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Green Synthesis of Phytogenic nanoparticles using Plant Extracts and their Promising Roles in Sustainable Agriculture: A Review

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Enhancing plant resilience is essential as the globe struggles with rising agricultural needs and unpredictable environmental stresses. To improve food security, we must develop stress-resilient plant varieties. This task requires understanding nanoparticles' ground-breaking role in reducing plant stress. Nanoparticles' unique chemical and physical properties can significantly enhance plant development, nutrient uptake, and stress tolerance, thereby revolutionizing sustainable agriculture. Various approaches are used in the synthesis of nanoparticles. Traditionally, physicochemical techniques raise environmental concerns due to using toxic substances and producing harmful byproducts. Recently, biosynthesis, an environmentally friendly method of synthesizing nanoparticles, has emerged, overcoming the limitations of conventional techniques. Biosynthesis of nanoparticles, which uses all living things, including plants and microorganisms, is a promising avenue. Plants stand out for their potential to produce green nanoparticles due to their rapid growth, stability, and suitability for large-scale biosynthesis.

Keywords: Green synthesis; phytogenic nanoparticles; plant extracts; NPs; Sustainable Agricultural

INTRODUCTION

Sustainable development, which balances present needs with the ability of future generations to meet their requirements, is a pressing issue in many sectors, particularly agriculture (Hano and Abbasi, 2021). The increasing need for agricultural production due to global climate change and population explosion presents an unprecedented challenge for the existing agricultural system (Bhandari et al. 2023), where food output must increase by 60–80% to feed about 10 billion people by 2050 (Etesami et al. 2021). Adverse environmental changes have harmed the world agriculture sector in recent years. As a result of these climatic changes, the abiotic environment of plants has changed, impacting plant physiology, growth, and productivity. Abiotic stress in plants is one of the most significant barriers to global agricultural output and food security (Al-Khayri et al. 2023). Therefore, there is a need to find new technologies to overcome these problems achieving the twin challenges of global food security and sustainable progress of modern agriculture (Zulfiqar and Ashraf, 2021).

One cutting-edge strategy to boost agricultural yield is nanotechnology, which uses nanoparticles (small particles ranging in size from 1 to 100 nm) and can create higher-quality materials and goods. Modern agricultural techniques rely heavily on nanomaterials, such as nano-sensors, nanocides, nano fertilizers, nano barcodes, and nano-remediators (Bhandari et al. 2023). However, the physical and chemical methods of producing nanoparticles are not environmentally friendly or cost-effective (Bhandari et al. 2023). Thus, green chemistry and bioprocesses have become the center of attention for researchers in their quest for a reliable, safe, non-toxic, and environmentally acceptable way to produce NPs (Radulescu et al. 2023). Green nanotechnology generally refers to applying several biotechnological approaches to biological pathways—such as bacteria, fungi, or plants—to synthesize nanomaterials (Pal et al. 2019). Plant extracts are one of the easiest ways to synthesize nanoparticles on a large scale compared to bacterial or fungal-assisted synthesis, among other greenways.

When used in this context, these substances are known as biogenic nanoparticles (Chopra et al. 2022). Green synthesis aims to develop chemical methods that minimize or eliminate the need for hazardous materials in creating, manufacturing, and using chemical products. This means minimizing the pollutants produced during the synthesis processes, eliminating the use of nonrenewable raw materials and the waste they make, and reducing the synthesis time required. (Pal et al. 2019). Thus, this review paper aims to illuminate the latest advancements and trends in plant-mediated nanoparticle production, the variables that influence the synthesis and characterization of NPs, and the mechanisms underlying phytogenic NP absorption in plants. It will also highlight the application of nanoparticles in sustainable agricultural practices.

