

Use of Nano pesticide in Agriculture and its Toxicity – A Review

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ABSTRACT

In today's world, population is increasing day by day, accordingly the need of population is also increasing day by day. The basic need of population for survival is food and therefore there is need to increase agriculture production. After 10-20 years the population will increase up to 9.8 billion and therefore there will be more need of food and to fulfill this demand of growing population Nanotechnology should be used in the field of agriculture. Nanotechnology is the developing field and it contribute to various fields like medicinal, electronics, transportation, agriculture, etc. In agriculture field, the nanopesticide are used for crop production and to destroy the pests and insects which cause damage to the plant. The nanopesticides are more effective and less toxic as compare to commercial pesticides. These synthetic pesticides can cause harmful effect on human health. The nanopesticides also has some toxic effect on human body. But nanopesticide has less toxicity as compare to synthetic pesticides.

Keywords: Agriculture, Pesticides, Nanotechnology, Nanopesticides, Toxicity.

INTRODUCTION

In this growing world the need of food is also growing and therefore the growing population of the world demanding more agricultural output. Agriculture is the science and art of cultivating plants and livestock. It is the process of producing food, fiber, and many other desired products by the cultivation of certain plants. The history of agriculture began from years ago. After gathering wild grains the nasant farmers began to plant them around 11,500 years ago. Pigs, sheep and cattle were

domesticated over 10,000 years ago. Plants were independently cultivated in at least 11 regions of the world. Agriculture is mainly divided into two types:

- a) Industrial Agriculture
- b) Subsistence Agriculture

Industrial agriculture is a modern form of farming that refers to the industrialized production of livestock, fish, poultry and crops. The various methods of industrial agriculture are Techno-scientific, Economic,

Political, etc. Subsistence agriculture is when farmers grow food crops to meet the needs of themselves and their families. It play important role in reducing the vulnerability of rural and urban food insecure households, also improve livelihoods and helps to mitigate high food price inflation. Subsistence agriculture is sub-divided into three types:-

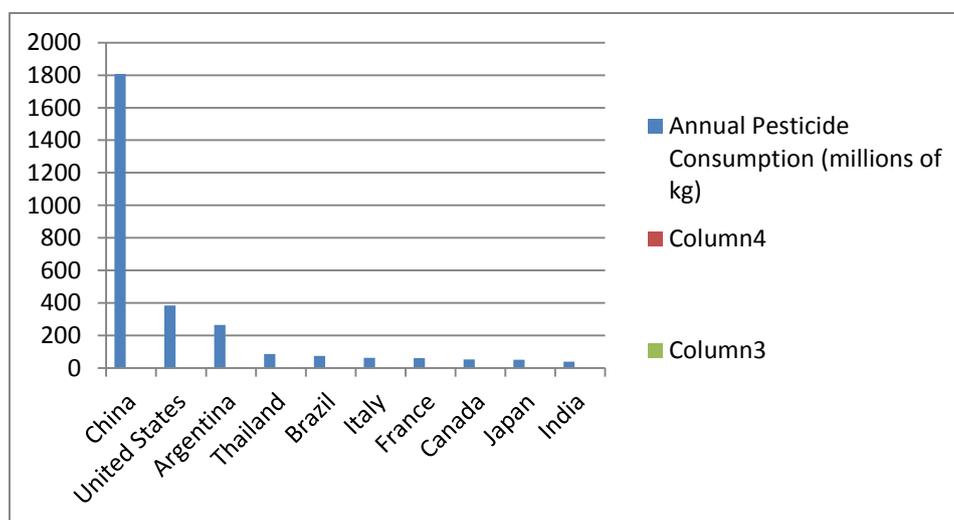
1. **Intensive Subsistence:-** It is the traditional method of farming.
2. **Shifting Cultivation:-** In this method forests are cleared to create new farm plots after every few years.
3. **Pastoral Nomadism:-** It relies on travelling with herds of animals.

The population of the world is growing day by day and to complete the needs of the population, large amount of plants should be cultivated. The living world is completely depends on agriculture. Without agriculture there will be no food and without food there will be no life on the Earth. In 2011 the population of the world were around 7 billion and today population is around 7.8 billion. This population will increase to 9.8 billion in 2050. As the population will increase the food need will also simultaneously increase. Therefore to fulfill the need of the world in future we should start the preparation from today itself. To increase the crop yield, crop growth various pesticides, fertilizers, insecticides, etc are used.

