Nanotechnology: An Advanced Approach to The Development of Pesticides

R. Urkude[1]S. R. Kochhar[2]

[1-2] Department of chemistry,Shivaji science college,Nagpur(M.S) India.

Email:kochharsoni@gmail.com

Abstract

Today the pests have become a major concern for the farmers across the world. The Indian agriculture is currently suffering an annual yield loss of about the 60-70% due to insect pests.The misuse and overuse of chemical pesticides in crop protection deteriotes soil health, water bodies ,affects human health ,cause resistance and increase the survival rate of insect pests . Nanotechnology is promising field of science and has great application in the field of agriculture especially in pest management. Management of insect pests can be done through the formulations of nanomaterials-based insecticides.Many nanoscale carriers, like encapsulation and entrapment, polymers and dendrimers, surface ionic and weak bond attachments and other mechanisms may be used to store, protect, deliver, and release by control of intended payloads in crop production processes. Nanotechnology finds application in the management of polyphagous pest *Helicoverpa Armigera* ,one of the serious pests which feed on more than 150 crops throughout the world.This review highlights some of the most promising and important nanotechnology applications in agriculture especially insect pest control and concern regarding its effects on human and the environment.

Keywords: Nanotechnology, pesticides

Introduction

Today the pests have become a major concern for the farmers across the world. In world food plant are damaged by more than 10,000 species of insect. Sometimes the yield loss by insects reaches as high as 60-70%. Indian agriculture is currently suffering an annual loss of about Rs. 8, 63, 884 million due to insect pests. There is a big challenge in meeting the increasing population ,estimated population of 6–9 billion by 2050 [1]. Several practices including chemical, biological and biopesticides are used for its management .Farmers mainly depend on chemical control method but misuse and overuse of chemical insecticides deteriotes soil health, water bodies ,affects human health , causes resistance and increases the survival rate of insect pests. Nanotechnology provide green and efficient alternatives for the management of insect pests in agriculture. These include management of insect pests through the formulations of nanomaterials-based insecticides.Many nanoscale carriers, like encapsulation and entrapment, polymers and dendrimers, surface ionic and weak bond attachments and other mechanisms may be used to store, protect, deliver, and release by control of intended payloads in crop production processes. *Helicoverpa armigera* , a highly polyphagous pest feeds on pigeonpea ,tomato cotton, chickpea, okra and groundnut. Studies have reported the potential of nanomaterials in this insect pest management.[2]This review highlights some of the most promising and important nanotechnology applications in agriculture especially insect pest control and concern regarding its effects on human and the environment.

1. Agronanotechnologies to Enhance Performance of Pesticides

Food and agricultural production are among the most important fields of nanotechnology application. Nanotechnology has the potential to protect plants, monitor plant growth, detect plant and animal diseases, increase global food production, enhance food quality and reduce waste for sustainable intensification.

Through advancement in nanotechnology a number of state-of-the-art techniques are available for the improvement of precision farming practices that will allow precise control at nanometer scale.

1.1Nanopesticides: Nanopesticides is used efficiently in agriculture[3].Nanopesticides is any formulation that intentionally includes elements in the nm size range and claims novel properties associated with these small size range.Nanopesticides can consist of organic ingredients (e.g., a.i., polymers) and/or inorganic ingredients (e.g., metal oxides) in various forms (e.g.particles and micelles). Other advantages of the use of nanoparticle insecticides are the possibility of preparing formulations which contain insoluble compounds that can be more readily dispersed in solution. It reduces the problems associated with drifting and leaching, due to its solid nature and leads to a more effective interaction with the target insect. These features enable the use of smaller amount of active compound per area, as long as the formulation may provide an optimal concentration delivery for the target insecticide for longer times. Since there is no need for re-applications, they also decrease the costs, reduce the irritation of the human mucous-membrane, the phytotoxicity, and the environmental damage to other untargeted organisms and even the crops themselves. [4]

1.2 Polymers: Polymers are often used in the nanoparticle production[5] The common polymers (synthetic and natural ones) used in CRFs for insecticides application are listed in Table 1.

Table 1. Polymers used in the nanoparticle production.

