FUTURE PERSPECTIVE OF NANOPARTICLE BASED BIOFERTILIZERS AND DISEASE CONTROL AGENT

Abstract

Agriculture and Horticulture cultivable land over usage of chemical fertilizer for soil application and then foliar spray for control of dumping pathogen such as pesticide, insecticide, fungicide, herbicide and bacteriacide. This point of view to development sustainable cultivable ecosystem and Nanoparticles based bioagent to agriculture input preparation emerging as promising alternative. Nanoparticle based agriculture fertilizers and pesticide, insecticide, fungicide, herbicide and bactericide support ecofriently nature and reduce transport cost with labour and chemical fertilizer cost. The agriculture and horticulture farming farmers facing lot of problems, farmers urgent require advance technology like nanoparticle based macro, micro nutrients and disease management agents (low cost with feasibility).

Keywords: Nano size particle; Pathogens; Plant; bacteria; Fungi; Biofertilizer; Biopesticide

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I. INTRODUCTION

Nano based plant nutrients and disease control agents is now used agriculture and horticulture practice area widely used in modern agriculture to bring the concept of precision agriculture to life, and it has applications in a variety science sectors. Huge demand of scope open in the fields of agriculture for nanotechnology refers to nanoparticles with one or more dimensions of fewer than 100 nanometers (6). Because of their small size, high surface-to-volume ratio, and unique optical properties, nanomaterials have uses in plant conservation against biotic and abiotic stress, nutrition, and farm management (17). Metal minerals and non metals mineral based, semiconductor are among the components utilised to form nanoparticles (47). In agriculture, chitosan nano particles are used in seed treatment and as a biopesticide to assist plants fight fungal infections. Plants differ in their ability to absorb nanoparticles and their impact on growth and metabolic activities. The concentration of nanoparticles has an impact on plant germination and growth (68). By decreasing the leaching and evaporation of dangerous compounds, nano encapsulation plays a critical role in environmental protection. Pesticides are consumed in around two million tonnes per year around the world, with Europe accounting for 45 percent, the US for twenty five percentage, and other country for 25% (15). Pesticide use that is haphazard and careless promotes disease and insect resistance, lowers diversity soil living organism, and kills beneficial living oraganism from soil; causes pesticide bio magnification, pollinator loss, and disrupts the natural habitat of birds and other Allied farmers (63). Some of the benefits of modern nanotechnology include nano particle-mediated gene or DNA transfer in plants for the development of insect pest resistant varieties and the use of nano materials for the preparation of various types of biosensors that could be useful in remote sensing devices required for precision farming (49). Traditional agricultural solutions such as integrated pest management are insufficient, and the use of chemical pesticides has negative consequences for animals, beneficial soil bacteria, and soil fertility. To address this issue, genetic modified insecticides, according to making low cost product, must be developed (48). Micro fabrication and nanotechnology advances are currently playing a vital role in virus detection, lowering observation level, improving working standard, and low cost technology of viral detecting kits (13).

II. NANOBIOFERTILIZERS

Biological fertilizers formulation made by different genus and species of bacteria and fungi combine make consortia mode to application that improve nutrient availability to plant roots and ability produce hormones and iron chelating in the rhizosphere zone with modern technology of nano based biofertilizer to elongavation the plant organs. Controlling the delivery of biological fertilizers in the land profile and extending the helathy life of the formulation are fundamental to achieve (27, 39, 60). (Fig.1)

