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Review Article

Biological synthesis of nanoparticles and their uses in the field of agriculture

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ABSTRACT

During the past years, the world tended to a wide use of nanomaterials in various fields due to their properties that similar materials of large sizes does not have. Nanotechnology is one of the modern technologies that are involved in many fields, including agriculture, as it aims to use technology that is less harmful to human health and the environment. Environmental protection is one of the most prominent applied fields that nanotechnology pays great attention to due to the connection between human health and the environmental conditions in which they live. Therefore, it seeks to prepare Nanomaterials in a biological way, which is one of the easiest, fastest, cheapest and safest ways for the environment. Microorganisms or extracts of plant parts (roots, stems, leaves, seeds and peels of fruits) are used to produce natural Nanomaterials for many minerals, including iron and zinc oxides, as they are essential elements for plant growth, so the study aimed to manufacture Nanomaterials from plant extracts to produce metal oxides, such as iron oxide, zinc and copper and their effect on improving plant growth.

Keywords Nanomaterials, Biological synthesis, Environment, Agriculture

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1. Introduction

Technology is the art of applying theoretical sciences and concepts, and nanotechnology is the precise technology, and linguistically, it is the theoretical technology of the natural sciences at ultrafine levels. Recently, we often hear about nanoparticles and their many applications in the fields of life due to their scientific and life importance, including medical, electronic, industrial and agricultural applications. The word Nano means dwarf, a word taken from the Greek word 'nanos,'. Nano represents a part of a billion, so Nano is equivalent to 10^{-9}. It is common knowledge that materials are within the nanoscale if one of its dimensions does not exceed 100 nanometers. The science that deals with the applications and uses of these materials is called Nano-science, which is the science that deals with the study of the ultrafine world, which is the world of atoms and molecules [1]. In 2003, nanotechnology begun to be used in the field of agriculture and food industry, which led to a change in agricultural production systems, as this technology brought about radical changes in agriculture, as new tools were used to treat plant pests and quickly detect them. Agriculture faced many challenges, including climate change and the reduction of cultivated areas, which raised the need to advance the agricultural development. Hence, using nanotechnology in ways that are safe for the environment became important. This technology is one of the most important technologies that are involved in multiple fields, as it relies on the manufacture of materials with nanoscale dimensions, and these particles have different properties from the materials from which they are formed, based on the engineering of the particles of the material (metal) in various shapes and sizes[2].

In recent years, interest in producing metallic Nanomaterials from natural materials has increased, as they are used in various fields such as biological, agricultural and environmental[3]. This is because Nanomaterials manufactured by physical and chemical methods take longer time and require large energy, and the use of harmful materials such as organic solvents may be difficult to get rid of and have effects on the environment[4]. Nanomaterials are manufactured from the metabolites of microorganisms such as bacteria, viruses, fungi and algae, as well as from plant extracts for being environmentally friendly and this method is called green chemistry. In 2010, the increase of scientific research and scientific production in this field was evident until 2016, where the scientific production reached its peak by recording the highest number of scientific researches in this field [5].Therefore, the aim of the study was to update the researches in the field of biological manufacturing of metal nanomaterials using plant extracts, and their use in agriculture by improving the growth of plant production.

2. Nanomaterials and their biological manufacture from the extracts of plant parts

The process of manufacturing nanoparticles using plant extracts and other microorganisms is called green chemistry, as these plants and organisms contain proteins, fats, sugars and other natural compounds. Plants also usually contain organic compounds that are important in the production of nanomaterials in an easy, fast and safe way for the environment. Among these materials are phenols, alkaloids, and flavonoids. These compounds and materials play an important role in the formation of reducing agents that reduce metal ions to environmentally friendly nanomaterials as they contain effective groups [6, 7].

