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Nano-pesticide for Agriculture: Applications& Benefits

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Abstract

Use of pesticides are started in 1948 in India. Now a days the pesticides are become an unavoidable part of agriculture. The farmers are widely using of pesticides to protect their crop or make the good yield but if we use this chemical in excess so that could be because hazard to the environmental health for all that reasons the nanotechnology is used to making Nano pesticides to reduce the environmental hazard. Nanopesticide is revolution in pesticides, it's aimed are to lower the concentration of active ingredient and higher the solubility for avoid soil degradation. Nano size molecule or active constituent are present in nanopesticide. The research community have been expanding conceptions of controlled release formulation, nano emulsion, solid base Nano pesticides.The nanopesticides are that kind of materials which are formulated by nanomaterials they are specially hybrid substrate formulated in nanocarrier for enzyme mediated triggers. Nanopesticides are generally made-up of organic ingredients like polymer and inorganic materials like oxides or metals one of e.g., is silicananosphere that increase capability of pesticides. There are some methods to do nano-pesticides or eco-friendly nanopesticides. This review gives us summary of importance of pesticides in agriculture use and some ecological methods of pesticides. It has special properties to minimise dosage.

Keyword: Nanotechnology, Nano-pesticide for Agriculture, Nano pesticides applications, Pesticides

Introduction

The word "Nano" is the Greek word which means very small and is illustrated 1000 millionth of the meter. In Nanoscience the structure of molecule is studying at very small scale means at nanometre scale which is between 1 to 100 nanometre and 1 nanometre is equal to 1 into 10 raises to minus 9 m and the technology is applied in particle properties is called nanotechnology the American physics and Nobel prize laureate Richard Feynman introduce the nanotechnology in 1959. The worldwide utilization of pesticides is approximately 2 million turns per year. According to studies that farmers lose at least 20 - 40% of their crops to pests and pesticides allow the large-scale production. The commonly used pesticides are DDT hch health issue for human in Kerala 1958 there is first report of poisoning by pesticides in India(I - II).

Nanotechnology is the opportunity to do work in agriculture for improve nanosized agrochemicals which having ability to develop efficiency (fig 1).To grapple with conventional pesticide problems the Nano science come forward to develop Nano pesticide which contain better efficiency with less active ingredients. Some scientists are working on usingnanotechnology to

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control the release of pesticides which are useful to farmers to allow to use less and still get good production result. Paste population is very large and they are responsible for destroy farmer's crop or plantations and so more losses sometimes with the help of chemicals we impede their reproduction and feeding habits. In the study ofNanopesticides they found the toxic effect on thepest which investigate paste management in nanopesticide synthesized by plant, there are paste which are mosquitoes, beetles and moths etc.(Ⅲ-Ⅳ).Nanopesticides of Nano carrier is formulated by silica, polymers, metal, carbon, lipids, ceramic etc. (Ⅴ). They are three to two dimensions between 1 to 200 nm used in agropesticides and have to ensure that safety of Nano target organisms and also human health there is benefit come because of very small (nano) size of particle which help to spreading ingredients properly on the surface of pest, does more better action than conventional pesticides. In agriculture the dosage requirement and frequency are low in nanopesticides where conventional pesticides having high requirement and frequency.

Important role of nano-pesticides in Reduced Health Risks:(fig.2)

1. The most important thing is that nanopesticides can amend based on the target paste or crop nano particles which used in formulation.
2. It can use to lower the hazard of pesticide for farmers and environment also, it contributes to make better safety.
3. Control release and reduce application rate which reduce the risk.
4. Researchers are studying to do better work in application of effective use of Nano pesticides in agriculture, minimising primary risk of human health and safety of environment.

Applications of Nano-pesticides

Nano-pesticides have a wide range of potential applications in agriculture and pest management due to their unique properties. Some of the key applications of nano-pesticides include:

1. **Crop Protection:**Nanopesticides are applied for controlling pests, that are hard to manage hazard with conventional pesticides.Nanopesticides can be used to protect the crops from pests, which are fungi, insects, bacteria, viruses etc.
2. **Enhanced Efficacy:**Nanopesticides can better the efficiency of pest control. Their nano size and mechanisms of controlled release allow for good penetration of pests and plant tissues, resulting in mortality rates is high.
3. **Reduction in Pesticide Use**: It leads to decrease chemical residues on plants and lower the environmental hazard.Nano-pesticides can decrease the amount of pesticides require, that's why they are more capableto delivering active ingredients.
4. **Sustained Pest Control:**Controlled-release nano-pesticides can provide longtime pest control, lessen the need for repeatedly reapplications. If the pests have long life cycle, then it is advanatageous in killing pests with less danger.
5. **Targeted Pest Management:** Nano-pesticides are specially designed to target pests or diseases. It minimizes off-target effects. Nanoparticles are Functionalize to allow for accurate delivery of active ingredients to deliberatesite.
6. **Reduced Pesticide Resistance:**Thetargeted delivery of active ingredients and controlled release can lower the development of pesticide resistance in pests, as they are exposed to sublethal doses over time.
7. **Improved Adhesion:**Nano-pesticides cohere or adhere better on surfaces of plant,

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reducing drift. This characteristic improves their perseverance and become influential in the field.

