

Potential of Biogold Nanoparticles to Control Plant Pathogenic Nematodes

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Abstract

Increased uses of chemical pesticide were intensified to increase agriculture output in different crops in new agroecological zones. Pesticides are ineffective to solve the problem of nematodes, as nematodes population increased several months after the nematicidal were used. Due to increased selection pressure, new races of nematodes were developed. So in order to have effective management, nanoparticles offer a lot of potentials to effectively control nematodes population through its targeted approach, nanoparticles mediates higher penetration of chemicals pesticides with a minimum concentration of chemical used, as there penetrates easily through the cell wall and produces maximum effect. Gold nanoparticles kill nematodes itself, but when used along with chemicals nematicides their efficiency increased significantly.

Keywords: Nanoparticles; Pesticides; Pathogenic

Introduction

Plant pathogenic nematodes are microscopic but mighty as crop losses of \$85 billion have been estimated worldwide each year. Annual estimated crop losses due to nematodes in India have been worked out to be about Rs 242.1 billion. Nematodes continue to threaten agricultural crops throughout world including tropical and subtropical regions and for centuries they have affected crop plants by feeding on roots, pods, stems, crown, leaves, and seeds. Extensive research in developed countries and more than 70 developing countries have confirmed the concern of destructive nature of PPNs and it has become very significant to manage these to increase crop productivity. Plants pathogenic nematodes are microscopic, worm shaped organisms present within plant materials or rhizospheric soil itself. Out of total known species of nematodes, only 10% are plants pathogenic in nature and these feed on plants leading to the reduction in the growth of crops and yield efficiency [1]. Females of PPNs carry out the egg laying in the roots and surrounding rhizosphere soil followed by hatching leading to the development of worm like larvae reaching maturity through four moulting's. Survival, growth, and reproduction of nematode largely depends on soil moisture, temperature and plants to be used as food source and mostly underground parts of the plant are the possible food sources, which are consumed using a stylet, a spear like structure that withdraws plants sap juice by sucking leading to weakening of the plant. PPNs can be endoparasitic, semi endoparasitic, semi ectoparasitic or ectoparasitic. PPNs cause injury to the plants which leads to others problems followed by poor crop nutrition, crop management, a status of soil health and various infection affecting plant growth and harvest [2]. Most common PPN species reducing crop productivity are root knot nematodes e.g. *Meloidogyne* spp., root lesion nematodes e.g. *Pratylenchus* spp., bulb, and stem infecting *Ditylenchus* spp., leaves infecting *Aphelenchoides* spp., dagger shaped *Xiphinema* spp., lance shaped *Hoploaimus* spp., citrus nematodes *Aphelenchoides* spp., ring shaped *Criconemoides* spp., and growth stunting *Tylenchutus* spp., crops infected with significantly large nematode population on plant roots weakens the root to take-up water and minerals followed by their transportation to shoots of the plants affecting the crop quality and yield because shoot and root growth is restricted and plant vitality is affected. This leads to unhealthy and not uniform plant growth followed by weakening, chlorosis, and stunting, the formation of knots and galls, lesions on roots, bifurcation of roots leading to poor root health and growth. *Meloidogyne* spp. commonly known as root knot nematodes is of major serious concern for most of the crops grown in light soils e.g. tomato, okra, cucumber etc. Root

knot nematode is sedentary endoparasites whose larva feed on roots and reduce crop productivity and takes 3-4 weeks [3].