Nanoparticles (NPs)

Nanoparticles are particles that have at least one dimension less than 100 nm(Thabet and Alqudah, 2024) and have a variety of distinctive characteristics, including a high surface area to volume ratio, crystal structure, adjustable pore size, and Living organisms' cellular and molecular activity (Azameti and Imoro, 2023). The two main strategies for synthesizing nanoparticles are top-down and bottom-up methods. Many synthetic routes have been used, including chemical, physical, and biosynthetic ones (Jadoun et al. 2021). Synthesis of nanoparticles (NPs) is typically accomplished by costly and environmentally hazardous chemical and physical procedures that need a lot of energy and produce dangerous byproducts (Chakraborty et al. 2022). However, green biogenic methods are simple, convenient, eco-friendly, and safe (Ragab & Saad-Allah, 2020). Recently, Plant and algal tissues have been used as reducing agents to synthesize biogenic nanoparticles, using a bottom-up approach to green nanotechnology. This low-energy method reduces metal ions from liquids (figure 1) (Bhandari et al. 2023)**.**The biosynthesized NPs could be used in agricultural systems to increase their resilience, sustainability, and efficiency in the face of global environmental stressors(Zulfiqar and Ashraf, 2021).

Biosynthesis of NPs

The biosynthetic process uses microorganisms and plants to safely, environmentally friendly, and sustainably synthesize nanoparticles. The three essential requirements for synthesizing nanoparticles are choosing a safe stabilizing substance, an effective reducing agent, and an environmentally friendly solvent (Sarkar and Kalita, 2023). Fungi, algae, bacteria, plants, and other organisms can all be used in this synthesis. Plant parts such as leaves, fruits, roots, stems, and seeds have all been used to synthesize different kinds of nanoparticles due to the phytochemicals in their extract having reducing and stabilizing properties (figure 2) (Jadoun et al. 2021). When comparing utilizing plant extract to produce nanoparticles to other environmentally benign biological systems such as bacteria, there are advantages, such as the ability to do away with costly and time-consuming preparation and isolation techniques (Chopra et al. 2022), where the time required to complete NPs synthesis depending on the kind of plant biomolecules and the concentration of plant extracts. However, cultivating microorganisms requires a significant amount of time, typically 2 to 10 days. The toxicity of certain microorganisms impacts the qualities of produced NPs. While bacteria are still challenging to get, plants are readily available, processing of nano-synthesis based on plant extracts takes place at room temperature. Conversely, high temperatures are necessary for producing metallic NPs using microorganisms (Azad et al. 2023). Plant-based biosynthesis offers a significant advantage over other methods because it is a simple process that can be easily scaled up for the large-scale production of nanoparticles.(Chopra et al. 2022).

Green synthesis of nanoparticles: the involvement of plants

Different plant parts, including bark, fruit, leaf, latex, peel, seed, stem, shoot, root, phytochemicals, and essential oils and their extracts are extensively utilized for eco-friendly nanoparticle production because of their abundant sources of proteins and carbohydrates, enzymes, vitamins, organic acids, flavonoids, phenols, tannins, and terpenoids are responsible for metallic ions bio-reduction (Ahmed et al. 2021). There are many studies concerning the use of plants and their biomass in the synthesis of nanoparticles are underway (Bhandari et al. 2023), as shown in Table (1).

There are three methods to use plants to synthesize green nanoparticles: intracellular, extracellular, and phytochemical-mediated. The Intracellular approach is quite similar to the intracellular method employing microorganisms in that the synthesis occurs internally in the plant cell, and disassembling the structure yields the nanoparticles. Plant species' growth factors must be controlled to prevent them from interfering with synthesis (Saim et al. 2021). Extracellular: This approach is the most popular due to its simplicity and quickness. The first step in the procedure is to extract a plant. Usually, a metal salt precursor is added to a water-based extract. The various components in the extract work together to create and stabilize nanoparticles in one step. (Naikoo et al. 2021). Phytochemically mediated: this approach resembles the extracellular strategy but uses separated phytochemical chemicals and other materials to stabilize the nanoparticles. More components and stages are involved, but there is more control over the synthesis (Álvarez-Chimal and Arenas-Alatorre, 2023).

