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Nanofertilizers: The Next Generation Fertilizer

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Abstract

Agriculture is the backbone of our country. 35-40 % of the crop productivity depends upon fertilizers. Fertilizer is essential for the higher productivity but enormous quantity of fertilizers are being dumped in the cropped fields leading to loss of nutrients by leaching, denitrification and volatilization and causes eutrophication of water bodies. So, the development and adoption of nano-based fertilizers in Agriculture would help to reduce the adverse effects on environment.

Introduction

Farmers normally have a practice of mixing bulk quantity of different fertilizers of their need manually and broadcasting the same to crop fields. This conventional practice of fertilizer application results in uneven distribution of nutrients which leads to low efficiency of nutrient assimilation and crop response.

Nanotechnology is an emerging tool it deals with structures in size range between 1 to 100 nm. Nanotechnology helps for enhanced bioactivity and bio-availability these types of fertilizer can lead to a era of agriculture revolution (Gutierrez *et al.*, 2011). Here comes the role of nanofertilizer. It can be synthesized by fortifying the nutrients in combination or singly on to the absorbents with nano dimension. Nanofertilizer is the product which delivers nutrients to crops in different ways like the nutrient can be encapsulated inside nano-materials such as nanotubes or nano-porous materials, coated with a thin protective polymer film and it is delivered as emulsions or particles of nanoscale dimensions. The uses of nano fertilizer in soil reduce the toxicity of excessive consumption of fertilizers in soil and reduce the frequency of application of fertilizers.

Nanofertilizers

Nutrients are fortified singly or in combination on to the absorbents with nano dimension are nanofertilizers. Fertilizer particle can coated with nano membranes that facilitate in steady and slow release of nutrients this process helps to reduce loss of nutrients while improving fertilizer use efficiency of crops.

Preparation of Nano Fertilizers

Nano particle synthesis can be done by top down and bottom down approach. Without bouncing the particle atomic reactions, the nano objects and materials are created by larger entities in top down approach. But top down approach is practiced less compared to bottom down approach. Top down approach methods includes, chemical methods, milling or attrition, and volatilization of a

solid followed by condensation of the volatilized components (Ghorbani, 2014).

In the bottom up approach molecular components of their own is used for construction of different materials and devices. In the bottom up approach molecular components of their own is used for construction of different materials and devices. In bottom up approach methods includes sol gel processing, chemical vapour deposition, atomic or molecular condensation, laser pyrolysis and plasma or flame spraying synthesis. Nanofertilizer is eco-friendly and improves soil aggregation, moisture retention and carbon build-up. It is suitable for all crop varieties like food grains, vegetables and horticulture and there is no health hazard of using nanofertilizers.

Methods used for Nanofertilizer Delivery to Plants

In Vitro Methods

1. Aeroponics

In this technique, the nutrient solution is sprayed continuously and roots of the plant are suspended in air. Gaseous environment around the roots can be controlled by this method. However, the use of aeroponics is not

widespread because it requires a high level of nutrients to sustain rapid plant growth.

2. Hydroponics

The plants are grown with their roots are immersed in a liquid nutrient solution (without soil) and this method is commonly known as solution culture. Maintenance of oxygen demands, volumes of nutrient solution, and pH are factors that need attention while using this method of nutrient delivery.

In Vivo Methods

1. Soil Application

Chemical and organic fertilizers are supplemented by soil application. The factors that need attention while choosing this method of fertilizer applications are pH of the amendment, how long the fertilizer will last in the soil, soil texture, soil salinity, plant sensitivities to salts and salt content.

2. Foliar Application

In this method, liquid fertilizers are directly sprayed onto the leaves. Generally, trace elements are supplied by foliar application. It reduces the time lag between application and uptake of nutrient by plant from soil.

Table 1: Comparison of nanofertilizers and conventional fertilizers applications (Cui *et al.*, 2010)

Properties	Nanofertilizers	Conventional fertilizers
Solubility and dispersion of mineral micronutrients	Improve solubility and dispersion of insoluble nutrients in soil, reduce soil absorption and fixation and increase the bioavailability	Less bioavailability to plants due to large particle size and less solubility
Nutrient uptake efficiency	Might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer resource	Bulk composite is not available for roots and decrease efficiency
Controlled-release modes	Release rate and release pattern of nutrients for water-soluble fertilizers might be precisely controlled through encapsulation in envelope forms	Excess release of fertilizers may produce toxicity and destroy ecological balance of soil
Effective duration of nutrient release	Nanofertilizers can extend effective duration of nutrient supply of fertilizers into soil	Used by the plants at the time of delivery, the rest is converted into insoluble salts in the soil
Loss rate of fertilizer nutrients	Reduce loss rate of fertilizer nutrients into soil by leaching and/or leaking.	High loss rate by leaching, rain off and drift.

Future Perspectives

Future studies must be focused on generating comprehensive knowledge in these underexplored areas in order to introduce this novel frontier in sustainable agriculture. Consequently, nanofertilizer application safety and the study of the toxicity of different nanoparticles used for nanofertilizer production must be a research priority. Furthermore, an in-depth evaluation of the effect of nanofertilizers in the soils with different physio-chemical

properties is necessary in order to recommend a specific nanofertilizer for a specific crop and soil type. Biosynthesized nanoparticles-based fertilizers and nano-biofertilizers should be explored further as a promising technology in order to improve yields while achieving sustainability.

Conclusion

Nanofertilizers have the potential to enhance nutrient use efficiency, reduce the toxicity of the soil, reduce the frequency of fertilizer application, controlled

release of nutrient elements, decreased nutrient loss, enhance the agriculture production and help to achieve food security. This emerging new science and technology, raises hope for new innovations in the field of fertilizers which can improve nutrient uptake and enhance fertilizer use efficiency. Use of these nanofertilizers can act as a boon to the farming society, if properly established.

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