Role of Nanotechnology in Precision Farming

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Abstract

Nanotechnology is the modernized, advanced system of applied technologies in research field. The present scenario of polluted and degraded environment due to heavy use of inorganic fertilizer, pesticides have caused more damages to not only crops, soil, animals but also to humans. Precision farming is the modern age farming that includes various advanced technologies with it. Nanotechnology can be a suitable enhancement option for better agriculture in future as it uses techniques like nanoparticles, nano-capsules, nano-encapsulated fertilizers, pesticides that help in slow and sustained release of nutrients and chemicals for better use efficiency and plant growth. Various nanotech kits have been evolved for early detection and proper control of plant diseases and pests.

Introduction

Nanotechnology uses various new and advanced techniques or instruments like nanoparticles, nano capsules of size 0.1 to 100 nm. The smaller size of these nano-devices provides higher surface area and unique optical properties hence proved to be efficient in case of delivering agrochemicals to plant systems for controlling diseases and pests. The nano-devices are made from metal oxides, ceramics, magnetic materials, quantum dots, lipids, polymers and semi conductors etc. Nano-encapsulated particles protect it from degradation and provide longevity to the chemicals, pesticides, fertilizers and keep environment clean. Chitosan nanoparticles are used in controlling fungal infection and seed treatment.

Applications of Nanotechnology in Precision Farming

1. Biofertilizers

Biofertilizers are the living strains of various microbes that are useful in agriculture. Limitations to the biofertilizers are storage losses, temperature sensitivity, lesser shelf life, degradation to external environment. But the applications of nanoparticles (gold and silver) and encapsulated biofertilizers enhance shelf lives, improve cell viability, reduce cell sedimentation. The uses of nanoparticles have enhanced soil rhizospheric microbial activities and can be a source of plant growth promoters (Dikshit *et al.,* 2013). Different biofertilizers strains of *Bacillus* Sp., *Pseudomonas* Sp., *Azospirillum* sp. etc have been used in case of nanotechnologies to make them more effective for use in case of agriculture.

2. Insect-Pest Management

Nanoparticles used in insect pest control are smaller in size as well as have protective coating over active chemicals that provide large surface area, slow release

and prolonged use, better use efficiency, degradation to external environment. Their absorption also increases by plants so that proper control of insect-pest in crop is possible. These are cost-economic so that can be adopted on large scale basis. These particles do not interfere with plant metabolisms, its nutrient uptake capacities, and its growth so that proved effective.

3. Micro-Nutrient Supply

Various micronutrients like copper, zinc, iron, manganese, boron, molybdenum etc. are useful in growth and periodic development of different crops grown. Losses of micronutrients are also reported and along with lesser shelf life. Thus use of encapsulated nutrients can be a better option for increasing its availability along with long and slow release of nutrients to the plants.

4. Nano-Fungicides

Chemicals used against fungus creates problem by polluting environment, soil health. Losses due to environmental variations, degradation are also reported in case of fungicide application. The use of nanoparticles like silver, titanium dioxide and zinc oxide etc. are effective against various soil borne pathogens, fungal species, protect chemicals against degradation. The smaller size of nanoparticles provides large surface area for better utilization and adsorption on fungal cells for controlling plant fungal diseases.

5. Nano-Herbicides

Crop yield loss due to weed infestation has emerged as a serious issue in agriculture now a day. Uncontrolled use of herbicides not only kills weeds but also damages crops surrounding it. Prolonged use of herbicides decreases soil fertility, interferes with soil microbial activities, residual effects are seen which cause problems in future and application of same herbicides may create resistance in weeds. The use of nanotechnology overcomes these problems by creating eco-friendly system of weed removal, improves efficiency, provide long lives, and enhance its absorption by plants.