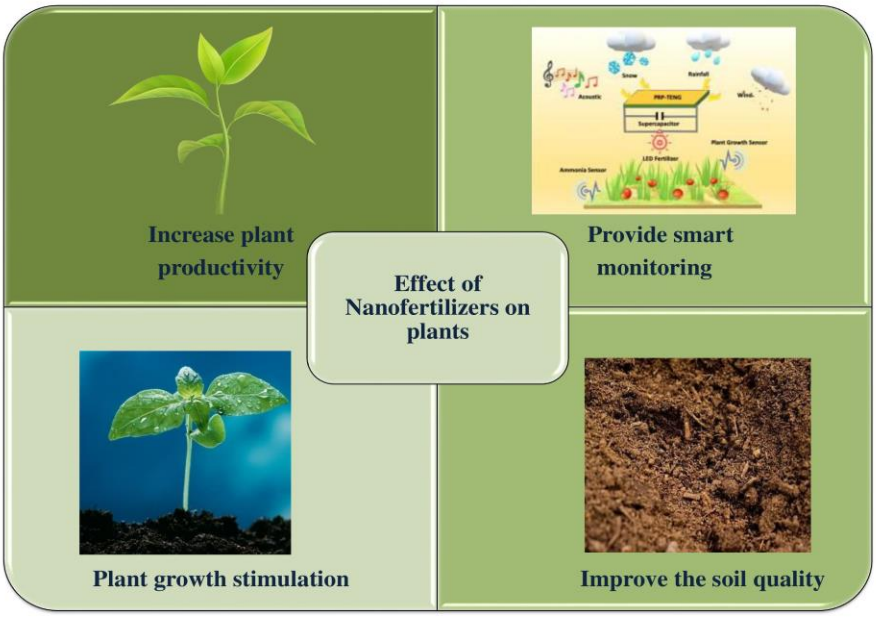

Figure 1: Improvement of Soil, Plant health and Monitoring status by Nanofertilizer

The healthy relation with nanoparticles and plant beneficial microorganisms, as well as the shelf life and delivery of biological fertilizers, are key considerations for the creation of nanobiological fertilizers. The interaction between gold nanoparticles and rhizosphere bacteria that promote plant growth was found to have beneficial results (38, 57). On the other hand, silver nanoparticles cannot be used with biological fertilizers because they can disrupt the biological processes of microorganisms, such as changing the structure and function of cell membranes. Most important the withstand microbes in long duration for incubation (shelf life) of biological fertilizers for these formulations, which can be improved by introducing nanomaterials (Fig.2).

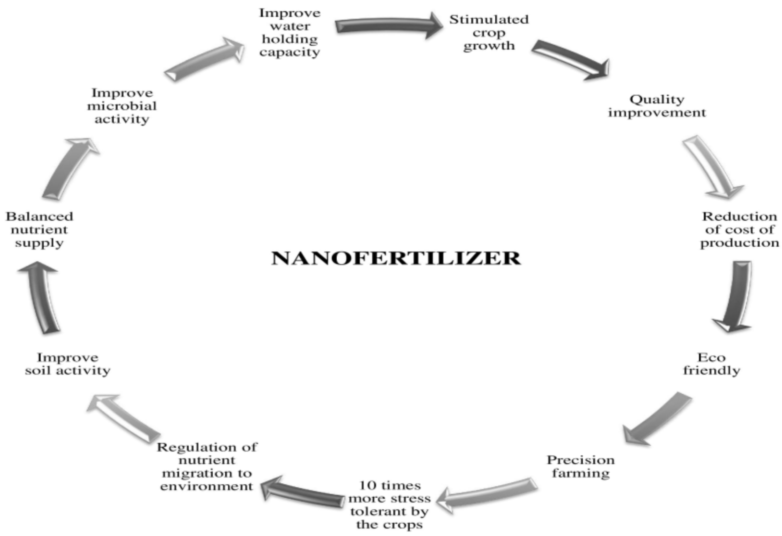

Figure 2: Nanobiofertilizer mode of action

The use of nano-products helps to improve the stability of biological fertilizers in terms of biotic and abiotic stress. For example, polymer nanoparticle coatings can be used to make anti-drying formulations to extend the life of these items (59, 19). However, since nanostructures are usually smaller than cells, there is a fundamental problem in the manufacture of nano-biofertilizers. In this sense, a macroscopic filter constructed with radically arranged carbon nano tube walls that can intake *E. coli* will be efficient products that can combine the other beneficial microorganism for ferment the substrate and easily transport the plant root system Therefore, nano-biological fertilizers may overcome some limitations of biological fertilizers, but further research and development are needed (59, 64).

