

Chapter 7

Innovations in Nanotechnology for Amelioration of Nutrient Use Efficiency in Agriculture

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ABSTRACT

Nanotechnology has drastically shepherded a magnanimous period in the global agricultural landscape. Nutrient use efficiency is one of the most imperative concepts for invigorate crop production systems, which can be influenced by various factors such as fertilizer management and soil and plant-water relationships. The nutrients are used with an objective of enhance the overall performance of crops and cropping systems by providing optimum nourishment and supporting sustainable agricultural production systems through contributions to soil fertility and other important soil quality components. Improvement in nutrient use efficiency has been today's most critical and formidable research issues. With the advent of green, modern agriculture techniques are not only confined to augment crop yield/food productivity but, aim to elevate the nutritional content of the food/crops. Various nano-structured formulations may also be developed in order to deliver active ingredients in response to environmental cues and biological demands more properly.

1. INTRODUCTION

Advanced and innovative agriculture based technology is need of the hour to overcome the apprehension of supportable food availability to meet global food demand. In recent years, advancement in nanotechnology has been exploited to resolve the problems related to agriculture. Since two decades, much research on nano-technology has been carried out in agriculture field. Appliance of fertilizers plays a fundamental role in improving the crop production; but, unnecessary fertilization also restricts the crop production due to many unavoidable factors. Therefore, sustainable farming demands the minimal use of fertilizers which do not cause toxicity and also protects the environment. Nanotechnology is the cutting-edge

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technology that has the possible potential to alter dramatically, more accurate targeted delivery, release of components in controlled manner and fulfilling the demand of nutrients in ecosystem/agriculture system using nano-formulations of plant foods/fertilizers. Nano-technology builds nano-particle based nano-fertilizers which can be made accessible to plant using plant's capability, efficiency and is able to receive real time components from a nano-fertilizer and ultimately enhances the nutrient use efficiency (NUE). Therefore, nano-technology has a great prospective for attaining regenerative farming, typically in the under developed regions.

Sustainable agriculture practices using nano-fertilizers is the main area of research in agri-technology. Soil-plant quality and conservation of climate in an ecosystem are main concern and nano-technology based nano-fertilizers are the best option without affecting the existing ecosystem. In nano-technology, extremely small size nano-particles are used which results in increased surface area and can easily penetrate in to a plant cell resulting in better absorption and enhancing the metabolic activities of the plant and ultimately raise the crop production. Nutrient use efficiency (NUE) is the most important parameter to assess the crop production It has become very exigent nowadays to improve the NUE. Nutrient components in the form of nano-fertilizers are supplied to the crops for betterment of crop/soil type to make certain the maximum crop yield.

Nano-particles may activate enzymes, releases polysaccharides and become efficient catalysts in microbial and plant metabolism (Bahrololum H et al., 2021). Nano-fertilizers produced from nano-particles improve nutrient absorption, are critical in farming sector to meet the demand of crop, superiority and perfect yield. Conventional fertilizers may result in nutrient toxicity to the plant thus limits the plant growth. But, nano-fertilizers are responsible for time bound absorption and precise use of nutrients to the crop. Efficient nano-particles are related to special regions of the crop/plant in comparison to conventional fertilizers due to their high surface area to volume ratio. Nano-particle based nano-fertilizers increases the surface of photosynthesis, helps plants to sustain in exigent environmental circumstances such as drought, high salt content, increased or decreased water supply. Nano-particle based formulations are able to release only active and required components in response to agriculture and biological demands of the plants (Wu H & Li Z, 2022; Yadav A et al., 2023). This ever growing nanotechnology is improving nutrient use efficiency and able to generate superior and useful products in farming sector and significantly enhancing the food accessibility. Nano-technology modernizes the farm demands like nano-nutrients, nano-fertilizers, nano-pesticides, nano-sensors, nano-carriers, nano-chips, nano-cellulose, quantum-dots etc. after transforming them to more competent and sophisticated farming practices. Besides all these applications, nano-technology requires more exploitation to scrutinize the side effects and gradation of nano-particles inside humans and maintaining a healthy environment. Nano-particles are small entities having high surface to volume ratio which makes possible their entry into the plant cell and enhancing metabolic process. Nano-fertilizers through foliar administration proved to be most significant in improving the productivity of the crop and also reported maximum penetration in to the seed and improving the seed germination.

2. NANO-FERTILIZERS

Nano-fertilizers potentially deliver the required nutrients in a controlled manner at their target site of the plant and minimize the wastage of nutrients to other sites. The nano-fertilizers have also been exploited in the form of nano-scale formations with better nutrient uptake by the plants thus improving the nutrient

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