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NANOTECHNOLOGY IN MODERN FARMING

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ABSTRACT

Nanotechnology, a swiftly advancing field, holds transformative potential in agriculture, spanning manufacturing, processing, storage, packaging, and transport. Its applications enhance precision farming, nutrient uptake, disease detection, and environmental resilience. Key innovations include efficient fertilizer use, soil fertility improvement, and "smart seeds" with nano-coatings. Nano-herbicides aid in weed control, while nanoparticles like iron and silver boost livestock health and sanitation. Additionally, nano-sensors, including smart dust and gas sensors, enable rapid pollution detection. Overall, nanotechnology is set to revolutionize agriculture and the food industry.

KEYWORDS: Agriculture, Nanofertilizers, Nanoherbicides, Nanopesticides, Nanopolymers, Nanotechnology

INTRODUCTION

It is thought that modern technologies will meet the world's food demands while also improving the environment and the economy. Food security is a serious issue, and the difficulties have become worse in recent decades. With the use of this potent technology, we can study the atomic and molecular levels and build things at the nanoscale. Nanotechnology may be used in agriculture to boost agricultural production for a bigger population, repair agricultural land, and build highly productive greenhouses. It can also stop the extinction of flora and animals (Mousavi and Rezaei, 2011). The development of chemical pesticides, genetically engineered crops, animal production inputs, and precision farming methods are expected to be aided by research and development in nanotechnology. By safely removing toxic elements from agricultural environments, nanostructured catalysts may lower pollution and improve the environmental friendliness of agriculture. Nanotechnology targets viruses and other pathogens and may operate either top-down or bottom-up. Chemical processes may be regulated and catalyzed by manipulating nanomolecules at the nanoscale. Herbicides, chemicals or genes may be contained in nanoparticles that act as "magic bullets," and nanocapsules allow herbicides to enter tissues and cuticles with efficiency. Nanobiotechnology is the term for this combination of biology and technology at the nanoscale.

WHAT IS NANOTECHNOLOGY

The multidisciplinary topic of nanotechnology focuses on creating materials and electronics with novel or drastically altered features by manipulating individual atoms, molecules, or molecular clusters into structures. It may operate in either a top-down or bottom-up manner, concentrating on objects and materials with sizes between one nanometre (nm) and 100 nm. Because it takes into account the size of viruses and other diseases, nanotechnology offers a great potential for pathogen identification and elimination. It is possible to control and catalyze chemical processes by manipulating nanomolecules on a nanoscale. Nanocapsules allow herbicides to be effectively absorbed through tissues and cuticles, and nanoparticles may act as "magic bullets," carrying chemicals, DNA, or herbicides.

APPLICATION OF NANOTECHNOLOGY IN MODERN FARMING

With its ability to improve plant nutrient absorption and provide new tools for disease treatment and quick disease diagnosis, nanotechnology has the potential to completely transform agriculture and food production. Smart delivery systems and sensors will aid in the fight against agricultural diseases and viruses. Utilizing cutting-edge technology for crop management, controlled environment agriculture (CEA) is a popular technique in the USA, Europe, and Japan. Agricultural vitality, timing of agricultural harvest, and food security concerns might all be improved by nanotechnology devices for CEA (Ditta, 2012). Below are some important uses of nanotechnology in modern farming/agriculture-

Precision farming: Precision farming employs sensors and monitoring systems enabled by nanotechnology to minimize agricultural waste and contamination to the environment. These GPS-enabled gadgets can track crop development and soil conditions in real time. The integration of nanotechnology and biotechnology in sensors results in more sensitive equipment that can react to environmental changes sooner. When pollutants are present, nanosensors may produce chemical or electrical signals, monitor particular proteins or molecules, or bind to target chemical sand proteins using nano-engineered branching molecules called dendrites as probes.

Pests and diseases management: Through the use of nanoparticles and nanocapsules to regulate absorption and distribution, making pesticides and diseases more environmentally friendly and effective, nanotechnology is transforming the regulation of these substances. The precise stage of viral replication and disease application is being detected by developing nano-based diagnostics, including multiplexed diagnostic kits. By detecting problems with plant health before farmers see them, these tools may also be used to "smart" agricultural systems. This has significance for human medication delivery since it enables

the tailored distribution of molecules in a manner akin to nanomedicine. It is anticipated that this strategy would result in more effective and ecologically friendly pesticide and disease control.

Application in animal science: Nanotechnology holds potential in veterinary and treatment of domesticated animals, providing solutions for food items, veterinary care, prescription medicines, and vaccines. Nanocapsules can be used to protect enzymes and proteins in livestock and poultry food rations, increasing yield and effectiveness. Nano-level medications, such as antibiotics, vaccines, and probiotics, can be more effective in treating infections, nutritional, and metabolic disorders. Nanotechnology can remove biological barriers, increasing medicine efficiency. Silver nano particles are strong antiseptics used for disinfection in livestock and poultry. In cancer treatment, nano particles can destroy cancer cells by increasing their temperature to 55°C through infrared waves and magnetic radiation. Nano-tubes can also be used in dairy cattle farms to monitor estrus and estrogen hormone levels and insemination.

Application in agronomy: Farm managers can remotely identify crop pests and stress indicators like drought using nanomaterials and GPS technology to automatically change pesticide and irrigation levels. Plant viruses and soil nutrients may be detected using nanosensors. Nano-encapsulated slow-release fertilizers are useful for conserving fertilizer and reducing pollution since plants absorb them quickly and thoroughly. Slow nutrient release using zeolites, honeycomb-like minerals, lets plants absorb most nutrients without waste. Nanotechnology may improve agricultural equipment structure and tools, make robust mechanical components, and provide alternative fuels. It can also enhance agricultural plant genetics. Nano-encapsulated seeds like Smart Seed lower seed rate and increase crop performance. Nano membrane seed coating, aerial broadcasting, storage moisture detection, and bio analytical nano sensors for seed ageing are under study.

Application in food industry: Nanotechnology is utilized to create food packaging polymers that resist oxygen deterioration and discolouration. Zigzag nano particles in the new material prevent oxygen from entering. This resulted to fruit nano-coatings that prevent weight loss and shrinking. Smart packaging technologies are being developed to extend product shelf life, patch minor holes, adapt to environmental conditions, and notify consumers of food contamination. Nanotechnology may adjust foil permeability, increase barrier characteristics, improve mechanical and heat-resistance, generate active anti microbic and anti fungal surfaces, and sense microbiological and biochemical changes. Nanotechnology-produced ethylene absorbent materials can check agricultural product quality. Nano-based bar codes provide food quality information in minutes. Biosensors, which use biological components and transducers, detect cell and molecular changes to indicate food safety (Abd-Elrahman and Mostafa, 2015).

CONCLUSION

Pesticides and other agrochemicals pollute soil and groundwater and threaten ecosystems. Nanotechnology improves disease resistance, plant growth, and nutrient utilization by controlling pesticide delivery. Carbon, silver, silica, and titanium dioxide nanoforms increase crop management, while nanoencapsulation minimizes dose and waste. Nanosensors detect infections at low levels but toxicity is uncertain. Nanotechnology may help agricultural pollution and protection by detecting, sensing, and remediating.

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