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Nano Technology in Agriculture

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Abstract
Nanotechnology has covered all the sectors even the agriculture. In last few decades nanotechnology has gained intense attention. Due to its wide applications in several areas like medicine, medical drugs, catalysis, energy and material. Nanotechnology is all about the understanding and controlling of the matter of sizes in the range of 1 -100 nm. Now a days we are working on sustainable agriculture. In the field of agriculture there is a huge scope of nanotechnology like insecticides, pesticides, fungicides, herbicides, fertilizers, and antimicrobial properties. Nanotechnology applications include nanoparticle-mediated gene or DNA transfer in plants for the development of insect-resistant varieties, food processing and storage and increased product shelf life. Nanotechnology may increase the development of biomass-to-fuel production. Nanotechnology is considered as the best option of as solution of every problem related to plant like insects, pest, fungi and weeds. In the food industries nanotechnology is leading to forming the food with high quality and good nutritive values.

(**Keywords**: Nanoparticles, Nano-chemicals, Nano-Herbicides, Nano- Pesticides, Nano-Fungicides)

Introduction
Nanotechnology is all about the size reduction of the particle in the range of 1-100 nanometers. Anything which comes in this range, it is considered as a nanoparticle. Bulk materials when reduced to the nanoscale show some properties (melting point, physical strength, surface area, penetration power, electric conductance, optical effect mangnetism etc.) which are different from what they exhibit on a macro scale enabling unique applications. At nanoscale, gravity would become less important, whereas surface tension and van der waal force would become more important. Nanoparticles are of two types natural and engineered. Nanotechnology brings together all the researcher or scientist from various field like physics, chemistry, biology and engineering. There is a revolution due to the nanotechnology in the each and every field. Nanotechnology is helping to develop processes and products that are very difficult to evolve through the conventional methods. Nanotechnology applications are nano-nutrients, nano-pesticides, insect repellants, nano-sensors, nano-magnets, nano-films, nano-filters etc. Nanotechnology has the potential to change agriculture production by allowing better management and conservation of inputs.

Concept and Basics of Nano-Science and Nanotechnology
Nanoscience is the investigation of matter at a scale which is intermediate between 'bulk matter', explain by Newtonian Physics and 'atomic matter' explained by Quantum Physics. Bulk materials possess continuous macroscope physical properties. The same applies to micro-sized material. But when particles assume nano-scale dimension, the principles of

classical physics are no longer capable of describing their behavior. At these dimensions, quantum mechanics principles apply. The same material at the nanoscale can have properties which are very different from the properties the material has at the macro scale.

There are three important "nano" terms

1. **Nanoscale:** Nano-scale objects have at least one dimension (height, length, depth) that measures between 1 and 999 nanometers (1-999).
2. **Nanoscience:** Nanoscience is a science of observing, measuring and understanding the properties behavior, functionality and phenomena of nano-sized objects due to the influence of small dimensions. In nanoscience, one studies the thermodynamics, mechanical, electrical, structural, optical and chemical property variation as a function of the physical size and shape of the material.
3. **Nanotechnology:** The prefix 'NANO' derived from the Ancient Greek word nano and later the Latin word nanus, both meaning "DWARF" and 'technology' is the application of practical sciences to industry or commerce. In short, nanotechnology depicts the application of nanoscale materials and properties to solve a problem or serve a purpose.

Nanoparticles fall into three major types

i. **Naturally occurring** - Sea spray, mineral composites, volcanic ash and viruses.
ii. **Incidental** - A result of man-made industrial processes, incidental nanoparticles include cooking smoke, diesel exhaust, welding fumes, industrial effluents, sandblasting.
iii. **Engineered** - Nanotubes, sunscreen pigment and nano-capsules.

Application of Nano-technology in Agriculture field

In today's world, the nanotechnology is the upcoming revolution after the semiconductor revolution which has the potential to open doors to completely new applications in many fields such as agriculture, information technology, medical science, energy, food safety, transportation etc.