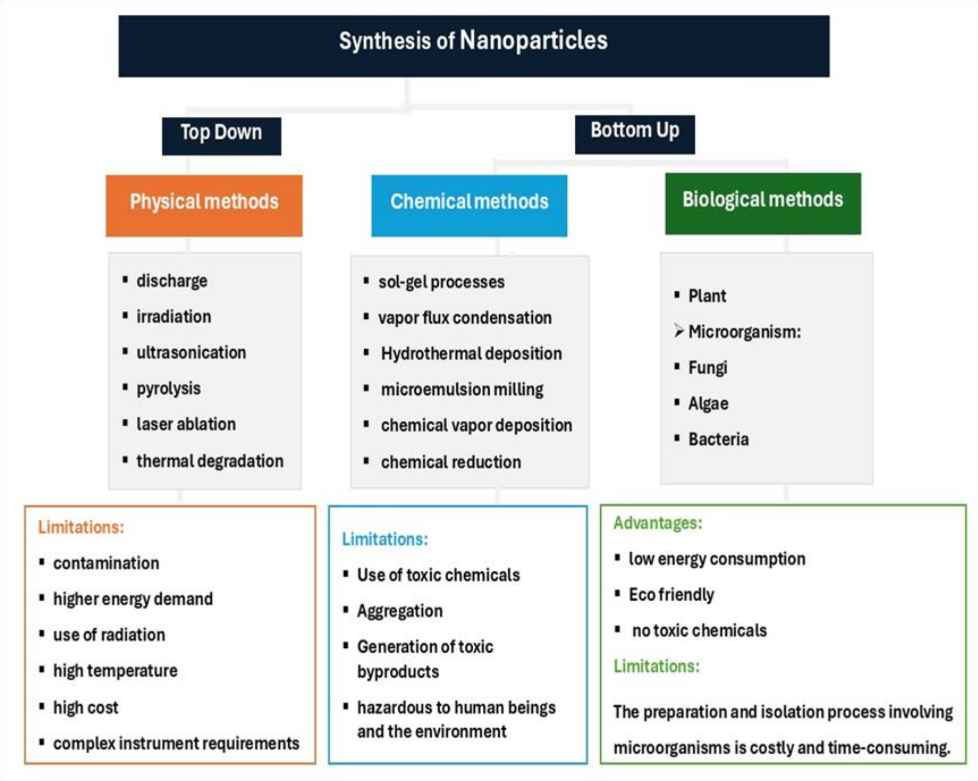

Figure 1: Nanoparticle synthesis techniques

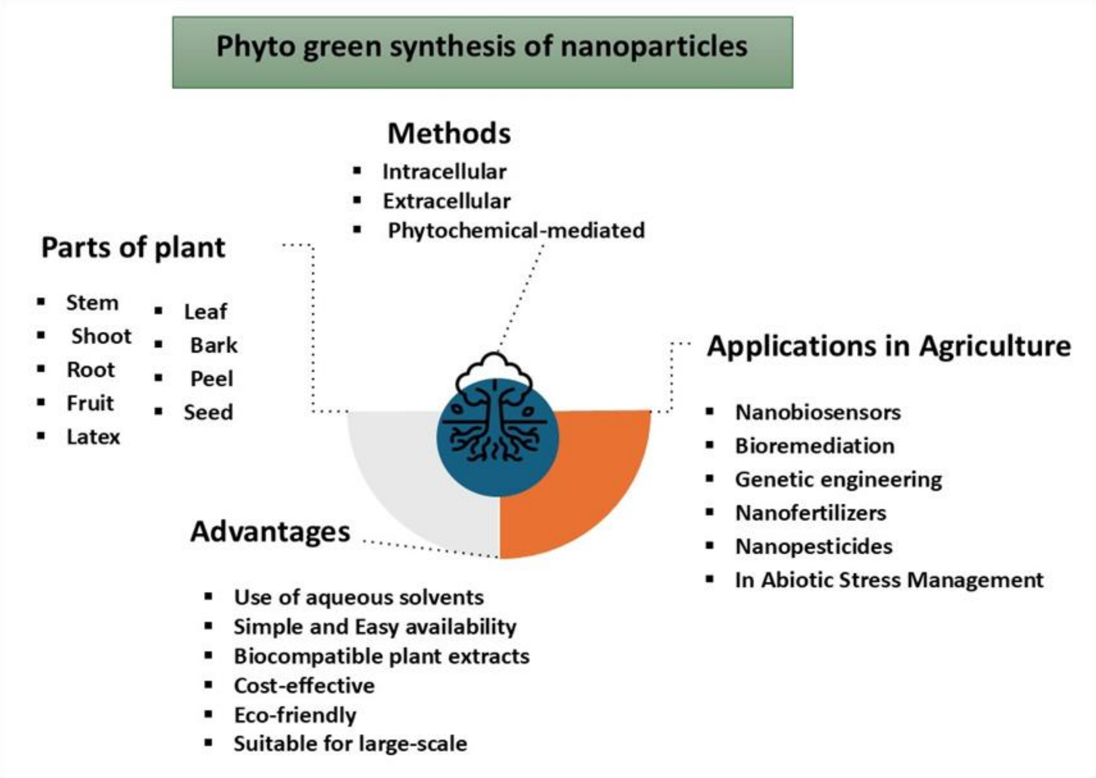

Figure 2: Green synthesis of phytogenic nanoparticles

Table 1: Green nanoparticle synthesis using various parts of plant source

Plant	Source of Plant extract	Phytogenic Nanoparticles	Size (nm)	References
Jasmin sambac	Leaf	Copper	13.4	Nouren et al. (2024)
Cakile maritima	Seed	Silver	9.45–17.15	Elazab et al. (2024)
Nymphaea tetragona	Flower	Platinum	4.04±1.31	Zhang et al. (2023)
Cynara cardunculus	Flower petals	Silver	8 - 20	Saygi et al. (2024)
Nigella sativa	Seed	Copper	98.23	Kumar et al. (2023)
Pteris vittata	Leaf	Silver	17	Jha et al. (2022)
Litchi chinensis	Peel	Zinc	<10	Sachin et al. (2023)
Carica papaya	Peel	Zinc	170	Easmin et al. (2024)
Musa acuminata	Peel	Nickel	20–80	Şahin et al. (2024)
Actinidia chinensis	Fruit Peel	Silver	10 to 70	Bharathi et al. (2024)
Barleria buxifolia	Leaf	Silver	80	Sekar et al. (2022)
Nymphaea tetragona	Flower	platinum	4.04±1.31	Zhang et al. (2023)
Nigella sativa	Seed	Copper	98.23	Kumar et al. (2023)
Rubia cordifolia (L.)	Leaf	Silver	20.98	Chandraker et al. (2022)
Cissus quadrangularis (L.)	Stem	Zinc	88	Nazneen and Sultana (2024)
Turmeric curcumin	Root	Gold	8.5	Kabak et al. (2024)
Allium cepa	Yellowish peel	Silver	19.47±1.12	Baran et al. (2023)
Abelmoschus esculentus	Fruit	Copper	20	Javid-Naderi et al. (2023)
Terminalia chebula	Fruit	Copper	10-12	Munusamy and Shanmugam (2023)
Solanum nigrum	Fruit	Selenium	87	Saranya et al. (2023)
