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Nanotechnology application in pest and pollution control (Nano pesticides, Nano fungicides, Nano gels)

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Abstract
Nanotechnology has a wide array of opportunities in the variant fields i.e., agriculture {ex: pesticides, fungicides, weedicide etc.,}, medical, pharma, Electronic etc..,. The reduction of pests by the application of Nano-technology through Nano-chemicals application. The indigenous application of chemicals for the control of agriculture pests and diseases. Due to the application of the inorganic chemicals enormously leads to drastic losses like soil pollution, water pollution and also their residual effect leads to the loss in the yield of succeeding crop along with the effects on animals and human beings.
Agriculture in developing countries is a major part of their income which comes from agriculture sector and more than half of the population depends on it for their livelihood. A large proportion of those livings in developing countries face daily food shortages as a result of environmental impacts, pest & fungal occurrence. For developing countries, the drive is to develop drought and pest resistant crops which also maximize yield.

Keywords: nanotechnology, control of pesticide pollution, Nano-pesticides, nanogels, integrated pest management

Introduction: Nanotechnology

According to Bhattacharyyal *et al*. (2010) the word "Nano" is developed from the Greek word meaning "dwarf". In more technical terms, the word "nano" means 10-9, or one billionth of something. For example, a virus is roughly 100 nm in size. Naturally, the word nanotechnology evolved due to use of nanometer size particles (size of 1 to 100 nm). The potential uses and benefits of nanotechnology are enormous. These include agricultural productivity enhancement involving nanoporous zeolites for slow release and efficient dosage of water and fertilizer, nanocapsules for herbicide delivery and vector and pest management and nanosensors for pest detection. The atom by atom arrangement allows the manipulation of nanoparticles thus influencing their size, shape and orientation for reaction with the targeted tissues. It is now known that many insects possess ferromagnetic materials in the head, thorax and abdomen, which act as geomagnetic sensors. In this paper, our discussion is focused on nanoparticles in insects and their potential for use in insect pest management. Leiderer and Dekorsy (2008) [8] found that targeted nanoparticles often exhibit novel characteristics like extra ordinary strength, more chemical reactivity and possess a high electrical conductivity. Thus, nanotechnology has become one of the most promising new technologies in the recent decade. Nanoparticles possess distinct physical, biological and chemical properties associated with their atomic strength.

The application of chemical in Nano pesticide is controlled release formulation (CRF), gives efficacious effects. Nano capsules can enable effective penetration of herbicides through cuticles and tissues, allowing slow and constant release of the active substances. This convergence of technology with biology at the nano level is called nano biotechnology (Perea-de-Lugue and Rubiales, 2009) [11]. Nanotechnology considers the topics with viruses and other pathogens scale. So has high potential to identify and eliminate pathogens (Prasanna, 2007) [12].

Nano-pesticide, the formulation is based on releasing of the chemical at intervals to the requisite of the crop. The dispense of the pesticides in the form of inorganic chemical is indiscriminate which is due to the external factors like air, water etc. which is managed with the help of nano-pesticides from its core as it releases slowly. The application of the nano pesticides will show the better result and also decreases the pollution.

The pest attack of pest in the crop is one of the factor which lead to the minimise yield of the crop. (18%)**.** Monitoring and control systems already in place, nanotechnological devices for CEA that provide "scouting" capabilities could tremendously improve the grower"s ability to determine the best time of harvest for the crop, the vitality of the crop, and food security issues, such as microbial or chemical contamination (Allah Ditta, 2012) [1]. The endeavors are direct towards the successful application of those compounds on crops and their efficacy and availability improvement and reduction of environmental contamination and workers exposure (Savary *et al*., 2006) [13]. Non material which have potential to exert hazardous effects on human and the environment and when we have a nano-pesticide, it becomes a double edged weapon. Nanomaterials need to be evaluated, so that this novel technology does not meet the same apprehensions and bottle-neck as faced by genetically modified crops (Gopal *et al*. 2012) [5]. The agricultural application of nanotechnology can suggest development of efficient and potential implications for overcoming of the management of pests in crops. Nanoparticles can be used in the preparation of new formulations like pesticides, insecticides, insect repellents, pheromones and fertilizers (Barik *et al*., 2008) [4]. Among the different diseases, the viral diseases are the most difficult to control, as one has to stop the spread of the disease by the vectors. These nano-based diagnostic kits not only increase the speed of detection but also increase the power of the detection (Prasanna, 2007) [12].

