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Review Article

New Insights and Biological Role in Agricultural Based Development of Novel Crops through Nanotechnology and Biotechnological Advances for Gene Modification

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Abstract

Seed germination is the critical stage in plant's life cycle, assisting sapling development, survivorship, and population trends. Plants, as sessile life forms, are easily exposed to abiotic stresses like heat, salinity, cold, soil alkalinization, drought. The interaction of nano-materials with the plant, soil, and the holobiont systems is critical for understanding their behaviors within every complicated ecosystem. The use of nanoparticles has a beneficial impact on germinating seeds and also plant growth and development. Titanium based nanoparticles triggers the development of carbohydrates, which promotes rates of photosynthesis and plant growth. It is hoped that nanotech will provide long-term remedies by replacing conventional bulk fertilizers with nano-particulate counter parts that have excellent characteristics for overcoming current problems such as mineral bio-availability and absorption. Nano-priming could be practiced to seeds to preserve them during storage, enhance germination rate, germination synchronization, and plant growth, and also enhance resistance of crop to biotic and abiotic stressful conditions.

Keywords: Seed germination, life cycle, nanoparticles, plant growth and development.

INTRODUCTION

In last few years, the use of Nano - materials in the horticulture has been increased. The nano-materials components are utilized in the diseases and pest control to improve plant productivity and growth. Nevertheless, both positive as well as negative effects of the nano-material on the plants have been investigated. The effects of nanomaterials on the germination of seed, growth and yield of horticulture crops are discussed in detail. Despite the fact that the techniques are not adequately elucidated, reports indicate that increased doses of nanomaterials are harmful to the plants [1-3]. Plants, as sessile life forms, are easily exposed to abiotic stresses like heat, salinity, cold, soil alkalinization, drought, and contamination of heavy metals, all of which have a significant impact on safety and food production. Numerous researchers have found that various nano-materials, like TiO_2 NPs, Si NPs, ZnO NPs, nano-ceria, Fe_2O_3 NPs, MWCNTs and graphene oxides reduce the negative impacts of abiotic stresses on agricultural plant species like barley, sugar beet, potato, maize, Arabidopsis thaliana, alfalfa and flax [4, 5].

Nanoscience is modern research innovation platform that entails the growth of methodologies to a variety of low-cost nanotech applications for improved germinating seeds, development, and acclimatization to environments. Seed germination is a critical stage in plant's life cycle, assisting sapling development, survivorship, and population trends.

Moreover, germination of seed is heavily influenced by a variety of factors such as soil fertility, environmental factors, genetic traits and moisture availability [6]. In this regard, various researches have revealed that the use of nanoparticles has a beneficial impact on germinating seeds and also plant growth and development. For instance, the use of multiwalled carbon-nanotubes (MWCNTs) improves germinating seeds in a variety of crop species, such as corn, soybean, wheat, tomato, maize, garlic peanut, and barley [7, 8].

The interaction of nanoparticles and plant cellular components endows cells with improved native features, resulting in a novel field of nano-bioengineering. A series of researches have revealed that the using nano-materials such as SWNTs improves photosynthesis. In vitro cell, SWNT chloroplast configurations displayed higher proportion of leaf electron transport via a pathway reliable with enhanced photo-absorption. Plasmon resonant frequency of metallic nano-particles can boost solar energy uptake and thus improve carbon fixation [1, 3, 9].

New insights in development of novel crops

Titanium is a hard, stunning, and corrosion-resistant metal. Its composite titanium-dioxide is a well-known photocatalyst that is utilized in the production of pigments [10]. Titanium triggers the development of carbohydrates, which promotes rates of photosynthesis and plant growth. Titanium- dioxide has photocatalytic properties for pesticide deterioration [11, 12]. Germination of seed is first and most delicate stage of a plant's life cycle. Many investigations have showed that the use of nano-technology has a positive impact on the seed germination. Nano-particles have been shown in research findings to boost absorption of water and utilization, as well as to enter the seed coat, that can enhance germination and growth by boosting the enzymatic activity [13, 14].

