

A Review on Plant Sources for Nano Biopesticide Production

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Abstract: Biopesticides are substances or mixtures of biological substances used to prevent, destroy, kill, control, or mitigate pests. Pesticide plants are also known as botanical pesticides, are derived naturally from plants. The use of chemical pesticides led to conflicts like environmental degradation and health issues like cancer, adverse effects on immune systems, neurological disorder, and metabolic diseases such as diabetes, endocrine system disruption, and infertility. Biopesticides are a type of pesticides obtained from natural sources such as animals, plants, bacteria, and certain minerals. Nanotechnology is a developing field dealing with materials having a size of 10^{-9} . Farmers have been using this technology for proper plant growth stimulation, diagnosis of plant disease, and pest control. This paper briefly explains some evidence of plant species used to control pests and the presence of nanoparticles in that species for pest control are reviewed from different articles. These observations, perceptions, and notions provide an idea for future research to help the environment and humankind.

Keywords: Biopesticide; Nanoparticles; Pest control; Medicinal plants; Nanotechnology.

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1. Introduction

Biopesticides are substances or mixtures of biological substances used to prevent, destroy, kill, control, or mitigate pests. Pesticide plants are also known as botanical pesticides, are derived naturally from plants. Plants having pesticide activity are an ancient form of controlling pests. They act as a natural defense against pests developed over millions of years. Many plant species produce chemicals that affect pests. Plants having pesticide activity have been used for thousands of years. They were used widely in commercial agriculture up to the 1940s until chemical pesticides were developed. The use of chemical pesticides led to conflicts like environmental degradation and health issues like cancer, adverse effects on immune systems, neurological disorder, and metabolic diseases such as diabetes, endocrine system disruption, and infertility. Since biopesticides are now a small part of the overall pesticide market due to the development of chemical pesticides, the present environmental movement has provided a platform for the emergence of biopesticides. Nanotechnology is a developing field dealing with materials having a size of 10^{-9} . Farmers have been using this technology for proper plant growth stimulation, diagnosis of plant disease, and pest control [1]. Chemical pesticides have various effects. It is estimated that due to insecticide poisoning, 200 deaths are occurring every year in the USA. WHO estimated that every year there are 25 million cases of pesticide poisoning, and 20,000 deaths are occurring in developing countries [2]. Because of the high exposure of chemical pesticides, the Netherlands rejected 130 containers of fresh

grapes sent from India [3]. A global ban was called by the World Wildlife Fund on the production and use of DDT by 2007 [4].

2. Nanoparticles based biopesticides

Biopesticides are one of the types of pesticides obtained from natural resources such as animals, plants, bacteria, and certain minerals. They include fungi such as *Beauveria* sp., bacteria such as *Bacillus* sp., and neem extract. Likewise, canola oil and baking soda have applications of controlling pests, so they are known as biopesticides. From the above sources, both plants and microbes are employed in the synthesis of nanoparticles. For example, nanoparticles such as silver, nickel, cobalt, zinc, and copper are synthesized from plants, and they are employed in controlling pests [5]. Biopesticides are less harmful and eco-friendly in nature. They are employed to target only specific pests and decompose at a faster rate. It indicates the lower exposure and helps in controlling pollution. They are cost-effective and are biodegradable. By considering these advantages, a biopesticide is used for nanoparticle synthesis and plays an important role in agriculture for the welfare of human beings and also to our environment.

Nanotechnology involves nanoparticles (NPs) having a size of 100 nm or less or 10 and 1,000 nm. Metallic Nanoparticles are mostly synthesized from metals such as gold, silver, copper, and platinum. Nanotechnology is an emerging field in modern research. They are developing day by day, including life sciences, especially biomedical devices and biotechnology [6]. Nanotechnology has many applications in the field of chemical, agricultural, medical, and biological and cosmetics industries. In the beginning, mesoporous silica nanoparticles (MSNs) were used as a water-soluble pesticide against validamycin [7]. Alumina nanoparticles were used against two major insect pests in stored food, such as *Sitophilus oryzae* L. and *Rhyzopertha dominica*. Silver nanoparticles are used in packing food, clothing, disinfectant, and several household appliances. They also play an important role in treating diseases and prevent various health issues. The recent chemical researches show that the plant kingdom is a rich source of organic compounds. The nanoparticle-based biopesticide production process was mentioned in figure.1. Most of the plants are used as medicine, pesticides, and some are known as hallucinogens. Still, there is a lack of knowledge in this research. Hence, we should focus on plant species with uses reported in ethnobotanical and anthropological literature. This paper briefly explains some evidence of plant species used to control pests is reviewed from different articles. Their observations, perceptions, and notions provide an idea for future research to help the environment and humankind.

