The Planta RBS, Vol.-5, Issue-2, October 2024: 1580 – 1585 // ISSN: 3048:8494
MATHPAL SUDHA, (Series Chapter No. – 173 // ISBN: 978-81-965701-9-4)
https://www.pgrindias.in

NANOTECHNOLOGY: A STEP TOWARDS ECOFRIENDLY INSECT PEST MANAGEMENT

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Abstract

Nanotechnology is new promising tool of research which opens a wide range of opportunities in diverse areas of pharmaceuticals, insecticides, agricultural and electronics. Over various roles in different field, the use of nanotechnology in insect pest management is quite interesting and novel which exclude the traditional method of using insecticide and its accumulation on environment. This includes the management of insect pest through the formulations of insecticide based on nanomaterial (nanoparticle), enhancing agricultural productivity by using bio-conjugated nanoparticles (encapsulation) for deliberate release of water and nutrients. For the production of insect pest resistant varieties, as well as the use of nanomaterials for the preparation of various biosensors, nanoparticle-mediated gene or DNA transfer in plants might be beneficial which is also utilized in remote sensing devices for precision farming. As a result, nanotechnology could provide effective and environmentally friendly insect pest management. This artwork serves as a warning about old insect pest management practices and the possibility of nanomaterials as current nanotechnology approaches.

Keywords: Nanotechnology, Insecticide, Nanoparticle, Biosensor, Precision farming

Citation: Mathpal Sudha (2024), Nanotechnology: A Step towards Ecofriendly Insect Pest Management, *The PLANTA Research Book Series*, 5(2), 1580-1585. www.pgrindias.in

Introduction

It has been a decade where, the use of synthetic insecticide cause resistance in the insect and this will lead a new direction for the researchers. All the synthetic insecticides were replaced by new ecofriendly mode of insect management practices therefore; there is a need for advanced agriculture techniques that are viable and economically and environmentally feasible. Excessive and unmanaged use of harmful pesticides left various problems due to the presence of residue and contamination of our ecological systems including soil, sediments various waterways and transfer of residues across the food chain. One of the methods of this new mode of management for resolving this issue is the formation of nanoparticles. What is Nanotechnology? Is this word explains about its role? Interestingly, the answer of this question is “Yes”. The name "Nano" comes from a Greek term that means "dwarf." If we define “Nano” in a technical sense, it signifies one billionth of something. As Bhattacharyya *et al.* (2010) explains it “Nanotechnology is the science of manipulating matter at nanoscale”. Nanotechnology has shown great promise in industries like as electronics, medicine, catalysis, cleanup, and agriculture in the last decade. This technology might be developed and used to monitor crop development and field conditions in real time,

such as moisture levels, soil fertility, temperature, crop nutrition status, insects, plant diseases, and weeds, among other things.

Nanoparticles have a unique form, a large surface area, a small size, and a high reactivity, giving them excellent physical, chemical, and optical capabilities. There are various nanoparticles which are synthesized using heavy elements some of them are silver nanoparticle, zinc oxide nanoparticle, titanium dioxide nanoparticle (Duhana *et al.,* 2017), sodium alginate nanoparticles. Various techniques, such as chemical, physical, enzymatic, and biological, are used in the formation of nanoparticles. Plasma arcing, ultra thin films, thermal evaporate, ball milling, spray pyrolysis, lithographic techniques, layer by layer growth, pulsed laser desorption, sputter deposition, diffusion flame synthesis and molecular beam epistaxis of nanoparticles are examples of physical methods (Joerger *et al.*, 2000). Different materials used in nanoparticle formation include metals, plant parts etc. and used for making nanoparticle with different shapes and sizes (Palaniselvam *et al.*, 2014). The nanoparticles are identified through the scanning tunnelling microscope (STM), atomic force microscope (AFM), the Dynamic Light Scattering (DLS) studies, Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) studies.

Insect pest management (IPM) is a program to manage the harmful pest which causes economical damage. Insects are one of the biggest animal populations with a very successful evolutive history. Majority of insects are oligophagous and polyphagous that is why they cause damage to various crops. Farmers have traditionally employed traditional insect pest management tactics such as crop rotation, healthy crop variety, manipulations in sowing dates, integrated pest management (IPM), and so on. IPM is consequently more difficult for farmers to execute, as it necessitates pest monitoring expertise and a thorough grasp of pest dynamics, as well as the collaboration of all producers for efficient implementation. Dhawan and Peshin, 2009; Peshin *et al.,* 2009 and Torney, 2009 reviewed that nanotechnology has promising applications for protection of host plants against insect pests.