Nanoparticles and Management of Different Diseases

Use of nanoparticles in plant disease management is a novel and fancy approach that may prove very effective in future with the progress of application aspect of nanotechnology [4]. A nematicide is a chemical used to kill plant parasitic nematodes. These are broad spectrum toxicants possessing high volatility or other properties promoting migrating through a soil e.g. Aldicarb (Table 1). Common Natural nematicide in neem cake root exudates of marigold (*Tagetes*) is also found to be nematicidal *Paecilomyces* fungi is also *Neomalophagou* fungi, superheated steam is also used. The nanotechnology has the immense potential prospect of applications in agriculture and plants disease management in particular direct application of nanoparticles to soil or seed or foliage in the simplest to protect plants from different types of pathogen invasion by suppressing there as by the chemical methods. But a direct application of nanoparticles in soil and exposed parts of plants may also affect the on target organisms such as significant symbionts, solubilizers and nanoparticles may act as carriers of unwanted chemicals, concentrated intermediates of various pesticides/insecticides etc. [5]. Thus to reckon the scope and applications of nanoparticles in plant disease management the effect can be divided into two perspectives direct effect of nanoparticles on nematodes and use nanoparticles in formulating nematicides (Table 2). Due to their ultra-sub microscopic size nanoparticles gain the high degree of reactivity and sensitivity and thus have potential to prove very useful in control the PPNs, in addition, nematicidal residue analysis. As chemical and physical properties of nanoparticles vary greatly as compared to larger form, thus it has become imperative to evaluate the effect of nanoparticles on nematodes to harness the beneficial effects of this technology in the plant protection,

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Chemical name	Trade name	Formulation
Fumigants		
Methyl bromide	Dowfume	Gas
1,3 dichloropropene	Telone/DD-95	Liquid
Ethylene dibromide	Dowfume W-85	Liquid
Metam-sodium	Vapam	Liquid
Dazomet	Basamid	Dust (prill)
Methyl isothiocyanate	Di-Trapex	Liquid
Chloropicrin	Larvacide	Liquid
Organophosphates		
Thionazin	Nemafof	Granular or emulsifiable liquid
Ethoprophos	Mocap	Granular or emulsifiable liquid
Fenamiphos	Nemacur	Granular or emulsifiable liquid
Fensulfothion	Dasanit	Granular
Terbufos	Counter	Granular
Isazofos	Miral	Granular or emulsifiable liquid
Ebufos	Rugby	Granular or emulsifiable liquid
Carbamates		
Aldicarb	Temik	Granular
Aldoxycarb	Standak	Flowable
Oxamyl	Vydate	Granular or emulsifiable liquid
Carbofuran	Furadan/Curaterr	Granular or flowable
Cleothocarb	Lance	Granular

Table 1: List of chemicals used as nematicides.

especially against PPNs. Ultra small size and very high reactivity will affect the activity of PPNs [6]. Gold in different Variety of structure has been reportedly used in medicine since the history of civilization. Its compounds have been reported to be used in a treatment of various diseases such as rheumatism, lupus erythematosus, restorative dentistry, various skin disorder and even gold eyelid implants have been found the use for various medical conditions such as facial nerve palsy, lagophthalmos. In the modern time's nanostructures which possess and display variation in properties as compared to bulk gold. Due to their unique photocatalytic photothermal, optical and electrical properties and stability. The gold nanoparticles AuNPs have gained much significance in research since the last decade. AuNPs synthesized using various physical and chemical methods which are becoming less popular due to disadvantages of their expressiveness and non-ecofriendly nature. Now bio gold nanoparticles syntheses by various biological organisms including bacteria are becoming popular as these overcome the disadvantages [7]. Cited above and highly stable AuNPs of different size and shapes can be synthesized using bacteria, fungi, actinomycetes, and yeast. Bacteria with their ability to reduce various metals grab target Au²⁺ ions from the environment and convert these into Au⁰ enzymatically. Various bacteria have been reported with the ability to synthesize AuNPs. An indigenous bacterial strain isolated from indigenous gold mines identified as *Bacillus* sp. GPI-2 was found to convert AuCl₄ into AuNP of size 20 nm with the spherical shape. These

