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Nano-Nutrients and their Dynamic Role in Global Sustainable Agriculture for Future Generation

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Abstract

Agriculture is essential for human survival and society's long-term sustainability. Agriculture is inextricably related to civilization. Because ecologically friendly agricultural techniques may nourish ecosystems where civilization relies on ecosystem services, agriculture still is at the foundation of today's societal challenges. Sustainable agriculture is the use of agricultural techniques that safeguard ecosystems, the environment, and human health while producing enough grain, meat, plants, or any other form of life from the produce. agriculture products with a social purpose This article examines nanotechnology in agriculture, with a focus on Indian agriculture. Nanotechnology's applications in several agricultural and food sectors, including crop production, forest conservation, water conservation, water resource management, wastewater treatment, conservation land, land resource management, nutrition, drug distribution, and farm animal husbandry, aquaculture development. For the efficient implementation of nanotechnology for sustainable agriculture in India, land tenancy simplification, land mapping, and infrastructural development are necessary.

Keywords: nano fertilizer; sustainable technology; agriculture

Introduction:

Escalating nutrient use efficiency (NUE) with minimal threat to the environment has become critical for agri-food production systems (AFPS) to support the rapidly increasing population worldwide. Nanotechnology with nanoscale inputs for nanoscale agricultural inputs (NAIP) has emerged as an innovative solution to focus on low or declining Nutrient Use Efficiency (NUE) with minimal environmental footprint. Nanotechnology is a promising area of research that has the potential to provide sustainable solutions to the increasingly pressing challenges facing today's modern intensive agriculture. Nanotechnology uses nanomaterials that are typically small in size (1-100nm) that offer special properties and benefits. In addition to various other advantages, the large surface-to-volume ratio provides better and more efficient interactions between the nanoparticles and the target sites. Nano-fertilizers have the potential to meet the nutritional needs of crops while providing sustainability to crop production systems (CPS) without compromising crop yields. Absolute BioX has been at the forefront of advancing agricultural technology and new agricultural inputs to alleviate the problems faced by farmers. These nano Bio-fertilizers use dynamics of shape, size, surface, and biodegradation. This article reviews the benefits of nano fertilizers (Nano N, Nano Zn, and Nano Cu) to increase nutrient utilization efficiency and crop yield.

Nano Nutrient Application:

Nanotechnology has received a great deal of press in recent years because of its vast range of applications in fields like agriculture, medicine, medications, catalysis, energy, and materials. Nanoparticles with a small size but a big surface area (1–100 nm) can perform a variety of tasks. Nanoparticles in the food business result in foods of excellent quality and nutritional value. In comparison to standard fertilizers, nano fertilizers are being investigated as a technique to improve nutrient efficiency and plant nutrition. Any product created with nanoparticles or employing nanotechnology to improve nutritional efficiency is considered a nano fertilizer.

Although numerous approaches have been presented under the aegis of agriculture, nanotechnology in agriculture has had good momentum over the last decade thanks to ample financial investment. Agriculture's unique nature as an open system where energy and matter are freely transferred could explain this. Unlike industrial nanoproducts, where the supply of nanomaterials is uncontrolled, the scale of demand for the input material remains large. Nanotechnology is bringing new agrochemicals and delivery mechanisms to the market, with the potential to reduce pesticide use. Nanotechnology can increase agricultural yields, and its applications include (1) agricultural nano chemicals formulations for the agricultural improvement using pesticides and fertilizers; (2) application of Nanosensors in plant protection to identify diseases and residues of agrochemicals; (3) nanodevices for plant genetic engineering; (4) diagnosis of plant diseases; (5) veterinary, livestock, poultry; and (6) post-harvest management.

Maximization of Nano Fertilizers Efficiency:

The nutrient use performance in agriculture is 20-50% for N, 10-25% for P, and 30-40% for K fertilizers. It shows the want for meal manufacturing to be tons extra efficient (1). Fertilizers that are typified in nano-debris have expanded accessibility and uptake of vitamins. The usage of nano-fertilizers has a nice impact on the effectiveness of fertilizers and dietary supplement uptake via way of means of flora from soil (2). Navarro et al. (3) approved the excessive talent of nano fertilizers. The reactivity of nano-substances with different compounds is better than the ones of regular ones.

Climate Change Effects on Biodiversity, Ecosystems, and Ecosystem Service. Enhancement of vitamins penetration and plant uptake, because of the small length of nanoparticles, particular floor region, and particle quantity in step with the unit is expanded that inflicting a boom withinside the touch floor among nano-fertilizers and flora (4). Plant molecular wall pores are large than the nano-particle aggregates which makes it simpler for nano-molecules to go into the plant via the molecular wall and attain the plant molecular membrane (5). Nair et al., (6) of their research emphasized that nano-particle uptake via way of means of plant cells happens via binding to the provider protein, via aquaporin, endocytosis, or ion channels. Nano-pores and stomatal openings in plant leaves facilitate nanomaterial uptake and their penetration of deep inner leaves main to better nutrient use performance (NUE). Nano fertilizers have better delivery and transport of vitamins via plasmodesmata, which are nanosized (50–60 nm) channels among cells.

