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Application of Nanotechnology in Plant Disease Management

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Introduction

The need for greater food production has presented agriculturalists with numerous difficulties. The majority of agriculturalists claim that increasing our production of food and fibre is possible, but only at the expense of our environment. Pests and diseases in plants significantly lower crop productivity, by 20–40% annually. Currently, insecticides, fungicides, and herbicides are used heavily in pest control. In spite of their numerous benefits, such as high availability, quick action, and dependability, pesticides can cause harm to non-target organisms, a resurgence in insect populations, and the emergence of resistance. New ideas and agricultural products with enormous potential to solve the aforementioned issues have been made possible by nanotechnology. Nanotechnology involves nanoparticles (NPs) having a size of 1 to 100 nanometres. Metallic Nanoparticles are mostly synthesized from metals such as gold, silver, copper, and platinum.

Nanoparticles

Nanoparticle is an amorphous or semi-crystalline zero dimensional (0D) nano structure with at least ranges between 1 to 100 nanometres in size, Undetectable by the human eye. Nanoparticles can have quite different physical and chemical characteristics than bigger materials.

Properties of nanoparticles

Nanparticles exhibit peculiar physical, chemical, and biological characteristics that their molecule completely lacks. Because of their small size and high surface to volume ratio, nanoparticles are more reactive and biochemically active. As a result of the numerous interactions between the components that are mixed together in nanocomposites due to the huge surface area of nanoparticles, these materials acquire unique features like improved strength and/or greater chemical resistance. Nanoparticles are currently made out of a wide variety of materials, the most common of the new generation of nanoparticles being ceramics, which are best split into metal oxide ceramics, such as zinc, titanium, aluminium and iron oxides, to name a prominent few, and silicate nanoparticles.

Plant disease diagnosis

Nanosensors

Nanosensors can function in a variety of ways, for as by using nanoparticles specifically designed to glow a range of colours or ones built of magnetic materials that can selectively adhere to food pathogens. The benefit of such a technology is the ability to load hundreds, maybe thousands, of nanoparticles on a single nanosensor to quickly, precisely, and economically detect the presence of various diseases and germs. Given their small size, nanosensors also have other advantages. The detection of microbiological pathogens may take two to seven days now require only a few hours, minutes, or even seconds thanks to nanotechnology.

Biosensor

A biosensor is made up of a biological component, such as a cell, enzyme, or antibody, that is coupled to a small transducer, which is powered by one system and then transfers electricity (in another form) to another system. The biosensors detect changes in cells and molecules, which are subsequently utilised to measure and identify the test chemical, even at extremely low concentrations. When the drug attaches to a biological component, the transducer generates a signal proportionate to the amount of substance bound. So, if a product contains a high concentration of germs, the biosensor will give a strong signal signalling that the foodstuff is dangerous to ingest. With this technique, large quantities of food may be easily verified for safety before consumption.

Nanoparticles in plant disease management

Use of nanoparticles in plant disease management is a novel and fancy approach that may prove very effective in future with the progress of application aspect of nanotechnology. The most straightforward and apparent method is to apply nanoparticles directly to seeds or leaves in the soil to protect plants from disease invasion. As a result, NPs may control infections in a way comparable to chemical pesticides.

Nanoparticles as Protectant

By themselves, nanoparticles have the potential to be applied directly to plant seeds and leaves for pest and disease defence against insects, bacteria, fungi, and viruses. The antibacterial, antifungal, and antiviral characteristics of metal nanoparticles like silver, copper, zinc oxide, and titanium dioxide have been the subject of extensive research. By using a well diffusion experiment, silver nanoparticles have demonstrated antifungal inhibition against Alternaria alternative, Macrophomina phaseolina, Rhizoctonia solani, Botrytis cinerea, and Curvularia lunata. Sun-hemp rosette virus was completely suppressed after bean leaves were treated with silver nanoparticles.

Nanoparticles that Act as Carriers

The most often utilised nanoparticles as carriers for insecticides, fungicides, herbicides, and RNAi-inducing compounds are listed below.

Silica nanoparticles with regulated size, shape, and structure may be easily produced, making them excellent delivery vehicles. They are often made in a spherical shape with pore-like openings, such as porous hollow silica nanoparticles (PHSNs) or mesoporous silica nanoparticles (MPSNs) (MSNs). The shell structure of PHSNs protects the active molecules inside the nanoparticles against degradation by UV light. Silicon has already been utilised to improve plant tolerance to different abiotic and biotic stressors, therefore silica nanoparticles appear to be the ideal choice for the creation of pest-control agri-products.

Chitosan nanoparticles have limited solubility in aqueous solution, due to their hydrophobic characteristics. As a result, Chitosan is typically combined with an organic and inorganic copolymer to increase its solubility. Chitosan adheres effectively to the epidermis of leaves and stems, extending contact duration and promoting bioactive molecule absorption.

Nanoparticles as Carriers for Insecticides

Insecticides were initially put into nanoparticles in the early 2000s. Since then, experiments with a variety of nanoparticles have included conventional pesticides and bioactive substances with insecticidal effects. Silica, chitosan, and lipids were the most frequently studied nanoparticle carriers. The most often targeted pests were *Spodoptera litura, Tetranychus urticae,* and *Helicoverpa armigera.*

Conclusion

Existing technologies utilized in a variety of fields, including agriculture, could undergo a revolution thanks to nanotechnology. Nanotechnology has great potential as a tool in plant pathology, especially for managing pest and plant disease control. It can also be utilised in agricultural products that safeguard plants, track their growth, and look for diseases.

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