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CONTENT

IMPLEMENTATION OF NANOPESTICIDES AS SUBSTITUTION FOR CONVENTIONAL PESTICIDES IN AGRICULTURE: A REVIEW

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Abstract:

According to several research articles, implementing Nanopesticides in place of conventional pesticides effectively reduces insect infestations. Considering all the above factors, farmers should look at nanopesticides as a new pest control method and use them to prevent pest or insect infestation. The use of nanopesticides will contribute to the development of agriculture and herald a new era of agribusiness. Agriculture is most affected by the effects of climate change, and as a result, farmers must deal with various issues, including heavy and erratic rains. Using various nanopesticides will enable farmers to prevent the infestation of insects and pests in the future; as a result, farmers should advocate using nanopesticides rather than conventional pesticides in the future. In this article, the author describes in detail the study of the importance and benefits of nanopesticides as a substitution for conventional pesticides in agriculture.

Keywords: Nanopesticides, Implementation, Agriculture and Conventional pesticides.

Introduction:

Pesticides are becoming a necessary component of agriculture. There are numerous environmental and health risks as a result of the larger dosage of these pesticides per hectare. Nanopesticides have been created as a result of the growth of a new scientific discipline called nanotechnology. The carrier molecule or active component in these chemicals is nanosized. The research community has created several formulations, including nanoemulsions, nanosuspensions, controlled release formulations, and solid-based Nanopesticides. In comparison to conventional insecticides, the chemical's smaller size aids in proper distribution on the pest surface. In the meanwhile, we should be more aware of the negative consequences of using these Nanopesticides (Rajna *et al.*, 2019). The potential prospect of agricultural nanotechnology uses is gradually becoming an improving innovation. The genetic modification of plants and animals made possible by nanotechnology has the potential to increase agricultural productivity. The potential for precision agriculture, resource management, and effective delivery systems for fertilisers, pesticides, food processing, packaging, and other areas is growing as suitable techniques and sensors are identified. For India to become a key participant in the field and contribute to the creation of new technologies, the Department of Science and Technology developed the Nano Science and Technology initiative in 2001, which was directed by Prof. C.N.R. Rao (Jaga *et al.*, 2021).

Nanotechnology is a rapidly evolving field that has the potential to change food systems and address the current problem of food security. It plans to transition agriculture from the era of careless resource use and environmental degradation to the brave new world of advanced systems with improved material use efficiency and targeted applications to reduce crop losses brought on by abiotic-biotic stresses as well as to give the environment proper consideration. Pesticides must be used in agriculture to control plant diseases and insect pests. The increasing concentration of these chemicals per hectare has, however, led to numerous environmental and health risks. A new branch of research known as nanotechnology has resulted in the development of novel pesticides to address problems associated with conventional pesticides. The main benefit comes from the particle's small size, which aids in evenly dispersing the components on insect surfaces and produces a better effect than traditional pesticides. Due to their better efficiency and lower dosage requirements, nanoparticles are increasingly being used as Nanopesticides, Nano fertilizers, and Nano delivery systems. However, humans and other species are exposed to nano-entities during or after the application. It is currently mostly unknown how these created nano-entities interact with biological systems. Therefore, a deeper knowledge of their interactions and potential negative effects is essential for a sustainable transition before widespread use in crop production and crop protection (Yadav *et al.*, 2022).

The extensive use of pesticides in agriculture has been a topic of much debate due to their negative effects on the environment and human health. Chemicals like carbamate, pyrethroids, and organophosphorus are employed as pesticides in conventional agriculture. The majority of the time, even though these chemical pesticides are effective, researchers have found that they either miss the target insect and are lost in the air or are leached out into the soil and water. Farmers experience significant agricultural losses as a result of insect infestation because of the overuse or improper use of these chemicals, which can lead to resistance. These chemicals are also toxic to humans and have negative impacts on agricultural fields. The use of nanotechnology has made it possible to combat these negative effects. Plant protection pesticides made with nanotechnology use active chemicals that are applied on a nanoscale. Nanoparticles have been used by scientists to deliver active compounds that are effective against specific pests or as components in novel insecticidal compositions. Contrary to traditional hydrophobic pesticides, nanocides are water-soluble substances that can replace them without the use of harmful organic solvents. They also have homogeneous coverage and strong bioactivity. Due to their frequent application in small doses and fast uptake by cells, these nano-based insecticides can impede the emergence of resistance in pests that are their intended targets. For instance, an analysis of the fruits and leaves of the green sweet pepper used in the study revealed no metal nanoparticle accumulation (Bose, 2021).