III. NANOBIOPESTICIDES

Nanobiopesticides are compounds with nanoparticles obtained from biological sources and are intended to be used as pesticides. Polymers, metal oxides, active particles mixed with micelles and other materials are used to improve the efficiency and effectiveness of nano biopesticides. Qualified nano biopesticides must have the following qualities: enhance complex molecule to simpler radicals of chemicals and then quickly dissolved in water, segregation of active target molecules through gradually, and not prematurely destroy active list of essential (48). Although the amount of nanobiopesticide used is small, its effectiveness should not be compromised. Additionally, by manufacturing nanobiological pesticides rather than utilizing information on the existence cycle and conduct of plant problematic microorganisms or pests, target specificity and results can be improved. The quality and fate of its active ingredients are significantly affected by nano formulations. Before use, the diameter range, structure or properties of the nanoparticles, the surface characteristics of the nanoparticles, the auxiliaries utilized, and their trademark discharge in the genuine climate over the long run not really settled (48). Nano-biological pesticides consist of active chemical pesticides in nanoparticles or other small man-made structures with insecticidal ability (8). For instance, the fourth larval phase of the filariasis vector *Culex quinquefasciatus* Say (Diptera: Culicidae) and the malaria vector *Anopheles subpictus* Grassi (Diptera: Culicidae) were evaluated. Ag nano particle with sizes of 35 and 60 nm reacted to C in a crude aqueous solution. *Quinque fasciatus* and *A. subpictus,* which indicates size of the nanoparticles assumes a significant part in the adequacy of the item (31). In the cotton bollworm, the tree leaf extracts of *Ficus religious* (FR) and *Ficus benghalensis* (FB) are used to produce Ag NP and have been found to affect the function of intestinal protease activity (50). The modification of nano-biopesticides with biocomposites will produce some characteristics, such as greater spreading, faster degradation of the soil and levels of plant residues lower than the food regulatory standards or rigidity, permeability, crystallinity, thermal stability, solubility and slower degradation (11, 12, 20). Biodegradability is all characteristics of the polymer carrier structure. The larvae of the Egyptian cotton leafworm *Spodoptera littoralis* are toxic to the pyrethroid nanoparticles (30-100 nm) of novaluron (a water-insoluble insecticide). However, these nanoproducts have been demonstrated to be destructive to the climate and removal has proven challenging. This clearly raises concerns about environmental safety, which must be taken into account when creating nano particle by products (16).

1. **Nanofungicides:** Around the world, fungal diseases cause significant economic losses, and their management has historically involved using copious amounts of chemical fungicides, frequently quite carelessly. Such a treatment not only affected pathogenic

organisms but also had negative consequences on the soil, water, air, biota, and other environmental matrices. Using nanoparticles of metal oxides that do not harm the environment and behave as a macronutrient (like MgO, CaO) or micronutrient (like ZnO, CuO) in the soil, nanobiotechnology is currently thought to be a very beneficial, innovative method for managing common fungal diseases in plants. Previous research has demonstrated the antifungal effectiveness of ZnO-NPs against a variety of fungi. Additionally, the study of nanofungicides (1), substances that use both nanoparticles, which are typically of an inorganic nature, and nanobiohybrids, which are a combination of inorganic and organic materials, to combat plant fungal pathogens, has been encouraged in the interests of a sustainable agriculture that respects biodiversity.