Cinnamomum verum	Leaf	Silver	10 -45	Zhou et al. (2022)
Euterpe oleracea Mart.	Seed	Zinc	60	Vieira et al. (2024)
Elettaria cardamomum	Seed	Silver	21	Mohammed et al. (2024)
Moringa oleifera	Leaf	Selenium	71.2	Banerjee and Rajeswari (2024)
Abrus precatorius	Bark	Magnesium	100	Ali et al. (2023)
Balanites aegyptiaca	Stem bark	Copper	10–30	Teklu et al. (2023)
Jasmin sambac	Leaf	Copper	13.4	Nouren et al. (2024)
Mangifera indica	Seed	Zinc	40–60	Rajeshkumar et al. (2023)
Nauclea latifolia	Fruit	Zinc	9 -12	Abegunde et al. (2024)
Capsicum annum	Fruit	Gold	20–30	Patil et al. (2023)
Pteris vittata	Leaf	Silver	17	Jha et al. (2022)
Barleria buxifolia	Leaf	Silver	80	Sekar et al. (2022)
Rubia cordifolia (L.)	Leaf	Silver	20.98	Chandraker et al. (2022)
Cakile maritima	Seed	Silver	9.45–17.15	Elazab et al. (2024)
Artichoke	Flower petals	Silver	8 to 20	Saygi et al. (2024)
Mangifera indica	Seed	Zinc	40–60	Rajeshkumar et al. (2023)
Ficus Carica	Leaf	Iron	43–57	Üstün et al. (2022)
Peltophorum pterocarpum	Leaf	Iron	85	Shah et al. (2022)
Lysiloma acapulsensis	Stem and roots	Silver	1.2–62	Garibo et al. (2020)
Euphorbia granulata	Shoot	Silver	5–20	Periyasami et al. (2022)
Taraxacum officinale	Leaf	Silver	15	Periyasami et al. (2022)
Camellia japonica	Leaf	Gold	40	Sharma et al. (2019)
Plukenetia volubilis (L.)	Leaf	Copper	6–10	Kumar et al. (2020)
Mentha spicata	Leaf	Zinc	11–88	Abdelkhalek and Al-Askar (2020)
Punica granatum (L.)	Fruit peel	Iron	21–23	Bouafia et al. (2022)