3. Biological manufacture of metallic Nanomaterials

Metal oxides have important uses, applications and a place in nanotechnology, as they are widely used in the installation of sensors, fuel cells, electronic radars, and anti-corrosion coatings [8]. Among these metal oxides are the following:

3.1. Nano iron

The researcher [9] synthesized nano iron in a biological way using the aqueous extract of the roots of the plant *Chromolaena odorata*. The roots of the plant were washed with water and dried under sunlight for 14 days, then 5 gm of root powder was added to 50 ml of distilled water and the mixture was heated at 85°C for two hours with continuous stirring. The extract was filtered and placed in a centrifuge to separate the impurities. Then iron salts were added to the extract and then the mixture was heated at a temperature of 70°C. One hour later, it was observed that iron nanoparticles formed. These particles were spherical with dimensions of 5.6-18.6 nm under the electron microscope. The researcher [10] added that the nano iron was bio-manufactured in an easy, fast and economical way from the fruits of the *Cornus mas* L. plant, as it had a clear effect on increasing the biomass of the stems and roots of barley plant when added to the plant at a concentration of 10-100 mg/L, which made the researcher to recommend fertilizing plants with iron nanoparticles.

3.2. Nano-copper

Many plant extracts were used to manufacture copper nanoparticles for its benefits in different fields, including agriculture. The researcher [11] used the seeds of the bean plant *Caesalpinia bonducella* to manufacture nano-copper oxide, as the size of the synthesized particles was 13 nanometers. While the scientist [12] made nano-copper oxides from the fruits of the *Quercus robur oak* plant, after making a mixture of the fruit extract, adding copper salts, then the mixture was boiled until heating at a temperature of 500 ° C for 4 hours, and then nano-copper oxides with a size of 40 nanometers were obtained. Different parts of several plants were used, such as the leaves of *Ziziphus mauritiana*, the root extract of *Rhenum palmathum* and the flowers of *Aglaia sp*. [13,14,15].

3.3. Nano-Zinc

Scientists paid great attention to the manufacture of nano-zinc for its wide uses., since it acts as an anti-fungal, anti-bacterial and anti-viral without causing any toxicity, and this feature made this material to have medical and agricultural applications, so it called on researchers to conduct several studies in which plant extracts were used to manufacture nano-zinc oxide. The researcher [16] used the roots of *Raphanus sativus*, as he dried the roots and crushed them, then added distilled water and boiled for 30 minutes, and the roots extract was gradually added to the zinc acetate solution at a concentration of 0.1 mol/liter with continuous stirring and a temperature of 80 °C until a precipitate was formed, which indicates the formation of spherical zinc nanoparticles with a size of 25-40 nm and agglomerated in chains. There are studies that used the fruit's peel of banana *Musca acuminate* and the leaves of *Moringa oleifera* and *calotropic procera*, and the flowers and stems of *Ocimum basilicum* to manufacture nano-zinc, as it had an inhibitory effect on the growth of bacteria and fungi. [17,18 , 19, 4].

3.4. Other metallic nanomaterials

Some studies were conducted on plant extracts to manufacture nano-metals. The researcher [20] manufactured manganese nanoparticles from the aqueous extract of the seeds of the sunflower. Electron microscopy confirmed that the particle size ranged between 10-70 nm. Another study by the researcher[21] , the aqueous extract of the seeds of the *Cucurbita pepo* L. plant was used to manufacture titanium nanoparticles Tio2Nps. The researcher [22] was also able to prepare nano-titanium dioxide from the extract of *Citrullus colocynthis* plant, the red tea plant and the papyrus plant, and the size of the prepared crystals was within the nanoscale, which is less than 100 nanometers and has a lumpy sphere shape.

4. Nanoparticles and their uses in agriculture

At the present time, countries are working to maximize the capabilities of bio-nanotechnologies in the service of the agricultural and environment economy. There are many challenges facing the agricultural sector, including the increasing demand for healthy and safe foods with the increasing risks of diseases and the great threats facing agricultural production as a result of climate changes. Nanotechnology includes the possibility of making radical changes in agriculture through new tools for molecular treatment of diseases, rapid detection and improvement of plants' ability of Nutrient absorption.

The nano-applications in the agricultural field are one of the most important mechanisms to reach modern farming methods, which is represented in the low economic cost resulting from the absence of epidemic diseases that affect various agricultural crops, as well as the increase in the efficiency of manufactured fertilizers with their low material cost and the resistance of the agricultural product to different environmental conditions [23]. The rapid developments led to the emergence of new technologies and methods in various ways of agriculture and food production during the past ten years, where food companies seek to produce the best agricultural crops, and scientists believe that the use of nanotechnology will help food companies to produce foodstuffs free of preservative damage and less expensive than it is today, through the less- use of chemicals in the preparation and production of foodstuffs in the future [24].

