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Agronanotechnology

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Introduction :

Agriculture is the major source of income in developing countries, it provides food and fodder. Indian agriculture suffers from low productivity due to conventional farmers' practices. Indian population is increasing at alarming rate. Therefore, it is crucial time to use modern technology such as bio and nanotechnology to maintain the ever increasing demand of food crops.

Nanotechnology is defined as the branch of the science that deals with the understanding and control of matter at the dimensions of about 1-100 nm, and their implications for the welfare of humans .

Globally, a large proportion of people face daily food shortage due to changing agro-climatic conditions particularly in developing countries. The situation is even poor in developing countries. Thus, there is need to develop drought and pest resistant crops with increased minerals uptake to maximize production . Nanotechnology will increases the crop yield by withstanding environmental conditions, detection and control of crop diseases, improved crops with efficient capabilities for mineral uptake from the soil. Although the scientific studies on the applications of nanotechnology in the agriculture are less than a decade old yet the prospects of nanotechnology in this field are considerable. Nano-technology is making its way in agriculture throughout the world. Traditional farming techniques have attained saturation and are neither able to increase productivity nor able to restore ecosystems damaged by existing technologies. The global requirement of food is increasing gradually. Nanotechnology would prove a boon for modern agriculture farming by increasing the efficiency of nutrient uptake employing nano fertilizer.

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Areas of Nano-science Research in Agriculture And Food Science

Contribution of nanoscience research in agriculture will be in the following areas:

- Food safety and biosecurity.
- Material science.
- Food processing and product development.

Applications of Nanotechnology :

- **Detection and control of the plant diseases :**

  Nanoparticles may be useful in the treatment and monitoring of food crops diseases by targeting pathogens . Some of the nanoparticles are nano-forms of carbon, silver, silica and alumina silicates that are use in control of crops diseases. Nano silver is the most exploited nano particles in biological system. The capsulated nano silver removes unwanted microbes in planting soils and restricts several other plant diseases .

- **Nano-fertilizers :**

  The augmentation of fertilizers in soil is essential to supplement the soil fertility for better yield of food crops. However, the use of chemical fertilizers cause many adverse environmental effects and damaged the soil health. Thus, there is requirement a new cost effective ecofriendly technique for better crop production. In this context, the use of nano-fertilizers instead of using conventional fertilizers will assist in controlled release of nutrients in soil and prevent loss due to chemical fertilizers. In nano-fertilization, nutrients may be entraped using nano-materials coated with a thin film or delivered as emulsions. The slow release of nutrients from nanoparticles coated fertilizers increase the use efficiency of nutrient by crops.

- **Nano-pesticides :**

  In agriculture, pesticides or weedicides are used to control pests or weeds for increasing crop yield. However, they also damage the soil health. Nano-pesticide is an agro-chemical combination used to overcome the problems caused by conventional

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pesticides . Several types of materials viz., surfactants, organic polymers and mineral nanoparticles that fall in the nanometer size range are used in formulation of nano-pesticides. The new generation of nano-pesticides will be specific in action against insects and does not have any other harm to other important insects of soil.

- **Nano-sensors**

The crops growth depends on proper agro-climatic conditions. For effective protection of crops, the fast and sensitive sensors are required to detect plant pathogens. Nanosensors can be use all over the agricultural fields for monitoring the fertility of soil and other climatic conditions.

- **Nano-fibers**

Nanotechnology with use of biological, chemical and physical processes plays a role in recycling the residual materials of agricultural products to energy and industrial chemicals. For example when cotton is processed into fabric or garment, some of the cellulose or the fibers are discarded as waste or used for low-value products such as cotton balls, yarns and cotton batting. With the use of newly-developed solvents and a technique called electro spinning, scientists produce 100 nanometer-diameter fibers that can be used as a fertilizer or pesticide absorbent. These high-performance absorbents allow targeted application at desired time and location . Nano-fibers are also used for encapsulating chemical pesticides, to prevention of scattering of chemical pesticides in the environment and water and soil pollution. This technology increases the chemical pesticides durability and security applications. When the fibers are degraded through biological, chemical materials are released slowly in the soil. When hydrophobic organic pollutants are enters to the soil through water, easily absorbed by the water insoluble solids. Porous nano-polymers have a very similar to the pollutants molecules, and considered the most suitable means for separating organic pollutants of soil and water. Similar nano fiber-based fabrics are being used as a detection technology platform to capture and isolate pathogens. The nano fibers in this fabric are embedded with antibodies against specific pathogens. The fabric can be wiped across

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a surface and tested to determine whether the pathogens are present, perhaps indicating their presence by a change in colour.

