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Nanotechnology in Agriculture

(*Rajvinder Singh[1] and R. G. Zala[2])
[1]Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana-125004
[2]Junagadh Agricultural University, Junagadh-362001
* singh.rajvinder111@gmail.com

Nanotechnology is a rapidly evolving and intriguing technology that blurs the lines between physics, chemistry and biology at the scale of a billionth of a metre. Nanotechnology is the control of shape and size at the nanoscale scale in the design, characterization, manufacture and application of structures, devices and systems. Nanotechnology in biochemical research has quickly established itself as a multidisciplinary discipline with applications in imaging, diagnostics, treatments as well as drug delivery and tissue engineering. At the nanoscale level, nanomedicine may create, build, manipulate and optimize biological components. This covers nanomaterials applications and nanodevice fabrication for use in nanodiagnose, nanodrug delivery and drug delivery. Nanotechnology in agriculture has gained a lot of traction in the recent decade thanks to a lot of government financing, but the stage of development is still good, even though many ways have fallen under the agricultural umbrella. This may be due to the unique character of agricultural production, which operates as an open system in which energy and materials are freely transferred. In contrast to industrial nanoproducts, the scale of demand for input materials is constantly huge, and there is no control over the input of nanomaterials [1] Nanotechnology can increase agricultural production, and its applications include: (1) nanoformulations of agrochemicals for applying pesticides and fertilizers for crop improvement; (2) the applications of nanosensors in crop protection for the identification of disease and residues of agrochemicals; (3) nanodevices for the genetic engineering of plants; (4) plant disease diagnostics; (5) animal health, poultry production; and (6) post harvest management. Nanoparticle-mediated gene or DNA transfer in plants for the development of insect-resistant varieties, food processing and storage, and product shelf life extension are all examples of nanotechnology uses.

Nanotechnology in Pesticide and Fertilizers

Long-term experiments are required to demonstrate the impact of various techniques on soil qualities that are critical to long-term sustainability and to provide critical data for this goal. Nano-chemicals have emerged as promising agents for plant growth and pest control in the United States, according to a federal body. Nano-materials used as fertilizers may have properties such as crop improvement and lower environmental toxicity. Plants can provide an important route for bioaccumulation into the food chain. Recent advancements in agriculture cover the use of NPs for more effective and safe chemical application to plants. Several researchers have reported on the effects of different NPs on plant growth and phytotoxicity, including magnetite (Fe_3O_4) nanoparticles and plant growth [2], alumina, zinc, and zinc oxide on seed germination and root growth of five higher plant species; radish, rape, lettuce, corn, and cucumber, silver nanoparticles and seedling growth in wheat, sulphur nanoparticles on tomato, zinc oxide in mungbean, silver nanoparticles can increase wheat yield and growth.

Wheat growth and yield were significantly boosted by 25 ppm SNPs applied to the soil. Zinc is required for the synthesis of auxin or indoleacetic acid (IAA) from tryptophan, as well as for biochemical reactions that result in the formation of chlorophyll and carbohydrates. A lack of Zn can have an impact on crop yield and produce quality.

Nanotechnology Application as Nanofungicides

Recently, the use of nano silver against the phytopathogen *Colletotrichum gloeosporioides* has been investigated. Apart from antimicrobial properties, other nanoparticles (Fe, Cu, Si, Al, Zn, ZnO, TiO_2, CeO_2, Al_2O_3 and carbon nanotubes) have been shown to have negative effects on plant growth. Nanoparticles can sometimes inhibit the growth of beneficial soil bacteria, such as *Pseudomonas putida* KT_{2440} [3]. Several research groups have focused their attention on the use of environmentally friendly pesticides. Nanoparticle-based pesticides and herbicides, like chemical pesticides, are being researched for the application of antimicrobial agents to protect crops from various diseases. Extensive research on nanoparticle-based systems may eliminate the need for pesticides in agriculture. Nanoparticles antifungal properties can aid in the development of nanoparticle-based pesticides.

