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Nanotechnology- A New Emerging Aspect of Agriculture

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A nanoparticle is defined as any particle with a diameter of less than 100 nano meters. These particles begin to exhibit features that their larger counterparts do not because of their unique size. When working at the nano scale properties including cation exchange capacity, improved diffusion, ion adsorption and complexation improve. Metal oxides, ceramics, magnetic materials, semiconductors, quantum dots, lipids, polymers (synthetic or natural), dendrimers and emulsions are among the materials utilised to make nanoparticles.

The green revolution led in the indiscriminate use of pesticides and artificial fertilisers resulting in the loss of soil biodiversity and the development of pathogen and pest resistance. Only nanoparticles or nano chips can transport materials to plants via nanoparticles and improved biosensors for precision farming. Traditional fertilisers, insecticides and herbicides that have been nano encapsulated aid in the delayed and sustained release of nutrients and agrochemicals resulting in precise dosage to the plants. Plant viral disease detection kits based on nanotechnology are also gaining popularity and are beneficial in detecting viral illnesses quickly and early.

Development of environmentally conscious nano fertilizers to provide efficient ion, nutrient delivery into plant cells and plant gene transformations to produce plants with desirable genes such as drought resistance and accelerated growth cycles are currently areas of focus for nanotechnology development in the agricultural industry. With the world's population growing, it's more important than ever to enhance sustainable agricultural practises that provide larger yields in order to fulfil rising food demand. It must however, be done without causing long-term effects like depletion of arable land or water sources, toxic runoff or bio-accumulative toxicity. In order to meet these expectations, scientists are investigating the use of nanotechnology in agriculture.

Biosynthesis of nanoparticles

Because there are many chemical processes for synthesis of nanoparticles that employ harmful compounds, it is critical to use environmentally benign, greener and eco-friendly ways. Researchers are looking for biological organisms that can reduce salts to matching nanoparticles such as bacteria, fungi, higher plants, actinomycetes and viruses to synthesise nanoparticles. Nanoparticles have been synthesised from a variety of biological sources and are now being employed in agriculture for precision farming. Silver nanoparticles, zinc oxide nanoparticles and titanium dioxide nanoparticles are a few examples.

Applications of nanotechnology in agriculture

Massive volumes of fertilizer in the form of ammonium salts, urea and nitrate or phosphate compounds have significantly enhanced food production but they have a number of negative impacts on the beneficial soil micro flora. Because of run-off, most fertilizers are unavailable

to plants resulting in pollution. This problem can be solved by using fertilizers that have been coated with nano materials. Nano materials have the ability to aid in the gradual release of fertilizers since nanoparticles have a higher surface tension than ordinary surfaces and thus hold the material more tightly from the plant. Nano coatings also shield bigger particles from the elements.

Uses of nano-technology

a) **Nano-fertilizers:** Because of the massive volume of runoff generated by conventional fertilizers they can be hazardous to the environment. According to studies, more than half of the fertilizer applied to soil is lost to the environment and up to 90% of it is lost to the environment in extreme circumstances. Nano fertilizers on the other hand are able to address this problem due to their great absorption efficiency into the targeted plant which is due to their incredibly high surface area to volume ratios. Absorption efficiencies of up to 90.6 percent were observed in a study on the usage of phosphorus nano-fertilizers making them a highly desirable fertilizer material. Another advantage of employing nano fertilizers is that they can deliver a steady release of nutrients into the plant for 40-50 days rather than the 4-10 days that conventional fertilizers can provide. This is also cost-effective as it requires less resources to transport fertilizer and reduces the quantity of overall fertilizer required.

b) **Nanotechnology in plant transformations:** Most plant genetic modifications were previously done with Agrobacterium or tools like the gene gun (biolistics); however, these older methods have low species compatibility, lack versatility/compatibility with Chloroplastial/Mitochondrial gene transformations, and the potential for cell or organelle damage (due to impact of biolistics). While biolistics and Agrobacterium are useful in some plant species more refined techniques using nano materials are being investigated allowing for a less invasive and forced delivery approach. These technologies make use of carbon nanotube (CNT) and porous nanoparticle (NP)-based delivery systems which could allow for higher-throughput plant transformation while avoiding legal GMO constraints. Plant transformation is primarily approached using biolistics. To impart genetic change, micro projectiles (typically gold micro particles) bearing genetic information are launched through cell walls and membranes. Biolistics may cause damage to the targeted cells or organelles; therefore, nano-biolistic approaches have been developed to reduce the risk of cell damage. Because the particle being released into the cell is substantially smaller the impact can be lowered while maintaining a similar level of genetic transformation efficiency as classical biolistics. However, because the majority of studies involving nano scale biolistic techniques are conducted on animal cells, plant transformation is still relatively new and may confront hurdles not observed in animal cell studies. Nanotechnology, in general, offers an innovative and competitive method to plant genetic change. Future study into the uses of these systems will focus on a wider range of crops with a goal of using less expensive, more scalable ways and investigating potential environmental consequences. Finally, whether nanomaterial plant transformations will become a common practise in the future of agriculture will be determined by these design requirements.

c) **Nano-fungicides:** When nanoparticles of AlO, CuO, FeO, MnO, NiO and ZnO were sprayed on different crops like tomatoes and subsequently grew in soil infested with the fusarium wilt fungus, disease estimates of CuO, MnO or ZnO were reduced when compared to untreated controls.

d) **Nanotechnology in yield enhancement:** In agriculture, nanoparticles aim to reduce the amount of chemicals spread, reduce nutrient losses in fertilization and boost output through insect and nutrient management. Nanotechnology has the potential to improve the

agriculture and food industries by providing revolutionary nano tools for disease management, nutrient absorption capacity enhancement and other applications. Specific applications like nano fertilisers and nano pesticides to trail products and nutrients levels to increase productivity without decontaminating soils, waters and protection against several insect pests and microbial diseases are among the major interests of using nanotechnology in agriculture. Nanotechnology could be used as sensors to monitor the soil quality in agricultural fields ensuring the health of the plants.