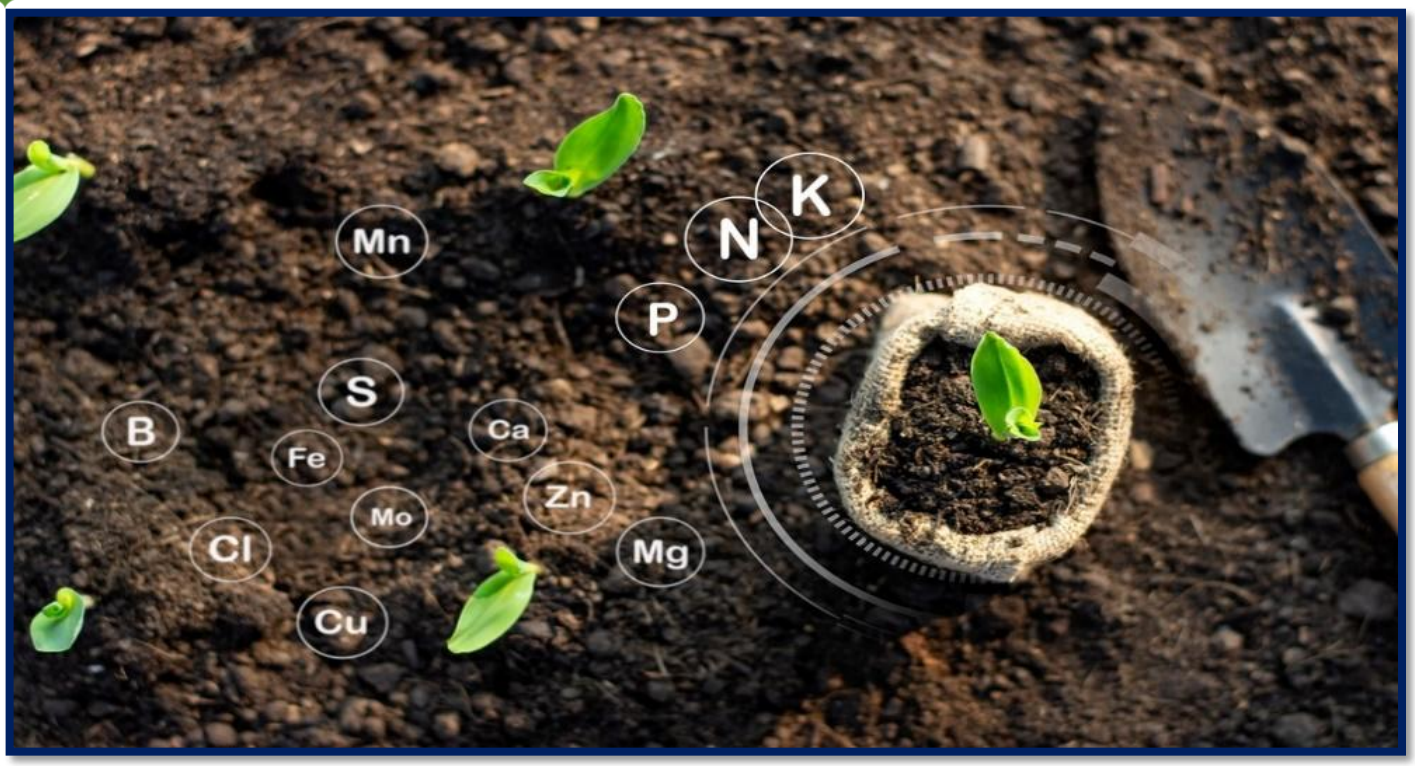
Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791



Nano fertilizers

A Revolutionary Approach for Enhancing Nutrient Use Efficiency and Crop Productivity

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Received: November, 2023; Accepted: November, 2023; Published: January, 2024

Abstract

Nano fertilizers are most important tools in agriculture for improving crop growth, yield, and quality characteristics while increasing nutrient use efficiency, reducing fertilizer waste, and lowering cultivation costs. Nano-fertilizers are extremely effective for accurate nutrient management in precision agriculture. Agriculture with crop growth stage matching for nutrition and may give nutrient during the crop growing phase. Nano-fertilizers boost crop growth to optimal levels. A further rise in level may limit crop development due to nutrient toxicity. Nano-fertilizers offer the surface area available for various metabolic reactions in the soil. Plants that improve the rate of photosynthesis and produce greater dry matter and crop production. The level of food grain production has become a source of concern due to a declining trend over the past ten years. Nanofertilizers are essential for protecting soil fertility and increasing crop productivity as well as quality. Traditional fertilisers are not only expensive for the grower, but they are also potentially hazardous to persons and the environment. As a result, people are looking for environmentally friendly fertilisers. Nanotechnology is developing as a possible option, particularly for those with great nutrient-use efficiency. Because of their high ability to increase nutrient consumption, nanofertilizers can help with nutrition control efficiency. Although the use of nanofertilizers in agriculture provides numerous options to increase plant nutrition and stress tolerance in order to obtain higher yields in the face of changes in the climate, not all nanomaterials will be equally secure for all uses. The potential risks of nanofertilizers should be thoroughly tested before use, and further biotechnology developments are required for a successful application of nanomaterials in agriculture that is correct and safe. Nanofertilizers are one of the most intriguing alternatives to conventional fertilisers. These synthetic materials are made up of nanoparticles which contain macro- and micronutrients and are given to plants rhizosphere in a controlled manner. The vital nutrients and minerals (such as calcium) found in nanofertilizers. The elements (N, P, K, Fe, and Mn) are bound either alone or in conjunction with nano dimensional adsorbents.