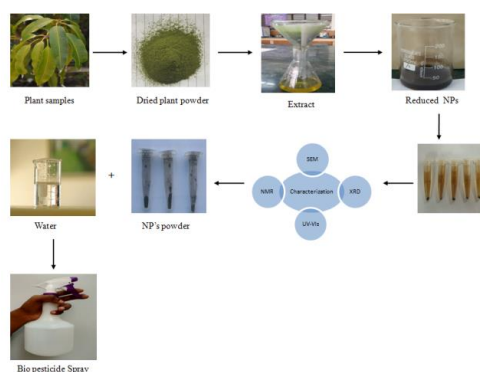


Figure 1. Nanoparticle-based biopesticide production process.

3. Plant-derived nanoparticle-based biopesticide

Plants are one of the important sources of nanoparticles based biopesticides, and it contains different types of nanoparticles as a pesticide component in agriculture applications. Table 1 listed the biopesticide plants with scientific names, common names, types of nanoparticles present, insect or pest against which the plant is used, and plant parts used is listed.

Table 1. Plant-derived nanoparticle-based biopesticides.

Plant name	Common name	NPs Present	Part of the plant used	Application
<i>Acorus calamus</i>	Sweet flag	Au, Ag	Root	Insecticide [8]
<i>Agave Americana</i>	Sentry plant	Ag	Leaf	White ants [9]
<i>Ageratum conyzoides</i>	Chickweed	Ag	Leaf	Lice in hair [10]
<i>Albizia lebbek</i>	Lebbeck	Ag, Ni, Fe	Seed, leaf, bark and root	Insecticide [11]
<i>Albizia procera</i>	White siris	Zn, Ag, Cu	Leaf	Insecticide [12]
<i>Aloe secundiflora</i>	Newcastle in chicken	Cd, Ag	Sap	Insecticide [13]
<i>Alysicarpus bupleurifolius</i>	Alyce clover	Ag, P	Whole plant	Bed bugs, white ants [14]
<i>Anacardium occidentale</i>	Kaaju	Au, Ag, Cu, Pt	Shell oil	White ants, insecticide [15]
<i>Anamirta cocculus</i>	Indian berry	Zn, Ag, Au	Fruit	Insecticide [16]
<i>Annona reticulate</i>	Wild-sweetsop	Ag	Leaf, seed, and bark	Body lice, insecticide [17]
<i>Annona squamosa</i>	Sugar apple	Ag, Fe	Seed, stem, bark, leaf, and fruit	Body lice, insecticide [18]
<i>Arisaema tortuosum</i>	Whipcord cobra lily	Ag, Au, Zn	Tubers	Insecticide [19]
<i>Aristolochia bracteolate</i>	Worm killer	Ag	Juice	Insecticide [20]
<i>Artemisia japonica</i>	Mugwort	Ag, Au, Fe	Whole plant	Insecticide, housefly repellent [21]
<i>Artemisia nilagirica</i>	Wormwood	Ag	Leaf	Insect repellent, prevent moths [22]
<i>Azadirachta indica</i>	Neem tree	Ag, Cu	Whole plant	Insecticide, rice and wheat weevil [23]
<i>Bambusa arundinacea</i>	Bambusabambos	Ag	Shoot	Kill mosquito larvae [24]
<i>Bidens pilosa</i>	Black jack	Ag, Au	Leaves	Aphids [25]
<i>Blumea eriantha</i>	Buradi	Zn	Whole plant	Mosquito repellent [26]
<i>Boswellia serrata</i>	Indian frankincense	Ag	Gum	Fumigation repel houseflies and mosquitoes [27]
<i>Brassica campestris</i>	Field mustard	Ag, Zn	Seed oil	Beetles [28]
<i>Butea monosperma</i>	Sacred tree	Ag, Au, Zn	Seed and flower extract	White ants [29]
<i>Calotropis procera</i>	Rubber bush	Ag, Zn, Ni, Fe	Leaf	Larvicidal, insecticide [30]
<i>Cannabis sativa</i>	Kumbhi	Au, Ag	Whole plant and leaf	Bugs & pests [31]
<i>Capsicum annuum</i>	Hot pepper	Cu, Ag, Au	Fruit, leaf	Thrips, aphids and white flies [32]
<i>Careya arborea</i>	Karanda	Ag	Root, bark and leaf	Kill leeches [33]
<i>Carica papaya</i>	Pawpaw	Ag, Zn	Leaves, seeds	Several [34]
<i>Carissa congesta</i>	Hemp	Ag	Root and bark	Vet worms in wounds [35]
<i>Cassia hirsute</i>	Cassia	Ag, Zn	Bark	Insecticide [36]
<i>Cassytha filiformis</i>	Love vine	Ag, Cu, Mg	Whole plant	Insecticide [37]
<i>Catunaregam spinosa</i>	Mountain pomegranate	Sn, Zn, Ni	Fruit	Insecticide [38]
<i>Cinnamomum camphora</i>	Camphor tree	Ag, Au, Pt, Pd	Bark powder	Protect clothes against insects [39]
<i>Citrus limon</i>	Lemon	Ag, Au	Dried leaf	Wheat weevil and flour beetle [40]
<i>Commiphora wightii</i>	Indian bdellium tree	Ag	Resin	Mosquito repellent [41]