Polymer	***Active Compound***	***Nanomaterial***	***Reference***
Polyethylene	Deltamethrin	Capsule	[6]
Lignin-polyethylene glycol-ethylcellulose	Imidacloprid	Capsule	[7]
Polyethylene glycol	Cyfluthrin	Capsule	[8]

1.3 Microencapsulation and Nanoencapsulation: Nano and microencapsulation (a process by which particles are given a certain functionality through surface coating) are used as plant-growth regulators for effective pest-control products for cotton, rice, peanuts and soybeans.[9] Microencapsulation has been used as a versatile tool for hydrophobic pesticides, it enhances their dispersion in aqueous media and allow a controlled release of the active compound .Nanoencapsulation is a process through which a chemical is slowly but efficiently released to the particular host for insect pests control. Release mechanisms include dissolution, biodegradation, diffusion and osmotic pressure with specific pH.

1.4 Nanoparticles: Nanoparticles can be used in the preparation of new formulations like pesticides, insecticides, insect repellents, pheromones and fertilizers [10] .Nanoparticles possesses distinct physical, biological and chemical properties associated with their atomic strength. Nanoparticles loaded with garlic essential oil are efficacious against *Tribolium castaneum* Herbst.[11]Gold nanoparticles may potentially be another useful material for removing contaminants, such as toxic chlorinated organic compounds, pesticides and inorganic mercury from water.The researchers suggest that nanoparticles can be attached to host polymer materials, such as porous resins, cellulose and silica to reduce potential harm to human health and the environment derived from the release of nanoparticles into the environment. The nanoparticles fixed to the host material becomes bulkier and can be more easily removed. Nanoparticles, such as nanoscale zinc oxide fixed in this way are used to break down organochlorine pesticides, halogenated herbicides and azo dyes. Nanoparticles can be used for the bioremediation of resistant or slowly degradable pesticides otherwise these harmful compounds enter the food chain and result in serious problems for the body. Recently, a novel photodegradable insecticide involving nanoparticles has been prepared. Nanotechnology has promising application in nanoparticle mediated gene transfer it can be used to deliver DNA and other desired chemicals into plant tissues for protection of host plants against insect pests [12]

1.5 Nanosensors and nano based smart delivery systems could help in the efficient use of agricultural natural resources like water, nutrients and chemicals through precision farming. Through the use of nanomaterials and global positioning systems with satellite imaging of fields, farm managers could remotely detect crop pests or evidence of stress such as drought. Once pest or drought is detected, there would be automatic adjustment of pesticide applications or irrigation levels. Nanosensors dispersed in the field can also detect the presence of plant viruses.

1.6 Nanophotocatalysts: Nanophotocatalysts assist in removing Agricultural Pesticides. Pesticides degrade with exposure to sunlight (photocatalysis). The rate of this degradation depends on surface area and surface roughness both of which can be manipulated via nanotechnologies to increase degradation and minimize persistence in the environment.

1.7 Nanotubes: Clay nanotubes (Halloysite) have been developed as carriers of pesticides for low cost, extended release and better contact with plants,this reduces the amount of pesticides by 70–80%, hence reduces the cost of pesticide and also the impact on water streams [13]. Nanotube filled with aluminosilicate sticks to plant surfaces while the ingredients of nanotube have the ability to stick to the surface hair of insect pests and ultimately enter the body and influence certain physiological functions [14].

Conclusion

Nanotechnologies have much to offer agriculture as it strives to provide a safe and secure food supply from limited cropland to an increasing world population.Nanotechnology will revolutionize agriculture including pest management in the near future. While nanotechnologies offer tremendous benefits for society, they may also pose significant risks. Nanoparticles, owing to their extremely small size have been shown to penetrate readily in the skin ,they can also reach potentially sensitive organs such as bone marrow, lymph nodes, the spleen, the heart and have been found to affect aquatic organisms in the environment .These are difficult and expensive to monitor, measure, and control. The potential benefits of nanotechnology for agriculture, food, fisheries, and aquaculture need to be balanced against concerns for the soil, water, and environment and the occupational health of workers.

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