



The impact of biosynthetic nano pesticides in controlling insect pests: A review

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Abstract

Recently, the focus of scientific research workers in the field of plant protection has been on the use of nanotechnology, which has emerged as an activity in many other areas of life, there are many techniques for the synthesis and production of nanoparticles, including physical, chemical, and biological techniques. the best methods of synthesis are biosynthesis or green synthesis, due to its characteristics: it is easy and quick to prepare, inexpensive, and has little harm to the environment. Plants, fungi, and bacteria are considered the basis for the biosynthesis of nanoparticles because their secondary metabolic products are considered to have an effective role in the preparation process through their role as reducing agents and as a safe alternative to the toxic chemicals, pressure, and heat required in the chemical and physical preparation processes of nanoparticles. This review discusses the role of biosynthetic nanoparticles, such as silver, zinc, gold, etc., in the control of various insect pests to evaluate them before they were practically used as nanopesticides, as happened with the chemical pesticides that preceded them, which affected the environment, humans, and non-target organisms.

Keywords: Nanopesticides, insect, biosynthesis, green synthesis

Introduction

Food security at present is based on securing the necessary food needs for billions of people, and providing these food needs faces many major obstacles, Insect pests and recent changes in weather are two of the most important factors for agriculture today that have the characteristic of resistance to chemical pesticides in addition to pesticides having negative side effects on organisms that are not the intended targets. and the damage to the environment (Khan *et al.*, 2023) ^[16]. As a result, scientific researchers have turned to searching for alternatives that are safe for the environment and humans, effective in pest control, and do not cause harm to non-target organisms. Nanotechnology has emerged as a promising solution to the problems caused by chemical pesticides, utilizing nanoparticles as nanopesticides (Khaleel *et al.*, 2023) ^[15]. Carbon nanotubes and metallic nanoparticles (NPs) like silver, zinc, copper, gold, titanium oxide, etc. have all been used as nanoinsecticides (Hilal *et al.*, 2021) ^[11]. Nanotechnology has shown a rapid transformation in the field of agriculture, principally in the fields nanofertilizers and nanopesticides, due to the properties possessed by nanoparticles, such as size, which ranges from (1–100 nm), in addition to other properties such as high surface area, shape, and distribution compared to bulk materials. (Benelli and Lukehart, 2017) ^[4]. Using physical and chemical methods for the synthesis of nanoparticles is expensive and involves the use of hazardous chemicals. These led the researchers to search for new, eco-friendly, and cheap viable procedures for nanoparticle synthesis: the biological procedure of nanoparticles by using ecology-friendly methods include plants, bacteria, and fungi that is renewable, easy, and cheap, and the reducing agents are available in nature. (Rajan *et al.*, 2020) ^[20]. In biological synthesis methods of nanoparticles, aqueous plant extracts

and bacterial and fungal filtrates are used, which contain enzymes and toxins. work as capping and reducing agents as well as being employed to stabilize many types of NPs, such as zinc, silver, and gold (Ali *et al.*, 2024) ^[3]. where the coronas are formed when biomolecules adhere to nanoparticle surfaces from the reaction fluid, which causes the creation and stability of the nanoparticles, and this outer coating enhances their biological activity and biocompatibility (Santos *et al.*, 2021) ^[23]. Recently, many research studies and articles have been published on nanoparticles and methods of preparing and using them as nanopesticides against many insect pests. This review comes as a documentary addition to documenting many research studies that deal with the effect of biosynthetic nanopesticides on some aspects of the life performance of insect pests in stored and fields.

Insect stored

Stored grain products have been linked to around 500 insect species. Grain-infesting insects create significant economic losses not just from the material they eat but also from the amount of food they pollute and their excrement, rendering it unfit for human consumption (Ahmad *et al.*, 2021) ^[2]. To prevent insect damage, several non-chemical and synthetic chemical pesticide strategies were adopted. Despite their drawbacks, the most popular approach is the use of synthetic chemical pesticides. Due to these problems of synthetic chemical pesticides, better and more environmentally friendly ways of controlling insect pests in storage are being searched for (Bezabih, 2022) ^[5]. One alternative control method is to use nanoparticles (Zayed, 2018) ^[29], especially biosynthetic nanoparticles. Zahir *et al.* (2012) ^[28] discovered that aqueous leaf extracts of *Euphorbia prostrata* were used to synthesize silver