- **Nano silver:**

  Nano silver is the most studied and utilized nano particle for bio-system. It has long been known to have strong inhibitory and bactericidal effects as well as a broad spectrum of antimicrobial activities. Silver nano-particles, which have high surface area and high fraction of surface atoms, have high antimicrobial effect as compared to the bulk silver. Antifungal effectiveness of colloidal nano silver (1.5 nm average diameter) solution, against rose powdery mildew caused by Sphaerotheca pannosa Var rosae. It is a very wide spread and common disease of both green house and outdoor grown roses. It causes leaf distortion, leaf curling, early defoliation and reduced flowering. Double capsulized nano silver was prepared by chemical reaction of silver ion with aid of physical method, reducing agent and stabilizers.

Nanoformulations For the Control of Plant Diseases

Nanotechnology provides new ways for improving and modifying existing crop management techniques. Plant nutrients and plant protecting chemicals are conventionally applied to crops either by spraying or broadcasting. Due to problems such as leaching of chemicals, degradation by photolysis, hydrolysis and microbial degradation, only a very low concentration of chemicals which is much below the required minimal effective concentration, reach the target site of crops.

Recent Developments

With nanotechnology gaining recognition in the agricultural and food sectors, scientists and experts in the scientific field have recently showcased their nanotechnology expertise to farmers in Africa.

Three significant innovations were demonstrated:

- The scientists have planned to develop a plastic storage bag lined with nanoparticles that are capable of reacting with oxygen and preventing cassava from rotting. In this way, the African farmers can prolong the shelf life of cassava and prevent wastage of this vegetable.

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- A milk container was designed with a nano patterned, antimicrobial coating that helps the diary farmers in Africa to preserve milk for a prolonged time period as they take almost a whole day to reach

- The cooling centers. These nanotechnology-based milk containers replace the currently used plain plastic bags.

- The scientists have also planned to develop nanopatterned paper sensors to detect bovine pregnancy in order to enable the dairy farmers determine if their cows will run dry without milk due to udder infection or pregnancy.

- Plant mineral nutrition is important for obtaining higher agricultural productivity to meet the future demands of the increasing global human population. It is envisaged that nanotechnology can provide sustainable solutions by replacing traditional bulk fertilizers with their nanoparticulate counterparts possessing superior properties to overcome the current challenges of bioavailability and uptake of minerals, increasing crop yield, reducing fertilizer wastage, and protecting the environment. Recent studies have shown that nanoparticles of essential minerals and nonessential elements affect plant growth, physiology, and development, depending on their size, composition, concentration, and mode of application. The current review includes the recent findings on the positive as well as negative effects that nanofertilizers exert on plants when applied via foliar and soil routes, their effects on plant associated microorganisms, and potential for controlling agricultural pests. This review suggests future research needed for the development of sustained release nanofertilizers for enhancing food production and environmental protection.

Plant Pathogens in Biosynthesis of Nanoparticles

Fungi:

Fungi are relatively recent in their use in synthesis of nanoparticles. There has been a shift from bacteria to fungi to be used as natural 'nanofactories' owing to easy downstream processing, easy handling and their ability to secrete a large amount of enzymes. However, fungi being eukaryotes are less amenable to genetic manipulation compared to prokaryotes.

Bacteria:

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Among microbes, prokaryotes have received the most attention for biosynthesis of nanoparticles. Bacteria have been used to biosynthesize mostly silver, gold, FeS and magnetite nanoparticles and quantum dots of cadmium sulphide (CdS), zinc sulphide (ZnS) and lead sulphide (PbS).

Plant virus:

Plant virus especially spherical/icosahedra viruses represent the examples of naturally occurring nano-materials or nano-particles. The smallest plant viruses known till date is satellite tobacco necrosis virus measuring only 18 nm in diameter. Plant viruses are made up of single or double stranded RNA/DNA as genome which is encapsulated by a protein coat.

Conclusion

Nanotechnology will play a vital role in the development of the agricultural sector, as it is capable of being used in agricultural products that protect plants and monitor plant growth and detect diseases. Scientists have been working towards exploring new applications of nanotechnology in agriculture and the food industry - if these discoveries are applied sensibly, the environment, the agricultural sector and the food industry will indeed see tremendous changes for the better in the coming years.

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