MgO is an essential inorganic compound with numerous applications including flame retardants, adsorbents, raw sewage remediation, innovative ceramics and photo electronics. As a result, multiple methods and paths for MgO nano-particles synthesis have been indicated [1]. MgOH was synthesized utilizing non - toxic neem leaf extract [13], acacia gum and citrus limon leaf extract [15]. Silver nano-materials are widely used as anti-microbial agents against a huge variety of phytopathogens. Silver nano-particles have also been shown to improve plant growth, according to researchers. The interaction of nano-materials with the plant, soil, and the holobiont systems is critical for understanding their behaviors within every complicated ecosystem. Nanomaterials can act as a magic bullet, comprising herbicides, chemical products, or genes that target specific parts of the plant to discharge their contents. Herbicides can be effectively penetrated via the cuticles and tissues using nano-capsules, enabling for the delayed and consistent release of active materials [16, 17].

Furthermore, evolutionary biology can be used to create novel plant varieties. In a current invention in this field, investigators entirely replaced one bacterium's genetic material with that of another, transforming it from one species to another. Nanobiotechnology has the ability to increase agricultural output by genetically improving animals and plants, as well as delivering genes as well as drug molecules to specific locations in animals and plants at the cell level [18-20].

The engineered nano-materials are modelled on the natural ones that support life at the ocean's depths. Pyrite nano-materials from hydro-thermal vents are the good iron source in ocean depths, providing iron to the microbes and small plants that live there for proper growth and development. Many companies around the world now are releasing genetically modified seeds with improved combos of desirable traits. Scientists are making all of these efforts to improve agricultural production in order to feed the world's ever-increasing population. Previously, all major corporations used an Agrobacterium tumefaciens-mediated technique for this intent, or in a few plants, a gene gun [16, 17]. Whereas these techniques for Gene delivery in plant tissues are now comparatively popular and frequently used, scientists believe that, in addition to Genetic material, the integration of other molecules such as proteins in cells is much more time-consuming, complicated, and demanding. The major benefit of delivering protein together with Genetic material in to the plants is that it allows for more comfortable genetic manipulation of plants in the preferred way. Using a biolistic method, this co-delivery of Genetic material has been successfully tested in maize, onion and tobacco plant tissues [21-23].

Phyto-nano-technology enables the targeted delivery of nano-particles to farm crops and the other crop plants, which may improve or add plant capabilities, as well as accomplish environmental monitoring and pollution opposition. As a result, phyto-nano-technology has the ability to change agriculture and plant sciences in general [24]. Food manufacturers are pioneering the development of nutrient-dense foods. For instance, high impervious packaged nano-materials are utilized to safeguard food from the ultra violet rays and to provide so much strength to keep food secured from the environment, thereby raising shelf lives. Nano-sensors are utilized in food to identify pathogens, gases, and chemicals. Smart packaging is a term used in modern terms to describe this type of packaging. According to some research findings, people are resistant to the direct inclusion of nano-particles in foods due to a variety of risk factors. As a result, some protection measures are required to lower the risk and ensure human safety [17, 18, 21].

Limiting the use of agriculture products (pesticides, fertilizers, herbicides, etc.) by enhancing their performance with nano-carriers, sensing environmental factors and crop growth and yield development in the field instantaneously with nano-sensors, lessening the sample size and quantity of analyte used with nano-arrays, effective therapy of water supplies with nano-filters, and advancing crop development with nano-particles are the main goals. Nanoparticles not only directly catalyze the degradation of pollution and hazardous materials, but they also help micro-organisms degrade waste and dangerous substances more efficiently. Toxins as well as harmful substances are broken down or removed from farmland and water using living organisms. Other terms that are commonly used include biological treatment (beneficial microbes), myco-remediation (mushrooms and fungi) and phytoremediation (plants). Thus, heavy metals can be removed from soil and water in an environmentally friendly and efficient manner by microorganisms using bioremediation [19, 20, 23].

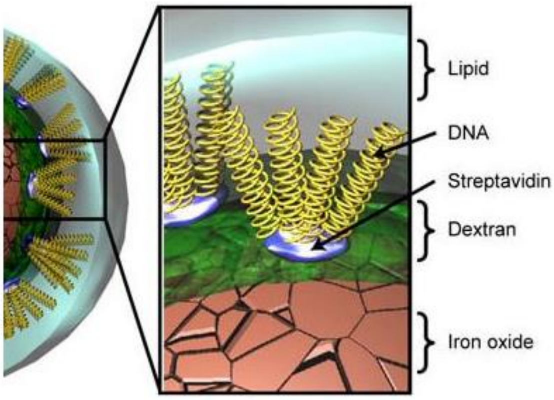

Fig-1: Shows the agricultural roles of nanotechnology in the crops improvement for varieties