nanoparticles (Ag NPs) as insecticides against adult *Sitophilus oryzae*. based on the results, the synthesized Ag NPs could be used to control *S. oryzae*. After recording the varying concentrations of produced Ag NPs used in the study over a period of 14 days, the LD50 and LD90 values were found to be 44.69 and 168.28 mg/kg⁻¹, respectively. Sankar and Abideen (2015) [22] reported that adult *S. oryzae* are susceptible to the insecticidal effects of silver and lead nanoparticles made from *Avicinia marina* aqueous extract. The overall death rate was noted with lead nanoparticles, achieving 100% mortality by the third day of the experiment, while the silver nanoparticles solution demonstrated higher mortality, reaching 100% by the fourth day of the experiment. Jafer and Annon (2018) [13] assessed the activity of pure and green-synthesized silver nanoparticles (Ag NP's) by *Nerium oleander* against *Tribolium castaneum* and *Callosobruchus maculatus* where the green-synthesized silver nanoparticles appear to have more Larvicidal effect than pure silver nanoparticles at many concentrations (500, 1000, 1500, and 2000 ppm), where the high concentration of 2000 ppm was recorded at 85% compared with 50% of pure silver. Yerragopu *et al.* (2019) [27] investigated the effect of plant-mediated silver nanoparticles by using curry leaves on the *C. chinensis* pulse beetle. They observed at two concentrations (70 ppm and 35 ppm), adult death rates were 100.00% and 96.67% after 7 and 14 days of treatment, respectively. When mixed with black gram seeds, NiO NPs made from aqueous *Rauvolfia serpentina* leaf extract were evaluated against the insect *C. maculatus*, according to Rahman *et al.* (2020) [21]. The insect's developmental period was extended, and fecundity was reduced at 10, 20, and 40 ppm of NiO NPs. When exposed to six different types of nanoparticles (AgNPs, SeNPs, SiO₂NPs, CuONPs, TiO₂NPs, and ZnONPs), which ranged in size from 8 to 33 nm and were synthesized using extracts from the fungus *Fusarium solani*, Helmy *et al.* (2023) [10] observed decreased hatchability and decreased larva-to-adult survival in *C. chinensis* and *C. maculatus*. Using two plant extracts, *Acacia cornigera* and *Annona purpurea*, Solorzano Toala *et al.* (2024) [25] reported the manufacture of copper nanoparticles and evaluated their efficacy as insecticides against *T. castaneum*. Effective insecticidal activity against *T. castaneum* was proven by the copper nanoparticles derived from *A. cornigera*, which produced 90% death, as opposed to 76.6% mortality from the copper nanoparticles derived from *A. purpurea*. Abdel-Megeed *et al.* (2024) utilized an aqueous extract from the duckweed plant *Lemna minor* to biosynthesize silver nanoparticles (AgNPs) and applied them as an insecticide against *S. oryzae* and *T. castaneum*. The results indicated that longer exposure times and higher concentrations led to a gradual increase in the mortality rates of adult *S. oryzae* and *T. castaneum*, with the highest insecticidal activity recorded at an LC₅₀ value of 6.08 µg/mL for *S. oryzae*, compared to 7.03 µg/mL for *T. castaneum*. Additionally, the findings demonstrated a reduction in the offspring of both *S. oryzae* and *T. castaneum*.

Insects economic

One of the most successful animal classes on the planet, insects play important role in the environment. Both the good and negative aspects of insects' economic significance are included. Frequently found on the leaves, flowers, and stems of agricultural plants, insects harm crops directly by