Despite the fact that a variety of fungicides are commercially available, their use has negative consequences for plants. Antifungal drugs made from nanoparticles have been tested against harmful fungi. Using nanoparticles of ZnO (35-45 nm), Ag (20-80 nm) and TiO_2 (85-100 nm), the antifungal efficacy of *Macrophhomina phaseolina*, an important soil-borne pathogen of legumes and oilseeds, was studied. At lower concentrations, silver nanoparticles have a stronger antifungal effect than ZnO and TiO_2 nanoparticles (58). In terms of resistance to soil born fungal plant pathogens, corn treated with nano silica (20-40 nm) was compared with block silica. In leaf extracts obtained from plants treated with nano-silica, the expression of phenolic compounds was higher (2056 and 743 mg / ml, respectively), while the expression of stress response enzymes against these fungi was lower. At 10 and 15 kg / ha, these results indicate that the disease index and the expression of defence enzymes are better than bulk corn. The treated corn has greater resistance. Therefore, SiO_2 based nanotechnology to use strong antifungal agent to replace plant pathogens (62). Ag heavy metal has much stronger antifungal properties than other metals. This is because silver ions deactivate thiol groups in the fungal cell wall, leading to destruction of the transmembrane, energy metabolism, and the electron transport chain. Other pathways include mutations in fungal DNA, dissociation of key enzyme complexes for the respiratory chain, reduced membrane permeability, and cell lysis (65). The efficacy of silver nanoparticles is proportional to their size and shape, and diminishes as particle size increases. The “cidal” effect of truncated triangular particles was found to be larger than that of spherical and rod-shaped particles (42, 43). The antifungal capabilities of silver nanoparticles have been used to treat plant diseases (24). Due to high adherence on the surface of bacterial and fungal cells, well-distributed and sustained Ag metals nanoparticles aqueous can operate as an efficient fungicide (26).

Sl. No	Nanoparticles	Plant species	Target fungi	Advantages	Disadvantages	Reference
1	Hexaconozole, Dazomet and chitosan	Oil palm	*Ganoderma boninense*	Suitable for consortia formulation and ability degradation	Above permissible limit may cause toxic to plant	37
2	Chitosan and Dazomet	Oil palm	*G. boninense*			37
3	Chitosan/ Pectin	Cucumber Maize Tomato	A. *parasiticus* and *F. oxysporum*	Control release		30
4.	PHSN	Cucumber	*B. cinerea*	Higher crop production by creation nutrient cycle		67
5.	Chitosan	Maize grains	*F. graminearum*	Control soil born disease	--	23
6.	Bacterial ghosts	wheat, cucumber and Barley	*L. nodorum*, *P. teres*, *S fuliginea* and *E. graminis*,	It possesses a multifunction al delivery platforms	Genetic modification by bacteria under stress condition	18
7.	PVP and PVP copolymer	Southern yellow pine	*G. trabeum*	Good solubilising ability with binding nature	Good absorbtion capacity and easily contamination microbes	35
8.	Eugenol oil Nanoemulsion	Seed cotton	*F.oxysporum* *F. vasinfectum*	Antifungal properties	---	54
9.	PVC	Southern and Birch yellow pine	*T. versicolor* (Turk ey tail) *G. trabeum*	Degradation ability with water soluble	----	36
10.	Nickel ferrite (NiFe2O4)	capsicum, lettuce, and tomato	*F. oxysporum and Colletotrichum gloeosporioides, Fusarium wilt*	Improvement of vegetable production	Continue practice	55
11.	Zinc oxide	vegetabls	*Aspergillusflavus and Aspergillus niger. A maximum*	Prevent zinc deficiency due to zinc will act as catalyst	-----	51
12.	Silica-silver	cucurbits	*powdery mildew*	-----	-----	44
13.	Silica-silver	maize	*Fusarium oxysporum Aspergillus niger*	-----	-----	62
14.	Silver ions	cereals	*Bipolaris sorokiniana and Magnaporthe grisea*	-----	-----	21
15.	Metal oxides	Coffee crops	Soil borne fungal disease	-----	-----	46

2. **Nano-herbicides:** The biggest threat to agriculture is weeds because they deplete the nutrients that crop plants would otherwise have access to, which lowers agricultural productivity. Traditional methods for getting rid of weeds take a very long time. Herbicides come in a range of commercially available forms. In the field, they can eliminate undesired herbs, but they can also harm crops. They should also be responsible for depleting soil fertility and polluting the environment. Nano based herbs control particles major role minimize the herbs in the agriculture and horticulture cultivable in the soil or the environment (45). The encapsulation of the herbicide in polymer nanoparticles also ensures environmental safety (29). Long-term overuse of herbicides excess herbicide will deposit in soil system further reduce agriculture production (14). Weeds become resistant when the same herbicide is used repeatedly over a long period of time. Zero nanovalent iron (Nano ZVI) has been tested to remove the herbicide atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3-triazine) from water and soil (52). The transport of herbicide-laden nanoparticles to weed roots has been established. These chemicals enter the root system of weeds, transfer into cells, and block metabolic pathways such as glycolysis, the plants will eventually die from this (41, 4).

