Expanding the horizons of Nanoscience in protection of horticultural crops

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Introduction

A significant reduction of horticultural production cause by pests and disease, with an estimated global loss of 20 to 40 percent. To address the emerging challenges of sustainable horticultural production and notational secularity a significant technological advancement and innovation have been noticed in recent years. Presently crop protection heavily relies on the application of pesticides such chemical emerging as a threat to the environment as it contaminates almost all the components of nature, kill non-targeted and friendly organisms. In many cases, insects and pathogens developed the resistance against such chemicals. Furthermore, it is estimated that only 0.1% of applied pesticides reach the targeted pest and rest 99.9% lost during or after the application (Carriger et al., 2006). So there is an increased motivation to develop some alternative, effective, non-polluting, eco-friendly crop protection technology. Nanoscience and technology have the potential to provide an effective solution for this concern. Nanoparticles (NPs) are organic in organic or a hybrid material having at least one of their dimensions between 1 to 100 mn. Such particles are very effective than their parent bulk material due to their size. The surface area is also very high for NPs, make the very active. The physicochemical properties of NPs are also different from their parent bulk material and needed a minute quaintly to use. Top-down and bottom-up are the two major approaches for the synthesis of NPs. Chemical, biological and physical synthesis are the major techniques for the synthesis of NPs. Recently, the popularity of NPs are rising due to cost-effective green synthesis technique though it has its own limitations. Nanoparticles (NPs) are being used in various way to manage the pest and diseases such as a protectant, carriers etc.

Nanoparticle for disease management

Various NPs such as AgNPs, ZnNPs, MWCNTs, FeNPs, CuNps, TiNPs, SiNPs, AlNPs, MgNPs are strong agent different plant pathogenic organisms. AgNPs are effective against number of pathogen like *Alternaria alternata, Alternaria porri, Sclerotinias clerotiorum, Macrophomina phaseolina, Rhizoctonia solani and Botrytis cinerea* (Das and Deb, 2017; Jo et al., 2009). AgNPs act on the DNA of cell and disrupt leads to the death of the organisms. ZnNPs and CuNPs are effective against *B. cinerea* and soil borne diseases. AlNPs found very effective against *Fusarium* root rot in tomato. Yet there is no economical way to manage the plant virus disease. But it has been reported that AgNPs and Chitosan developed the viral resistance in plant. Chitosan NPs induce viral resistance in potato and cucumber mosaic resistance which open a new dimension of plant virology. Recently, DNA directed silver nanoparticles on grapheneoxide (Ag@dsDNA @GO) was tested against *Xanthomonas perforansl,* cause bacterial leaf spot on tomato and show excellent antibacterial property at a very low concentration (16 ppm) (Ismail et al, 2013).

Nanoparticle	Concent-ration used	Targeted pathogen
AgNPs	50–100 µg/ml	*Xanthomonas axonopodis pv. malvacearum X. campestris pv. campestris, Alternaria porri* and *Alternaria alternata*.
CuNPSs	150–340 µg/ml	*Phytophthora infestans*
MgNPs	7–10 µg/ml	*Ralstonia solanacearum*
AlNPs	400 µg/ml	Controlled *Fusarium* root rot in tomato
TiNPs	100-500 µg/ml	*Alternaria* salina

Table 1: Effective concentration of different NPs to manage plant pathogens.

Nanoparticle for insect pest management

Insecticides are the second most heavily consumed agrochemicals after herbicide. Still, it is a challenge to manage insect pests effectively. Climate change is also encouraging the incest population by shortening the breeding time and also helping minor pest to become a major one. To address such challenges new and advanced technology is on-demand. NPs are also found effective to manage potential insects. Chitosan nano-formulation has the potential to manage many insect pests like *Aphis nerii*, *Spodoptera littoralis*, *Meloidogyne javanica*, and *Cacopsylla pyricola*. Nano formulation of hexanal found promising to manage mango fruit fly.

Nanoparticle as a carries

NPs are getting popularities as a carrier to entrap, encapsulate, absorb or attach active molecules. Most of the pesticides react with UV light and degenerate. Porous hollow silica nanoparticles (PHSNs) hold the active ingredient in its inner core, protect it from UV and provide a sustained release. Hybride Chitosan-NPs use efficiency is much higher than bulk formulation as Hybride Chitosan-NPs adheres well to the epidermis result to prolong and batter uptake of the bioactive molecules. Similarly, Layered double hydroxides (LDHs) and Solid lipid nanoparticles (SLNs) are used as a carrier for many of the molecules (Elizabeth et al., 2018).

The discovery of the RNAi technology has heralded a new approach to pest management. This technique is successfully demonstrated in many of the commercial crops. However, GMOs are highly controversial, so dsRNA delivery technique is being untaken. But it has a major limitation such as short longevity due to environmental degradation. A significant breakthrough was achieved when dsRNA loaded onto LDH nanoparticle (LDHNPs). This dsRND-LDHNPs hybrid was long longevity and successfully used to against cucmber mosic virus (CMV) and pepper mild mottle virus (PMMOV) (Mitter et al., 2017).

Conclusion

The *agri-nanotechnology* has immense potential and opportunity to contribute to the field the crop protection but this technology in its primary stage. Material scientists and the Agriculturists need to work closely to bring a deeper understanding of the bio-nano complex. The present achievements of nanoscience in this field indicate that the multidisciplinary and collaborative research will provide a concrete platform to bring nanoscience for the plant protection a reality.

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