6. Delivery of Fertilizers

Chemical fertilizers like urea, di-ammonium phosphate, murate of potash are principal sources for nitrogen, phosphorus and potash used in agriculture. Heavy use of fertilizer has caused decrease in soil fertility, pollution, reduced microbial activities in soil, decline in soil health etc. The losses of fertilizers like volatilization and leaching loss in case of nitrogen (40-70% approx.), phosphorus (80-90%) and potassium (50-60%) force farmers to apply huge amount of fertilizers without concerning about soil health. Nanotechnology provided techniques like coated fertilizers like neem coated urea etc. not only controlled the losses but also increase its efficiency, long life, slow and controlled release of nutrients to plants. The sulphur nano-coated fertilizers provided sulphur in deficient conditions in slow and sustained manner. The crop nutrients demands are also fulfilled by these techniques and these are eco-friendly in nature. The nanoparticles are so made that it can be adsorbed on cell wall of harmful microbes and controls plant from infections thus plants can grow better. The large surface area of nano-fertilizers improves the use efficiency of fertilizers. The nano-fertilizers are easily absorbed by plant roots and foliar applications have proved to be efficient.

Table 1: Uses, Origin, Function and Scope of Nanoparticles in Agriculture (J.S Duan *et al.*, 2017)

Nanoparticles	Origin	Size	Special features	Functions	Scope
Silver nanoparticles	Plant, bacteria, fungi	6-38nm	Antimicrobial	Enhanced Seed germination, germination index, potential etc.	Pest and diseases control
Zinc oxide nanoparticles	Plant leaf extract	<100nm	Antimicrobial	Zinc solubility enhancement, toxicity reduction in plants	Antimicrobial and antifungal against microbe strains
Titanium dioxide nanoparticles	Aquous leaf extract of *Psidium guajava*	32.58-68nm	Antioxidant, antimicrobial	Photo-catalyst, enhance growth and photosynthesis etc.	Plant protection

Use of Sensors in Precision Farming

Various biosensors are used for diagnosis and controlling mechanisms in this field. Precision agriculture also uses modern systems like computers, sensors, GIS, GPS for monitoring and surveying purposes. Thus nanotechnology and precision farming complement each other.

1. Green Seeker

Green seekers are the devices which actually measure the biomass of the plants. It works on the principle of absorbance of red and infra red light by the healthy plants as healthy plants absorb more red lights and reflect more infrared light.
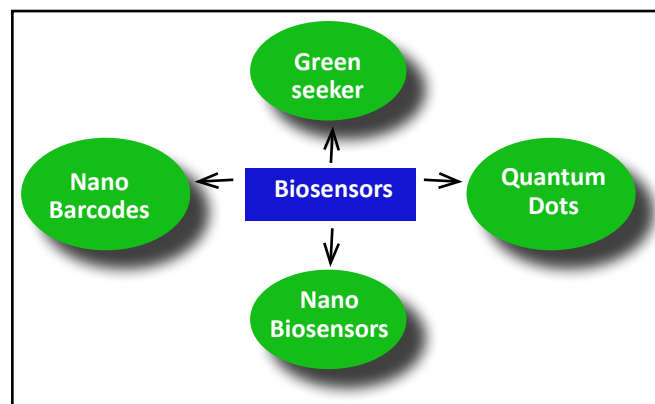
Figure 1: Types of biosensors (J.S Duan *et al.*, 2017)

2. Quantum Dots

Quantum dots are fluorescent in nature with wide spectrum thus helpful in detection of various microorganisms and helpful in controlling plant diseases.

3. Nano Biosensors

These sensors are useful in case of detection of microbes (bacteria and viruses), crop pathogen detection, plant nutrient movement tracking etc. These are ecofriendly in nature and smart technologies are helpful for better agriculture.

4. Nano Barcodes

These are produced by electroplating of inert materials like gold and silver etc. Nano barcodes are used as identification tags for gene expression. Nano barcodes are used in case of biotechnology for generating disease, drought, and salinity resistance in plants.

Conclusion

Nanotechnology has shown great potential in case of precision farming. As precision farming uses modern techniques, the nanotech aids farming by providing various advanced techniques and instruments for easy and high efficiency performances. Use of nano-devices provides protection to chemicals against degradation, longer shelf lives, high use efficiency and ecofriendly in nature. Slow and prolonged release of nutrient to plants cause better plant growth. Thus scope of nanotechnology in precision farming is always at high priority.

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