

Nano Fertilizers- Nature's Boost

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SUMMARY

Nano fertilizers are an advanced form of plant nutrients developed using nanotechnology, where materials in the size range of 1- 100 nm are used to enhance nutrient efficiency. These fertilizers are coated or encapsulated to ensure controlled and slow release of nutrients, improving plant uptake and reducing losses. Various application methods such as foliar spray, soil and root application have shown promising results in different crops. Studies indicate increased germination, productivity and nutrient use efficiency. Although they may seem costly initially, their long-lasting effects and reduced application frequency make them economically beneficial. However, concerns about nanoparticle accumulation and potential health and environmental risks still exist, requiring further research.

INTRODUCTION

Agriculture has developed in tandem with human evolution. Conventional agriculture relies on the regular application of fertilizers and traditional agricultural methods, which can greatly increase crop growth, yield, productivity, and nutritional value. While these methods have greatly increased production, they also have a number of negative effects, such as lowering soil nutritional quality, reducing resistance to pests and diseases, and negatively affecting the environment. In order to address these issues, new technology has been developed.



A Brief Overview of Nano Fertilizer:

In the modern era, nanotechnology and its related applications have become extremely significant. Materials and particles handled at the nanoscale range of 1–100 nm are referred to as nanomaterials. Nano fertilizer are nutrients that have been coated or encapsulated in nanomaterials to allow for controlled release and gradual soil diffusion.

Methods of Application:

Numerous application strategies, such as foliar spraying, soil or root application, and combination methods, have been investigated in studies involving a variety of crop species. This application approach was demonstrated in a study on *Curcubitta pepo* [pumpkin], where it was observed quickly and led to improved plant responsiveness and water retention capabilities. It has been shown that foliar spraying nano fertilizer can either decrease fertilizer consumption or even boost crop production.

How it Works:

Traditional fertilizers have low uptake efficiency; thus considerable volumes must be applied. The low nutrient uptake efficiency and rapid transformation into chemical forms that plants cannot use are the two biggest problems with fertilizers based on phosphorus and nitrogen. Due to the rise in eutrophication and the release of harmful greenhouse gases, this has had a detrimental effect on the soil and the environment. With no associated negative effects, nano fertilizers may help increase nutrient usage efficiency by releasing nutrients gradually. These nano fertilizers are made to ensure environmental safety by reducing nutrient loss significantly and delivering nutrients gradually over an extended period of time. In order to enhance agricultural nutrient usage efficiency and avoid eutrophication. Perhaps the best choice would be nano fertilizers. Aggregation happens first when nano fertilizers are introduced to the soil, reducing the area of action. As the aggregates get bigger, they become less mobile in porous materials. Therefore, the mobility of NPs can be increased or decreased depending on the amount of organic matter in the soil, the surrounding environment, and the chemical characteristics of the nano fertilizers. Furthermore, there are numerous ways in which nano fertilizers might affect the activity of soil microorganisms. Both the horticultural and agricultural sectors are facing pressure to use alternative fertilizers instead of chemical fertilizers in order to achieve significant efficiency in food security. Numerous nano fertilizers, including N, K, P, Zn, Fe, Cu, Mn, Mo, and CNTs, have demonstrated remarkable targeted delivery when applied to a variety of crops at a particular concentration.

Effects on Nano Fertilizers:

Numerous scientists have stated that Nano fertilizers affected the growth of seeds and the production of plants. It also causes the fruits to be more succulent and nutritious than normal. Nano formulation of zinc oxide demonstrated higher germination rate and root vigour as compared to bulk zinc sulphate positively impacted on soya bean seed germination. According to Kale and Gawade, in Zn-deficient soil, the addition of ZnO NPs to other fertilizers boosted barley productivity by 91% and improved the nutrient use efficiency when compared to that of the control; however, bulk ZnSo₄ increased the productivity by only 31% when compared to that of the control. Moreover, research has shown that using “controlled release fertilizer” decreases nitrogen leaching and run off loss by 25% and 22% respectively. Which also increases wheat yield and soil residual mineral nitrogen by 6% and 10% respectively.

Comparative Advantage:

The composition of Nano fertilizers can facilitate the efficient nutrient uptake, soil fertility restoration, ultra-high absorption, increased photosynthesis, increased production, reduced soil toxicity, decreased frequency of application, increased plant health, and reduced environment pollution.

Cost Effectiveness:

Although compared to conventional fertilizers that are available in India, Nano fertilizers may seem like an expensive investment. However, their higher nutrient absorption and reduced wastage ultimately lead to cost savings for farmers. Moreover their long-lasting effects reduce the need for frequent applications making them more economically viable in long run.

Limitations:

The accumulation of Nano particles, in plants and potential health concerns. It is reported that inhalation of Nano particles, during applications caused chronic lung effects and exposure to metal based Nano particles cause skin irritation, rashes, headaches. These include not only those exposed to Nano particles application in the field. Some studies have reported Phyto toxic effects of Nano particles due to bioaccumulation. The impact of nutrition in supplying such molecules in pastures through a transformation within poorly understood. It is unknown whether all Nano fertilizers are converted into ionic forms in the plants and then incorporated into proteins and other metabolites or whether some survive intact and reach consumers through the food chain, this remains an open question. Another major concern regarding Nano fertilizers is their potential impact on non-target organisms. Studies have demonstrated that exposure to NPs can cause adverse effects in various organisms including insects, fishes, birds.

CONCLUSION:

Nano fertilizers represent a promising innovation in sustainable agriculture by improving nutrient use efficiency and reducing environmental impacts. They help enhance crop productivity, soil health, and resource conservation. Despite their advantages, careful usage and further studies are necessary to address potential risks and ensure safe and effective adoption in the future.

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