8. **Biological Pest Control Enhancement:** Nano-pesticides candeliver important biological agents, which areparasitosis or predators, to target pests.
9. **Organic Farming:**Nano-pesticides plays an important role in organic farming as areplacement to conventional chemical pesticides while keeping the principles of organic agriculture.

Comparison of advantage and disadvantages of conventional pesticides and nanopesticides

There is so much difference between conventional pesticides andnanopesticides. If pesticides become in nanosized their properties are change and it becomes more effective about target delivery with less amount of pesticides used and reducing environmental hazard.

In nanopesticides the active ingredients are nanoparticles but other side conventional pesticides areacting as active ingredient. The degradation of nanopesticides in soil or plant is faster than conventional pesticide.The toxicity to nano-target organism is present in nanopesticides but it is low compared to conventional pesticides. In conventional pesticides organic solvent content are high but in nanopesticides there are not required the organic solvent content or it is in lower. There are some more comparisons are discussed in the table below in table no.1.

Commonly used nanoparticles in agriculture

Some nanoparticles like polymeric nanoparticles, silver nanoparticles, carbon nanoparticles, nanoalumino-silicate are given in table no. 2 with their applications.

Materials used in nanopesticides

Preparation of nanopesticides from organic materials

there are two types of sources of organic material which are synthetic organicmaterial and polymer materials are eco-friendly and biocompatible. It has benefit of malleability and stability. Natural polymers are obtained in nature and have environmental consistency and biodegradability (XII).

1. Synthetic organic material

It has application of allow flexible target delivery. Synthetic polymers are having beneficial use of pesticide Carriers. Some synthetic Polymers are having pharmaceutical career. Yang et al. used a star cationic polymer (SPc).It is in calcium glycine pesticide which targeted on tomato mosaic virus, it improved control of virus (XII-XIV). Some synthetic organic materials given in table no.3.

2. Natural Polymers

One of example of natural polymer is chitosan it is occurred by deacetylation of chitin. It having functional groups NH2 andOH which allow chitosan to react with glutaraldehyde, ginpinil, and vanillin to prepare microcapsules or hydrogels and combination of this with pesticides prepare nanopesticides (XV)

Another natural polymer is sodium alginate, it is anionic polymeric polysaccharide. Amino and carboxylic group is observed on surface of sodium alginate in large amount. Calcium alginate hydrogels are prepared from sodium alginate. The hydrogel helpful to induced plant antagonism to the tobacco mosaic virus (XVI).

Preparation of nanopesticides from inorganic materials

Inorganic materialscontain clay minerals, metal organic skeletons, silicon dioxide, graphene, etc. One of the examples is PCM-SS/PMT, in it the delivery system was make with porous calcium carbonate microsphere (PCMs) filled with PMT. It having good herbicide effect as compared to traditional herbicide. Materials given in table no.4.

Chemical and physical systems as carriers in the formulation of Nano-pesticide

Refertableno**.** 5

Conclusion

Nanotechnology is very useful in nanopesticides for agriculture. It contributes important and beneficial work in agriculture. It helpful to farmers to improve food quality and production. Conventional pesticides are very harmful to crop production and environmental health and also for soil health.The replacement of conventional pesticides the nano-pesticides are come forward to become an ecofriendly solution of environment. When reducing the size of pesticide to nano, then it changes its properties and become more effective less hazard. Nanopesticides are designed specially to target pest. It can enhance efficiency of release pest control. It improves solubility of active ingredients. By using nanopesticides crops can maintain the nutrients balance and become more healthy than conventional pesticides crops. It concludes that nanopesticides are better than conventional pesticides.