3. **Nano-insecticides:** Through discharge components like disintegration, biodegradation, dissemination, and osmotic pressing factor with particular pH range, nano encapsulation can limit the release of chemicals to specific hosts for pest management (66). *Tribolium castaneum* uses nanoparticles containing garlic essential oil to successfully combat it (7). Compared with ordinary pesticides, nanocapsule pesticides have the ability to attack specific insects, thereby minimizing the dosage. Compared with traditional pesticides that are washed away in the rain, nano-pesticides will be absorbed on the surface of plants to achieve a longer-lasting release (53). Two pests, *Sarocladium oryzae* and *Rhyzopertha dominica*, died three days after exposure to aluminum-treated nanostructured wheat (61). *Halloysite nanotubes* can be used as nano containers to encapsulate compounds with chemical and physiological activities, such as agricultural drugs and pesticides (2, 40). The pesticide ethiprole is encapsulated in polycaprolactone and poly (lactic acid) nanospheres. According to the nano formulation, the nanospheres do not regulate the segregation of agriculture chemical active principles, but their small size improves the rate of penetration into the plant body compared to traditional solutions (10). In vivo tests on the larvae of the Egyptian cotton leafworm *Spodoptera littoralis* showed that the toxicity of novaluron nanoparticles is comparable to that of commercial preparations (16). The biological effects of nano-formulations and commercial formulations on two important soybean pests Soybean smut and Bemisia tabaci were tested respectively. Compared to commercial formulations, most imidacloprid controlled release (CR) formulations have better pest control. Aiming at the target pests, the amphiphilic polymer formulation of poly [poly (polyoxyethylene1000) oxy suberoyl] is superior to other CR formulations (3). Compared with commercial formulations and controls, some CR formulations have higher yields. In potato crops, the CR preparations of carbofuran and imidacloprid have excellent or equivalent control effects on the aphid Aphis gossypii and the leafhopper Amrasca biguttula biguttula Ishida. In any formula, carbofuran and imidacloprid residues in potato tubers and soil were not detected at harvest (28). Pheromones are naturally occurring volatile chemical pheromones that are used as biological control agents in an environmentally friendly manner. In the open garden, the pheromone fixed on the nanogel has high residual activity and excellent efficacy. According to reports, the use of pheromones for environmental management of fruit flies

can reduce pest populations. Methyl eugenol nanogel, 15 nano fertilizers and nano pesticides in crop improvement applications. Low molecular weight gelling agents, such as all-trans tris (p-phenylene vinylene) dialdoxime, are used to make pheromone 419. Nanogels provide stability in open environmental conditions, reduce evaporation, and allow long-term release of pheromones (9). This formula requires less frequent pheromone supplementation in the garden and can be easily handled and transported without refrigeration. This nano-pheromone also provides a simple sample method for capturing insects in mango and guava orchards. The Nanogel pheromone has been particularly successful in controlling the dorsal fruit fly (Bactrocera dorsalis), which is a common pest of many fruits, such as mango and guava (9).

IV. CONCLUSION

This chapter focuses on reducing fertiliser and pesticide consumption in the agriculture sector, as a result of lower energy consumption by manpower and higher machinery costs. Agriculture will be supported by nanotechnology-based products such as nanofertilizer and nanopesticide, which are both low-cost and high-efficiency. Furthermore, agricultural productivity and output would be zero without the help of soil nutrients and beneficial microbes, while soil-borne pathogens such as pests, bacteria, fungi, insects, and herbs would result in a loss of agriculture production. In addition, microbes-based nanomaterials produced from various heavy metals have the capacity to control plant microbial disease and promote plant health under asbiotic and biotic stress conditions. Farmers who are unaware of the application of nanoparticle-based products would benefit from this information.

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