eating their leaves, fruits, or vegetables and frequently destroying them before they ripen. They also cause indirect damage by spreading bacteria, fungi, and viruses between crops (Osei *et al.* 2021) [19]. Nanoparticles, which were synthesized from natural sources, were tested as a modern option for controlling agricultural pests. After the problems of using chemical pesticides continued, Ag NPs were prepared using an aqueous leaf extract of *Aristolochia indica* and tested for larvicidal effects on *Helicoverpa armigera* larvae in their third instar. The results indicated that the crude aqueous and synthesized Ag NPs had the highest larvicidal and antifeedant efficacy against *H. armigera* larvae (LC50 = 127.49, 84.56 mg/L, 766.54 and 309.98 mg/mL), respectively (Siva and Kumar, 2015) [24]. *Ocimum sanctum* (L.) green synthesized silver nanoparticles (AgNPs) were tested against *Corcyra cephalonica* (S.) at dilutions of 200, 300, 400, and 500 ppm. After the fifth day of treatment, the lowest LC50 value was 244.04 ppm, which indicates larval mortality of *C. cephalonica*. Larval mortality rose as nanoparticle concentration and the number of days after treatment increased. Differences between concentrations in larval mortality were statistically significant (Gogate *et al.*, 2018) [8]. *Bacillus thuringiensis* (Bt) was used to produce silver nanoparticles (AgNPs), which were then used to manage *Pectinophora gossypiella*. Larval and pupal mortality increased to 55% and 44.4%, respectively, at the fatal concentration LC50. When *P. gossypiella* larvae were used, the fatal concentration LC50 prevented adult emergence and interfered with the life cycle (Gabarty *et al.*, 2021) [7]. ZnO nanoparticles were green-synthesized at different concentrations using *Zingiber officinale* rhizome extract. This study assessed the effectiveness of green-synthesized ZnO NPs against tomato crop-related insect pests, including *Macrosiphum euphorbiae*, *Spodoptera litura*, and tobacco cutworm. Following 144 hours of exposure, the adults of *M. euphorbiae* and the third-instar larvae of *S. litura* both displayed 100% mortality at a concentration of 500 ppm ZnO NPs. The findings showed that higher ZnO NP concentrations led to higher fatality rates among insects at various stages. (Thakur *et al.*, 2022) [26]. Green-synthesized ZnO nanoparticles were prepared using *Petroselinum crispum* (parsley) extract to conduct a toxicological evaluation of ZnO nanoparticles on honey bees *Apis mellifera*. The calculated values for the LC50 range varied over the 288 hours of feeding on ZnO nanoparticles, with increased mortality observed as the concentrations increased (Karim *et al.*, 2023) [14]. Zinc oxide nanoparticles were produced using a biosynthesis process by extracting the plant *Eucalyptus camaldulensis* as a reducing agent, and their insecticidal efficacy was estimated against the various stages of mealworms (*Tenebrio molitor* L., 1758). The results indicated that zinc oxide nanoparticles have larvicidal and adulticidal properties. Statistical analysis revealed significant variations in the average mortality rates based on the insect's stage and different time periods; the highest average larval mortality rate was observed at 5000 ppm (61.25%), while the overall average percentage of adult emergence was 42.53% (Omar *et al.*, 2023) [18]. The green-synthesized silver nanoparticles (AgNPs) from the crude filtrate of *Lecanicillium lecanii* were evaluated for their insecticidal properties against adult *Eurygaster testudinaria*. The AgNPs showed significant effectiveness in inducing mortality among adult *E. testudinaria* over different time

intervals, reaching a 100% mortality rate at a concentration of 100 ppm, compared to 0.00% mortality in the control treatment after 10 days. (Jabbar *et al.*, 2023) ^[12]. Plant leaf extracts from *Cardaria draba* were used to manufacture AgNPs, which were then prepared and tested for the mortality of the stages of *Schizaphis graminum* at different concentrations. After three days of exposure, the highest mortality rates for adults and nymphs were 52.99% and 57.13%, respectively, at the high concentration of 100 ppm, compared to 4.79% and 5.87% in the control treatment. (Hasoon *et al.*, 2023) ^[9]. leaf extract of *Datura metel* L. was used to create and produce AgNPs evaluated as insecticidal against grubs *Epilachna vigintioctopunctata* F. at varying levels of concentrations, when comparing the aqueous and AgNPs synthesized leaf extracts, AgNPs nanoparticle-synthesized leaf extracts were more efficient as larvicides than aqueous leaf extract, with an LC50 of 396.09 ppm (Chitharanjan and Sudarmani, 2023 ^[6]). *Pelargonium citronellum* extract was effectively used to create silver nanoparticles (AgNPs), which were then applied to mealybugs for 72 hours at a concentration of 100 ppm. For the three mealybug stages — eggs, first-instar nymphs, and adult females—this treatment produced the highest mortality rates, 40.0%, 68.0%, and 70.0%, respectively. (Mutter and Hassan, 2024) ^[17].

Conclusion

The diversity of the environment, food, and other things that helped insects spread around the world prompted humans to use chemical pesticides, which limited the spread of insects when they were first used, but the problems worsened later, especially when the resistance trait appeared in insects towards pesticides. All these problems prompted researchers in the field of pesticides to test safe and effective alternatives. The alternatives began with biopesticides and ended with the use of nanopesticides, mainly composed of nanoparticles, which have shown high effectiveness in controlling many other stored and economic insects. The development in the use of nanopesticides in terms of the diversity of synthesis methods, the latest of which was biosynthesis, in addition to the diversity of methods of their use, opened future horizons for their wider adoption and verification of the fate of their residues and their impact on the environment, humans, and non-target.

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