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Tables: Table no. 1(Ⅵ)

Characteristics	Conventional pesticides	Nanopesticides
Active ingredients	Pesticides as active ingredients	Nanoparticles as active ingredients or nanoformulation with pesticides as active ingredients active ingredi-ents
Organic solvent content	High	Low or not required
Solubility	Low	High
Dispersibility	Low	High
Dosage requirement and frequency	High	Low
Efficiency	Low	Increased uptake/efficacy
Bioavailability	Low	High
Degradation in soil or plant	Slower	Faster degradation
Controlled release and targeted delivery	Low	High
Protection against premature degradation	Low	High
Toxicity to target organism	Present	Enhanced toxicity to target organism
Toxicity to Non-target organism	Present	Present (comparatively low)
Bioaccumulation	High	Moderate or low
Environmental risk assessment methods	Available	Partially available
Regulatory guidelines	Available	Partially available (under development)

Table no. 2(Ⅶ)

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Polymeric nanoparticles	• delivery of agrochemicals • superior biocompatibility • minimal impact on non-targeted organisms.
Silver nanoparticles	• antimicrobial property • enhance plant growth.
Nano alumino-silicates	• an efficient pesticide
Titanium dioxide nanoparticles	• disinfecting agent for water
Carbon nanomaterials	• as graphene, graphene oxide, carbon dots, and fullerenes, are used for improved seed germination.

Table no. 3(XV-XXVII)

Material	**Pesticide**	**Target**	**Performance**	**Reference**
AL/PEG–acetamiprid	Acetamiprid Increased insecticidal performance	Xanthogaleruc aluteola	Insecticidal performance is Increased	XV
ABA@AL-CTAB	Abscisic acid	Rice	Slow-release performance and resistance to photolysis	XVI-XVII
SPc–calcium glycine	Calcium glycine Tomato mosaic virus Improved control of virus [87]	Tomato mosaic	Improved control of virus	XVIII
Polyhydroxybutyrate–trifluralin	Trifluralin	Barnyard grass	Improved photostability and herbicidal activity	XIX
Chitosanpolylactic acid	Chlorpyrifos	-	Good slow-release effect	XX
Chitosan–sodium tripolyphosphate	Hexazole alcohol	-	Good bacteriostatic effect	XXI
Beeswax–corn oil–liposomes	Deltamethrin	-	Resistance to photolysis	XXII
AL-azo-H@AVM	Avermectin	-	Excellent UV-blocking and controlled-release performance	XXIII
AVM@P-Zein	Avermectin	-	Excellent UV-blocking and controlled-release performance	XXIV
SPc–dinotefuran	Dinotefuran	Aphids	Better distribution and enhanced uptake	XXV
SPc–chitosan Chitosan	Chitosan	Phytophthorain festans	It enhanced effect of control	XXVI
Polyhydroxyalkanoate	Chlorhexine	-	Herbicidal activity performed Greater	XXVII

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Table no. 4(XII)

Material	Pesticide	Target	Performance
MSN	Mildamine	Cucumber	Enhanced uptake by cucumber
PRO@DMON–GA–Fe(III)	Prochloraz	Rice	Better fungicidal activity against *Magnaporthe oryzae* with longer duration
Pro@HMS–TA–Cu	Prochloraz	Oilseed rape leaves	Better antifungal activity against *Sclerotinia sclerotiorum* and lower toxicity against zebrafish compared with prochloraz technical
Nano-AVM–GO	Avermectin	Diamondback moth	Better insecticidal effect
MOFs	Cyfluthrin	-	Slow-release performance
Fe(III)-MOFs	Azoxystrobin	Wheat seed	Increased weight of the aboveground parts of wheat
IV-Porphyrin-MOFs	Tebuconazole	Pathogenic microbes	Good fungicidal effect
AM@CuBTC	Avermectin	Pine wilt disease	Improved solubility, photolysis performance, and pesticide efficacy
ZIF-90-KSM	Kasugamycin	Rice	Great potential synergistic antifungal functions and provides an eco-friendly approach to managing rice diseases
PRCRC	Chlorpyrifos	Tick	Excellent pH sensitivity and excellent insecticidal performance
MSN	Zobactamide	*Phomopsis asparagi*	Good bacteriostatic effect
Biochar	Glyphosate	Weeds	Good control of weeds
ZuO	Chunleimycin	-	Excellent UV blocking
GO	Pyridaben Chlorpyrifos Cypermethrin	-	Improves insecticide efficiency
GO-MSN_{10}	Camptothecin	-	Good slow-release performance
PCM-SS/PMT	Prometryn	Grass	Effective control and improved utilization rate

Table no. 5: Chemical and physical systems as carriers in the formulation of Nano-pesticide(XI)