Nanotechnology in Agriculture

As the population is gradually increasing and thus the requirement of crop production increased as well and because of the shortage of natural resources (e.g., land, soil, water, etc.) and limited crop productivity, there is a growing demand for advanced agricultural techniques that are viable economically and environmentally (Bouchet *et al.,* 2016). Thus, to increase the performance of a farming system nanotechnology based innovative technologies must be included for high productivity, economic viability, environmental impact and lower labor cost. Using this technology in pesticide delivery has created many opportunities for safe application of conventional pesticides (Fig.1).

1. **Potential in agriculture:** Nanotechnology has the potential to change the agricultural and food industries by providing contemporary tools for disease treatment, hasty disease recognition, increasing the capacity of plants to absorb nutrients, etc. Smart sensors and smart delivery systems will help the agricultural industry combat viruses and other crop pathogens (Rickman *et al.*, 1999). In the near future, nano-based catalysts will be accessible increasing the effectiveness of herbicides and pesticides and enabling for lower doses to be utilized.
2. **Precision Agriculture –** Precision agriculture has been a long-desired target to maximize output (i.e. crop yields) while minimizing input (i.e. fertilizers, pesticides, herbicides, etc.) through monitoring environmental variables and applying targeted action. Precision farming makes use of computers, global satellite positioning systems

and remote sensing devices to measure highly localized environmental conditions, thus determining whether crops are growing at maximum efficiency or precisely identifying the potential in insect pest management.

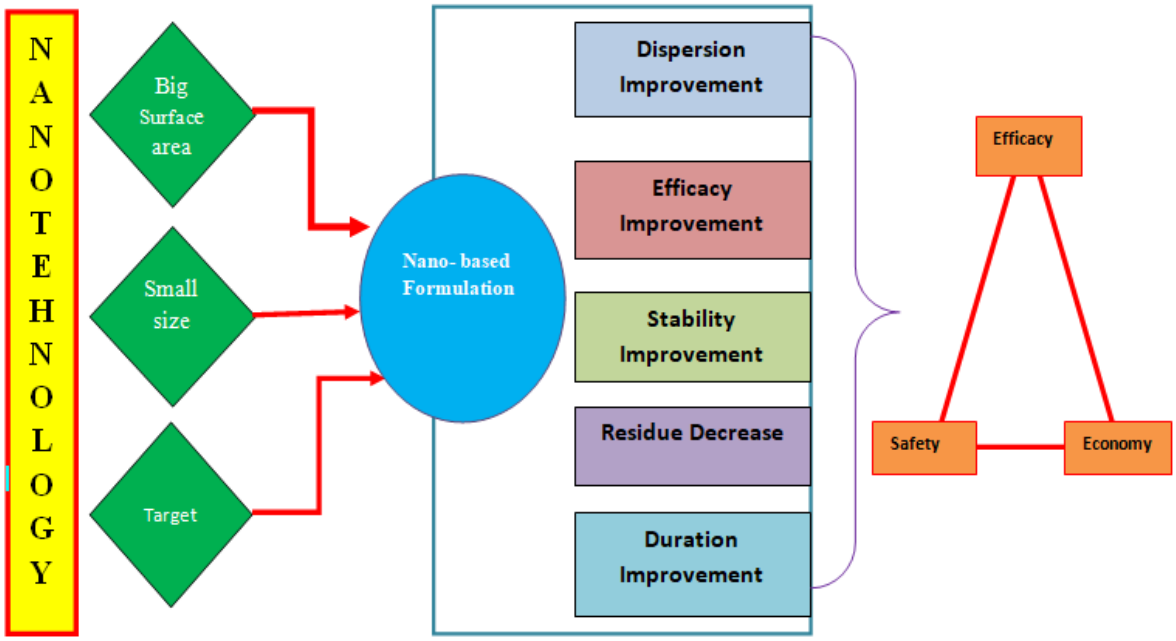

Fig 1. Schismatic representation of Nano based formulations improving pesticide properties

Nano-Based Forumulations

Plants provide a prospective pathway for the transport of nanoparticle to the environment and provide an important route for their bioaccumulation into food chain. Prasad *et al.* (2017) stated about carbon nanotubes, nanorods and quantum dots as nanodevices like quantum dots and fluorescent nanoparticle have been developed for labeling the plant proteins. Some methods for applying and using nano formulations are as follows:

1. **Nano emulsion:** In pesticide formulation, microemulsions are considered to be optically transparent or translucent dispersions of pesticides either in water or in oil and solubilized by additives such as surfactant.
2. **Nanoencapsulation:** Nanoencapsulation is the coating of a range of substances within another material at diverse sizes in the nano-range. The encapsulated materials are commonly referred to as the core material, the internal phase, the filler, for instance, pesticides.
3. **Nano-fibers:** Nanotechnology with use of biological, chemical and physical processes plays a role in recycling the residual materials of agricultural products to energy and industrial chemicals.
4. **Nanopesticide:** Nanotechnology efficiently involved in the manufacture application and manipulation of nano based formulation formation. These nanopesticides have unique properties such as size dependent qualities, high surface to volume ratio and unique optical properties at a critical length scale of less than 100nm (Ghormade *et al.*, 2011).
5. **Nano-silica:** An exclusive nanomaterial, prepared from silica and has numerous applications in drug development and medicine as catalyst and prominently it can be

used as nano-pesticide. Barik *et al*. (2008) reviewed the use of nano-silica as nano-pesticide.

Nanotechnology in Insect Pest Management

Nanotechnology has a huge range of possible applications and benefits. Nanoporous zeolites for gradual release and efficient dose of water and fertilizer, nanocapsules for herbicide delivery and vector and pest management, and nanosensors for pest detection are just a few examples. Insects can be found chiefly in all possible environments all over the world, and the number of species and individuals. Their success can be attributed to several important evolutionary aspects like wings, malleable exoskeleton, high reproductive potential, habits diversification, desiccation-resistant eggs and metamorphosis, just to name a few**.** Insects that do not cause more than 5% harm are not considered pests those, who cause damage between 5% and 10% are classified as minor pests, whereas those that cause damage greater than 10% are classified as severe pests (Dhaliwal *et al*., 2010). El-bendary and El-Helaly (2013) investigate a new control technique by assessing the impact of applying hydrophobic nano-silica on the resistance of tomato plants to the pest *Spodoptera littoralis.* The results of treating hydrophobic nano-silica in larva revealed that all concentrations utilized randomly with concentrations had a strong harmful effect. This experiment was considered as first report of using such rational new nano pesticides as new method of control using new approach that demonstrated that nano-silica could be used in *Spodoptera littoralis* control.

Examples of Insect Pest Management

There are a number of researches have been done, where the use of nanotechnology in insect pest management has been successfully shown e.g *Tribolium castaneum* Herbst is resistant to nanoparticles containing garlic essential oil (Yang *et al.,* 2009). A study was initiated by Chakravarthy *et al.* (2012) to explore the potential of Nano-Ag, CdS and Nano-TiO2 nanoparticles in causing adverse effects on *Spodoptera litura.* A study carried out to establish the larvicidal effect of synthesized silver nanoparticles (AgNPs) using leaf extract of *Euphorbia hirta* (Euphorbiaceae) against the first to fourth instar larvae and pupae of the crop pest of cotton boll worm , *Helicoverpa armigera*. Kamaraj *et al.* (2018) evaluated the impact of Neem gum nano formulation (NGNF), for its antifeedant, larvicidal and pupicidal activities against *Helicoverpa armigera* (Hub.) and *Spodoptera litura* (Fab.) at 100 ppm. The NGNF showed significant (100%) antifeedant, larvicidal and pupicidal activities against *H. armigera* and *S. litura*.

Future Prospects

In future, the plants may have extensive perspective for the synthesis of metallic nanoparticles in commercial products and healthcare. Even if, there are two reasons to be explored in the field of nanotechnology for biological production of nanoparticles, they are: i) identification of phytochemical compounds (active metabolites) which are involved in the reduction reaction, ii) Laboratory scale manufacture of metallic nanoparticles to the level of large scale production, and need to explicate their functional mechanism against various pathogenic organisms. In agriculture there are many applications of nanotechnology such as, potential residue carry-over in foodstuff, toxicity of the ecosystem and nanomaterial phytotoxicity. For their applications in agriculture, like other technologies, field application technologies and low-cost nanomaterials are required.

Conclusion

Nanotechnology is leading to the development of an array of inexpensive nanotech applications for improved plant growth less harmful effect on non-target organism is the best outcome of this technique by efficient and sustainable utilization of pesticides by target delivery. Apart from this, the use of nanopesticide results in efficient management system to surpass chemical pesticide in terms of several conditions like no premature degradation, high water solubility and decreased plant resistance. It is also essential for researchers to focus on residue degradation in the environment therefore; more research and funding for the successful implementation of nanotechnology in agriculture are required.