Some of the important applications in the agriculture field

1. **Nano-fertilizers:** Nano-fertilizer technology is very innovative. Significant increase in the yield has been observed due to foliar application of nanoparticles as fertilizer. Currently research is undergoing to develop nanocomposites to supply all the required essential nutrients in the suitable proportions through the smart delivery system.
2. **Biosensors:** Nanotechnology is playing an increasingly important role in the development of biosensors. The sensitivity and performance of biosensors is being improved by using nano- materials for their construction. Portable instruments capable of analyzing multiple components are becoming available. The nano-sensors are effective device to detect the composition of the soil, the nutrients and also the toxic substances in the soil. A microbial biosensor is an analytical device with a biologically integrated transducer that generates a measurable signal indicating the analytic concentration. This method is ideally suited for the analysis of extracellular chemicals and the environment, and for metabolic sensory regulation. These microbial sensors are integrated with many more micro or nanodevices to overcome the limitation like low sensitivity, poor selectivity and impractical portability.
3. **Smart Delivery of Nutrients:** A very smart delivery system for agriculture should consider the factors or combination of factors such as time controlled, specifically targeted, highly controlled, remotely regulated/ pre-programmed release and multifunction characteristics to avoid biological barriers for successful targeted release of required nutrients.
    a) Nano-herbicides: Herbicides are chemicals used to kill weeds especially when the moisture content in the soil is not as per required by the crop. Nano-herbicides

provides better penetration in the soil and allow slow and controlled release of active ingredients in reaching the targeted weed causing minimum environment damage.

b) Nano-insecticides: The insecticides are chemicals used to kill insect and other pests that try to harm the crop. Nano-insecticides like surface modified hydrophobic nano-silica have been put to use instead of conventional insecticides as they are safe for plants and cause less environmental pollution.

c) Nano-fungicides: Fungal pathogens are a major part of the pesticides which harm the crop hence fungicides are prepared to deal separately. The small size of nanoparticles puts them to use in nano-fungicides as they penetrate easily and colonize the fungal spores which are a source of fungal pathogens. Example A-NPs are common source of fungicides but if used in very high concentration can produce chemical injuries in crops such as cucumber.

4. **Rhizosphere studies:** Controlled foliar application of nanoparticles (P, Zn, Mg) as nutrients may trigger enzymes and growth promoting substances to release through roots, thereby influencing the microbial population in the rhizosphere. Nano sensors can help in tracing particular microbial activity in the rhizosphere.
5. **Precision farming:** Precision farming is a farming management concept based on maximizing output (crop yield) while minimizing input (fertilizers, pesticides, herbicides, etc.) through managing environmental variables and applying targeted action. With the help of technologies like global satellite positioning system (GPS), remote sensing devices, we can determine whether the crops are growing at their maximum efficiency, and if not, determine the respective problems. Various factors like soil composition, weather, plant development, fertilizers used, chemicals and water provided, are analyzed such that the production costs can be minimized and production potentially increased. Examples, nano-device and sensors are developed which can penetrate the soil and can inform about any environmental changes taking place so that we can act accordingly.

Future Prospective

The potential of nanotechnology in agriculture is large, but a few issues are still to be addressed as the risk assessment. In this respect, some nanoparticle attractants are derived from biopolymers such as proteins and carbohydrates with low effect on human health and the environment. Nanotechnology has many uses in all stages of production, processing, storing, packaging and transport of agricultural products. Nanotechnology will revolutionize agriculture and food industry such as in case of farming techniques, enhancing the ability of plants to absorb nutrients, disease detection and control pests.

Conclusion

Nanotechnology has a great impact on the modern world. It has proved to be a gateway of new applications in agriculture as well as other sectors. Due to their small size, nanoparticles act as an excellent catalyst in many chemical reactions taking place in industries. Their small size also allows them to penetrate into the soil and through the plants more readily making them extremely viable in the field of soil science. We have seen how nanotechnology extents its scope into each and every field like foods, medicines, tissue engineering with optimized outputs. Synthesis of NPs depends on various factors, like the medium in which they are prepared or the method used for its preparation, etc. Generally its synthesis is differentiated in four ways, physical, chemical, physico-chemical (aerosol) and biological methods. The characterization of NPs is also a important task to perform. The shape, size, chemical bonds functional groups, electron alignment, etc. of NPs allowing us to replicate the NPs and also provide it with some modification to make it more efficient. Like, nanoparticles are coated with several substances to prevent their decay or agglomeration in the soil. There are several limitations of NPs. NPs produce waste toxic materials which if contacted with the soil and

aquatic environment can cause contamination or pollution. It also depends on environmental factors like temperature, pH, solubility, etc. if these factor are altered, it may alter the function of NPs. If these limitations are overcome, then the nano-technology will become a revolutionizing technology of 21st and 22nd centuries.

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