Which the application of pesticides for reduction of pest has been increased. so, the consumption of pesticides has been lead to the toxic effects which is by the residuals of applied pesticides. The utilization of the inorganic pesticide unrelavant to required quantity, leads to the formation of the toxicity in external climatic condition (water, soil, air) which leads to eternal situation and caused pollution. The utilization of pesticides in India has started before the independence which initially used to over come the drought conditions of food, which were overcame in decades. But the consumption of the pesticides has been increased.

Table 1

Crop	Actual production (million tonnes)	Approximate estimated loss in yield due to insect pests (%)	Approximate estimated loss in yield due to insect pest (total- million tonnes)	Hypothetical production in the absence of losses due to insect pest	Monetary value of estimated losses**
Rice	93.1	25	31.0	124.1	164300
Wheat	71.8	5	3.8	75.6	23560
Maize	13.3	25	4.4	17.7	21340
Chickpea	5.3	10	0.6	5.9	7200
Groundnut	6.9	15	1.2	8.1	16080
Rapeseed	5.0	30	2.1	7.1	27300
Mustard	5.0	30	2.1	7.1	27300
Sugarcane	300.1	20	75.0	375.1	46540
Cotton (lint)	10.1	50	10.1	20.2	287600
Other cereals	20.6	30	8.8	29.4	42680
Other pulses	7.9	20	2.0	9.9	26400
Other oilseeds	8.6	20	2.2	10.8	26400
Total					689400

Materials and methods

Nanoparticles: Nanoparticles of defined concentrations could be successfully used for the control of various plant pests & diseases caused by several phytopathogens and entomopathogens.

Nanotechnology helps agricultural sciences and reduce environmental pollution by production of pesticides and chemical fertilizers by using the Nano-particles and Nano capsules with the ability to control or delayed delivery, absorption and more effective and environmentally friendly and production of Nano-crystals to increase the efficiency of pesticides for application of pesticides with lower dose. They can also be used to alter the kinetic profiles of drug release, leading to more sustained release of drugs with a reduced requirement for frequent dosing (Sharon *et al*., 2010) [14].

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Nanotechnology will also protect the environment indirectly through the use of alternative (renewable) energy supplies and filters or catalysts to reduce pollution and clean-up existing pollutants. There are new challenges in this sector including a growing demand for healthy, safe food, an increasing risk of disease and threats to agricultural.

There is a great concern regarding the nonmaterial which have potential to exert hazardous effects on human and the environment and when we have a nano-pesticide, it becomes a double edged weapon. Nanomaterials need to be evaluated, so that this novel technology does not meet the same apprehensions and bottle-neck as faced by genetically modified crops (Gopal *et al*. 2012) [5].

The potential of nanotechnology to revolutionize the health care, textile, information and communication technology and energy sectors has been well documented. In fact, several products enabled by nanotechnology are already in the market and they include antibacterial dressings, transparent sunscreen lotions, strain-resistant plants and nano-particles in eco-friendly pesticides (Bhattacharyya, 2009) [2].

Several nanotechnology applications for agricultural production for developing countries within next 10 years. They include: -

1. Nano forms zeolite for slow release and efficient dosage of water and fertilizer for plant; drugs for livestock; Nano capsule and herbicide delivery.
2. Nano sensors for soil quality and for plant health monitoring; Nano sensors for pest detection.
3. Nano magnets for removal of soil contaminants and
4. Nanoparticles for new pesticides, insecticides, and insect repellents.