Functioning of silver Nano-Fertilizers:

Nanotechnology has immense potential uses and advantages. These include controlling disease, and insect- pests through nanomaterial-based insecticide and fungicide formulations and increasing agricultural productivity using fertilizers encapsulated in nanoparticles to release slow and maintain nutrients and water. Nanotechnology solutions, methods, and applications are predicted to contribute significantly to environmental and climate protection by lowering greenhouse gases and hazardous wastes while saving raw materials, energy, and water. In addition, many potential benefits such as improving food quality and safety, reducing agricultural inputs, enriching the nano-scale nutrient absorption capacity of the soil, and saving raw materials, energy and water.

Advantages and Role:

It helps to increase the number of flowers in the plant which results in to increase in the final product of the crop and helps to maintain hormones in the plant to give assurance of fruit fullness. It helps to fruit bud differentiation in the dormant state of the plant. It helps to reduce the flower and fruit dropping in the plant, in the vegetable crop, it will help to increase. The number of female flowers in the plant helps to germinate the healthy and strong bud after pruning. It promotes the uptake of major and micronutrients. It is specially developed to improve the metabolic activities of plants. It aids in the improvement of fruit quality by stimulating photosynthesis. It gives a high-quality crop yield.

The emergence and evolution of new pathogenic races is a continuous issue, and the use of chemicals for pest control is expensive and not always effective. In recent years, the use of nanomaterials is considered an alternative to control plant pathogens. Nanotechnology has eight systematic applications of a wide range of compounds active at different doses and frequencies, representing a wide range of selective regimens. Metal oxide nanoparticles controlled green peach aphid. Zinc oxide nanoparticles synthesized using an aqueous extract of the skin of *Punica granatum* were tested for their potential antibacterial activity against selected bacteria. In addition, this study determined the effect of synthetic ZnONPs on green peach aphids and antibacterial efficacy against standard strains of Gram-positive and Gram-negative *Staphylococcus aureus* and *Escherichia coli*. Nickel nanoparticles at a concentration of 100 ppm inhibited the growth of the fungal mycelium of *F. oxysporum* sp. *lactucae* and *F. oxysporum* f. sp. *lycopersici.* Green methods of synthesizing nanoparticles with plant extracts have the advantages of being simple, convenient, environmentally friendly, and requiring little reaction time. Nanomaterials processed using green and environmentally friendly methods can increase the potential of agriculture in improving the application of fertilizers, plant growth regulators, and pesticide delivery to plants, a chosen target location, wastewater treatment, and increasing the plant's absorption capacity nutrients. In addition, they also reduce the number of harmful chemicals that pollute the environment. Therefore, this technology helps to reduce environmental pollutants. The large surface area provided by the small, high surface area nanoparticles makes them attractive to solve challenges that are not met by different control methods. Nanotechnology applications are now being investigated, tested, and in some cases implemented across a broad range of food technology, from agriculture to food processing to packaging and functional meals. Chemical, physical, and mechanical qualities are all unique to them. In recent years, agricultural waste has gained attention as a source of renewable raw materials. Pesticide resistance is one of the prime examples of evolution occurring on ecological time scales. The study of pesticide resistance is important because it helps to better understand the evolutionary mechanisms that operate in real-time. The development of insecticide resistance in insect pests is a growing problem for agriculture and public health. General agricultural practice that includes the systematic application of a wide range of active

compounds at varying doses and frequencies

Nanotechnology has been applied in several agricultural fields including nano agrochemicals, nano fertilizers, nano pesticides, water management, wastewater treatment, disaster management, drug delivery by tube nano, plant genetics, epidemics, diagnostics, disease prevention, poultry production (e.g., nano bionic-Ag), aquaculture and fishing, pharmaceuticals, drug distribution, farm production, etc. Major agriculture in rural India suffers from a lack of land restoration and reform, where sustainability far exceeds public practices. Depending on agricultural practices, this may impede or sustain the ecosystem's ability to sustainably function to provide goods and services. To succeed in sustainable agriculture and food processing, human resources also need training and awareness (7). However, the application of nanotechnology in agriculture and food processing is in its early stages and it may take several decades to move from the laboratory to the soil and from the soil to human use, especially because it has to avoid the pitfalls to the ecosystem. The potential advantages of nanotechnology for agriculture, food, fisheries, and aquaculture must be weighed against the concerns for soil, water, the environment, and the occupational health of workers.

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