Cont. Table:1

Plant	Source of Plant extract	phytogenic Nanoparticles	Size (nm)	References
Euphorbia falcata	Leaf	Copper	5−10	Motahharifar et al. (2020)
Eryngium planum	Leaf	Iron	26–42	Dehghan et al. (2022)
Torreya nucifera	Leaf	Silver	10–125	Kalpana et al. (2019)
Cissus quadrangularis	Stem	Silver	24	Kanimozhi et al. (2022)
Ziziphus mauritiana	Leaf	Silver	10–45	Sameem et al. (2022)
Conocarpus lancifolius	Fruits	Silver	21	Oves et al. (2022)
Tecoma capensis	Leaf	Gold	10–35	Hosny et al. (2022)
Jatropha integerrima Jacq.	Flower	Gold	38.8	Suriyakala et al. (2022)
Cucumis prophetarum	Leaf	Silver	30–50	Hemlata et al. (2020)
Cochlospermum gossypium	Tree gum	Selenium	105.6	Kora (2018)
Anogeissus latifolia	Gum ghatti	Palladium	4.8±1.6	Kora and Rastogi (2018)
Euterpe oleracea Mart.	Seed	Zinc	60	Vieira et al. (2024)
Elettaria cardamomum	Seed	Silver	21	Mohammed et al. (2024)
Carissa carandas	Fruit peel	Iron	33–37	Bouafia et al. (2022)
Spinacia oleracea (L.)	Leaf	Gold	16.7	Zhu et al. (2022)
Cinnamomum verum	Leaf	Silver	10 -45	Zhou et al. (2022)

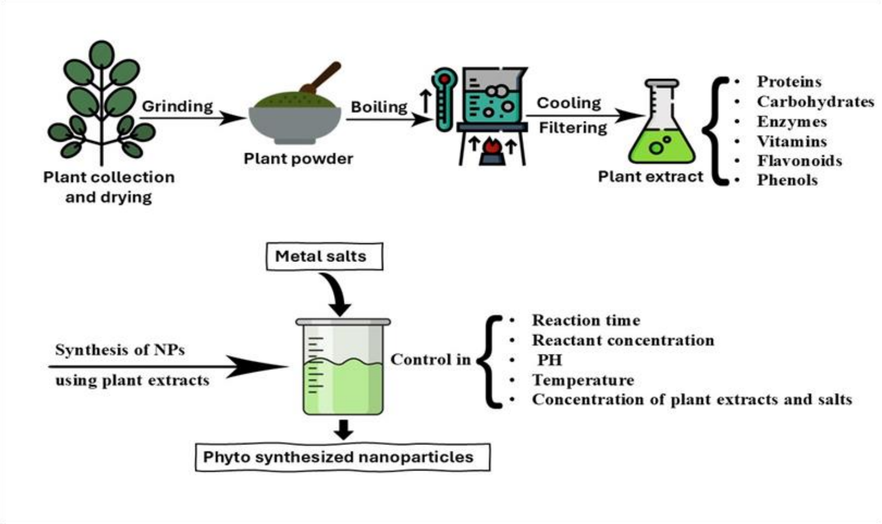

Figure 3: Synthesis of phytogenic nanoparticles using plant extracts

One way to summarize the basic steps for the eco-friendly synthesis of various nanoparticles is as follows: get plant extract, mix it with the metal salt solution under specific circumstances, filter the mixture, reduce the amount of metal particles, and carry out additional steps to get the required nanoscale metal (Ying et al. 2022). Figure 3 explains the synthesis procedure and how to obtain plant extract.