Introduction

A nano-fertilizer is a product that provides plant nutrients by encapsulating the nutrients inside nano-materials or nano-porous materials, or by coating the nutrients with a thin protective polymer coating. A nanofertilizers have such distinct physicochemical features that they can satisfy plant root requirements with greater productivity than conventional fertilizers. The usage of nanoscale fertilisers may aid in reducing nutrient loss, leaching/run-off and limit its rapid deterioration and instability, hence improving nutrient availability. Long-term crop productivity is promoted by improving fertility and soil quality. Furthermore, due to the high surface area-to-volume ratio and excellent penetrating ability nanofertilizers may be an excellent substitute to chemical fertilisers. Furthermore, the use of nanofertilizers or "nano-biofertilizers," can minimise environmental hazards to a large extent. According to some investigations, nanofertilizers may increase crop production by 10%, promoting seed germination, nitrogen metabolism,

photosynthesis, and protein synthesis. Nanofertilizers technology is very innovative and scanty reported literatures are available in the scientific journals. Nutrient use efficiencies of conventional fertilizers hardly exceed 30-35 %, 18-20 % and 35-40 % for N, P and K respectively. For the past few decades, the data has remained consistent, and study efforts have produced no positive results. Nano-fertilizers are nutrient carriers produced employing substrates with nano diameters ranging from 1 to 100 nm. Nano particles have extensive surface area and capable of holding abundance of nutrients and release it slowly and steadily such that it facilitates uptake of nutrients matching the crop requirement without any associated effects of customized fertilizer inputs. A judicious application of NPK in conjunction with S, Zn, B, and Mo will be an efficient solution for increased grain production of pulses in red soils as well as lateritic soils. Appropriate NPK fertilization boosted green and blackgram yields by 13% and 38%, respectively. Nano-fertilizers and nano composites have the potential to be used to regulate nutrient release from fertiliser granules in order to increase the efficiency of nutrient utilisation while preventing the nutrient ions from getting fixed or lost to the environment. Nano-fertilizers limit the release of nutrients, reducing the impact on the environment and the pollution of soil. With very small sizes (less than 100), nanoparticles (nm) can be utilised as fertilizer material for nutrient management that is both efficient and environmentally conscious. However, just like any other fertiliser, the use of Nanofertilizers have some limits and drawbacks. In this review, we will try to highlight the necessity for and use of nanofertilizers for environmentally friendly and smart agriculture.

Polymers used into slow released nanofertilizer

Polymer helps in the regulated release of nutrients, which can be used in the production of polymer coated nanofertilizer as smart fertilizer. The matrix architecture of polymeric nanoparticles is made up of biodegradable and biocompatible polymers of synthetic or natural origin. The most common synthetic polymers include polylactide, polylactide-polyglycolide copolymers, and polylactide-polyglycolide copolymers. Polycaprolactones and polyacrylates are examples of polycaprolactones and polyacrylates. Among the many natural polymers, alginate, albumin, and chitosan have all been widely used explored. Chitosan nanoparticles are biodegradable polymeric chitosan nanoparticles. 78 nm in size were employed for the controlled release of Fertiliser NPK. Phosphorous fertilizer releasing pattern expanded by surface modification of fertiliser using various nano clays and zeolite. It has been demonstrated that nano-formulations release phosphate over a time of 40-50 days, and the Conventional fertilisers release nutrients for only 10-12 days.

Commercial nanofertilizers

Nano Urea

The term "nano urea" refers to urea in the form of a nanoparticle. It is a nutrient (liquid) used to deliver nitrogen to plants as a replacement to urea. Urea is a white chemical nitrogen fertiliser that artificially delivers nitrogen, a key ingredient for plants. It is designed to replace

conventional urea and can reduce the need for it by at least 50%. In a 500 mL container, it contains 40,000 mg/L of nitrogen, which is similar to the nitrogen nutritious impact delivered by one bag of ordinary urea. Its goal is to eliminate the uncontrolled and excessive use of conventional urea, boost crop production, and decrease soil, water, and air pollution. While conventional urea has an efficiency of roughly 25%, liquid nano urea has an efficiency of 85-90%. The plant absorbs nano urea liquid sprayed straight onto the leaves. A bottle of nano urea can efficiently replace at least one urea bag. The liquid nano urea is available in a half-litre bottle for Rs 240 and is now subsidy-free.

