UTILIZATION OF NANOBIOTECHNOLOGY IN AGRICULTURE

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Abstract

Science in the modern world has become a necessity for human life, but by employing beneficial and protective means to protect the overall health of the ecosystem, we survive in. In the previous decades, the use of tiny nanoscale particles have caught the interest of scientists because of their valuable and harmless properties. The use of nanoscale materials has been tested and approved by scientists in many fields related to medicine, drug delivery systems, health care departments, and agriculture. This article suggests the use of beneficial nano-materials in agriculture because they are less harmful to the environment and safer for plants. Nanobiotechnology comes with its vast and plentiful measures to benefit the overall ecosystem, many of which are discussed in the following article.

Key words: Health, Nanoparticles, nanotechnology, nanocomposites, silver

Introduction: In the modern-day world, science and technology have become a major part of everyday life. They helped to improve the lives of human beings in many ways like greater access to revolutionary health care systems, improved agricultural systems, diagnostics, medicine, and different areas of research. One of the most significant achievements of science in the past few decades is "Nanobiotechnology". Nano-technology involves present-day engineering and science used at a tiny scale (about 1-100 nanometers). A nanomaterial is known to be any material that has a single or more dimension on a nanoscale.

Nanoparticles are eco-friendly and also have the ability to duplicate. Some of these include magnetosomes, viruses, ferritins, lipoproteins and exosomes (Dieudonne *et al.,* 2019; Yong *et al.,* 2019).

In addition, nanoparticles, due to their smaller size with a larger surface area, are more valuable for addressing specific challenges than many biochemical or physical means (Zhao *et* al., 2020; Sekhon, 2014).

Agriculture has been used to get food, fibrous materials, and many profitable products through several domestic animals and many plants. However, changing climate conditions, limitations of energy and different assets, and increasing population have put immense pressure on the growth of agricultural resources. Due to these reasons, the agricultural assets also need to rise. As a result, it puts a particular burden on farmers to increase crop growth and animal feed (Rangasamy, 2011). Because of these circumstances, modern technologies like nanotechnology have become a useful means to increase global food production (Batmanova *et al*., 2013).

Nanoparticles if used as macro and micronutrients, they are more efficient for being more active physiologically owing to their very small size, can increase agricultural production by multifolds. They are also helpful in preserving the present food production.

Nanotechnology in agriculture is newer than nano-pharma and has become one of the most widely used technologies among medicine and environmental nanotechnology. With the help of nanotechnology, it has become much easier to find diseases in plants, increase plant growth, provide protection, increase food from plants and make better quality food (Kashyap *et al*., 2019; Gruere *et al*., 2011).

Scientists have put immense effort in synthesizing nanoparticles by using biological, chemical and physical means. But such methodologies have certain shortcomings (Pilarska *et al*., 2013). Therefore, sustainable ways that require lesser chemicals called "green methods" are used instead of other methods. It involves nanomaterials that are biologically synthesized with the help of microbes or phyto-engineered organisms. This technology is safe, fast and creates lesser waste material (Ghidan *et al.*, 2017).

The combination of microorganisms and plants for making metal nanoparticles is being acknowledged as an effective way to form nanoparticles. Because of their small size and distinctive properties, metal nanoparticles have gained recognition in the agricultural field. Metal nanoparticles are used for germination of seeds, carriers for delivering fertilizers, as regulatory materials for crop development, etc. In addition, microorganisms have reductase enzyme, which helps in toxic detoxifying elements in metal nanoparticles like metal salts.

Many bacteria, *Pseudomonas deptenis*, *Visella oriza*, *Bacillus methylotrophic*, *Bhargavaea indica* and *Brevibacterium rigoritolerans*, can help in the synthesis of gold and silver metal-nanoparticles. In addition, several other microbes such as algae, yeast, fungi can also form metal nanoparticles within or outside cells (Golinska *et al*., 2014). Metal nanoparticles that synthesize outside microbial cells have great importance because particles formed externally do not need economic downstream processing and are readily available (Hulkoti and Taranath, 2014).

Over time, pests have become more resistant to plant pesticides and, in return, have destroyed plant production. To protect plants from getting destroyed, nanoparticles are used to transfer a gene or DNA to plants that will help make plants resistant to many types of pest growth, aid in increasing the quality of storing and processing food and also helps in increasing the shelf-life of agricultural products (Asmatulu *et al*., 2020).

A very innovative tool called microencapsulation, in which a thin dissolvable covering coats tiny particles, has been used to form hydrophobic pesticides, which helps spread molecules quickly in water and releases those particles in a controlled way. Reports show different types of polymers that are included as nanoparticles using microencapsulation (Perlatti *et al*., 2013). Polymers allow nanosized pesticides, insecticides, fungicides and many chemicals that enhance growth (Ashfaq *et al*., 2019). For example, by combining many aliphatic di-acids and polyethene glycol, 2- Imidazolidinimine is formed via a controlled system by using encapsulation technique to enhance efficiency in certain crops (Yao *et al*., 2021). Preparations of this formulation also proved viable for pests of different significant plants such as *Bemisia tabaci Gennadius*, soybean, stem fly,

whitefly and *Melanagromyza sojae* (Adak *et al*., 2012).

Another nano-pesticide that has proved efficient is garlic oil (filled in nanoparticles) and coated with polyethene glycol. It helps to prevent the growth of *Tribolium castaneum*, also known as Herbst. The nanoparticles slowly dispersed in the plant and had about 80% control over the pesticide in 5 months. (Yang *et al*., 2009).

