


Chapter 12


Field Application Approaches: Foliar Sprays, Soil Additives, and Seed Treatments

Zakir Ullah

 <https://orcid.org/0000-0002-1819-5753>

University of Bradford, UK

Sidra Shafqat

 <https://orcid.org/0009-0009-2243-2051>

University of Peshawar, Pakistan

Ghaida Mustafa

University of Bradford, UK

Sajid Ali

Bacha Khan University, Pakistan

ABSTRACT

Plant viral diseases represent a major global threat to food security, necessitating the development and implementation of innovative, effective, and sustainable management strategies. Nanoparticles (NPs) have become a significant candidate to plant viral disease management using several application methods. Among them, foliar spray is the most practical approach since it allows the direct interaction of NPs with the plant surfaces along with systematic translocation, Soil amendment strategies utilize the soil matrix as a NPs reservoir, and Nanoprimering of seeds is not only a protective seedling way of management but also a more proactive method of seedling management. The present research outlines the potential of the future based on NPs-based strategies as a potential solution to the challenge of plant viral pathogens management. These treatments enforce plant defense and improve the absorption of nutrients. Future studies should focus on the customizable delivery mechanisms, and the traditional management strategies to define their efficacy and survival in crop protection.

DOI: 10.4018/979-8-3373-4913-8.ch012

1. INTRODUCTION

Agricultural crops are highly susceptible to a wide range of biotic and abiotic stresses (Bibi et al., 2025). Abiotic stresses include drought, temperature extremes, salinity, water logging, and heavy metal stress while biotic stresses comprise of bacterial, fungal, and viral infections, as well as insect pests. Abiotic stresses alone can cause losses of 20–50% of crop yields annually, with drought potentially reducing yields by over 50% in some regions (Rahman et al., 2022). Plant viruses are particularly significant among biotic stresses, accounting for over 47% of crop losses and thus substantially reducing agricultural productivity (Dutta et al., 2022). Viral infections cause over 50 percent of crops disease losses in developing countries, underscoring the fact that there is a dire need to develop effective management approaches (Rahman et al., 2022). Plant viruses are particularly difficult to manage due to their inevitable nature and regular transmission through insect vectors (Gul et al., 2025). Plants deal with the stress using intricate physiological and molecular responses, such as hormonal signalling (e.g., abscisic acid), metabolic modifications and the production of protective substances. Growth, photosynthesis, susceptibility to pathogens, and product quality are affected by these responses (Dutta et al., 2022). Different strategies have been discussed to alleviate such pressures; they include, crop breeding, biotechnology (genetic engineering and genetic editing), bio-stimulants, precision agriculture, and nanotechnology (Rahman et al., 2022).

Over the last few years, nanotechnology has become a viable solution towards enhancing the health of plants, especially in diagnosis, prevention and infection to the viral conditions (Mittal et al., 2020). Nanophytovirology in plant is broadly explained as disease diagnostics, therapeutic delivery, inactivation of plant defense systems, genetic transformation, and bio-stimulation (Rahman et al., 2022). Nanotechnology is the method of designing, preparing, and using materials and machines at the nanoscale, which is less than 100 nanometers (Ullah et al., 2023; Ullah et al., 2024). NPs have a high surface area-to-volume ratio that can volatilize their reactivity relative to bulk counterpart (Ullah et al., 2025). This characteristic allows active compounds with extended protection capabilities to be delivered more effectively and with greater specificity (Dutta et al., 2022).

The growing world population, coupled with rising food demand, also stresses the importance of efficient and sustainable food farming solutions (Ullah et al., 2025b). Interferences based on NPs can achieve this by enhancing the prospects of controlling the disease, cutting issued dependence on chemical pesticides, and growing more crops (Mittal et al., 2020). NPs act either as autonomous protectants, or as vectors of pesticides or RNA interference (RNAi) molecules, to provide high-specificity delivery of active functionalities (Ullah et al., 2024). NPs are also powerful bio-stimulants or biosensors to identify plant viruses at great accuracy (Awasthi et al., 2025). Metallic and non-metallic NPs (silver (Ag), copper (Cu), zinc oxide (ZnO), gold (Au), titanium oxide (TiO) and Iron oxide (FeO), have shown to possess antibacterial, antifungal, and antiviral properties and have been successful against pathogenic agents like potato virus Y (PVY), cucumber mosaic virus (CMV) and bean yellow mosaic virus (BYMV) (Ahmad et al., 2022).

NPs which are used in field applications are usually applied as a foliar spray, soil additive, or seed treatment, increasing NPs intake, boosting the delivery of the active compounds in these applications, and offering shield against viral diseases (Awasthi et al., 2025). Nano-encapsulation may also increase the effectiveness of pest management and minimize off-target, and achievement of sustainable agriculture (Mittal et al., 2020). Though there is increasing evidence on the potential of engineered nanomaterials in plant pathogen combating there is an evident lack of research that specifically looks at the antiviral

24 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/field-application-approaches/399425

Related Content

Preparation of a Uranium Conversion Plant's Nuclear Waste for Final Disposal by Means of Magnetically Assisted Chemical Separation

Ahad Ghaemi, Mehdi Maghsudi, Fatemeh Hanifpourand Mohammad Samadfam (2014). *Nanotechnology: Concepts, Methodologies, Tools, and Applications* (pp. 1483-1493).

www.irma-international.org/chapter/preparation-of-a-uranium-conversion-plants-nuclear-waste-for-final-disposal-by-means-of-magnetically-assisted-chemical-separation/102080

Towards the Sixth Kondratieff Cycle of Nano Revolution

Jarunee Wonglimpiyarat (2011). *International Journal of Nanotechnology and Molecular Computation* (pp. 65-77).

www.irma-international.org/article/towards-the-sixth-kondratieff-cycle-of-nano-revolution/104148

Synthesis and Characterization of Mullites From Silicoaluminous Fly Ash Waste

Virendra K. Yadav, Pallavi Saxena, Chagan Lal, Govindhan Gnanamoorthy, Nisha Choudhary, Bijendra Singh, Neha Tavker, Haresh Kalasariyaand Pankaj Kumar (2020). *International Journal of Applied Nanotechnology Research* (pp. 10-25).

www.irma-international.org/article/synthesis-and-characterization-of-mullites-from-silicoaluminous-fly-ash-waste/273614

Recent Advancements in Photocatalytic Nanocomposites

Aruni Shajkumarand Ananthakumar Ramadoss (2021). *Research Anthology on Synthesis, Characterization, and Applications of Nanomaterials* (pp. 952-972).

www.irma-international.org/chapter/recent-advancements-in-photocatalytic-nanocomposites/279181

Designing Biomedical Stents for Vascular Therapy: Current Perspectives and Future Promises

Arghya Paul (2014). *Nanotechnology: Concepts, Methodologies, Tools, and Applications* (pp. 972-996).

www.irma-international.org/chapter/designing-biomedical-stents-for-vascular-therapy/102052