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Applications of Nanotechnology in Plant Disease Management

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Plant pathogens cause significant reduction in production (20-40%) of various crops. Current disease management relies heavily on the application of chemicals like fungicides, bactericides and nematicides. It is estimated that 90% of chemicals are lost in the environment during or after application of chemicals. Therefore, nanotechnology would provide green and efficient alternatives for the management of plant disease without harming nature. The use of nanotechnology in agriculture is currently being explored in plant hormone delivery, seed germination, water management, transfer of target gene, nano sensor and controlled release of agrochemicals. Nanotechnology is the design, characterization, production and application of structures, devices and system by controlling shape and size at Nano scale. Nanoparticles used in plant disease management are Nano chitosan, Nano silver, Nano silica, Nano copper etc. Fungicides that have low water solubility require organic solvent to solubilize them for this purpose nano particles act as carrier of fungicides and are exploited to improve low water solubility, decrease volatilization and improve stability (Worrall *et al*., 2018). Nano particles have also been used for biosensors including metal and metal oxide nanoparticles, quantum dots, carbon nanotubes and graphene. Application of nanotechnology can offer unprecedented advantages like improved solubility of poorly water-soluble pesticides, enhanced shelf-life and controlled delivery of actives. Nanoparticles helps to improve the selective toxicity and overcome pesticide resistance.

Keywords: Nano Technology, Nano sensors, Nanao particles and Plant disease management

Introduction

Plant disease is important challenge faced by agriculturist in plant production globally. It is estimated as the 20-40% loss per year (Flood 2010). Current disease management relies heavily on the application of chemicals such as fungicides bactericides and nematicides. Since there are many advantages like fast action, easily available in market, they are harmful to non target organisms, soli health and the development of resistance. It is estimated that 85-90% of applied pesticides are lost during or after the application. Therefore nanotechnology would provide green and efficient alternatives for the management of plant diseases in agriculture without harming nature.

The term ''Nanotechnology'' was coined by Taniguchi 1974. it is a science that deals with synthesis and application of nano size particles 1-100nm. Nanotechnology impacts on development have a lot of application such as production of energy, improve agriculture production, drinking water treatment and disease diagnosis. There are several advantages for using nanotechnology. One very attractive advantage is the large reduction in active chemicals that actually enters the agroecosytem. Large proportion of applied fungicides/bactericides and fertilizers do not reach their target and enter into ground water, contaminating ecosystem. Nanotechnology stand as a weapon against factors that affect plant health. Therefore nanotechnology would provide green and efficient alternatives for the management of plant diseases in agriculture without harming nature. Nanotechnology will support agriculture and decrease environmental challenges by pesticide production and plant disease management. This can be achieved by using nanoparticles as environmentally friendly to improve the efficiency of chemicals with lower dose. Agriculture nanotechnology and its techniques helps improves crop productivity and reduce disease impact.

Nanotechnology has good practices in management of plant diseases in many ways the most common is nanoparticle application on seed, soil and leaves to protect the plant from pathogen or to control infection (Khan and Rizvi 2014). Nanoparticle can suppress the pathogens that cause damage to plants in soil or plant parts because nanoparticles have ultra small size, they are even smaller than virus, and they have high reactivity against microorganism.