Plant name	Common name	NPs Present	Part of the plant used	Application
<i>Cordia latifolia</i>	Sebestan plum	Ag	Leaves	Maize weevil, butterfly [42]
<i>Corypha umbraculifera</i>	Talipot palm	Cu, Ag	Young fruit	Insect repellent [43]
<i>Croton roxburghii</i>	Croton	Ag	Seed	Insecticide [44]
<i>Cucumis melo</i>	Muskmelon	Ag	Leaf	Kill lice [45]
<i>Cucumis sativus</i>	Cucumber	Ag ,Cu,Zn	Rhizome	Kill lice and insects [46]
<i>Curcuma longa</i>	Turmeric	Ag,Zn	Rhizome	Drive away ants [47]
<i>Cuscuta reflexa</i>	Amar bel	Cu,Ag	Whole plant	Kill lice [48]
<i>Cymbopogon nardus</i>	Citronella grass	Ag	whole plant	Mosquito repellent [49]
<i>Derris scandens</i>	Gewel vine	Ag	leaf, bark	Insecticide [50]
<i>Derris trifoliata</i>	Karanjvel	Ag	Bark	Insecticide [51]
<i>Desmodium triflorum</i>	Tick clover	Ag,Cu,Au	Whole plant	Insecticide [52]
<i>Dioscorea hispida</i>	Asiatic bitter yam	Ag	Bark	Insecticide [53]
<i>Duranta erecta</i>	Brazilian skyflower	Ag ,Zn	Whole plant	Insecticide [54]
<i>Euphorbia antiquorum</i>	Spurge	Ag	Milky juice	Maggots in wound [55]
<i>Euphorbia dracunculoides</i>	Dragon spurge	Ag	Latex	Kills lice [56]
<i>Euphorbia thymifolia</i>	Thyme leaf	Pd	Whole plant	Flies, mosquitoes [57]
<i>Fioria vitifolia</i>	Grape leaved mallow	Ag	Root, bark	Kills lice [58]
<i>Gloriosa superba</i>	Flame lily	Ag,Au,Ce, Cu, Pt, Pd	Leaf	Lice in the hair [59]
<i>Haldina cordifolia</i>	Kadam	Ag	Bark	Insecticide [60]
<i>Hardwickia binata</i>	Anjan	Zn	Wood	Insecticide [61]
<i>Harpullia arborea</i>	Tulip wood	Zn, Sn	Bark	Leech repellent [62]
<i>Holarrhena pubescens</i>	Indrajao	Ag	Flower and seed	Insecticides [63]
<i>Hyptis suaveolens</i>	American mint	Ag ,Cu	Twig	Repel bed bugs [64]
<i>Kalanchoe integra</i>	Never die	Au ,Cu	Leaf	Insecticide [65]
<i>Lagenandra ovata</i>	Malayan sword	Ag	Whole plant	Insecticide [66]
<i>Lavandula bipinnata</i>	Lavender	Zn	Whole plant	Insect repellent [67]
<i>Lavandula lawii</i>	Lavender	Ag	Whole plant	Insect repellent [68]
<i>Leonotis nepetifolia</i>	Klip dagga	Ag	Leaf	Housefly repellent [69]
<i>Leucas aspera</i>	Thumbai	Ag, Ce, Cu	Whole plant	Insecticide [70]
<i>Lippia javanica</i>	Fever tea	Ag	Leaf	Insecticide [71]
<i>Madhuca longifolia</i>	Ilippai	Ag,Cu,Au	Seed, seed oil and cake	Worm killer, insect repellent [72]
<i>Melaleuca leucadendron</i>	Cajuput tree	Au ,Ag	Oil	Mosquito repellent [73]
<i>Melia azadarach</i>	China berry	Ag	Fruit and seed	Insecticide [74]
<i>Melia volkensii</i>	Melia	Ag	Fruit pulp	Termites [75]
<i>Millettia extensa</i>	Benth	Ag	Root	Insecticide [76]
<i>Mimosa pudica</i>	Shame plant	Ag,Zn,Fe,Au, Cu	Leaf	Veterinary woundmaggots [77]
<i>Mundulea sericea</i>	Cork bush	Zn	Seed,root and bark	insecticide [78]
<i>Nigella sativa</i>	Black seed	Ag ,Zn	Seed	Pesticide [79]
<i>Ocimum americanum</i>	Hoary basil	Ag	Whole plant	Insecticide [80]
<i>Ocimum gratissimum</i>	Ram tulsi	Ag,Au	Whole plant	Insect repellent [81]
<i>Ocimum kilimandscharicum</i>	Camphor Basil	Ag	Leaves, flower	Mosquito, fleas [82]
<i>Ocimum tenuiflorum</i>	Tulsi	Ag	Whole plant	Insect repellent [83]
<i>Peganum harmala</i>	Wild rue	Ag,Zn	Root	Mosquito repellent [84]
<i>Psidia punctulata</i>	Mpepe,	Ti,Cu	Leaves	Lice, fleas, mites [85]
<i>Pongamia pinnata</i>	Indian beech	Ag	Seed, root, and seed oil	Repellent and insecticide [86]
<i>Riccinu scommunis</i>	Castor bean	Ag,Au	Seed oil	Flies repellent, rice moth and rice weevil [87]
<i>Ruta graveolens</i>	Herb of grace	Zn,Ag	Whole plant	Insects [88]
<i>Sarcostmma viminale</i>	Caustic vine	Ag	Leaf	White ants [89]