Crop	Nematode pest	Nematicide	Application rate ²	Application techniques
Potato	<i>Globodera</i> sp.	Aldi carb	2.24-3.36	Incorporated in row
		Oxamyl	4.0-5.5	-
		Carbofuran	4.0-5.5	-
Tomato, cucurbits	<i>Meloidogyne</i> spp.	Aldi carb	3.36	Incorporated in 30 cm bands
		Ethoprophos	0.9-2.9	Incorporated in bands
		Oxamyl	0.6-1.2	Incorporated in bands
		Fenamiphos	1.6-3.3	Incorporated in bands
	<i>Meloidogyne</i> spp.	Dazomet	30-50g/m ²	Incorporated in bands and irrigated time interval before planting
Citrus	<i>Tylenchulus semipenetrans</i>	Fenamiphos	10.8-21.6	Annual treatment applied along drip-line
	<i>Tylenchulus semipenetrans</i>	Aldi carb	5.5-11.0	Annual treatment applied along drip-line
Grape	<i>Xiphinema index</i>	Aldi carb	10-May	In band for nursery use
	<i>Meloidogyne</i> spp.	fenamiphos (e.c. formulation)	10	In band for nursery useIn band for nursery use
Banana	<i>Radophlus similis</i> and/or	Carbofuran	2-4 ga.i.per plant	Applied around plant 2-3 times per year
	<i>Helicotylenchus multinctus</i> and/or	Ethoprophos	2-4 ga.i.per plant	Applied around plant 2-3 times per year
	<i>Pratylenchus</i> spp.	Fenamiphos	2-4 ga.i.per plant	Applied around plant 2-3 times per year
	<i>Meloidogyne</i> spp.	Isazofos	2-4 ga.i.per plant	Applied around plant 2-3 times per year
		Ebufos	2-4 ga.i.per plant	Applied around plant 2-3 times per year

Table 2: List of Nematicides along with dose and application techniques for management of different nematodes.

Organisms	Size nm	Author
<i>Bacillus licheniformis</i>	50	Kalimuthu et al. (2008)
<i>Bacillus licheniformis</i> (culture supernatant)	50	Kalishwaralal et al. (2008)
<i>Corynebacterium</i> sp.	10-15	Zang et al. (2005)
<i>Bacillus subtilis</i> (culture supernatant)	5-60	Saifuddin et al. (2009)
<i>Geobacter sulfurreducens</i>	200	Law et al. (2008)
<i>Morganella</i> sp.	5-20	Parikh et al. (2008)
<i>Bacillus subtilis</i>	5-60	Saifuddin et al. (2009)
<i>Escherichia coli</i>	1-100	Gurunathan et al. (2009 a,b)
<i>Proteus mirabilis</i>	10-20	Samadi et al. (2009)
<i>Bacillus</i> sp.	5-15	Ganesh B abu and Gunasekaran (2009)
<i>Bacillus cereus</i>	4,5	Pugazhenthiran et al. (2009)
<i>Staphylococcus aureus</i>	1-100	Nanda and Saravanan (2009)
<i>Brevibacterium casei</i>	50	Kalishwaralal et al. (2010)
<i>Bacillus flexus</i>	20-40	Thakur and Shirkot (2017)

Table 3: List of microorganism synthesizing nanoparticles.

bio gold AuNPs were evaluated for their ability to kill nematodes [8-10]. As an active preparation, AgNP is well known to possess fungicidal and bacterial properties and thus used in the field of medicine, and are now catching attention in the fields of agriculture and horticulture. The Biological control agents play an important role in controlling the play pests like nematodes, weeds, insect, and mites [11].

Gold, Silver NP possess nematicidal activity that may provide an alternative to high-risk synthetic nematicides or inconsistent biological control agents. High frequency (biweekly) and high application doses (\$ 90.4 mg/m²) of Gold, Silver NP may be required to achieve effective field efficacy for root-knot nematode [12-17]. Combining AgNP with an irrigation system such as fertigation or tank-mixture with compatible chemicals that supplement the AgNP nematicidal effect may increase applicability of AgNP. Further understanding of the mechanism in the nematicidal action of Silver NP also warrants improvement of Gold, Silver NP efficacy (Table 3) [18-24].

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