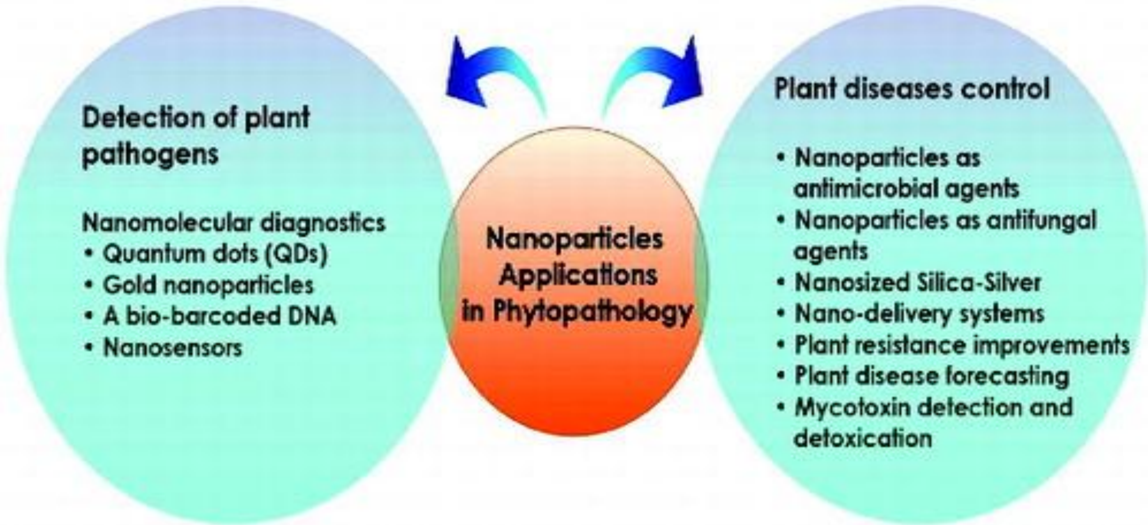

Fig: Applications of Nanoparticles

Application of nanoparticles in management of plant diseases:

The nanoparticle are used to protect plants in two different mechanisms
(a) Nanoparticle act as carrier for pesticides can be applied by spray application.
(b) Nanoparticle themselves providing protection to crop.
Nanoparticle act as carrier can provide several benefits
(a) Increases shelf life of pesticides
(b) It increases the solubility of poorly water soluble pesticides
(c) Increases the site specific uptake into target pest (Hayles *et al*,. 2017).
(d) Reduces toxicity.

Nanoparticles can also be directly applied to plant seed, foliage, roots for protection against pest and pathogen. Metal nanoparticles such as silver, copper, zinc oxide and titanium oxide have been intensively researched for their antibacterial and antifungal properties. Silver nanoparticles have shown antifungal inhibition of *Alternaria alternata*, *Sclerotinia sclerotiorum*, *Rhizoctina solanai* (Krishnaraj *et al.*, 2012*)*. When poly-dispersed gold nanoparticles introduced into plant through mechanical abrasive was seen to melt and dissolve the *Barley yellow mosaic virus* particles conferring resistance to plant (Alkubaisi *et al.*, 2015).

Commonly used Nanoparticles for plant disease management

The nanoparticles of metalloids, nonmetals, metal oxides and carbon nanoparticles have antifungal and antibacterial activity. Some of these nanoparticles also have nutritional benefits on plants and also increase host resistance to disease. The nanoparticles Cuo, Sio_2 can enhance the defence products in plants. The nanoparticle which are commonly used as carries for fungicides, insecticides, herbicides are as fallowing:

Silver nanoparticle: Silver can disinfect almost 650 microbes and also nontoxic to humans but controls the metabolism function inside the microbes (Morones *et al*., 2005). It could be applied for controlling of many plant pathogens in a safer way compared to synthetic fungicides (Parlk *et al*., 2006). Nano silver reduces different plant diseases caused by spore producing fungal pathogens. The silver nanoparticles are applied before the penetration and colonization of fungal spore within the plant tissues. The small size of the active ingredient (1-5 nm) of silver effectively controls diseases like powdery mildew. The *in vitro* and *in vivo* evaluation of antifungal action of silver nanoparticles on *Bipolaris sorokiniana* and *Magnaporthe grisea* showed decreased disease development by plant pathogenic fungi.

Silica nanoparticle: Silica is known to be observed into plants to increase the disease resistance and sress resistance. Silica nanoparticles can be easily synthesized with controlled size and shape, making them as delivery vehicles, it promotes the physiological activity and growth of plants and also induces the diseases and stress resistance in plants. Mesoporous silica nanoparticles can be used for targeted delivery of DNA and chemicals. The shell structure of porous hallow silica nanoparticles protect the active molecule inside the nanoparticle against degradation by UV light. The silica coating causes the plant to receive the particles through cell wall of the cell, where the genes are put in and stimulated in an accurate and controlled manner with no toxic side effects. This method has been used to successfully introducing DNA into plants such as corn and tobacco. Silica-silver nanoparticles reportedly have antifungal activity against *Botrytis cinerea, Rhizoctonoa solani, Collectotrichum gloeosporioides.*

Chitosan nanoparticle: Chitosan nanoparticles have hydrophobic properties due to this property it is low soluble in aqueous solution. As a result, chitosan is commonly mixed with organic and inorganics to improve solubility. The chitosan inhibition mode against fungi is defined by these three mechanism

- it is proposed that chitosan can penetrate the cell wall of fungus and bind to its DNA and hinder mRNA synthesis and in turn, impact the production of vital enzymes and protin.
- chitosan chelates with metal ions, which are suggested as a possible antimicrobial action mode (Rabea *et al.,* 2003).
- The positively charged chitosan interact with negative charge of phospholipid components of fungi membrane, which alter cell permeability of plasma membrane and lead to leakage of cellular components, which subsequently leads to death of cell.