Nanoparticles

1. Carbon tubes -1) single walled 2) multiwalled
2. Fullerenes
3. Graphenes
4. Clay -1) montmorillonite 2) Halloysite 3) Vermiculite
5. Poss -1) molecular silicas 2) monomers 3) silanois 4) polymers
6. F) Dendrimers G) Nanofibers H) Metal oxides I) silica

Agriculture and nanotechnology

Nanotech research and development is likely to facilitate and frame the next stage of development of genetically modified crops, animal production inputs, chemical pesticides and precision farming techniques. The effects on society as a whole will be dramatic. Recent advances in materials science and chemistry have produced mastery in nano particle technology, with wide ramifications in the field of Agriculture. The use of nanotechnology in agriculture has been mostly theoretical but it has begun and will continue to have a significant effect in the main areas of the food industry development of new functional materials, product development and design of methods and instrumentation for food safety and bio-security (Joseph and Morrison, 2006) [6].

Nanoscience research in agriculture and food science

Contribution of nano science research in agriculture will be in the following areas:

Food safety and biosecurity

Material science.

Food processing and product development.

Nano-particles controlling the plant diseases

Nano particles that are used in protection from plant pests & diseases are nanoforms of carbon, silver, silica and alumina-silicates.

Nanoparticles used for control of disease and pest incidences in plants

Nano silver: Silver nanoparticles, which have high surface area and high fraction of surface atoms, have high antimicrobial effect as compared to the bulk silver. Antifungal effectiveness of colloidal nano silver (1.5 nm average diameter) solution, against rose powdery mildew caused by *Sphaerotheca pannosa* Var *rosae*. Double capsulized nano silver was prepared by chemical reaction of silver ion with aid of physical method, reducing agent and stabilizers. They were highly stable and very well dispersive in aqueous solution. It eliminates unwanted microorganisms in planter soils and hydroponics systems. It is being used as foliar spray to stop fungi, moulds, rot and several other plant diseases. Moreover, silver is an excellent plant-growth stimulator.

Nano alumino-silicate: Nano scale pesticides are efficiently formulated in chemical companies. Alumino-silicate nanotubes sprayed on plant surfaces are easily picked up in insect hairs, they actively groom and consume pesticide-filled nanotubes. Nanotubes biologically more active and relatively more environmentally-safe pesticides. Silica nanoparticles have shown that mesoporous silica nano particles deliver DNA and chemicals into plants thus, creating a powerful new tool for targeted delivery into plant cells and help in control of pests.

Titanium dioxide (TiO_2) nanoparticles: Titanium dioxide (TiO_2) is a non-toxic white pigment widely used in the manufacture of paints, study, ink, cosmetics, ceramics, leather, etc. and is a very strong disinfectant as compared to chlorine and ozone. Since TiO_2 is harmless, it is approved for use in food products up to 1% of product final weight. Scientists have been trying to improve the phytopathogenic disinfection efficiency of TiO_2 thin films by dye doping and other suitable methods (Yao *et al.*, 2009) [15]. TiO_2 photo catalyst technique has great potential in various agricultural applications, including plant protection since it does not form toxic and dangerous compounds and possesses great pathogen disinfection efficiency.

Carbon nanomaterials: Among the various engineered nano materials, carbon based nanomaterials (such as single called carbon nanotubes (SWCNTs), multi walled carbon nanotubes (MWCNTs), buckyballs, graphene, etc.), occupy a prominent position in various nano-biotechnolgy applications. Increased use and exposure to carbon nano materials could cause environmental concerns. Hence, it is extremely important to systematically study the effects that carbon nanomaterials in plants occupy a major component of the food chain.

Magnetic nanoparticles: The scope of magnetic nanoparticles for site-targeted delivery of drugs has been exploited widely in biomedicine for the treatment of various diseases (Mornet *et al.*, 2004; Jurgons *et al.*, 2006) [9, 7]. Magnetic-based nano materials could be utilized for site-targeted delivery of systemic plant protection chemicals for the treatment of diseases that affect only specific regions of plants. If the movement of internalized magnetic nano materials could be tracked externally using high power external magnets. The advantage of using carbon-based nanomaterials (such as SWCNTs and MWCNTs) functionalized with magnetic nano particles is that the internal space allows filling of suitable plant protecting chemicals and the functionalized magnetic nano particles allow external control of the movement of nano carriers inside the plant system.

