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Editorial

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Control of *Fusarium* wilt of tomato in the greenhouse using silver nanofungicides

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Introduction

Tomato (*Solanum lycopersicum*) is considered as one of the most economically important vegetable crops in the world. Its production is about 130 million tons, of which 88 million are specified for the fresh markets whereas, 42 million are processed (Anonymous, 2016). *Fusarium oxysporum* f. sp. *lycopersici* causes a highly destructive vascular wilt disease of tomato leading to significant crop losses in the field and in protected tomatoes, thus remains as one of the main limiting factors for production of this crop (McGovern, 2015).

Control of infectious plant diseases is the most important concern of crop production. However, resistance of phytopathogenic fungi to synthetic fungicides must be considered. According to Bouwmeester *et al*., (2009), the use of new mechanisms for plant disease control is basically required, however, recent development of nanopesticides can help to control many plant diseases. Sekhon, (2014); Ahmed and Lee, (2015) later added that the use of nanoparticles (NP) is considered as a promising alternative way to control phytopathogens. In a previous study, Jo *et al*., (2009), explained that multiple mechanisms of actions of these NP targeting mainly on several biological pathways in microbial cells, provide a novel solution for avoiding development of pathogen resistance that was observed on using chemical control of most plant diseases. Application of silver and gold NP in particular elicited beneficial results on different crop plants with low and/or no phytotoxicity (Muthuramalingam *et al*., 2015).

In reference to Quester *et al*., (2013), different types of microbes such as bacteria, yeast and mold fungi have shown high capabilities for biosynthesising several NP as silver, gold, and palladium. Mold fungi such as *Aspergillus niger* (Gade *et al*., 2008), *Epicoccum nigrum* (Qian *et al*., 2013) and *Chaetomium globosum* (Madbouly *et al*., 2017) showed high potency for producing AgNPs.

AgNPs can efficiently penetrate into the microbial cells as well as low concentrations of these NP would be sufficient for microbial control (Samuel and Guggenbichler, 2004). Moreover, AgNPs showed lower toxicity to humans and animals compared with synthetic fungicides (Elamawi and El-Shafey, 2013).

In a recent study of Madbouly *et al*., (2017), AgNPs showed pronounced efficacy to cause *in vitro* inhibition of the growth of *F. oxysporum* on three types of cultivation media i.e. Potato dextrose agar

(PDA), Malt extract agar (MEA) and Corn meal agar (CMA), however, its potency was recorded more on PDA medium. In addition, AgNPs caused *in vivo* reduction in the severity of wilt disease of tomato in the greenhouse by 90%. This was detected through reducing the number of wilted seedlings especially after placing their roots in a suspension of 500 mg/l of AgNPs for 4 h prior to infestation of soil with pathogenic *F. oxysporum*, compared with soil treated with the pathogen only.

Moreover, application of AgNPs under the same conditions caused significant promotion of the growth parameters of the tomato seedlings such as; root, shoot fresh weight, and height of seedlings in soil infested with *F. oxysporum*, compared with positive control soil treated with Carboxin–Thiram fungicide, and negative control soil treated with the pathogen only without AgNPs or fungicide. This antifungal potential increased with increasing the corresponding concentration and incubation periods of AgNPs. Results obtained were similar to those observed on application of the chemical fungicide in the positive control soil.

The *in vivo* antifungal potency of applied AgNPs could be ascribed to the shielding effects of these NP around the seedlings roots which acted thus as a barrier to prevent entrance of the pathogen and subsequent development of wilt symptoms. This efficacy was enhanced by increasing the incubation period of AgNPs with the seedlings root, because longer incubation caused complete saturation of the roots with these NP thus better shielding effect, consequently leading to pronounced control of wilt disease (Madbouly *et al*., 2017).

Similarly in a previous study, Kim *et al*., (2012) reported that inhibition of mycopathogens at significant concentrations of AgNPs might be ascribed to the high density of this NP solution, thus became able to saturate and cohere to the fungal hyphae leading to deactivation of these mycopathogens. In a later study on wheat seedlings, Mishra *et al*., (2014) confirmed that treatment of these seedlings with AgNPs prior to infestation with the mycopathogen enhanced their lignification thus acting as a hindrance against pathogen infection. However, lesser lignification was observed in wheat seedlings treated with the mycopathogen only, thus favored its pathogenecity.

Recently in agricultural industry, engineered NP serves as ‘‘nano carriers” which carry herbicides or genes that target a certain parts of the plant to release their contents (Zakaria *et al*., 2015). According to Thangavelu *et al*., (2018), nowadays nano-scientists build a concept of AgNPs acting as ‘‘nanobullets” which act for dual mechanism such as root enhancer and pathogen killer on the targeted site.

Conclusively, AgNPs could be formulated into a simple, economic and available formula to be applied on a wide scale in the fields of crops to antagonise the different pathogens, and also to promote the growth of these crop plants. These formulated AgNPs may thus act as effective nanofungicides, so we could displace using the health hazard, expensive, and non-ecofriendly synthetic fungicides.

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