Silica has gained a lot of attention due to its ability to degrade quickly and its benefits in the medicine, optical and agriculture industry. In its amorphous form, silica is quite effective as biopesticide. Silica packed in nanoparticles is hydrophobic and lipophilic (Barik *et al*., 2008). It proves highly effective in making silk cocoons by transforming the alpha-helix structure to a beta-sheet framework to form a stable crystal structure. It is used in the manufacturing of clothes. Without adding the nanostructure containing silica, the silkworm does not provide a stable structure (Zhou *et al*., 2020). Mycelia growth on pumpkins and cucurbits is repressed by nano-materials containing silverof 100 mg/kg size. Nanostructure in which silica and silver are combined are effective against *Rhizoctonia solani* and *botrytis cinerea*. Silica-silver nanosized molecules combined give antifungal properties (Hae-Jun *et al*., 2006).

Copper induced in nanoparticles withcombining soda lime, which has a low melting point, kills microbes that are either gram negative or positive in nature. Sodalime shows good effects against many microbes especially yeast (Esbetan *et al*., 2009). In many plants, with the help of many endo-mycorrhizal fungi transfigured copper to form metal nanoparticles in roots. Several chemical reactions like response to stress caused by oxidation may cause copper to change. Thus, plants are mineralized with copper under roots in environments with oxygen (Manceau *et al*., 2008). Pests such as fruit flies can be reduced by the use of "pheromones" that are biochemical which cause change in the nature of an organism by taking signals. These chemicals are also known to be involved in the management of plants as they are environmentally friendly. A nanogel is prepared by a pheromone (methyl eugenol) by using gelator with a low mass weight. The gelator in the pheromones prefabricate themselves to form the nanogel. The nanogel offers a stable structure to the gelator. When this nanogel is given to plants it traps the pests inside it (Zhang *et al*., 2022). This way many plants such as guava, melons, grapes and tomatoes can be saved. This effective and easy to use methodcan help in creating a healthier environment for agricultural plants and is also eco-friendly (Bhagat *et al*., 2013).

Composite Structures for Soils and Plants

A strong composite structure derived from metals and ceramic of nano-size can be formed. Hard and unbreakable metals roughly the size of 10nm are formed, proving to be stronger than other usual composites. A composite formed by nanoparticles is multifaceted. One phase consists of 1 to 3 dimensions lesser than 100 nm (Ajayan *et al*., 2003).

Nano-clay, which is composed of octahedral aluminium hydroxide sandwiched between two tetrahedral layers of silica, is a good source of food packaging. This can keep food fresh longer after harvesting (Sozer and Kokini, 2009). Nano-crystals made through cellulose are used as eatable coatings, used to solidify food items and are cheap and organic (Cao *et al*., 2011). Carbon composites are another form of nanocomposites. They can help plant development and protect plants from several harmful agents (Ashfaq *et al*., 2019). Agricultural mulches are used to protect the crops from

harsh temperatures and the growth of weeds (Kader *et al*., 2017). Plastic mulches, made with polyethene, are widely used for this purpose, but polyethene is not environment-safe and consequently pollutes the environment. Hence, biodegradable mulches are used. These mulches are ploughed into the soil, where after serving their use, they are destroyed by microbes present in the soil. Biodegradable mulches are sourced from plant, microbes or fossil-fuel-based nanomaterials (Marechal, 2003). Common polymers used in these mulches are starch, cellulose, polylactic acid or poly-hydroxyl kanoates (Brodhagen *et al*., 2015). Nanosensors can help farmers sustain their farms by reporting the needs of plants at specific times and giving them accurate control over plants (Mousavi and Rezaei, 2011).

Hydroponics is a technique used to grow plants without soil and only use an aqueous environment with minerals and other nutrients essential for plant development. Nanoparticles made up of metals are also helpful in increasing hydroponic plants. For example, iron oxide nanoparticles and other nutrients are used to grow tomatoes in hydroponic conditions. The introduction of iron oxide does not allow any toxicity, and the plant can grow normally (Sharifan *et al*., 2019; Giordani *et al*., 2012).

Conclusion

Nanotechnology is proving to be a revolutionary technology for plants and agriculture. It has capacity to increase the food production by increasing the food production per area as well as by preserving the present food by protecting it from pests.

The use of silver nano-molecules can be used in animal feeding as they help kill microbes in animal bodies. They are also used to kill micro-organisms in broiler chicken (Pineda *et al*., 2012). Nano-materials magnetic can purify mycotoxins aflatoxin B1 and zearalenone, using monoclonal-antibodies against the two, through the feed. This can prove beneficial for sterilizing mycotoxins from animal bodies (Kim *et al*., 2012).

Nanobiotechnology has provided humankind with efficient, green and cheaper means of agriculture. Using nano-materials is known as a substitute method for controlling various deadly pathogens and other harmful microbes. Nano-biotechnology has brought about green strategies that can improve the process of fertilization, help treat wastewater for reuse, increase the rate of absorption of nutrients in the crops, and help make plant growth regulators. Nanotechnology has also helped in controlling the pollutants in the environment.

There is still research happening on nanobiotechnology, and its tools are still being investigated. The need to check the overall process of administration of nanoparticles, their activity when given to the crops, their toxic effects and the impact it has on the overall growth of the plants. Several measures have already been taken by researchers all around the globe to ensure these things.

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