



AGRI MAGAZINE

(International E-Magazine for Agricultural Articles)

Volume: 01, Issue: 04 (November, 2024)

Available online at <http://www.agrimagazine.in>

© Agri Magazine, ISSN: 3048-8656

Nanofertilizer: Next Generation Fertilizer

(*Shivani Chauhan¹, Himani Sharma², Arti Ghabru³, Preeti Sharma⁴ and Bandana Kumari⁵)

¹Department of Soil Science and Water Management, COHF, Neri, Hamirpur, H.P. 177001

²Department of Biotechnology, COHF, Neri, Hamirpur, H.P. 177001

³Department of Basic Sciences, COHF, Neri, Hamirpur, H.P. 177001

⁴Department of Floriculture and Landscaping, COHF, Neri, Hamirpur, H.P. 177001

⁵Department of Forest Products, COHF, Neri, Hamirpur, H.P. 177001

*Corresponding Author's email: shivanic9@gmail.com

Plant nutrients or the fertilizers are the materials which are responsible for the growth and development of the plant but in the current time excessive use of fertilizers although increases the crop yield but on the other hand it decreases the soil fertility therefore it is a need for alternative and eco-friendly nano fertilizers. Nano fertilizers can be manufactured from either conventional fertilizers or extracted from other plants by encapsulating them with nanomaterial. Nano fertilizer holds plenty of nutrients and release them slowly due to which crop is able to absorb nutrients according to its need.

Chemical fertilizers which we used to increase our crop yield have some drawbacks i.e the fertilizers which delivers nutrients in the chemical form but plants cannot readily absorb. These fertilizers are very poorly soluble in soil so we have to apply them frequently.

Types of Nanofertilizers

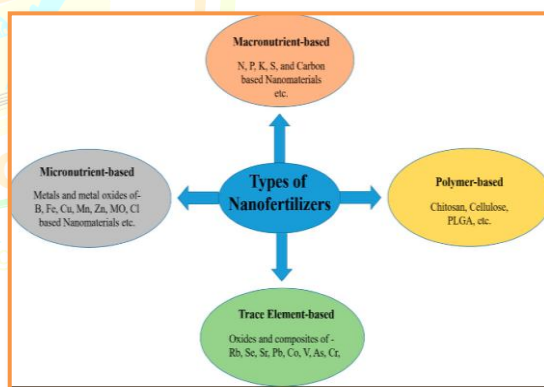
Nano fertilizers can indeed vary based on the type of nutrient they deliver and the carrier they use.

a) **Macronutrient based:** These nano fertilizers focus on delivering essential macronutrients like nitrogen (N), phosphorus (P), and potassium (K). They are designed to provide plants with the primary nutrients they need for growth, development, and overall health.

b) **Micronutrient based:** These nano fertilizers focus on delivering micronutrients, which are essential for plant growth but required in smaller quantities compared to macronutrients. Examples of micronutrients include iron, zinc, copper, manganese, boron, and molybdenum. Nano formulations can enhance the efficiency of micronutrient delivery to plants.

c) **Carbon based Nano fertilizers:** These fertilizers focus on delivering carbon-based compounds that can enhance soil health and plant growth. Carbon-based nano fertilizers may include substances like humic acids, fulvic acids, or other organic compounds that contribute to soil fertility, microbial activity, and nutrient uptake by plants.

d) **Polymer based Nano Fertilizers:** These fertilizers use polymers as carriers for nutrients, allowing for controlled release and targeted delivery of fertilizers to plants. Polymer-based nano fertilizers can improve nutrient uptake efficiency, reduce nutrient leaching.



Differences between Traditional Fertilizers and Nanofertilizers

Characteristics	Traditional Fertilizers	Nanofertilizers
Particle Size:	Consist of larger particles, typically in granular or powdered form, which need to be dissolved in water or broken down by soil microbes before plants can absorb the nutrients.	Composed of nanoparticles, which have a much smaller size compared to traditional fertilizers. This enables them to penetrate plant tissues more effectively and deliver nutrients directly to cells
Nutrient Release:	release nutrients slowly over time as they break down in the soil or dissolve in water. This can result in a longer-lasting effect but may also lead to nutrient leaching and runoff.	Designed to release nutrients in a more controlled manner, either through gradual degradation or through targeted delivery mechanisms. This can help reduce nutrient loss and improve nutrient uptake by plants.
Nutrient Efficiency	Often suffer from low nutrient use efficiency, as a significant portion of the applied nutrients may be lost through volatilization, leaching, or immobilization in the soil.	Enhance nutrient efficiency by increasing nutrient uptake and reducing losses through targeted delivery and improved solubility.
Environmental Impact	Contribute to environmental pollution through runoff, leaching, and emissions of greenhouse gases during production and application	May offer environmental benefits by reducing nutrient losses and minimizing the need for excessive fertilizer application, thus mitigating environmental impacts.
Cost and Availability	Widely available and relatively inexpensive compared to nano fertilizers, which may require specialized manufacturing processes and technologies	May be more expensive to produce and purchase initially, but their potential benefits in terms of nutrient efficiency and environmental impact could justify the higher cost in the long run.
Application Methods:	Typically applied through broadcasting, foliar spraying, or incorporation into the soil.	May require specific application methods to ensure efficient uptake by plants, such as foliar application or incorporation into irrigation systems.

Mode of Application of Nanofertilizers

The application techniques of nano-fertilizers are versatile and can be customized to meet the needs of different crop varieties a few typical application techniques are given below.