Plant name	Common name	NPs Present	Part of the plant used	Application
<i>Securidaca longepedunculata</i>	Violet tree	Ag	Whole plant	Stored grain pest [90]
<i>Senna didymobotrya</i>	Popcorn senna	Ag	Leaves	Nematodes [91]
<i>Solanum incanum</i>	Sodom apple	Ag	Fruit, leaf	Insecticides [92]
<i>Stephania japonica</i>	Snake vine	Au, Ag	Whole plant	Strong poison to frogs [93]
<i>Strychnos nux vomica</i>	Poison nut	Zn, Au, Ag	Fruit and seed	White ants [94]
<i>Strychnos spinosa</i>	Monkey orange	Ag	Whole plant	Insecticides [95]
<i>Symplytum officinale.</i>	Common Comfrey	Ag	Leaf, root	Insecticides [96]
<i>Tagetes minuta</i>	Wild marigold	Ag	Leaf, flower	Insecticides [97]
<i>Tanacetum cinerariifolium</i>	Pyrethrum	Ag, Au	Flower	Bees and insects [98]
<i>Teclea nobilis</i>	Small Fruited teclea	Ag	Bark and leaves	Insecticides [99]
<i>Tephrosia purpurea</i>	Fish poison	Ag, Au	Wood, roots	Cotton and woolen cloth moths [100]
<i>Tithonia diversifolia</i>	Marigold	Ag	Leaf, flower	Insecticides [101]
<i>Trachylobium ammi</i>	Ajwain	Ag,Zn	Seed	Mosquito repellent [102]
<i>Trigonellasfoenum-graecum</i>	Fenugreek	Au,Ag	Seed	Insect repellent [103]
<i>Vernonia amygdalina</i>	Bitter leaf	Ag	Leaf	Insecticides [104]
<i>Vernonia anthelminticum</i>	Kalijiri	Zn, Au	Seed	Fleas [105]
<i>Vitex negundo</i>	Chaste tree	Ag, Zn	Leaf	Insect repellent [106]
<i>Vitex trifolia</i>	Arabian lilac	Ag, Zn, Au	Leaf	Insect repellent [107]

4. Conclusions

This review paper provides an idea for future research to help the environment and humankind. Researchers have focused their attention on understanding the mechanism of synthesis of biopesticides and botanical-based nanoparticles for controlling pest, to prevent disease, and to protect our environment instead of chemical pesticides. Laboratory research, as well as field experiments, are encouraged to use nanoparticle-based insecticides to control pests and disease. Hence, the result shows that there are several ways to find an alternative source in the protection of human and environmental welfare.

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Conflicts of Interest

The authors declare no conflict of interest.

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