PESTICIDES

In this growing world, food is the basic need of each living organisms. But the agriculture pests like insects, weeds, fungi, and various disease pathogens destroy more than 30% of crops annually. If more than 30% of crops are destroyed by insects than it is difficult in future to fulfill the need of food of growing population. Pests eat away 35% of total crop yields says ICAR (Indian Council of Agricultural Research) scientist. Therefore to control the damage caused by insects, pests, etc various pesticides, fertilizers, insecticides are used. Pesticides are mostly used to kill the weeds, insects that damages the plants. Many questions may arise about the term pesticides like: What is pesticides? How they are used? Is, there are any harmful effect of pesticides on environment and human life?

Basically, pesticides are chemical compounds which are used to kill or to completely destroy the pests, insects, fungi, rodents, and weeds (unwanted plants). Pesticides are also used in public health to kill vectors of disease, such as mosquitoes and to kill pests that damage crops in agriculture field. Pesticides are used as physical control such as traps, barriers and mechanical removal. Pesticides also kill soft body insects by spraying it on plants with insecticide soap, example: grub, blight. Pests can also damage buildings, cloths, furniture, etc therefore pesticides are used to control or kill them. The largest users of pesticides are agriculture and forestry. Pesticides have largest demand in today's world and it is most commonly used by the countries as follow:



According to above table China is the country that consumes large amount of pesticides annually. Plant protection product (PPP) are pesticides that is used to protect the plants from pests, insects, weeds. As the pesticides provide protection to plants it must have at least one function from the following:

- Protect plants and plant products against pest, insects, disease before or after harvesting.
- Influence the life process of plants such as :- substance influencing their growth, excluding nutrients.
- Preserve plant products.
- Destroy or prevent growth of undesired plants or parts of plants.

The pesticides are classified and named according to the type of pest they control.

Types of Pesticides	Uses
Bio-pesticide	It is derived from natural material such as animal, plant, bacteria and certain minerals.
Fungicides	It kills fungi such as blights, molds, mildews and rusts.
Algicides	It kills algae in lakes, canals, water tanks and other sites.
Antimicrobials	It kills microorganisms such as viruses and bacteria.
Herbicides	It kills weeds and other plants that grow in unwanted areas.
Biocides	It is used to kill the microorganisms.
Desiccants	It promote drying of living tissue.
Miticides/ Acaricides	It is used to kill mites that feed on plants and animals.
Antifoulants	It is used to kill or repel organisms that attach to underwater surfaces, such as barnacles that cling to boat bottoms.
Ovicides	It kills eggs of insects and mites.
Rodenticides	It is used to control mice and other rodents.
Defoliants	It cause leaves or foliage to drop from a plant, usually to facilitate harvest.
Molluscicides	It is used to kill snails and slugs.
Repellents	It is used to repel pests, including insects and birds.



Insecticides	It kills insects and other arthropods.
Attractants	It is used to trap the pests.
Microbial Pesticides	They are microorganisms that is used to kill, inhibit pests including insects and other microorganism pests.
Plant Incorporated Protectants	It is the substance that plants produce from genetic material that has been added to the plant.
Fumigants	It produce gas and vapor intended to destroy pests.
Disinfectants	It is used to kill or inactivate disease producing microorganisms.
Pheromones	It disrupt the mating behavior of insects.
Insect Growth Regulators	It disrupt the molting, maturing for pupal stage to adult or other life processes of insects.
Nematicides	It is used to kill nematodes.
Plant Growth Regulators	It alter the expected growth, flowering or reproduction rate of the plants.

In the above table the pesticides are most commonly used in agriculture field. Some chemicals used in pesticides that are used to kill the insects, pests on the plants are 2,4 - dichlorophenoxyacetic acid, Aldrin, Atrazine, Chlordane, DDT, DDE, Chlordecone, Endrin, DDD, etc. As pesticides are used in large amount to kill the pests, insects, etc, it has various harmful effect on environment and human health. The chemical pesticides like DDT, methyl bromide, pyrethroids, etc, were provided but excess use of these pesticides cause severe health problems in humans. The main characteristic of pesticides as hazardous substance is it's toxicity. It depends on physical and chemical

properties of pesticides weather it is poisonous or harmful to animals and plants. The toxicity of pesticides to humans varies in wide range and it can be

- **Acute Toxicity:-** The pesticides causes harmful health disorders that develop rapidly or with in short period of time that is in few second or minute or hours or a day.
- **Sub-Chronic Toxicity:-** The pesticides causes harmful health disorders from few weeks to few months.
- **Chronic Toxicity:-** The pesticides causes harmful disorders from few months to years.