Chitosan nanoparticle exhibited antifungal activity *in vitro* and could protect the finger millet plants from blast disease caused by *Pyricularia grisea.* Chitosan nanoparticles were reported to be effective against plant pathogenic fungi and bacteria effecting tomatos. The growth inhibitory effects was maximum in *F. oxysporum* fallowed by *P. capsici* , *Xanthomonas compestris* pv . *vesicatoria* as well as *Erwnia carotovora* was inhibited.

Copper nanoparticles: Due to broad spectrum antimicrobial properties copper- based compounds has been used for centuries to manage plant pathogens. The first metal-based fungicides used in plant disease management comprised of copper and copper- containing compounds. Usage of copper oxychloride and copper hydroxide, Bordeaux mixture etc. to control bacterial blight in pomegranate continues even today. Bordeaux mixture that is composed of lime, copper sulphate and water, which was used to control grapevine downy mildew disease caused by *Plasmopora viticola* an oomycete pathogen. It was discovered that nanoparticle can be effective in controlling bacterial disease, namely leaf spot of mung and bacterial leaf blight in rice. Copper nanoparticles at a concentration of 200 mg/L were inhibitory to *Pseudomonas srringae,* where as the particle were not biocidal against

Rhizobium spp. and *Trichoderma harzianum*in comparison to copper oxychloride. This study demonstrated that nanocopper could potentially be used in agriculture because of evidence of the non-biocidal effect.

Gold nanoparticles: DNA-gold nanoparticle probes hold promise as a new generation of biosensors in the detection of pathogenic microorganisms. In this technique, the gold nanoparticle oligonucleotide probes are hybridized with the complementary DNA, which stabilizes gold nanoparticles against aggregation (retaining the native pink color of the colloidal gold). In the absence of complementary DNA, the solution turns purple because theaggregation of gold nanoparticles leads to the shift in absor-bance peak toward a longer wavelength. Gold nanoparticles feature agglomeration related to color production that was used in the detection of pesticide. Developing a color signal facilitated easy visual detection when gold nanoparticles marked antibodies bound to the pesticide residues. The gold nanoparticle-based dipstick technique suited the detection of numerous toxins in environmental and food samples and can be used for rapid examination of pesticides on the site (Lisa *et al*. 2009).Gold nanoparticle-based optical immunosensors have been developed for detection of Karnal bunt disease in wheat.

Zinc nanoparticles: In agriculture ZnO is primarily used as a micronutrient fertilizer however, its antimicrobial properties are well known. Mechanism of action of nano-Zn derived from zinc nitrate on important pathogen Aspergillus fumigatus demonstrated that it made cell wall deformity by hydroxyl and superoxide radicals mediated in fungal and finally led to death due to high energy transfer. ZnO nanoparticles (ZnO NPs) were also reported to beeffective against two postharvest pathogenic fungi (*Botrytis cinerea* and *Penicillium expansum*), thus contributing in agriculture and food safety application. ZNo nanoparticles prevented the development of conidiophores and conidia of *P. expansum*, which eventually lead to death of fungal hyphae.

Nano-biosensors: Sensors are complex instruments which respond to biological and physicochemical aspects and convey that response into a signal or output that can be used by humans. They allow the detection of contaminants such as pests, microbes, plant stress and nutrient content due to insect or pathogen pressure. The nanomaterials used forbiosensor construction include metal and metal oxide nanoparticles, quantum dots, carbon nanomaterials such as carbon nanotubes and graphene. Controlled Environmental agriculture (CEA) can be improved by use of nano-sensors enhancing the aptitude to determine the time of crop harvest, detect crop health and determine microbial or chemical composition of crop. Nano sensors may be used to diagnose soil disease caused by infecting soil microorganism, such as virus bacteria and fungi via quantitative measurement of different oxygen consumption in the respiration (relative activity) of good and bad microbes in the soil

Conclusion

Nanotechnology can provide solution for agricultural applications and has the potential to revolutionize the existing technology used in the disease management. Nanotechnology will also play an important role in the development of multiple new methods to improve plant health by application in disease diagnostics, disease control, or improving overallplant health by immune elicitors. Development of Nano-pesticides can offer unprecedented advantages like increased bioavailability and efficiency of pesticides when loaded onto nanoparticles can reduced toxicity, Enhanced shelf-life and controlled delivery of actives. Nanotechnology and Nano scale science clearly posses a great role in improved and innovative solutions. Nano sized materials alter their biological, physical and chemical properties and help the innovation and improvement of some pesticides and enable to fight with weeds, diseases and various pests much better.

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