- **Soil application:** Nano fertilizers can be administered directly to the soil surrounding a plant's root zone or combined with soil during land preparation. With this technique, the plants will receive nutrient releases gradually over time.
- **Seed Treatment:** Before sowing, Nano fertilizers can be applied to seeds. This promotes early growth and vigor by enabling direct nitrogen intake by the growing plants.
- **Foliar Spray:** Nano fertilizers can be sprayed into plant leaves after being dissolved in water. By avoiding soil nutrient limits thus increasing nutrient uptake efficiency.
- **Dusting:** Nano fertilizers can be applied to plants or the soil's surface in powdered form. This technique works well for giving targeted nutrient supplementation, and it can be especially helpful for certain nutrient-deficient plants.
- **Fogging:** Nano fertilizers can be administered as a mist or fog after being atomized into tiny droplets. By covering the entire surface of the plant, this technique facilitates effective nutrient absorption via the stomatal and cuticular channels.

- **Emulsion:** To be applied, Nano fertilizers can be combined to create emulsions. Emulsions guarantee that nanoparticles are distributed uniformly and make it easier for them to enter plant tissues or the soil.

The selection of an application method is contingent upon various aspects, including crop type, development stage, nutritional requirements, and environmental circumstances. Each approach has its own advantages. Farmers can choose the best application technique.

Synthesis of Nanofertilizers

Synthesizing nanofertilizers involves the production of nano-sized particles containing essential nutrients for plants. These nanoparticles are designed to enhance nutrient uptake, improve fertilizer efficiency, and promote sustainable agriculture. Here's a general overview of the synthesis process:

1. **Selection of Materials:** Choose the appropriate materials for the nanoparticles based on the nutrients required by the target plants. Common nutrients include nitrogen (N), phosphorus (P), potassium (K), and micronutrients like iron (Fe), zinc (Zn), and manganese (Mn).

Nanoparticle Synthesis Methods:

- **Chemical Synthesis:** Involves chemical reactions to produce nanoparticles. Common techniques include co-precipitation, sol-gel, hydrothermal synthesis, and chemical vapor deposition.
 - **Physical Methods:** Utilize physical processes to create nanoparticles, such as grinding, milling, or vapor condensation.
 - **Green method: Biological Synthesis:** We can use microorganisms, plants, or enzymes to synthesize nanoparticles. For example, certain microorganisms can reduce metal ions to form nanoparticles.
 - **Plant Extracts:** Utilize plant extracts rich in phytochemicals as reducing and stabilizing agents for nanoparticle synthesis.
2. **Surface Modification:** Modify the surface of the nanoparticles to improve stability, dispersibility, and interaction with plants. Surface functionalization with organic molecules or polymers can enhance these properties.
 3. **Characterization:** Characterize the synthesized nanoparticles to ensure their size, shape, composition, and surface properties meet the desired specifications. Techniques like transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR) are commonly used.
 4. **Encapsulation:** Nanoparticles can be encapsulated within biocompatible materials like polymers or lipids to protect them from aggregation, degradation, and nutrient leaching.
 5. **Compatibility Testing:** Evaluate the compatibility of nanofertilizers with different soil types, crops, and environmental conditions through laboratory studies and field trials.
 6. **Scale-Up and Production:** Once the synthesis method is optimized, scale up the production to meet commercial demands while ensuring consistent quality and safety standards.
 7. **Monitoring and Evaluation:** Continuously monitor the effects of nanofertilizers on plant growth, nutrient uptake, soil health, and environmental impact. Adjust the formulation and application strategies as needed based on feedback from ongoing studies.
 8. **Regulatory Compliance:** Ensure compliance with regulatory requirements and safety.

Advantages and Disadvantages of Nanofertilizers

ADVANTAGES	DISADVANTAGES
Nano fertilizers increase plant growth and metabolic processes like photosynthesis, which raises yield.	Reactive oxygen species production, cell death, and growth inhibition are all possible outcomes of nano fertilizers building up in plant parts.

Enhance crop plants' nitrogen uptake and use efficiency and stop nutrient loss.

Nanomaterials have the potential to be hazardous and interact with soil constituents.

Enhance the soil's ability to retain water and quality

Reactivity and variability of nanomaterials have raised safety concerns for workers

Conclusion

The world population is increasing, and so is the need to produce more food. Nutrient deficiency is a major cause of low crop productivity and significant economic losses in the agriculture sector. Despite the potential increase in crop productivity that chemical fertilizer applications offer, it is not a sustainable solution in the long term. Nano fertilizers have the scientific purpose of enhancing agricultural yields through precise seed selection, even seed distribution, proper watering, and controlled application of fertilizers. By utilizing nano fertilizers in optimal amounts, agricultural productivity can be significantly increased, surpassing the constraints associated with traditional fertilizers.

References

1. Verma K.K, Song X.-P, Joshi A, Tian D.-D, Rajput V.D, Singh, M, Arora J, Minkina T, Li Y.-R. Recent Trends in Nano Fertilizers for Sustainable Agriculture under Climate Change for Global Food Security. *Nanomaterials* 2022, **12**, 173.
2. Gade A, Ingle P, Nimbalkar U, Rai M, Raut R, Vedpathak M, Jagtap Pand Abd Elsalam K.A. 2023. Nanofertilizers: The Next Generation of Agrochemicals for Long-Term Impact on Sustainability in Farming Systems. *Agrochemicals*. **2**, 257–278.
3. Zulfiqar, F., Navarro, M., Ashraf, M., Akram, N. A., and Munné-Bosch, S. (2019). Nanofertilizer use for sustainable agriculture: Advantages and limitations. *Plant Sci.*, 110270.