Harmful effect of pesticides on human

The health disorders occurs to humans are:

1. Skin irritation, skin sensitization.

2. Carcinogenicity that is production of cancer.
3. Oncogenicity that is induction of tumor growth.
4. Hormone disruption that is ability to disrupt the endocrine system.
5. Neurotoxicity that is causing neurological problems.
6. Mutagenicity that is ability to cause genetic changes.
7. Teratogenicity that is ability to cause birth defects.
8. Reproduction disorders.
9. Damage to particular organ or system.

More than 20,000 deaths every year was recorded by World Health Organization (WHO) due to negative impact of the pesticides. Therefore to avoid such harmful effect of pesticides in human beings and for fulfilling the needs of growing population there is need to adopt new technology for food production. Therefore there is need to use nanotechnology in field of agriculture.



Spraying of Pesticides on Plants for Protection

NANOTECHNOLOGY

In current world, nanotechnology is the developing field. The term "Nanotechnology" was used by the Japanese scientist Norio Taniguchi in 1974 paper on production technology. The discovery of nanotechnology had taken place by the experiment of scanning tunneling microscope in 1981 and in 1985 fullerenes was discovered. Author said that with the elucidation and popularization of conceptual framework for the goals of nanotechnology beginning with the 1986 publication of the book "Engines of Creation". Nanotechnology provide a

research area, with the structure, devices and system, which also has its novel properties and function which is due to the arrangement of the atoms on the 1-100 nm scale. Nanotechnologies contribute to almost every field of science including biology, chemistry, physics, agriculture, computer science, engineering, etc. Nanotechnology is the creation of functional material, devices and systems. It can also be define as control of nano-scale material (1 to 100nm). Nanotechnology is the field of research and innovation concerned with discovering or making materials and devices on the scale of atoms and molecules.

Nanomaterials	Uses
Silver nanoparticles	Food packaging, clothing, disinfectants household appliances.
Carbon nanotubes	Stain resistant textiles.
Doxile (Approved by Food and Drug Administration)	Use on HIV related Kaposi's sarcoma and also used to treat ovarian cancer.
Abraxane is Nanotechnology based drug (Approved by U.S. Food and Drug Administration {FAD})	It is used to treat breast cancer, non-small cell lung cancer and pancreatic cancer.
Rapamune is nanocrystal based drug (approved by FAD)	It prevent organ rejection after transplantation.

Nanotechnology is being used in various developing countries to help to treat diseases and to prevent various health issues. The nanoparticles with small size having large surface area that is 1-100nm have potential industrial, medical and agricultural applications. Author said that nanomaterial which is prepared eco-friendly and with green methods can increase agriculture potential for improving the fertilization process, pesticides and plant growth regulators. This technology helps in reducing the environmental pollutants. Nanotechnology in agriculture field has good momentum in last few decades with various methods. Nanotechnology has also provided new agrochemical agents and new delivery mechanisms to improve crop productivity. Nanotechnology has various application to increase agriculture production like:

- Nanosensors is used in crop protection for the identification of diseases.
- Nanoformulations are made of various agrochemicals for applying pesticides for crop improvement.
- Nanotechnology is also used for the plant diseases diagnostics.

- Nanodevice is used for the genetic engineering of plants.

The main objective of nanotechnology is to reduce the spraying of agrochemicals on plants for protection and to improve crop yields. Nanotechnology is also used in production, processing, storing, packaging and transportation of agriculture products. Nanoparticles are proved to be effective and efficient agrochemicals agents to improve the crop yield and for reducing harmful pests, insects, etc. Nanoparticles also helps to increase the nutrient uptake of plants and also kill the pathogens infecting the plants. It penetrate the cuticle and tissue of the plants and allow slow and effective release to target area.

