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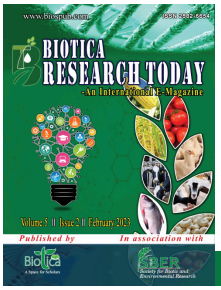

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Activity of Nanoparticles on Plant Growth and Development

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Abstract

Nanotechnology has emerged as a promising field, with applications in agriculture, food, and medicine. Because of their non-threatening use in agriculture, nanoparticles such as titanium dioxide (TiO_2), iron oxide (Fe_3O_4), zinc oxide (ZnO), silicon oxide (SiO_2), copper (Cu-NPs), and selenium (Se-NPs) have recently received significant attention. Nanoparticles can be produced using a variety of methods, including chemical, green, and physical processes. Plant growth and development are aided by nanoparticles; however, these effects vary depending on the origin, size, concentration, and time of application to crops. Nanoparticles have recently improved plant tolerance to biotic and abiotic stresses. Nanoparticles protect plants from oxidative damage by increasing antioxidant activity. Nanoparticles can help to reduce the toxic effects of drought.

Keywords: Antioxidant activity, Nanoparticles, Photosynthesis, Plant growth and Development

Introduction

Nanotechnology, a new emerging and fascinating field of science, allows for advanced research in a variety of fields, and nanotechnological discoveries may lead to novel applications. Applications include biotechnology and agriculture. In the field of electronic engineering, Nanotechnology provides an expanding research opportunity in energy, medicine, and life sciences such as reproductive science and technology, enzymatic nano-bioprocessing of agricultural and food wastes to energy and other useful byproducts, chemical sensors, water cleaning, disease prevention, and treatment in plants a variety of nanocides. The word "Nano" is developed from the Greek word meaning "dwarf". In more technical terms, the word "nano" means 10^{-9}, or one-billionth of something. Nanoparticles (diameters ranging from 1 to 100 nm) are agglomerated atom by atom, and their size (and, in some cases, shape) can be maintained through a specific experimental procedure. Nanoparticles can be ordered or assembled into mine layers. Forces such as hydrogen bonding, dipolar forces, hydrophilic or hydrophobic interactions, surface tension, gravity, and other forces cause such self-assembly. Self-assembly is the process by which many naturally occurring biological structures, such as membranes, vesicles, and deoxyribonucleic acid (DNA), are formed.

Effect of Nanoparticles on Plant Growth and Development

1. Zinc Oxide Nanoparticles

Lower concentrations of zinc nanoparticles (ZnONPs) increase plant growth and development in peanut, soybean, wheat, and onion. Higher doses of ZnONPs inhibited seed germination. The effect of nanoparticles on germination is dependent on the concentration. It differs from one plant to the next. Nano ZnO supplemented with MS media induced somatic embryogenesis, shooting, and plantlet regeneration, as well as proline synthesis, superoxide dismutase, catalase, and peroxide activity, thereby improving tolerance to biotic stress (Mahajan *et al.*, 2011).

2. Carbon Nanotubes

Because of their unique mechanical, electrical, thermal, and chemical properties, carbon nano tubes hold an important position. Carbon nanotubes have been linked to plant cells and plant metabolism. They have unique properties such as the ability to penetrate the cell wall and membrane, as well as provide a suitable delivery system for chemicals to cells. Single-walled carbon nanotubes function as nanotransporters for DNA and dye molecules into plant cells (Siddiqui *et al.,* 2014). Carbon nanotubes with multiple walls have the ability to influence seed germination and plant growth.

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3. Gold Nanoparticles

Gold Nanoparticles interaction improves seed germination, leaf number, leaf area, plant height, chlorophyll content, and sugar content; for example, lettuce and cucumber.

4. Silver Nanoparticles

Plant growth and development are influenced by nanoparticles in both positive and negative ways. Silver nanoparticles have a significant effect on seed germination, inducing protein and carbohydrate synthesis while decreasing total phenol content, catalase and peroxide activities.

5. Titanium Dioxide Nanoparticles

They promote seed germination and radicle and plumule growth by regulating enzyme activity involved in nitrogen metabolism such as nitrate reductase, glutamate dehydrogenase, glutamine synthase, and glutamic-pyruvic transaminase, which enables plant absorption of nitrate and also prefers the conversion of inorganic nitrogen to organic nitrogen in the form of protein and chlorophyll, which could increase the fresh and dry weight of plant.

Table 1: Types of nanoparticles and its effect on plants

Nanoparticles	Concentration	Plants	Effect on Plants
CNTs	75 wt% CNTs	*Triticum aestivum*	Root elongation.
ZnO-NPs	1000 ppm	*Arachis hypogaea*	Germination, stem and root growth and yield increases.
G-NPs	10 and 80 µg ml^{-1}	*Arabidopsis thaliana*	Germination and root length.
Ag-NPs	60 ppm	*Phaseolus vulgaris* L., *Zea mays* L.	Root length, shoot length, dry weight of root and shoot.
TiO_2-NPs	1000 mg L^{-1}	*Triticum aestivum*	Chlorophyll content.
Sulfur NPs	500, 1000, 2000 and 4000 ppm	*Vigna radiata*	Dry weight.
SiO_2-NPs	15 kg ha^{-1}	*Zea mays* L.	Growth parameters.
Iron oxide NPs	0.5-0.75 g L^{-1}	*Glycine max*	Yield and quality.
CuO-NPs	500 mg kg^{-1}	*Triticum aestivum*	Biomass.

Role of Nanoparticles in Photosynthesis

Photosynthesis is a vital process for plants that converts light energy into chemical energy. Single-walled carbon nanotubes improve photosynthesis activity threefold, increase maximum electron transport rates, and allow plants to detect nitric oxide. SiO_2-NPs improve activity of carbonic anhydrase and synthesis of photosynthesis pigments. TiO_2-NPs protect chloroplast from aging for long time illumination, improves net photosynthesis rate, conductance activity of photosystem and transpiration rate in plants (Table 1).

Conclusion

Because of their unique properties, a number of studies on the toxic effects of nanoparticles on plants have been conducted; however, studies focusing on the conclusion of the beneficial effects of nanoparticles on plants remain incomplete. Some studies have found that nanoparticles have a positive effect on plant growth and development. The effect of nanoparticles varies depending on the mode of application, size, and concentrations. This demonstrates that nanoparticles research is primarily for plants. More research is needed to investigate the mode of action of nanoparticles' interactions with biomolecules and their impact on gene expression regulation in plants.

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