Conventional pesticides and their disadvantages:

Pesticides have been utilised extensively in agriculture and are regarded as one of the key elements of crop protection strategies. In addition to using high-yielding crop types alone, their adoption during the green revolution era considerably increased crop yields (Popp *et al*., 2013). Investigations on the hazards of pesticide use, their toxicity to humans and animals, and their harmful effects on the ecological balance of life are ongoing worldwide. These days, one of the most researchable topics is said to be this one (Laborde, 2008). Only 0.1% of pesticides administered in various ways (spray, soil, seed treatment, etc.) have been shown to reach the intended target; the remaining 99.9% seep into the environment, causing soil and groundwater pollution, which eventually worsens the ecological imbalance (Goulson *et al*., 2015; Kumar *et al.,* 2018). Another limitation on pesticide use in agricultural applications (such as Wettable Powders) is their solubility, as appropriate dispersion of the active ingredient in the liquid phase is necessary for spraying. Due to its affordability, accessibility, and ecological compatibility, water is the most practical medium for applying pesticides. However, many pesticides are either weakly or even completely insoluble in water (Whitehouse and Rannard 2010).

Almost all types of plants, including crop plants, forest trees, medicinal plants, herbs, and weeds, are edible to insects, who make up around two-thirds of all known animal species. In addition to destroying stored grains and crops, they eventually reduce food quality. Pest insects are those that harm a crop and/or its food grains by more than 5%. (Rai and Ingle, 2012). A pesticide is any substance created to prevent, destroy, repel, or reduce pest populations. Additionally, they can function as desiccants, defoliants, or plant regulators. Pesticides are divided into various subgroups according to their chemical makeup and method of action (Pereira *et al.,* 2015; Sparks and Nauen, 2015). As a result, a practice known as bioaccumulation occurs where the pesticide concentration rises at each level of the food chain, having deleterious effects on both animal and human health. Sometimes, as a result of interactions between pesticide formulations, phytotoxic effects can also manifest, which might result in total crop failure (Rizzati *et al*., 2016).

There was no longer only a small concern about the effects of chemical pesticides on the environment and human health in the new era of the food revolution. Since then, pesticides have been sprayed onto the field as part of appropriate agricultural practices such as crop rotation, land, water, and post-harvest management (Yu *et al.,* 2017). They are first sprayed to deposit into the crop foliage, and then by mechanisms of diffusion, uptake, and/or transfer, they reach the pest attack site, resulting in poisoning or contact attacks (Nuruzzaman *et al.,* 2016). However, regular use of chemical pesticides has increased the risk of bio-magnification as well as the evolution of pesticide resistance in the targeted pest. Chemical pesticides' active ingredients frequently disrupt metabolic processes by preventing enzymatic activity (Pandey *et al*., 2016). Chemical pesticides have been used for a longer period because high-yielding crops are more susceptible to diseases, insects, and other biotic factors. In recent years, bee populations have experienced a significant decline. Around the world, 75% of the honey has been found to contain traces of insecticides that are harmful to bees, particularly neonicotinoids like acetamiprid, clothianidin, imidacloprid, thiacloprid, and thiamethoxam (Sheridan 2017; Zhang 2018). In the aforementioned situation, using biopesticides to manage pests in crops has become an essential substitute for using traditional chemical pesticides.

Due to the harmful environmental and public health consequences, the widespread use of insecticides in agriculture has received a lot of attention. Chemical insecticides used in traditional agriculture include carbamate, pyrethroids, and organophosphorus. The majority of the time, even though these chemical insecticides are effective, researchers have found that they miss their intended insect target and instead either evaporate into the air or get washed away in soil and water. Farmers suffer significant agricultural losses due to insect infestation as a result of the overuse or misuse of these chemicals, which may lead to resistance. These chemicals are also dangerous for humans and have negative impacts on agricultural fields.

Nanopesticides:

The term "Nanopesticides" refers to those little molecules that constitute just pest control derivatives or encase the active ingredient of a pesticide in a protective nanocarrier (Kookana *et al*., 2014). Through "smart field management," must guarantee the advancement of precision farming. ENMs can reduce photodegradation and improve the physicochemical stability of the materials due to their increased surface-to-volume ratio, quantum effects brought on by their small size, atypical phase change, and stabilisation (Bakshi *et al*., 2015; Kuswandi 2018), among other factors (de Oliveira *et al.,* 2014). To deliver an active pesticide component to the targeted agricultural pest with improved durability and efficiency and without posing any environmental risks (Chowdhury *et al.*, 2012), a new diffusion, erosion, and swelling controlled nanodevice can be tailored (Chowdhury *et al*., 2017).

There are certain disadvantages to using biopesticides with pesticidal activity. New creative formulations for biopesticides, including nanoformulations with a lower quantity of active ingredients for a variety of applications in crop protection, have been created to make these biopesticides more effective by overcoming existing disadvantages. In certain investigations, these biological molecules served as capping and reducing agents for the creation of stable nanoparticles with synergistic features from inorganic compounds (Ag, Cu, ZnO, and S) with pesticidal activity (Dimkpa *et al.*, 2013; Gao *et al*., 2014; Singh *et al*., 2014). These nanoparticles can be utilised as pesticides immediately after being stabilised with biopesticides and nanobiopesticides. With lower concentrations of the active ingredients, these nanobiopesticides successfully aid in pest management (Vimala Devi *et al*., 2019).