NANOPESTICIDE

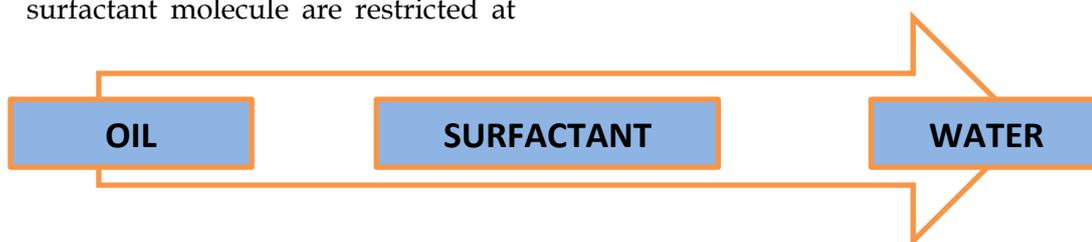
Nanopesticides is most used nanoproduct in agriculture. Nanopesticide is small engineered structure which provides pesticidal properties or formulation of active ingredient of pesticide in nanoform. It is mostly used to spray on various crops to kill the pests, insects which are damaging crops and to increase crop yields. Nanopesticides also helps to provide nutrients to the plants. Nanopesticides are the small engineered structure which provides pesticidal

properties or formulation of active ingredient of pesticide in nanoform. The chemical properties of nanopesticides are very different from commercial pesticides due to its small size and large surface area. Due to this chemical properties of nanopesticides it has better interaction and mode of action at a target site of the desired pests. The various methods are used to prepare nanoproduct of nanopesticides are effectively used to increase the efficiency and also used to reduce the environmental toxicity. Nanopesticides are formulated for improving solubility, slow release of active ingredients, prevent degradation, etc. Nanopesticides are formulated as follows:

1. **Nano-suspension:-** It is also known as nano-dispersions. A nano-suspension is a very finely colloid, biphasic, dispersed solid drug particles with size below 1 μ m. Nanopesticide is formulated by dispersing the pesticide as solid nano-sized particles in aqueous system. In the nano-suspension, the surfactant molecule are restricted at

the particle surface, where the polar portions is lengthened into the aqueous solution and non-polar portions associate with the solid pesticides.

2. **Nano-emulsions:-** Nano-emulsions is a colloidal system mainly consist of oil, surfactant and water, with high kinetic stability low viscosity and is optically transparent. It normally consist of an oil system dispersed in water system or water system dispersed in oily system. It form oil phase of nanometric sizes. For preparation of nanoemulsions three methods are used: Microfluidization, Pressure homogenization, Phase inversion temperature method. If pesticide is partially soluble in water system and if the surfactant, pesticide and water component are brought together that is a thermodynamically stable nano-emulsion, there is spontaneous formation of stable emulsion.



1. **Polymer based nano-particles:-** The polymer based pesticides with nano carriers are developed with slow and controlled release of active ingredients to the target site. Polymeric nanoparticle are sub-micron about 1-1000nm. Nano-fiber, nano-sphere, nano-gel, nano-encapsulation are some category.

- a) **Nano-fiber:-** It is the fibers with diameters in nanometer range. It is generated from various polymers and therefore have different physical properties. It is used in drug delivery, optical sensors, cancer diagnosis and even it is used for formulation of nanopesticides. Electro-spinning is the method for

production of fiber, which uses electric force to draw charged threads of polymer solutions.

- b) **Nano-sphere:-** It is the simplest type of nanoparticle. It has only one adjustable radius which exhibits resonant response under optical excitation. Nano-sphere is the homogeneous matrix system in which the dissolved active substance is entrapped on the surface through the solid sphere.
- c) **Nano-gels:-** It is also called as hydrogel nanoparticles. They are formed by cross linking of polymeric particles having hydrophilic groups, thus absorb high quantities of water.
- d) **Nano-encapsulation:-** It is also known as nano-capsule. Nano-encapsulation is technology of packaging nanoparticles of solid, liquid or gas within a secondary material like shell, matrix, etc, to form nano-capsule.

