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A review on nanotechnology and its implications in agriculture and food industry

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ABSTRACT

Nanotechnology a developing field of Science and Technology will leave no field untouched by its ground breaking scientific innovations. The agricultural industry is no exception. So far, the use of nanotechnology in agriculture has been mostly theoretical, but it has begun and will continue to have a significant effect in the main areas of the food industry: development of new functional materials, product development, and design of methods and instrumentation for food safety and bio-security. The effects on society as a whole will be dramatic. Recent advances in materials science and chemistry have produced mastery in nanoparticle technology, with wide ramifications in the field of agriculture. Obviously, there is an opportunity for nanotechnology to have a significant influence on energy, the economy and the environment.

Key words: Nanotechnology, Nanoparticle, Agriculture, Food industry

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INTRODUCTION

Agricultural scientists are facing a wide spectrum of challenges such as stagnation in crop yields, low nutrient use efficiency, declining soil organic matter, multi-nutrient deficiencies, climate change, shrinking arable land and water availability and shortage of labour besides exodus of people from farming. In spite of immense constraints faced, we need to attain a sustainable growth in agriculture at the rate of 4% to meet the food security challenges. To address these problems, there is a need to explore one of the frontier technologies such as 'Nanotechnology' to precisely detect and deliver the correct quantity of nutrients and pesticides that promote productivity while ensuring environmental safety and higher use efficiency. The nanotechnology can be exploited in the value chain of entire agriculture production system [4]. Nanotechnology is emerging as the sixth revolutionary technology in the current era after the Industrial Revolution of Mid 1700s, Nuclear Energy Revolution of the 1940s, The Green Revolution of 1960s, Information Technology Revolution of 1980s and Biotechnology Revolution of the 1990s. It is now emerging and fast growing field of science which is being exploited over a wide range of disciplines such as physics, chemistry, biology, material science, electronics, medicine, energy, environment and health sectors.

Nanotechnology applications in Agriculture and Food Industry

Application of Nanotechnology in Seed Science

Seed is most important input determining productivity of any crop. Conventionally, seeds are tested for germination and distributed to farmers for sowing. In spite of the fact that seed testing is done in well equipped laboratories, it is hardly reproduced in the field due to the inadequate moisture under rainfed conditions. In India, more than 60% of the net area sown is rainfed; hence, it is quite appropriate to develop technologies for rainfed agriculture. A group of research workers is currently working on metal oxide nano-particles and carbon nanotube to improve the

germination of rainfed crops. Carbon nanotube is used for improving the germination of tomato seeds through better permeation of moisture [2]. Their data show that carbon nanotubes (CNTs) serve as new pores for water permeation by penetration of seed coat and act as a passage to channelize the water from the substrate into the seeds. These processes facilitate germination which can be exploited in rainfed agricultural system.

Nanoherbicide for effective weed control

Weeds are menace in agriculture. Since two-third of Indian agriculture is rainfed farming where usage of herbicide is very limited, weeds have the potential to jeopardize the total harvest in the delicate agro-ecosystems. Herbicides available in the market are designed to control or kill the above ground part of the weed plants. None of the herbicides inhibits activity of viable belowground plant parts like rhizomes or tubers, which act as a source for new weeds in the ensuing season. Soils infested with weeds and weed seeds are likely to produce lower yields than soils where weeds are controlled. Improvements in the efficacy of herbicides through the use of nanotechnology could result in greater production of crops. The encapsulated nano-herbicides are relevant, keeping in view the need to design and produce a nano-herbicide that is protected under natural environment and acts only when there is a spell of rainfall, which truly mimics the rainfed system. Developing a target specific herbicide molecule encapsulated with nanoparticle is aimed for specific receptor in the roots of target weeds, which enter into roots system and translocated to parts that inhibit glycolysis of food reserve in the root system. This will make the specific weed plant to starve for food and gets killed [1]. Adjuvants for herbicide application are currently available that claim to include nanomaterials. One nanosurfactant based on soybean micelles has been reported to make glyphosate-resistant crops susceptible to glyphosate when it is applied with the 'nanotechnology-derived surfactant'.

Nanopesticide

Persistence of pesticides in the initial stage of crop growth helps in bringing down the pest population below the economic threshold level and to have an effective control for a longer period. Hence, the use of active ingredients in the applied surface remains one of the most cost-effective and versatile means of controlling insect pests. In order to protect the active ingredient from the adverse environmental conditions and to promote persistence, a nanotechnology approach, namely "nano-encapsulation" can be used to improve the insecticidal value. Nanoencapsulation comprises nano-sized particles of the active ingredients being sealed by a thin-walled sac or shell (protective coating). Recently, several research papers have been published on the encapsulation of insecticides. Nano-encapsulation of insecticides, fungicides or nematicides will help in producing a formulation which offers effective control of pests while preventing accumulation of residues in soil. In order to protect the active ingredient from degradation and to increase persistence, a nanotechnology approach of "controlled release of the active ingredient" may be used to improve effectiveness of the formulation that may greatly decrease amount of pesticide input and associated environmental hazards. Nano-pesticides will reduce the rate of application because the quantity of product actually being effective is at least 10-15 times smaller than that applied with classical formulations, hence a much smaller than the normal amount could be required to have much better and prolonged management. Several pesticide manufacturers are developing pesticides encapsulated in nanoparticles [3]. These pesticides may be time released or released upon the occurrence of an environmental trigger (for example, temperature, humidity, light). It is unclear whether these pesticide products will be commercially available in the short-term.

Nanofood

During the last three years, food industries have witnessed that the nanotechnology has been really integrated in a number of food and food packaging products. There are now over 300 nanofood products available on the market worldwide. These exciting achievements have encouraged a large increase of R & D investments in nanofood. Today, the Nanotechnology is no longer an empty buzzword, but an indispensable reality in the food industry. The impact of nanotechnology is huge, ranging from basic food to food processing, from nutrition delivery to intelligent packaging. It is estimated that the nanotechnology and nano-bio-info convergence will influence over 40% of the food industries up to 2015. There is a strong need to develop nanofood through nano-engineering of food ingredients. Under this, texture, taste, flavour and color of food ingredients can be modified using nano engineering without losing their nutritional value or with improved nutritional quality. Nanotechnology can extend the shelf-life of perishables like fruits, vegetables, and flowers during transportation, thus preventing the post-harvest losses.

CONCLUSION

The appearances of nanotechnology open up potential novel applications in different field of agriculture, biotechnology and food industry. Creation of nanomaterials and their application in scientific field cause a

tremendous positive change, particularly in Agriculture. Nanostructure formulation through mechanisms such as targeted delivery or slow/controlled release mechanisms, conditional release, could release their active ingredients in responding to environmental triggers and biological demands more precisely.

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