Although botanicals provide an environmentally friendly method of controlling insect pests, their use is constrained by their poor environmental stability (Forim *et al*., 2013). In this regard, nanotechnology holds out enormous potential, and nano-formulations can be employed to increase the stability and potency of these natural chemicals (Ghormade *et al*., 2011). Nanostructured botanicals are particularly efficient against insect pests, including azadirachtin, rotenone, carvacrol, thymol, and curcumin, among others (Shah *et al.*, 2016). According to (Forim *et al,* 2013), spray-dried neem (*Azadirachta indica*) nanoparticles can kill diamondback moth larvae completely while also having improved UV stability.

Advantages of Nanopesticides:

Toxic chemicals or pesticides employed in nano-formulations go through some modifications to prevent nano-pesticide runoff in the air, water, and soil, but the poisons may build up in the food chain, posing a serious threat to the environment and human health. To hold and improve the insecticidal value while also preventing accumulation in the environment, nanopesticides molecules are incorporated into a delivery substance such as biopolymers, micelles, or composites. These nanobiopesticides are triggered to release themselves by environmental factors including temperature, humidity, wetness, or light. Clay nanotubes (halloysite), designed as pesticide transporters, release when an environmental trigger occurs, similar to how biopolymers do. This allows for improved interaction with pests. Similarly, nanopesticides and nanofertilizers are encased in specialised carriers to allow controlled release for targeted effects (Bergeson 2010; Manjunatha *et al.*, 2016).

Nanotechnology offers a platform for developing novel formulations of eco-friendly pesticides because the majority of nanopesticide formulations are particularly target-specific. In general, targeted delivery and controlled release of nanopesticides can enhance pesticide usage, decrease residue, and reduce pollution. In particular, nanomicrocapsule formulations for the delivery of pesticides have gradual release and protective performance since they were created utilising high polymer materials that are light-sensitive, thermosensitive, humidity-sensitive, enzyme-sensitive, and soil pH-sensitive. Nanopesticides are remarkable tools for creating a system of agriculture that is eco-friendly and sustainable since they cut down on overall chemical use and hazardous residues and improve crop protection (Rajna *et al*, 2019).

Disadvantages of Nanopesticides:

It is yet unclear how dangerous nanoparticles (also known as Nanopesticides) may be for the environment and human health. Since nano-pesticides appear to be far more persistent and harmful than their conventional equivalents, nano-pesticides may also result in new types of contamination of soils and rivers (Rajna *et al.*, 2019). Due to their long persistence, improved mobility, and increased toxicity, nanopesticides may also result in new sorts of pollution of soils and rivers. The use of some nanoparticles could have negative effects; for example, silver nanoparticles (AgNPs) have more harmful effects than silver nitrate (Griffitt *et al.,* 2008) and can penetrate biological barriers including cell membranes (Verma *et al.,* 2008), which can result in toxicity (Sondi and Sondi, 2004; Morones *et al.,* 2005; Nel *et al.*, 2006). Nanosilver toxicity (bile duct hyperplasia) results from oral and inhalational consumption (Kim *et al.*, 2009). In five types of plants, cucumber, cabbage, carrot, corn, and soybean alumina nanoparticles (aluminium oxide) reduced the formation of roots (Yang *et al.*, 2005).

Conclusion:

Recent studies have demonstrated that nano-pesticides can reduce the harmful effects of chemical-based pesticides, provide target-specific pest control, and aid in the development of intelligent nano-systems for minimising issues like environmental imbalance and detrimental effects on crop productivity and food security (Nuruzzaman *et al.*, 2016). Due to the limited release of functional ingredients, they are effective for long-term utility and offer a solution to environmental-related issues including the nutrient-richness of water bodies and the accumulation of non-biodegradable components in the food chain. Furthermore, because of the enhanced solubility and stability of their active ingredients, nanopesticides exhibit effective pest control properties (Venugopal *et al.*, 2016).

Therefore, there is enormous potential for using nanoparticles in plant protection, and these new delivery mechanisms may lead to the creation of safer and more environmentally friendly pesticides. Nanoparticles can however have certain disadvantages in addition to their many benefits, such as limited selective toxicity, low biodegradability for inorganic nanoparticles, and the emergence of pesticide resistance in both target and non-target organisms as a result of their indiscriminate use. Additionally, there is a lack of evidence and limited data regarding the environmental fate of these nanoparticles and their potentially harmful effects on non-target creatures. As a result, there has to be more focus on the potential impact and negative consequences of nanoparticles on the environment, nontarget creatures, and the creation of environmentally friendly nanopesticides (Jayant Yadav *et al.*, 2022).

Considering all of these factors, future research should concentrate on the following aspects are as formulation of ingenious nanopesticide formulations to overcome the drawbacks of conventional formulations; Creating environmentally friendly nanopesticide development technologies using green chemistry; Creating technologies to lower the cost of producing nanopesticides; and Comparing the activity of nanoformulations with conventional analogues at the field level.

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