The author said that as farmers were using synthetic pesticides to kill the pests that damage the crop. But the synthetic pesticides have harmful effects on human health. Therefore nanopesticides were used as it is potentially less toxic than synthetic pesticides. The nanopesticides behave differently from conventional pesticides to increase their efficiency (Kah et.al., 2019). The nanoparticle based pesticides increase the solubility of the AI so they are considered to have less harmful impact on environment as compared to conventional pesticides (Kah and Hafmann, 2014). The pests are the big threat for the agriculture

which leads to damage the plants and reduce plant productivity. The silver nanoparticles act effectively on pests and even the silver nanoparticles based pesticide provides high dose of pesticides to target plants. As silver nanoparticles are non-toxic, safe and it is an improved tool to fight against pests. The silver nanoparticles based pesticides help to manage the pests. According to author antifungal activity of the silver nanoparticles has also been reported and thus they can be used in treating the fungal pathogen of the plants. Sap-lam et.al., reported the potential of U.V-irradiation induced silver nanoparticles in the bio control of pests such as mosquito larvae. As nanopesticides conserve water and energy so they are applied in smaller amount and less frequently than conventional pesticides. The adverse effects on soil bacteria and plants was reduced due to nanopesticides (Kumar et.al., 2013). The polyethylene glycol based nanoformulations of carbofuran and acephate also show similar results (Pankaj et.al., 2012, Pradhan et.al., 2013). The important inorganic nanoparticles having pesticidal properties are Copper (Gogos et.al., 2012), Silver (Kim et.al., 2012), Aluminum (Stadler et.al., 2012). The silica-silver nanoparticles are very effective for controlling plant pathogenic micro-organisms. The silica-silver nanoparticles when applied on pumpkin leaves it killed the pathogen on infected leaves 3 days after spraying. The silica-silver nanoparticles have antifungal activities against *Botrytis cinerea*, *Rhizochonia solani*, *Colletotrichum gloeosporioides* (Park et.al., 2006). The antifungal activity of silver nanoparticles was observed against *Raffaelea species* causing damage to oak trees (Kim et.al., 2009). According to author nanoform

of copper showed four order higher activity against bacterial blight on pomegranate at 10000 times less concentrated of recommended copper. The essential oils and bioactive agent based nanopesticides have potential for use in organic food production and sustainable agriculture. The Controlled Released (CR) formulations of imidacloprid have better control of pests. The CR formulations were evaluated against major pests of Soyabeans that is stem fly, *Bemisia tabaci*, *Melanagromyza sojae* and white fly. The poly(poly(oxy-ethylene-1000)-oxysuberoyl) amphiphilic polymer based formulation has better control effect against

stem fly incidence and yellow Mosaic virus infestation transmitted by white fly. The CR formulations of carbonfuran and imidacloprid has better control against *Aphis gossypii*, aphid and leaf hopper on potato crop. Nanomaterials like gold nanoparticles, iron oxide nanoparticles, silver nanoparticles and polymeric nanoparticles are exploited as pesticides. The synthesized silver nanoparticles have excellent effect against antilice and mosquito larvicidal activity. Nano copper particles suspended in water is used from 1931, in a product Bouisol as fungicide in growing grapes and fruit trees.



Pests destroying the leaf of the Grape plant.

Grape Leaf folder- *Desmia funeralis*



Common Grapevine Pests and Diseases

The author said that nanopesticides offer a way to both control delivery of pesticides and achieve greater effects with lower chemical dose. Many companies make various formulations of nanoparticles with

size range of 100-250nm which are able to dissolve in water more effectively and also increases their activity. The silver nanoparticles of 100mg/kg is used to inhibit the mycelia growth and conidial

germination on pumpkins and cucurbits against powdery mildew has been reported.



Powdery Mildew of Cucurbits

The ethanolic suspension of hydrophobic alumina-silicate nanoparticles are used for the treatment of *Bombyx mori* leaves against grasseric disease. Nano silica is used to control the agricultural pests and insects. The nanoparticles of silica get absorbed in cuticular lipids by the physisorption which causes death of insects when applied on stem and leaves surface of the plants. The antifungal activity of silica-silver nanoparticles against *Magnaporthe grisea*, *Botrytis cinerea*, *Bipolaris sorokiniana* has been reported. The DNA-tagged gold nanoparticles have successful effect against *Spodoptera litura* and it is very useful against pests management and some nano-encapsulated pesticides can killed the insects at targeted areas.