Agriculture is the practice of growing of various crops and to raise livestock for the production of food. It is regarded as the backbone financial system for the developing world, playing a critical role in development and progress. The world's growing population creates a higher requirement for more food supply, and engineers and scientists are now experimenting with new techniques to increase agricultural production [24]. When compared to the existing analytical biosensors, nano-sensors represent a great resource with advanced and efficient features. Nano-sensors are analytical devices with at least one detecting dimension of less than 100 nanometers that are used to monitor physicochemical characteristics in places that would otherwise be difficult to access. Nano-tubes, nano-crystals, nano-particles, and nano-wires are frequently used to optimize signal transduction derived from sensing devices in response to exposure to biological or chemical analytes of comparable size. They have distinctive surface chemistry, optical, electrical, and thermal properties, that can be used in multimode systems for improving sensitivities, improve detection limits and reduce response times [25, 26].

Table-1: Shows the role of nanotechnology in physiological proceses

Plant Characteristics/Features	**Role in development**	**Agricultural significance**
Seed germination	plant's life cycle, assisting sapling development, survivorship, and population trends.	abiotic stresses like heat, salinity, cold, soil alkalinization, drought.
multiwalled carbon-nanotubes	improves germinating seeds in a variety of crop species,	such as corn, soybean, wheat, tomato, maize, garlic peanut, and barley
Titanium based nanoparticles	Triggers the development of carbohydrates, which promotes rates of photosynthesis and plant growth	They are frequently used to optimize signal transduction derived from sensing devices in response to exposure to biological
Nano devices	nano-sensors represent a great resource with advanced and efficient features.	Nano-sensors are analytical devices that are used to monitor physicochemical characteristics in places that would otherwise be difficult to access.

Farmers follow the commonly used conventional pest management techniques such as healthy crop variety, integrated pest management, crop rotation, sowing date manipulations and so on to handle insect pests in agriculture. Among these, integrated pest management is the most widely used technique. The term "integrated pest management" was formalized by the United States Academy of Sciences. Integrated pest management was proposed as a solution to minimize the side effects of pesticides by combining the use of various pest control strategies (resistant varieties, chemical, biological and cultural control). Integrated pest management is thus more difficult for the growers to implement because it necessitates skill in pest nursing and understanding of pest dynamics, moreover, to the cooperation of all growers for effective application [27-29].

Clay minerals can be used as receptacles because they control such reactions. Nano-fabricated fertilizers could be used in aqueous suspension and hydrogel forms, allowing for risk-free usage, convenient delivery system and easy storage. Given the higher adsorption affinity of these nano-particles for heavy metals and organic compounds, zero - valent iron nano-particles and even iron rust nano-materials could be used for soil stabilization polluted with pesticide residues, radionuclides and heavy metals. Iron nano-particles, like calcium carbonate nano-particles, have outstanding soil binding capacity that aid in the establishment of soil macro-aggregates and micro-aggregates [22, 23, 28].

It is hoped that nanotech will provide long-term remedies by replacing conventional bulk fertilizers with nano-particulate counter - parts that have excellent characteristics for overcoming current problems such as mineral bio-availability and absorption, increasing agricultural output, minimizing fertilizer waste, and safeguarding the environment [29]. α -amylase is an important enzyme responsible for the breakdown of starch during cereal germinating seeds and subsequent seedling establishment. This enzyme is the only one which starts hydrolysis of the native starch molecules and is synthesized from scratch during cereal germinating seeds. It catalyses the hydrolysis of α-1, 4 linked glucose polymeric materials to release remnants that could be further degraded by other amylases [30-32].

Both subsequent drying and soaking may stimulate stress related responses (heat shock proteins and antioxidant mechanisms), actually results in cross resistance to certain other stress factors. Nano-priming could be practiced to seeds to preserve them during storage, enhance germination rate, germination synchronization, and plant growth, and also enhance resistance of crop to biotic and abiotic stressful conditions, which can contribute to minimize the amount of pesticides and fertilizers needed [33].

CONCLUSION

Plant physiological processes are crucial for seed and germination under the normal conditions Furthermore, faster germination can be possible through nanotechnology that reduces the time germination of seeds are exposed to undesirable soil conditions. Thus, priming of seeds has been utilized successfully to speed up and sync germination, raise seedling vigor, and make plants extra resilient to biotic and abiotic stresses, leading to improved efficiency and quality of food.

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