Plant extracts high in phytocompounds might be utilized as bio reductors, stabilizing agents, and bio activators to compress and trap extracellular NPs effectively. The synthesis of NPs can be significantly influenced by modifying a plant species' reduction capability, as varying levels of active, reducing chemicals are present in them. Moreover, NP synthesis is influenced by time, pH, calcination temperature, and plant extract (active phytocompound) content (Bhandari et al. 2023).

Factors affecting in phytogenic synthesis of NPs

The efficiency of NPs can be significantly increased by altering their size and form. The concentration of salts and plant extracts, temperature, pH, reaction time, and reactant concentration can all be changed in the experiment to alter these morphological characteristics. To maximize NP synthesis, these parameters must be properly controlled. (Azad et al. 2023).

Types of Plants and Biomolecules

One significant element that varies depending on the kind of plant utilized for NP synthesis is the kind of phytochemicals and biomolecules the plant contains. Following initiation, the following stage is called bio reduction, during which phytochemicals, or biomolecules, lower metal ions in salt solutions and change them from mono- or divalent oxidation states to zero-valent oxidation states. The sample solution will change color, indicating the nucleation. While smaller particles combine to produce larger, more stable particles during the development phase, the bioactive substances during the termination stage determine the morphology of the NPs. (Azad et al. 2023).

Plants differ in their NPs production pathways because of the composition and structure of their bioactive compounds. Plant extracts and metal ion solutions interact differently, leading to NPs of varying sizes depending on reaction duration, temperature, and pH. The distinct physical, chemical, and biological characteristics of the produced NPs are influenced by these size variations. Therefore, the bioactivities of the NPs depend on the characteristics of phytochemicals found in plant extracts. (Aboyewa et al. 2021).

Reaction Conditions

Optimizing the reaction parameters is essential for synthesizing nanoparticles (NPs) from plant extracts. This entails closely monitoring and managing the pH, reaction duration, temperature, and the proportions of metal salts to plant extracts.

PH of the Plant Extract

PH is important in defining the shape of NPs. Larger NPs typically develop in an acidic pH environment (Azad et al. 2023). Studies have shown that the pH impacts how strongly metal ions bind to the extracts' biomolecules. At different pH levels, NPs with tetrahedral, hexagonal, spherical, rod-shaped, and irregular shapes can be created. Higher pH usually results in smaller NPs (Dikshit et al. 2021).

Plant Extract Concentration

The amount of plant extract used to synthesize metallic nanoparticles (NPs) significantly affects their size, shape, and pace of creation (Dikshit et al. 2021). Increased T. Collinus leaf extract concentration resulted in more significant production of secondary metabolites and the synthesis of smaller and more stable nanoparticles (Soto-Robles et al. 2019).

Temperature

Temperature impacts nanoparticle size, shape, and production rate. Plant extracts containing phytochemicals are typically briefly heated below 60 °C. The phytoconstituents in biomass extract may disintegrate after prolonged exposure to high temperatures. It has been observed that NP production and average size are reduced at higher temperatures (Vanlalveni et al. 2021).

Reaction Time

One of the most critical factors in NPs synthesis is the reaction time. For NPs to fully nucleate and remain stable, the reaction must last the right amount of time. It's been demonstrated that longer reaction times lead to more NPs generation (Xiong et al. 2020).

