reduce risk and reduce application frequency. nano fertilizers are better alternatives to conventional fertilizers as they are environment friendly, cost effective, maintain soil fertility and plant health. Giving priority to environmental protection, nano fertilizers are a better solution to meet the increasing demand for security.

### Objective of nano fertilizers:

The main Objective of nano fertilizers is to increase the use and absorption of nutrients by plants, thereby increasing crop yield. Increasing crop yield can be achieved through controlled release and efficient delivery of nutrients, which is possible with nano fertilizers. Controlled release ensures that the plants receive the right amount of nutrients at the right time. Using nanotechnology, nano fertilizers can increase the surface area of nano fertilizers, which makes them more easily absorbed by plants.

Additionally, nano fertilizers reduce environmental pollution by reducing nutrient loss to the environment, which helps ecosystems and promotes sustainable farming. Overall, the aim of nano fertilizers is to create a more efficient, sustainable and environmentally friendly agricultural system, which benefits both the plants and the environment.

### Key Benefits of Nano Fertilizers:

- 1. Enhanced Nutrient Absorption:** The tiny size of nanoparticles allows them to be absorbed more easily through plant roots or leaves. This enhances nutrient uptake, ensuring that plants receive the exact amount of nutrients they need at the right time.
- 2. Improved Fertilizer Efficiency:** With traditional fertilizers, a significant amount of nutrients is lost to the environment, either through runoff into water bodies or evaporation into the air. Nano fertilizers can deliver nutrients in a more precise and controlled manner, reducing wastage and increasing their efficiency.
- 3. Targeted Delivery:** Nano fertilizers can be designed to target specific plant species or

developmental stages. This means that crops receive exactly what they need, preventing under or over-fertilization. This precision allows for better growth, healthier crops, and improved yields.

**4. Sustainable Farming:** Nano fertilizers contribute to more sustainable farming practices by reducing the need for excessive fertilization. This leads to lower environmental impact, reduced soil degradation, and decreased contamination of water sources.

**5. Reduction in Fertilizer Use:** By improving nutrient uptake, nano fertilizers require smaller amounts compared to traditional fertilizers. This reduces the overall amount of chemicals applied to the soil, leading to cost savings for farmers and a reduction in chemical runoff.

**6. Environmentally Friendly:** Since nano fertilizers are more efficient and require lower application rates, they contribute to the reduction of fertilizer-related environmental issues such as water pollution, greenhouse gas emissions, and soil acidification.

### Challenges and Future Outlook:

While nano fertilizers offer numerous benefits, their widespread adoption is still in its early stages. The technology behind nano fertilizers is still being developed, and regulatory hurdles must be overcome to ensure their safety and efficacy. Additionally, the potential impact of nanoparticles on soil health, biodiversity, and the environment is still being studied. Researchers are working diligently to address these concerns and ensure that nano fertilizers do not pose unintended risks. The cost of production can also be a barrier. Nano fertilizers require specialized equipment for manufacturing, which can make them more expensive than conventional fertilizers. However, as research progresses and

economies of scale come into play, these costs are expected to decrease. Despite these challenges, the potential of nano fertilizers in transforming agriculture is immense. As the technology matures, nano fertilizers are likely to become a key tool in the quest for more sustainable, efficient, and environmentally-friendly farming practices.

### CONCLUSION

Nano fertilizers enhance precision nutrient delivery by improving nutrient uptake efficiency and minimizing wastage. Their small size enables better targeting of plant cells, leading to improved absorption and reduced environmental losses, such as leaching and volatilization. These fertilizers allow controlled nutrient release, ensuring plants receive nutrients at the optimal time, boosting growth and yield. This precision reduces the need for excess fertilizers, cutting costs and environmental impact. While promising for sustainable agriculture, the long-term effects on soil health and biodiversity require further research. Overall, nano fertilizers offer a more efficient and eco-friendly approach to nutrient management in farming.

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