The application of nanomaterials in agriculture in particular aims to reduce the applications of plant protection products, reduce nutrient losses in fertilization [25] and increase yields through improved nutrient management. Nano-tools and technologies, nanoparticles, and even nanocapsules are examples of the uses of disease detection and treatment, to enhance the uptake of plant nutrients. The biologically manufactured nanoparticles specifically can be used to reduce damage to plant tissues [26]. Nanomaterials offer great opportunities in the field of agriculture due to their unique physical and chemical properties. The interaction of nanoparticles with plants leads to many physiological and morphological changes depending on the properties of these particles, including chemical composition, size, surface area, and the most important of which is the concentration [27]. The researchers found that there are two types of response, which are negative and positive, of nanoparticles to plant growth, depending on the properties of nanomaterials and the method of application, as well as plant species [28]. Studies shown that the use of zinc oxide by nanoparticles improved plant growth significantly. The results of [29] showed that the use of nanoparticles can improve plant growth.

5. The effect of nanoparticles in resisting plant pathogens

Nanotechnology is one of the most promising methods in resisting various plant diseases. Nanomaterials have been used as biological indicators to detect the pathogens of fungi, viruses and bacteria, as well as their role in resisting various plant pathogens. The use of nanomaterials in the field of resisting plant pathogens is one of the environmentally beneficial methods as these materials decompose in the ecosystem, on the other hand, it is difficult for pathogens to easily form resistant strains [30]. Nano-pesticides consist of organic materials polymersor inorganic materials (metal oxides) that have a clear solubility, releasing active substances in a slow and gradual manner, providing protection for the active substances against decomposition [31].

Viral diseases are considered one of the most difficult plant diseases, as a research was conducted by the scientist [32] using nanomaterials against tobacco mosaic disease. The results showed that the rate of disease inhibition was 92% and 86%, and the researcher confirmed that the use of silver nanoparticles against viral causes is a preventive treatment. In recent years, many studies were conducted on the use of nanoparticles as pesticides for plant fungal pathogens. The study conducted by [33] showed the ability of biosynthetic copper nanoparticles to inhibit fungal plant diseases in vitro as compared to a control treatment. The scientist [34] pointed out the role of these particles in controlling root rot on *Zingiber officinale* plant. Copper oxide nanoparticles were also used to resist the fungus Fusarium. The results of the research showed that the use of a concentration of 80 µg/ml in the culture media led to an inhibition of the growth of the fungus by 90% [35]. [36] also studied the effect of foliar spraying with different concentrations of both silicon and titanium oxide particles to resist powdery mildew and downy mildew on zucchini plants. The results showed a significant decrease in the severity of infection for both diseases when using the mixture of nano-oxides compared to the traditional pesticide. It was found that the use of silver nanoparticles at a concentration of 10 ppm was effective in resisting the disease of powdery mildew caused by the fungus *Sphaerotheca panrosa*, which infects ornamental plants, including rose, in greenhouses, as 95% of the infection was eliminated after two days of treatment. The use of zinc nanoparticles also prevented the growth and formation of conidial carriers of the treated fungi *Botryus cinerea* and *pencillium expansum* when they were used at a concentration of 3 mml/L.

6. Conclusion

We conclude from the above that the use of this very advanced technology and catch up with the countries that preceded us in this field is important, as the use of plant extracts in the biological manufacture of nanoparticles is one of the easy, fast and environmentally safe methods, and it contributes to a promising role in the field of agriculture as it contributes to increasing agricultural production and productivity as well as reducing costs. Despite of the great benefits of using nanomaterials, the potential environmental risks of using nanomaterials for a long time must be taken into consideration before adopting their application on a large scale. We recommend conducting useful scientific researches in this field and transferring these researches to take their share of practical application on the ground of reality in order to achieve new added value for the agricultural sector and the national economy.

Conflict of Interest

The authors declare that there is no conflict of interest.

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