(a) Chemical System

Covalent Bond	*Carrier System*	*Formulation*	*Pesticides*	*References*
Comonomers	Hybrid materials	(CNT-g-PCA)	Zineb Mancozeb	(Sarlak *et al.* 2014)
Multifunctional system	Peptide-polymer	Trypsin-PEG	Modulating Oostatic factor	(Shen *et al.* 2009)
Electrostatic complex	Polyelectrolyte complex	Clay-gelatin pGPMA-dsRNA	MCPA dsRNA	(Patel *et al.* 2018)
Ionic bond	Hallow sphere	Calcium-alginate	Cypermethrin	(Alromeed *et al.* 2015; Parsons *et al.* 2018)
Cluster	Metallic nanoparticles	Cu—TM Cu0 , Ag0	Thiophanate methyl	(Malandrakis *et al.* 2021; Keller *et al.* 2017; Starnes *et al.* 2015)

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(b) Physical System				
Encapsulation	Coprecipitation Polycondensation Vesicle	Polyelectrolytic interaction. Cation vesicular surfactants	Trichlorfon Acetochlor Benzoylurea-paraquat DNA, RNA Copper	(Huang *et al.* 2018; Kandpal *et al.* 2017; Kizilay *et al.* 2011; Skepö and Linse 2002; Guo *et al.* 2014; Nuruzzaman *et al.* 2016; Wang *et al.* 2018; Yu *et al.* 2016; Worthington *et al.* 2013)
Emulsion	Mixed micelles Pickering emulsion Nanoemulsion Liquid crystal Liposome	mPEG13–b–PLGA5–3 Alginate-Ca++ Water-in-oil Monoolein 18-99 PC-chitosan	Pyrethrin γ-cyclodextrin Citronella Phytantriol α-cypermethrin	(Zhang *et al.* 2019; Chen *et al.* 2017; Mustafa and Hussein 2020; Ali *et al.* 2017; Bisset *et al.* 2019; Bang *et al.* 2011)
Matrix system	Hybrid materials	mPEG-PLGA	Metolachlor	(Agostini *et al.* 2012; Parsons *et al.* 2018)
Porous system	Grafted-NP. Sol-gel composite	4-ethylortho-Silicate ATP-biochar colloidal silica	Benzoylurea-Fe2O3 Glyphosate	(Chen *et al.* 2017; Raileanu *et al.* 2010; Ciriminna *et al.* 2011; Xu *et al.* 2018; Chen *et al.* 2018)
Foams	Polymeric emulsion	Poly(alkylene-oxide] alkanol	Glyphosate acid Acetochlor	(Guo *et al.* 2014; Chaud *et al.* 2021)
Osmotic pumps	Polymeric coating	Cellulose ester/ PEG/ Inorganic salt	Diazinon	(Yalamalle *et al.* 2019)

Figures

Fig 1: Nanotechnology in

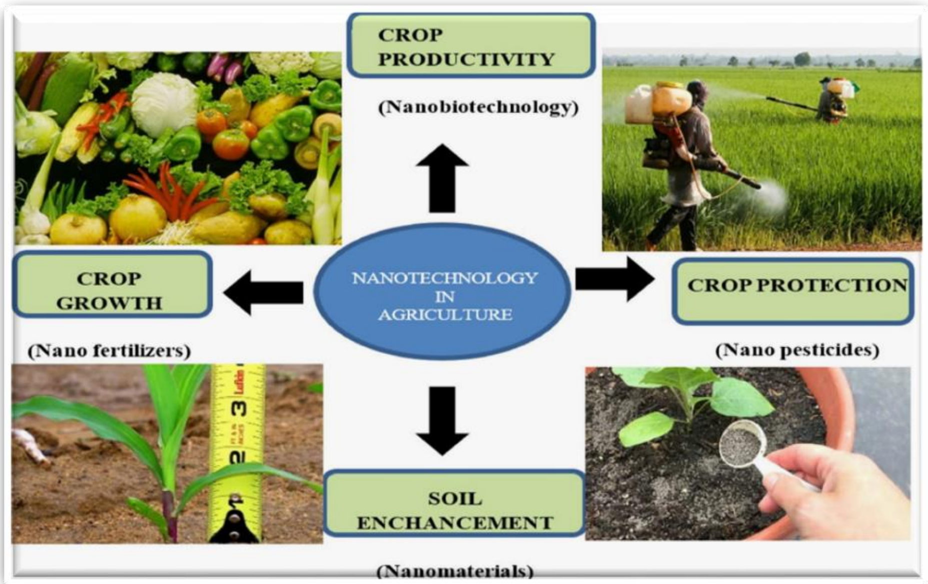

Fig 2: Impact of nano-pesticides in agriculture