Mechanisms of phytogenic NPs uptake in plants

There are various ways to apply NPs to plants, such as priming, irrigation, hydroponic substrate, foliar application, and direct injection (Abou-Zeid et al. 2021). There are multiple ways in which plants can absorb nanoparticles from the soil solution. For example, NPs can enter the roots of plants through the apoplast, which are non-living areas within the plant, the symplast, which are living sections of the plant, or endocytosis (Thabet & Alqudah, 2024). Moreover, NPs can enter plants through the tiny holes on the leaf surface known as stomata. This route is vital for airborne nanoparticles because, once within the plant, they can move through the xylem and phloem from the roots to other plant parts (X. Wang et al. 2023). The physiology and structural characteristics of the plant, the size, kind, chemical makeup, functionalization, and stability of the NPs, their interactions with the soil (the environmental conditions), root exudates (mucilage and metabolites), and microorganisms associated with the roots all affect how well the NPs are absorbed, translocated, and accumulated (Etesami et al. 2021). Furthermore, plants' nanoparticle absorption can cause various biological reactions, such as changes in gene expression, stress tolerance, and efficient nutrient use (X. Wang et al. 2023).

Application of phytogenic NPs in Sustainable Agricultural Practices

Application of phytogreen NPs as Nanofertilizers

Global efforts are underway to assure sustainable food production by creating fertilizers that, when applied over time, do not degrade soil fertility or the environment. NPs are increasingly being used as nano fertilizers in agricultural areas worldwide to reduce the use of chemical fertilizers (Agri et al. 2022). As an efficient supply of micronutrients and a less expensive alternative to conventional fertilizers, nano-fertilizers (NFs) lessen chemical fertilizers' phytotoxicity and environmental impact (Avila-Quezada et al. 2022). Apart from inducing various physiochemical and morphological alterations, boosting yield, and enhancing soil fertility, nano-fertilizers aid in accurately releasing nutrients, facilitating their easy absorption by plants (Bhandari et al. 2023).

Application of phytogreen NPs as Nanopesticides

The global economy is significantly impacted by the reduction in crop output caused by phytopathogens. Pathogenic fungi are the biggest obstacles to agricultural growth, which cause over 70% of plant diseases (Hassan et al. 2019). Applications of NPs in agriculture, such as germination, plant development, stress tolerance, and disease control, have been researched. Using NPs as antimicrobials is a novel and successful way to manage bacteria that cause illness in crop plants. NPs are widely known for having strong fungicidal, bactericidal, and nematocidal qualities because they contain phytocompounds and biocontrol agents (Bhandari et al. 2023). Two fungicides with NPs that are available commercially are Subdue and Cruiser MAXX. Specific nanoparticles cause harm to bacterial cell membranes, causing damage to DNA replication, membrane potential, ROS metabolism, ATP synthesis, apoplastic trafficking, and toxin production inhibition (Castillo-Henríquez et al. 2020). In fungi, NPs suppress the germination of fungal spores and the formation of hyphae and sporangia (Devatha et al. 2018). Nano-pesticides are innovative technological advancements with various advantages due to their concentrated distribution of active ingredients in soil and plants. These advantages include better efficacy, longer shelf life, fewer active ingredient quantities, fewer pesticide applications, and little nutritional loss. However, to determine the effective dose of nanoparticles, it is necessary to comprehend the concentration dependency of the natural soil system (Bhandari et al. 2023).

Applications of phytogreen NPs in Abiotic Stress Management

Plant growth is enhanced when Phyto green nanoparticles alter proline and nitrogen metabolism-related enzymes and proteins, osmotic pressure, and nutritional balance; They also affect the presence and functionality of vital antioxidant enzymes, including superoxide dismutase, catalase, and peroxidase. (Chakraborty et al. 2022).