Control of Plant Pest

Fusarium wilt is a devastating disease of tomato and lettuce in several countries due to severe yield loss, prolonged fungus survival in soil, and the generation of resistant races. The disease can be controlled to some extent by using resistant cultivars and chemicals. However, the occurrence and development of new pathogenic races is a continuing problem, and the use of chemicals is expensive and not always effective. In recent years, the use of nanomaterials has been considered as an alternative solution to control plant pathogens. The aqueous extracts of *Punica granatum* peels, *Olea europaea* leaves, and *Chamaemelum nobile* flowers were used to successfully synthesise nanomaterials of copper oxide (CuO), zinc oxide (ZnO), magnesium hydroxide (MgOH), and magnesium oxide (MgO). Nanomaterials created using environmentally friendly and green methods have the potential to improve agriculture by improving fertilization, plant growth and pesticides. Furthermore, this technology reduces the amount of hazardous chemicals that pollute the environment.

Nanoparticles in Controlling the Plant Viruses

Plant viruses, particularly spherical viruses, are thought to be naturally occurring nanomaterials. Satellite tobacco necrosis virus, measuring only 18 nm in diameter, is the smallest plant virus known to date. Plant viruses are composed of a single or double-stranded RNA/DNA genome encapsulated by a protein coat. Their ability to infect, deliver nucleic acid genome to a specific site in host cell, replicate, package nucleic acid, and exit host cell in an orderly fashion has necessitated their use in nanotechnology. A complete review on use of plant viruses as bio template for nanomaterials and their uses has been done recently by Young *et al*. [4].

Nanotechnology in Food Packaging

Food industries are pioneering the development of foods with high nutritional value. For example, high impermeable packaging nanomaterials are used to protect food from UV radiations and to provide more strength to keep food protected from the environment to increase shelf lives. Nanosensors are used in food to detect chemicals, gases and pathogens. Smart packaging is a term used in modern terminology to describe this type of packaging. According to some studies, people are not accepting the direct inclusion of nanoparticles in food due to some risk factors. As a result, some safety measures are required to reduce the risk and ensure human safety.

Nanoparticles Mediated Nonviral Gene Delivery

Gene delivery systems are a critical component of genetic nanomedicine. Gene delivery entails the transport of genes, which necessitates the use of a transport vehicle known as a vector. Potential vectors include viral "shells" and lipid spheres (Liposomes), both of which can be incorporated into host cells. Because of their incredible selectivity and ability to provide effective and potent action, peptides and proteins have become the drugs of choice for the treatment of a wide range of diseases.

Polymer based gene transfer:

Non-viral gene medicines have emerged as a potentially safe and effective gene therapy treatment method for a wide range of acquired and genetic diseases. Transient gene expression without safety concerns is a significant advantage of polymer-based gene delivery systems over viral transfection systems. In addition to polymeric systems for DNA delivery, therapeutic ultrasound has the potential to be useful because it can be transmitted through the body without damaging tissues and can be applied to a specific area where the desired DNA is to be expressed.

- **Liposome gene transfer**:

One of the most researched Nonviral gene delivery strategies is liposome-based gene transfer. A complete understanding of the physicochemical properties of the drug–liposome system is required for a liposomal delivery system. Many bacteria can control plant diseases by altering molecular processes that result in pathogenicity and/or virulence factors being produced by the pathogen. As vectors for gene delivery into plant cells, liposomes may have several advantages. Liposome-based gene therapy has no toxicity risk in humans or plants. The growth of gene therapies has been attributed to specific molecular changes. A complete understanding of the physiochemical properties of the drug–liposome system is required for the development of a liposomal delivery system.

- **Biobeads gene transfer:**

"Bio-beads" are micrometer-sized calcium alginate beads that encapsulate plasmid DNA molecules carrying a reporter gene. Protoplasts isolated from cultured tobacco cells were used to assess the efficiency of the bio-beads in mediating genetic transfection. Transfection efficiency reached 0.22%. The bio-beads have the potential for efficient transformation in plants. The use of nanoscale materials has increased exponentially due to their high sensitivity and quick response time.

Conclusion

The use of nanoparticles as 'smart' delivery systems is an intriguing application of nanoparticles in the field of life sciences. Nanoparticle tools are helpful for detecting plant diseases and analysing nanoparticles introduced into plants, as well as to evaluate the use of such nanoparticles in selected plant tissues. The findings suggest a wide range of applications for nanoparticles in general plant research and agronomy. Nanotechnology enhances their performance and acceptability by increasing effectiveness and safety while also lowering health-care costs.

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