

# Nano-Fertilizers in Agriculture: An Emerging Era of Research

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Nano-fertilizers hold potential to fulfil plant nutrient requirements, ensure farmers profitability and impact sustainability to crop production system without compromising on crop yields. Nanotechnology employs nanomaterials in the range of 1nm to 10nm, particles in this range unique characteristics having effective interaction at target sites. Nanotechnology is a possible route for sustainably and precisely attaining for which nanoparticles for use in plant sciences, organic and composite nanomaterials have been tested on various plant to assess their potential impact on plant growth, development and productivity. The influence of nanoparticles on plants depends greatly on the intrinsic properties like size, shape, surface area, surface charge, etc. and extrinsic nano bio interactions of the nanoparticles. At nano scale, physical and chemical properties of nano fertilizers are dynamic and different from their counterparts. Nanoparticles are very small and having different properties than 1 Nanometre =  $10^{-9}$  m = 1 billionth of a meter.

## Why nano fertilizer introduced

A Nano fertilizer refers to a product that delivers nutrients to crops in one of three ways. The nutrient can be encapsulated inside nanomaterials such as nanotubes or nanoporous materials, coated with a thin protective polymer film, or delivered as particles or emulsions of nanoscale dimensions. Owing to a high surface area to volume ratio, the effectiveness of nano fertilizers may surpass the most innovative polymer-coated conventional fertilizers, which have seen little improvement in the past ten years.

Ideally, nanotechnology could provide devices and mechanisms to synchronize the release of nitrogen (from fertilizers) with its uptake by crops; the nano fertilizers should release the nutrients on-demand while preventing them from prematurely converting into chemical/gaseous forms that cannot be absorbed by plants. This can be achieved by preventing

nutrients from interacting with soil, water and microorganisms, and releasing nutrients only when they can be directly internalized by the plant.

## Types of Nano fertilizer

Nano fertilizers contain nanosized particles, which plants can absorb and improve crop yields. They are the product of a new technology with potential applications in agriculture, but their classification has some inconsistencies. However, some definitions also include other products, such as nanoscale delivery systems and nano biosensors. The scientific community has been perplexed by the contradictory definitions of nano fertilizers. For instance, nano fertilizers are classified as a subset of nanotechnology and as a type of fertilizer. This uncertainty has led to a lack of clarity on the definition and categorization of nano fertilizers, which may lead to misunderstanding when debating their use and possible advantages.

Nano fertilizers can also be classified based on the material used. For example, some nano fertilizers are made with carbon nanotubes, while others are made with polymers or metals. Each type of Nano fertilizer has different properties and can have different effects on plants. Here in this review, they are broadly classified based on the nutrients they carry, the actions they perform, and consistency. Understanding the nature of Nano fertilizer is essential to find the best application method. Nano fertilizers can be applied to plants through foliar, water, and soil application.

## Nano fertilizer types:

### Action based

- Controlled release
- Target delivery
- Plant growth stimulating
- Water and nutrient loss controlling

### Nutrient based

- Inorganic

- Organic
- Hybrid
- Nutrient-based

#### Consistency based

- Surface coated
- Synthetic polymer coated
- Biological products based
- Nanocarrier based

#### Macronutrient Nano fertilizers

- Nano Nitrogen-based
- Nano Phosphorous-based
- Nano Potassium-based
- Nano Calcium-based
- Nano Magnesium-based
- Nano Sulphur-based

#### Micronutrient Nano fertilizers

- Nano Boron-based
- Nano Copper-based
- Nano Iron-based
- Nano Zinc-based

#### Methods to apply nano fertilizer

There are three primary methods of nano fertilizer application,

- ✓ foliar
- ✓ seed nano priming
- ✓ soil treatment

#### Advantages of Nano fertilizers over Conventional Chemical Fertilizers

- ✓ Greater Surface Area
- ✓ High Solubility
- ✓ Encapsulation of Fertilizers within NPs
- ✓ Easy Penetration and Controlled Release of Fertilizers
- ✓ High Nutrient Absorption Efficiency
- ✓ Effective Duration of Nutrient Release
- ✓ Improved Microbial Activity
- ✓ Improved Soil Activity
- ✓ Ecofriendly Nature
- ✓ Stimulates Plant Growth

#### The Benefits of Nano Fertilizers in India

As a result of the steady rise in world population, the demand for agricultural crops has increased drastically. Because of this, farmers have been forced to use conventional fertilizers and pesticides to increase their crop yield which contain chemicals that can be dangerous to both humans and the environment. But in all of this, there's a positive development as well. The need for environmentally sustainable options has encouraged innovation and has led to Nanotechnology being applied to agriculture, thus resulting in Nano Fertilizers. With more than 54% of its land classified as arable, India is one of the leading agricultural-producing countries. In terms of employment, there are about 151 million who depend on agriculture and related activities for their livelihood. Overall, the agricultural industry contributes to about 18% of the country's GDP and this share increases every year with improvements in technology.

#### Challenges

##### Cost

- The cost of producing nano-fertilizers is higher than conventional fertilizers due to the advanced technology and production methods used.
- This has made them unaffordable for small farmers and resulted in limited access to this technology.

##### Quality Control

- The production of nano-fertilizers requires strict quality control measures to ensure their effectiveness and safety.
- However, the lack of standardized regulations for their production and distribution has resulted in poor quality control and inconsistent results.

##### Environmental Concerns

- There are concerns about the potential environmental impact of nano-fertilizers, such as their long-term effects on soil health, water quality, and ecosystem balance.

- These concerns must be addressed through proper testing and regulation to ensure their sustainable use

### Conclusion

In present situation we are facing great challenges particularly due to an increase in world population and change in climate, the adverse climatic conditions effect the agriculture crop system i.e., reduce the yield and production quality, the implication of nanotechnology and introduction of

nanomaterials in agriculture, which improve sustainability. It enhances the efficient use of fertilizers and pesticides by using nanoscale carriers and compounds without loss of productivity. It also used for reducing the waste and efficient reuse of waste. Introduction of biosensors play a very important role to detect nutrients and contaminants, based on information we can provide recommend dose nutrients at the same time we can find the remedies for contaminants.

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