The main ways NPs under drought stress mitigate the osmotic stress caused by water scarcity are enhanced root development, increased aquaporin expression, modified intracellular water metabolism, compatible solute buildup, and ionic homeostasis. NPs also increase the photosynthetic activity of drought-induced plants. By lowering reactive oxygen species and triggering antioxidant defense mechanisms, nanoparticles mitigate oxidative stress damage by decreasing the amount of water lost from leaves due to ABA buildup through stomatal closure (Seleiman et al. 2020). When applied in varying quantities to mitigate the effects of heat stress, nanoparticles enhanced plant growth and hydration (Ali et al. 2021). When sprayed at low concentrations, NPs have antioxidative qualities; nevertheless, at large concentrations, NPs cause oxidative stress in plants. When plants are stressed by heat, they produce heat shock proteins and molecular chaperones. A heat shock protein is involved in heat stress resistance and helps other proteins stay stable under stressful circumstances (Khalid et al. 2022). According to reports, NPs can control how plants react to salt stress by enhancing chlorophyll content, photosynthetic rate, hormone concentrations, antioxidant enzyme activity, ion homeostasis, gene expression, and defense system activities in plants (Zulfiqar and Ashraf, 2021).

Under heavy metal stress, HMs can be absorbed and transformed by nanoparticles, which lowers HM mobility and bioaccumulation (Al-Khayri et al. 2023). Additionally, NPs cause the development of apoplast barriers, which lower the root's concentration of heavy metals. Furthermore, by forming complexes with them, certain NPs can regulate the genes that encode the metal transporter in plants, thereby intercepting heavy metals and preventing their translocation (Wang et al. 2021).

Applications of phytogreen NPs as Nanobiosensors

Various nanoparticles (NPs) are employed in nano-biosensors to detect physical and chemical variations, track bioactive substances, and measure pollutants. A nano biosensor for measuring water quality was successfully developed by Jebril et al. (2021) through the nanoengineering of environmentally benign silver nanoparticles using plant extracts. Nan biosensors have many applications throughout the agri-food supply chain, such as crop protection, soil condition monitoring, insect identification during storage, and quality control (Thakur et al. 2022). Nan biosensors have aided in developing precision farming and intelligent agriculture by detecting changes in seed viability, crop nutrient requirements, and fruit shelf life (Mittal et al. 2022).Precise farming offers comprehensive information about the soil or field conditions to maximize production. (Mittal et al. 2022).

Application of phytogreen Nanoparticles in Bioremediation

Human activities such as farming, industry, and other pursuits typically cause high levels of dangerous contaminants, including pesticides, heavy metals, textile dyes, etc.(Malik et al. 2022). NPs remove environmental pollutants as filters, adsorbents, immobilizing, and photocatalytic agents because of the unique properties of biogenic NPs, including their reduced intra-particle diffusion distance, high surface area, stability, and capacity for reuse and recycling, their use in identifying, removing, and the removal of dangerous pollutants from various environmental matrices has been increasing lately. Further improving these NPs' suitability for remediation investigations is their ease of synthesis and surface-functionalization (Bhandari et al. 2023).

CONCLUSIONS

The plant-mediated green chemistry technique has garnered significant attention among conventional approaches for nanoparticle synthesis because it is environmentally friendly. Additionally, producing nanoparticles using plants replaces expensive chemicals and is low-energy, simple, and easily scalable. Various parts of the plant, including leaves, stems, roots, peel, bark, flowers, fruit, and seeds, are used to synthesize nanoparticles. The size and form of phyto-nanoparticles are controlled by various physiochemical factors. Thus, the remarkable biocompatibility, potency, biofortification, and biocontrol ability of phytogreen synthesis NPs, along with their unique characteristics, make them promise to revolutionize the agricultural and environmental sectors.

Nevertheless, green plant-based nanoparticle synthesis also confronts challenges in identifying and forecasting the mechanisms involved in the specific chemicals that stabilize and bio reducing. Furthermore, plant extracts combine metal salt bio reduction processes to produce nanoparticles. Thus, more investigation is needed to pinpoint the precise phyto molecules mediating the pathway for nanoparticle production. Knowing which plant molecules to identify will make it easier to control the size and structure of nanoparticles, providing many industrial, medical, and agricultural applications.

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Supplementary materials

Not applicable

Author contributions

Conceptualization, Alsamadany H. and El-Zohri M.; methodology, Alrabie, H.; software, Alrabie, H.; validation, Alsamadany H. and El-Zohri M.; writing-original draft preparation, Alrabie, H.; Editing, El-Zohri M.; visualization, Alrabie, H.; supervision, Alsamadany H. and El-Zohri M.; All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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