References

Barik,T.K., Sahu, B. and Swain, V. (2008) Nano-silica—from medicine to pest control. Parasitology Research 103, 253–258.

Bhattacharyya, A., Bhaumik, A., Usha Rani, Pathipati, Mandal, S. and Epidi, Timothy T. (2010) Nano-particles - A recent approach to insect pest control. African Journal of Biotechnology 9(24), 3489-3493.

Bouchet, A.S., Laperche, A., Bissuel-Belaygue, C., Snowdon, R., Nesi, N. and Stahl, A. (2016) Nitrogen use efficiency in rapeseed.A review, Agron. Sustain. Dev. 36-38.

Chakravarthy, K., Chandrashekharaiah Subhash., Kandakoor, B., Bhattacharya, A., Dhanabala, K., Gurunatha, K. and Ramesh, P. (2012) Bio efficacy of inorganic nanoparticles CdS, Nano-Ag and Nano-TiO2 against *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae). Current Biotica 6(3), 271-281.

Dhaliwal, G.S., Jindal, V. and Dhawan, A.K. (2010) Insect pest problems and crop losses: changing trends. Indian Journal of Ecology 37(1), 1–7.

Dhawan, A.K. and Peshin, R. (2009) Integrated pest management: concept, opportunities and challenges. In: Peshin P, Dhawan AK (Ed.) Integrated pest management: innovation-development process. Springer, Dordrecht, Netherlands, pp 51–81.

Duhana, J.S., Kumara R., Kumara, N., Kaura, P., Nehrab, K. and Duhan, S. (2017) Nanotechnology: The new perspective in precision agriculture. Biotechnology Reports 15,11–23.

El-bendary, H. M. and El-Helaly, A. A. (2013) First record nanotechnology in agricultural: Silica nano- particles a potential new insecticide for pest control. Applied Science Reports, 4(3), 241-246.

Ghormade, V., Deshpande, M. V. and Paknikar, K.M. (2011) Perspectives for nano-biotechnology enabled protection and nutrition of plants. Biotechnology Advances 29,

Joerger, R., Klaus, T. and Granqvist, C.G. (2000) Biologically produced silver–carbon composite materials for optically functional thin-film coatings. Adv. Mater. 12, 407–409.

Kamaraj, C., Gandhi, P.R., Karthi Elangoc, Sengodan.,Min Chunge, I. and Rajakumar, G. (2018) Novel and environmental friendly approach; Impact of Neem (*Azadirachtaindica*) gum nano formulation (NGNF) on *Helicoverpa armigera* (Hub.) and *Spodopteralitura* (Fab.). International Journal of Biological Macromolecules 107, 59–69.

Palaniselvam K.,Manish M. Yusoff, Gaanty Pragas Maniam and Natanamurugaraj Govindan; 2014; Biosynthesis of metallic nanoparticles using plant derivatives and their new avenues in pharmacological applications – An updated report; Saudi Pharmaceutical Journal; 24,473-484.

Peshin, R., Bandral, R.S., Zhang, W.J., Wilson, L. and Dhawan, A.K., (2009) Integrated pest management: a global overview of history, programs and adoption. In: Peshin P, Dhawan AK (Ed.) Integrated pest management: innovation-development process. Springer, Dordrecht, Netherlands.pp 1–50.

Prasad, R., Bhattacharyya, A. and Nguyen, Q.D. (2017) Nanotechnology in Sustainable Agriculture: Recent Developments, Challenges, and Perspectives. Front. Microbiol.8:1014.

Rickman, D., Luvall, J.C., Shaw, J., Mask, P., Kissel, D. and Sullivan, D. (1999) Precision agriculture: changing the face of farming. Geotimes feature article. www.ghcc.msfc.nasa.gove/precisionag/. Accessed 19 November, 2011.

Torney, F. (2009) Nanoparticle mediated plant transformation. Emerging technologies in plant science research.Interdepartmental Plant Physiology Major Fall Seminar Series Phys, 696.

Yang, F.L., Li, X.G., Zhu, F. and Lei, C.L. (2009) Structural characterization of nanoparticles loaded with garlic essential oil and their insecticidal activity against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). J. Agric. Food Chem. 57(21), 10156-10162