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Importance of Nanotechnology in Agriculture

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- Nano is a Greek word, which literally means micro or small. Every particle whose size is 100 nanometers or smaller is considered a nanoparticle. The fineness of a nanoparticle can be estimated from the fact that the diameter of a human hair is 60 thousand nanometers. The term nano-technology was first used by Norio Taniguchi in the year 1974. Nano-technolog is the engineering of molecules and atoms, which integrates disciplines such as physics, chemistry, bioinformatics and biotechnological science.
- Since the beginning of life on Earth, various nanoparticles are being created along with the changes in nature continuously. Nanoparticles are being used in everything from consumer products to medical devices, cosmetics, chemicals, electronics and optics, environment, food and packaging, fuels, energy, textiles and paints, new generation medicines and plastics etc.
- Now agricultural scientists are realizing that smart innovation like nanotechnology is strongly required for agricultural growth, to face global challenges of food security and climate change. The importance of nanotechnology applications in agricultural sector came only in recent years, but the research was started about half a century back.
- Nanotechnology plays a role in agriculture, food processing and packaging, food security and water purification, environmental remediation, crop improvement and plant protection. Nanotechnology has many uses in all stages of production, processing, storing, packaging and transport of agricultural products.
- The uses of nanomaterials are required for increasing fertilizer use efficiency, yields, and reducing pesticide need; rapid and early pathogens and toxic chemical detection in food items; smart pesticides and fertilizer delivery systems; smart systems used for food packaging and processing; and regulating agricultural food security. In addition, they minimize the amount of harmful chemicals that pollutes the environment. Hence, this technology helps in reducing the environmental pollutants. Nanotechnology can increase agricultural production.
- The effects of different NPs on plant growth and phytotoxicity were reported by several workers including magnetite (Fe3O4) nanoparticles and plant growth, alumina, zinc, and zinc oxide on seed germination and root growth of five higher plant species i.e., radish, rape, lettuce, corn, and cucumber, silver nanoparticles and seedling growth in wheat, sulfur nanoparticles on tomato, zinc oxide in mungbean, nanoparticles of AlO, CuO, FeO, MnO, NiO, and ZnO . Silver nanoparticles can stimulate wheat growth and Yield. Soil applied 25 ppm SNPs had highly favorable growth promoting effects on wheat growth and yield.

Nanotechnology in agricultural sectors and their uses:

1. **Nanofungicides:** Nanoparticles encapsulated pesticides, nanocapsules, and nanoemulsions for controlled and on-demand release for better efficiency and disease pest control of plants. Noparticle based pesticides and herbicides are being explored for the application of the antimicrobial agents to protect crops from various diseases.The use of nanosilver has been studied recently against phytopathogen Colletotrichum gloeosporioid.
2. **Nanofertilizers**: A nanofertilizer is a product in nanometer level that supply nutrients to specific target sites and can improve nutrient use efficiency (NUE) and diminish environmental degradation. Buckyball fertilizer nanoparticles, nanocapsules and viral capsids for better nutrients absorption of plants and site-specific nutrient delivery.
3. **Antimicrobial activity:** zinc nanocrystal shows antimicrobial and antifungal activity. Zinc oxide nanoparticles synthesized using Punica granatum peel aqueous extract has shown effectiveness as antibacterial agents against standard strains of Gram-positive Staphylococcus aureus and Gram-negative Escherichia coli.
4. **Precision farming:** Nanosensors connected with global positioning system (GPS) navigation system for real-time monitoring of soil environments and crop growth, precise application of fertilizer and pesticide.
5. **Water or liquid retention:** Nanomaterials like zeolites and nanoclays are used to hold water and liquid agrochemicals in soil for their subsequent slow release to plants.
6. **Water purification and pollutant remediation:** Nanomaterials like nZVI nanoclays and carbon nanotubes (CNTs) are used for filtering and binding of toxic substances and their subsequent removal from environments.
7. **Plant genetic modification:** Nanoparticles loaded with desired DNA or RNA are delivered to plant cells for their genetic transformation or to trigger defense mechanism activated by pathogens.
8. **Nanosensors and diagnostic devices:** Nanomaterials and nanostructures like electro-chemically active CNTs and nanofibers are extremely delicate biochemical sensors used to closely assess environmental conditions, plant status, and growth.
9. **Livestock and fisheries**: Nanoveterinary medicine like nanoparticles, buckyballs, dendrimers, nanocapsules used for drug delivery, nanovaccines; smart herds, cleaning fish ponds.
10. **Nanoparticles from plants**: Production of nanofibers from bio-nanocomposite and Nanofibers from cotton waste and wheat straw and soy hulls for improved strength of clothing.
11. **Food packaging:** High impermeable packaging silicate nanomaterials are used for protection of food from UV radiations and providing more strength to maintain the food protected from environment, increasing their shelf lives. Nanosensors are used for the detection of chemicals, gases and pathogens in food.