NEW ERA AGRICULTURE MAGAZINE

Nano Fertilizer application in Agriculture

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Introduction:

The term "Nano" means one billionth part of a meter and is adapted from the Greek word meaning "dwarf." Particles with at least one dimension less than 100 nm are considered as "nanoparticles". There are various types of Nano-materials such as single or multiwalled nanotubes, magnetized iron nanoparticles, copper (Cu), aluminum (Al), silver (Ag), gold (Au), zinc (Zn) and zinc oxide (ZnO), silica (Si), cerium oxide (Ce2O3), and titanium dioxide (TiO2). Important properties of nanoparticles are they have high surface area to volume ratio which makes them suitable for developing need based products with higher efficiency. In this context, application of nanotechnology for the development of new types of fertilizers is regarded as one of the potentially promising option for significantly boosting global agricultural production. A correct application of Nano-fertilizers can feed plants gradually in a controlled manner along with the benefits of increasing the fertilizer use efficiency and reducing the environmental hazards. Nano-fertilizers have the potential to increase crop productivity by enhancing seed germination, seedling growth, photosynthesis rate, nitrogen metabolism, and protein and carbohydrate synthesis, aside from improving stress tolerance. Among other advantages, Nano-fertilizers can be applied in a comparatively smaller amount, ultimately reducing the transport expenditures and increasing ease of application.

Uses of Nano-fertilizers in Agriculture

Nano-fertilizer applications in agriculture may serve as an opportunity to achieve sustainability towards global food production. There is a tremendous food production pressure on the sector as nutritional deficiencies in human populations are mainly because of using less nutritious food and a low dietary intake of fruits and vegetables. Nano-fertilizers are eco-friendly and increases nutrient use efficiency (NUE) more than three times and 80-90 times less requirement than chemical fertilizers, 10 times more stress tolerant by the crops, 30% more nutrient mobilization by the plants and 17-54% improvement in the crop yield. Nano-fertilizers play a vital role in the improvement of yield in comparision to conventional fertilizers in the wide array of crops.

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Nano-fertilizers increase the bioavailability of nutrients through their high specific surface area, miniature size and high reactivity. On the other hand, by providing balanced nutrition, Nano-fertilizers enable the plant to combat various biotic and abiotic stresses, with overall clear advantages. However, the extensive use of Nano-fertilizers in agriculture may have some important limitations, which must also be considered.

Some of unique properties of Nano particles-

- Nanoparticles having smaller size, larger surface area.
- Increased surface area to volume ratio.
- Nanotechnology able to achieve the phenomena of delivering the required product at cellular level, so its technology is more advantage than the conventional methods.
- Slow release.
- Specific release.

Problems with conventional fertilizer

- Highly prone to losses.
- Pollution of environment.
- Low nutrient use efficiency.

Nano technological approach to enhance nutrient use efficiency

Encapsulation of fertilizer with nanoparticles; it is packaging the fertilizer within a kind of tiny "envelope" or shell.

Slow delivery: Coating, binding of nano and sub nano composites are able to regulate the release of nutrients from the fertilizer capsule.

Smart Delivery System: Smart delivery includes timely controlled, spatially targeted, self regulated, pre-programmed, avoid biological barrier to successful targeting.

Nano biosensor: Under nutrient limitation, crops can secrete certain compounds into rhizosphere to enable biotic mineralization of N or P from SOM and associated with soil organic colloids,

These root exudates can be considered as environments signals that can be recognized by nano biosenser and release of nutrient occur that synchronize with the plant need.

Limitations of Nano-fertilizers-

Recent progress is undoubtedly witnessing the successful use of some Nano-fertilizers for achieving enhanced crop productivity. However, the deliberate introduction of this technology in agricultural activities could result in many unintended non-reversible outcomes. In this scenario, new environmental and unintended health safety issues can limit the use of this technology in agriculture. Importantly, Nano-materials are very reactive because of their minute size with enhanced surface area. Reactivity and variability of these materials are also a concern. This raises safety concerns for farm workers who may become exposed to xenobiotics during their application. These include not only those exposed to Nano-fertilizer manufacturing but also Nano-fertilizer application in the field. Hence, it is crucial to consider the advantages of Nano-fertilizers, but also their limitations before market implementation.

Conclusion-

Nano-fertilizers have potential to increase crop productivity through slow or controlled delivery of nutrients required for plant growth, due to their small size and target specificity, they increase the use efficiency of the fertilizer and helps in reducing negative impact of fertilizers on environment. The availability and production process involved in nano-fertilizers is very complex because of lack of technologies and expertise in the field. Future studies must be focused on generating comprehensive knowledge on nanotechnology in order to achieve sustainable agriculture.