Nano formulations for the control of plant diseases

Nanotechnology provides new ways for improving and modifying existing crop management techniques. Plant nutrients and plant protecting chemicals are conventionally applied to crops either by spraying or broadcasting. Due to problems such as leaching of chemicals, degradation by photolysis, hydrolysis and microbial degradation, only a very low concentration of chemicals which is much below the required minimal effective concentration, reach the target site of crops.

Nanotechnology for detecting plant diseases

A need for detecting plant disease at an early stage so that tons of food can be protected from the possible outbreak, has tempted nano technologists to look for a nano solution for protecting the food and agriculture from bacteria, fungus and viral agents. A detection technique that takes less time and that can give results within a few hours, that are simple, portable and accurate and does not require any complicated technique for operation so that even a simple farmer can use the portable system. If an autonomous nano-sensors linked into a GPS system for real-time monitoring can be distributed throughout the field to monitor soil conditions and crop, it would be of great help. The union of biotechnology and nanotechnology in sensors will create equipment of increased sensitivity, allowing an earlier response to environmental changes and diseases.

Plant pathogens in biosynthesis of nanoparticles

The research on nanoscience and nanotechnology essentially involves preparation and use of nanoparticles of various elements and compounds. Among various uses, nanoparticles are also being used as antimicrobial agents for plant disease management. Formation of nanoparticles can be achieved via several processes which may be either physical or chemical.

Fungi: Fungi are relatively recent in their use in synthesis of nanoparticles. There has been a shift from bacteria to fungi to be used as natural 'nano factories' owing to easy downstream processing, easy handling (Mandal *et al*., 2006) [10] and their ability to secrete a large amount of enzymes. However, fungi being eukaryotes are less amenable to genetic manipulation compared to prokaryotes. Therefore, any alteration of fungi at genetic level for synthesis of more nanoparticles would not be so easy. It is important to know the mechanism of synthesis of nanoparticles in microbial

systems to get better control over shape, size and other desired properties of the synthesized nano materials.

Bacteria: Among microbes, prokaryotes have received the most attention for biosynthesis of nanoparticles (Mandal *et al*., 2006) [10]. Bacteria have been used to biosynthesize mostly silver, gold, FeS and magnetite nanoparticles and quantum dots of cadmium sulphide (CdS), zinc sulphide (ZnS) and lead sulphide (PbS).

Plant virus: Plant virus especially spherical/icosahedra viruses represent the examples of naturally occurring nanomaterials or nanoparticles. The smallest plant viruses known till date is satellite tobacco necrosis virus measuring only 18 nm in diameter. Plant viruses are made up of single or double stranded RNA/DNA as genome which is encapsulated by a protein coat. The protein coat/shell structurally and functionally appears like a container carrying the nucleic acid molecule as cargo from one host to another. Their ability to infect, deliver nucleic acid genome to a specific site in host cell, replicate, package nucleic acid and come out of host cell precisely in an orderly manner have necessitated them to be used in nanotechnology. A complete review on use of plant viruses as bio templates for nano materials and their application has been done recently by Young *et al*. (2008) [16].

Nanogels

Nanogels are prepared from a pheromone, methyl eugenol using a low molecular mass gelator (ME). The pheromones are naturally occurring volatile semichemical and are considered as eco-friendly biological control agents. They induce impaired sexual communication and mating disruptions among pests.

Nanogels are thermos reversible, which can be re activated by adding the pheromone material by changes in the temperature of the gels. These are mostly used for control of fruit sucking flies (*Batocera dorsalis*). *B. dorsaliis* suck the pulp from the fruit crops like Mango, Banana, Apple, Orange, guava, peach etc., which can be controlled by the use of nanogel pheromone traps.

Advantages of using Nanogels

- Low cost
- Green chemical (less toxic to animals and human beings)
- Long lasting residual activity
- Excellent efficacy

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