

Nanoplatfoms for Plant Pathogenic Fungi Management

Kamel A. Abd-Elsalam*

Plant Pathology Research Institute, Agricultural Research Center, Egypt

Plant pathologists are striving to develop a successful solution for protecting food and agricultural products from bacteria, fungal and viral agents. New technology such as nanoscale platforms, biological sensors, miniature detection devices and nano sensors could play a significant role in the future pathogen detection and disease management. Nano grower-friendly methods need to be integrated into present practices, and be readily useable for protecting crops and avoiding crop loss to pests and disease.

A number of nanotechnologies can improve existing crop control protocols in the short to medium term [1]. The applications of nanomaterials to the agricultural are also commanding attention. Nanotechnology applications are being developed and present significant opportunities to more proficiently and un hazardously treat fungicides, herbicides and fertilizers, by controlling precisely when and where they are released [2]. For example, an eco-friendly fungicide is under development that uses nanomaterials to liberate its pathogen killing properties, only when it is inside the targeted pathogen [3]. Control of food crop diseases is essential. Recently, effort has been made to develop harmless management methods that pose fewer hazards to humans and animals, and have focused on overcoming lack of synthetic fungicides.

The antifungal effect of silver nanoparticles (NPs) has received only minor attention and with only a few published articles on this topic [4]. Since, silver displays various modes of inhibitory action to plant pathogens, it may be used for controlling various plant pathogens in a moderately safer way, compared to synthetic fungicides [5]. Silver nanoparticles have strong potential as an antimycotic activity against fungi of grey mold, *Botrytis cinerea* [6]. Kirby-Bauer disc diffusion protocol was used to evaluate the communal effect of fluconazole and silver nanoparticles for their antifungal activity against three fungal pathogens, *Phoma glomerata*, *Phoma herbarum*, and *Fusarium semitectum* [7]. Ag₂S nanocrystals on amorphous silica particles show antifungal activity against *A. niger*. The potential biocidal efficacy of ZnO and ZnTiO₃ nanopowders against the fungus *A. niger* was assessed [8]. ZnTiO₃ nanopowder showed higher growth inhibition efficiency than ZnO.

Silver ions and nanoparticles were evaluated to determine the antifungal action on *Bipolaris sorokiniana* and *Magnaporthe grisea*. The *in vitro* and *in vivo* evaluations of both silver ions and nanoparticles decrease disease development of phytopathogenic fungi [9]. Min et al. [10] evaluated the antifungal effects of silver nanoparticles, especially on sclerotia forming phytopathogenic fungi. The antifungal activity of silver nanoparticles assessed against filamentous ambrosia fungi in South Korea [11]. The effect of silver nanoparticles on plant pathogenic spores of *Fusarium culmorum* was studied by Kasprowicz et al. [12]. The silver nanoparticles also found to exhibit antifungal activity against *Fusarium oxysporum* [13]. Silver nanoparticles strikingly decreased the number of germinating fragments and sprout length, relative to the control. Zinc oxide nanoparticles inhibited the fungal growth of *Botrytis cinerea* by influencing cellular functions, which caused deformation in mycelial mats. In addition, Zinc oxide NPs inhibited the growth of conidiophores and conidia of *Penicillium expansum*, which finally led to the death of fungal mats. The mycosynthesized silver nanoparticles

may be non-toxic to people and animals, than synthetic fungicides. Moreover, in addition to the toxicity that nanoparticles may cause on algae, plants and fungi, they may also have some positive effects.

The antifungal activity of the silver nanoparticles was evaluated on the phytopathogen *Colletotrichum gloeosporioides*, which is responsible for anthracnose in a wide range of fruits. Silver nanoparticles significantly reduced the mycelia growth of *Colletotrichum gloeosporioides* in a dose-dependent manner [14]. Antifungal properties of silver nanoparticles, silver ions, acrylate paint and cotton fabric impregnated with silver nanoparticles were assessed against *A. niger*, *Aureobasidium pullulans* and *Penicillium phoeniceum* [15]. Bioassay of elemental and nano-sulphur against *Aspergillus niger* showed that nanosulfur was more efficient than its elemental structure [3].

Smart delivery system has a huge potential for improving efficiency of fungicides in agriculture systems. Development of these technologies in plant protection would allow their use in crop protection [16].

Different concentrations of nanosized silica-silver were evaluated for growth inhibition of phytopathogenic bacteria and fungi; and it was found that 100% growth inhibition of *Pseudomonas syringae* and *Xanthomonas compestris* pv. *vesicatoria* occurred at 100 ppm. *Magnaporthe grisea*, *Botrytis cinerea*, *Colletotrichum gloeosporioides*, *Pythium ultimum*, and *Rhizoctonia solani*, showed 100% growth inhibition at 10 ppm of the nanosized silica-silver [5]. Antimycotic activity of some nanoparticles of silver has also been reported on some fungi like wood rotting fungi, *Fusarium* species and other phytopathogenic fungi [17].

Nano-dispersed formulations can be prepared in a simple cost-effective manner, and are suited for developing new forms of fungicidal materials. There are some records of the nano-sized or nano-formulation for agrochemicals development of existing pesticides, fungicides, plant, soil and seed treatments. Syngenta's Banner MAXX™ is a systemic fungicide offering broad-spectrum disease control in turf and ornamental plants. It is commercialized as a micro emulsion concentrate formulation, providing excellent tank mix compatibility and stability.

Resistance in plants would help in management of above mentioned agents to overcome the problem of economic loss. Nanoparticles mediated plant transformation has the potential for genetic modification of plants for further improvement. In particular, application of nanoparticles technology in agriculture targets specific

*Corresponding author: Kamel A. Abd-Elsalam, Plant Pathology Research Institute, Agricultural Research Center, Egypt, E-mail: abd-elsalam.k.a@post.com

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problems in plant protection, pathogen detection, plant-pathogen interactions and offers new methods for plant disease management [18]. For example, introduction of resistance genes in plant cells using nanotechnological approaches may lead to development of resistant varieties, which will minimize expenses on agrochemicals required for disease control. Presently, research is being carried out by using nanosensors to improve pathogen detection methods and plant disease forecasting in crop systems. Nanosensors can be linked to a GPS system for real-time monitoring of disease, and distributed throughout the field to monitor soil conditions and crop health [19]. Nano-Phytopathology can be applied as a tool to understand plant-pathogen interactions, which will provide new methods for crop protection.

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