Nano DAP

India launches the world's first Nano-DAP, developed by IFFCO. By incorporating it in the Fertiliser Control Order, the Centre allowed the commercial distribution of Nano Di-Ammonium Phosphate (DAP) made by IFFCO, a cooperative major. The Indian Farmers Fertiliser Cooperative Limited (IFFCO) developed Nano-DAP (Di-ammonium Phosphate), a nanotechnology-based agri-input. It will include 8% nitrogen and 16% phosphorus, as opposed to 18% nitrogen and 46% phosphorus in the conventional granular bag. A nano-DAP 500 mL bottle is equivalent to a 50kg bag of normal DAP. A bottle of nano-DAP costs Rs. 600 (without subsidies), while standard DAP costs Rs. 1,350 per bag (with fertilizer subsidies).

Crop nutrition with nano fertilizers

Providing the necessary plant nutrients in the form of nano- fertilisers can help plant nutrition in two ways:

- Including the necessary nutrient elements in nanostructured substances formulations (in suspension or encapsulated).
- Nanostructured elements are embedded in the carrier complex, which may or may not be a nanomaterial. It is integrated into a matrix by absorption or adsorption. Chitosan, polyacrylic acid, clay, or zeolite are some examples.

Nano fertilizer element movement inside the plant

When a necessary plant nutrient element is present in the substrate or soil in the form of nano fertiliser, it allows for greater dissolving, quicker absorption, and assimilation by the plants. This has been proved for traditional fertilisers. N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu are examples of nutritional elements. Because of their small size, nanoparticles employed as nano fertilisers are efficiently absorbed by plant roots. These are then moved along apoplastic and symplastic pathways then they travel to the xylem, cross the endodermis, and then migrate through the vascular bundles to the different areas of the plant, this mode of transport within the facility has been recognised for sometime SiO_2 nanoparticles and mesoporous silica nanoparticles.

Advantages of Nanofertilizers

Nanofertilizers are non-hazardous and safer for individuals and the environment than traditional fertilisers. Furthermore, they improve soil fertility, productivity, and crop quality while lowering costs and increasing profit. Farmers use chemical fertilisers in vast quantities to increase crop yield since they are synthetic, meaning they are created of non-organic agricultural elements. Nanofertilizers can improve availability of nutrients to plants, reduce nutrient losses through leaching, and have a low environmental impact. Overall, the goal is

to reduce energy use, reduce nutrient losses in the environment, and do so while maintaining (or improving) the yield of crops. Because of their high potential for increasing nutrient use efficiency, nanofertilizers can help with nutrition management. Nanofertilizers enhance soil structure and water retention capacity, increase organic matter, and foster the growth of beneficial microbes. They also have humic acid and clay in them, which bind soil particles and prevent water loss through runoff and evaporation, resulting in higher crop yields and greater soil health. Nanofertilizers can more efficiently supply nutrients to the plant root region and penetrate the soil surface, allowing for greater nutrient absorption. Furthermore, nanofertilizers prevent fertiliser runoff, which can be harmful to the environment.

Drawbacks of nanofertilizer

A release of nanoparticles into the natural environment may result in soil, water, and air contamination. Nanoparticles have the ability to accumulate in soil, altering soil ecosystems and lowering soil fertility. Because of the rapid accumulation of nanotechnology in the tissues of living bodies, researchers are obligated to find the correct method and doses of Nano fertilisers for the various plants, in addition to the attempt to use fertiliser environment friendly with high efficiency on growth and yield. Many nanotechnology products have been employed in agriculture as fertilisers, insecticides, and water purification, and as their use expands, we must move quickly to be aware of the potential benefits on human health and the environment. Nano-fertilizer manufacture necessitates stringent quality control methods to assure its efficacy and safety.

Conclusion

Nano fertilizers, which have various advantages over conventional fertilisers, have emerged as a promising tool for sustainable agriculture and global food security. Controlled release, targeted distribution, plant growth stimulation, and reduced water and nutrient loss are among the benefits. With the world's population predicted to surpass 9 billion by 2050, the development of nano fertilizers could become critical in addressing the growing need for food while minimising environmental implications. Finally, the development of nano fertilizers represents an exciting chance to revolutionise agriculture and encourage sustainable practises. The potential of nano fertilizers to contribute a great deal to global food security and agricultural sustainability can be realised by focusing on ongoing research, addressing potential risks, fostering interdisciplinary collaboration, educating farmers, and ensuring affordability and accessibility.