TOXICITY

The toxicity is defined as any chemical substance or a particular mixture of substances can damage organisms. Various nanopesticide is used in agriculture for crop production and for destroying insects. But many questions arise while using nanopesticides that is : Is it toxic to human and animals health? How it will react inside the human body? Weather it has any side effects? Various nanoparticles are used for

formulation of nanopesticides. The risk assessment of the nanoparticles have to take in to account the size for each material at which the nanoness is observed. At nanoness there is dramatic increase in surface reactivity and therefore most of the nanoparticles tend to have increased solubility and can cause toxic effects. The nanoness property of nanoparticles and the reactivity as well as surface structure are responsible for processes such as dissolution, redox reaction, etc. These properties can also lead to biological effect that may not be produced by the bulk particles with same chemical composition. The nanoparticles have some adverse effect on human health, as number of toxicity tests have been conducted in various media and using a variety of organisms. Nanopesticides may cause health issue due to different reasons as follow:

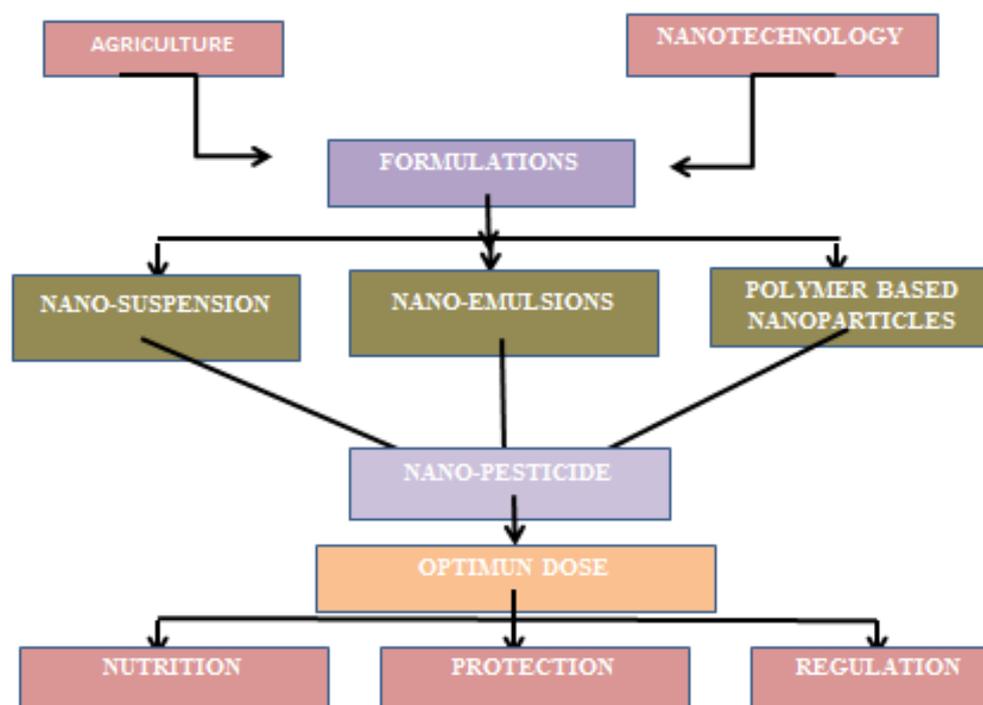
- Through inhalation, the nanopesticides can go deep inside the lungs and as they are small in size and they can translocate to brain by crossing blood brain barriers.
- Due to lack of knowledge to gauge environmental exposure to engineered nanomaterials.

- The dermal absorption of nanopesticides in to the body and due to there small size they can easily pass through the cell membrane.
- The durability and reactive potential of some nanomaterials which are used as nanopesticides can raise environmental concerns. The nanopesticides also has some adverse effect on human health. The excess use of it can cause environmental concerns as well as have some harmful effects on human health.

CONCLUSION

These review give overview on the use of Nanotechnology in agriculture. Agriculture is most important to fulfill the needs of growing population. Therefore to increase the production of good quality of crop, nanotechnology is used in agriculture field. The nanopesticides are used for the production of good quality of crop, it also provide nutrition to the crop and to kill the pests and insects

Below flowchart is the overview of use of nanotechnology product that is nano-pesticides in agriculture field.



Not every product has only advantages, but it also have some disadvantages to environment and human health. According to above statement, nanopesticides have

large advantages in agriculture field as well as it also has some disadvantages on environment and human health. Therefore nanopesticides should be used in lesser

amount and further research is needed to unravel the behavior of nanopesticides in field of agriculture.

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