Mycoviruses: Nature's Fungus-Fighting Allies

Dumpapenchala Vijayreddy
M.Sc. Agriculture, Plant Pathology, School of Crop Protection, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya-793103, India.
*Corresponding Author: dpvijayreddy@gmail.com

Mycoviruses are a special class of viruses that have drawn interest from researchers because of their fascinating nature and possible usefulness. The word "mycovirus" comes from the word "myco" which means "fungus" signifying that these viruses only infect fungi (Mastigomycota, Zygomycota, Ascomycota and Basidiomycota). Mycoviruses have evolved to form symbiotic or antagonistic relationships with a variety of fungal hosts, unlike viruses that infect mammals or plants.

Based on the type of genome, the International Committee on Virus Taxonomy (ICTV) now classifies mycoviruses into 23 families and 1 unclassified genus. In terms of their genetic makeup and manner of operation, mycoviruses are different. Their sizes range greatly and they can have genomes made of single-stranded RNA (ss RNA) or double-stranded RNA (ds RNA). While some mycoviruses cause disease and impair their fungal hosts, others have been shown to have positive effects (Abdoulaye *et al.*, 2019).

Unveiling Nature's Specialized Fungus Viruses

Mycoviruses are a specialised niche within the fields of virology and mycology. When compared to viruses that infect other organisms, these viruses have adapted to flourish in the specific environment of fungi, which poses significant difficulties and opportunities. Understanding how mycoviruses interact with fungal hosts, particularly how they enter, multiply and propagate within fungal cells, is key to unravelling their secrets. Researchers are eager to learn more about the mechanisms underlying these interactions because they may hold the key to novel methods to disease control, biotechnology and ecology.

Surprisingly, some mycoviruses can form mutualistic interactions with fungi, assisting in nutrition acquisition or stress tolerance. Others, on the other hand, act as pathogens, causing illnesses in economically and environmentally significant fungi. The scientific community acquire insights into the delicate balance between viruses and their fungal hosts by investigating mycoviruses, giving light on the larger principles of virus-host interactions in the natural world.

Mycoviruses play an important role in disease control in a variety of ecosystems, particularly agriculture and forestry. Because of their potential to resist fungal infections that can ruin crops and forests, they are considered natural fungicide alternatives. Mycoviruses, as opposed to chemical fungicides, provide an environmentally benign and sustainable alternative to disease treatment.

Role of Mycoviruses in Disease Control

When a mycovirus infects a pathogenic fungus, it can disturb the fungus normal functioning in many ways. Some mycoviruses, for example, can disrupt the fungal pathogens reproduction, decreasing its ability to create spores or infect new hosts. Others can inhibit pathogen development and metabolism, rendering it less virulent. This weakening effect is known as "hypovirulence."

Cryphonectria hypovirus 1 (CHV1) is one of the most intriguing instances of a mycovirus that can be employed to control disease. CHV1 induces hypovirulence in its fungal host, *Cryphonectria parasitica*, which causes chestnut blight. Chestnut blight is a deadly disease that has wiped out billions of American chestnut trees. CHV1 can be transmitted to other *C. parasitica* individuals by hyphal anastomosis or the union of hyphae from separate fungal individuals.

In some places, CHV1 has been used successfully to control chestnut blight. In Italy, for example, CHV1 has been employed to rehabilitate disease-ravaged chestnut woods. In the United States, CHV1 is also used to control chestnut blight (Romon-Ochoa *et al.*, 2023).

Other mycoviruses that have been shown to have potential for disease control include:

- *Sclerotinia sclerotiorum* hypovirus 1 (SsHV1): SsHV1 causes hypovirulence in its fungal host, *Sclerotinia sclerotiorum*, which is a fungus that causes a variety of plant diseases, including white mold and sclerotinia stem rot (Longkumer, and Ahmad, 2020).
- *Rosellinia necatrix* hypovirus 1 (RnHV1): RnHV1 causes hypovirulence in its fungal host, *Rosellinia necatrix*, which is a fungus that causes white root rot of avocado trees (Chiba *et al.*, 2009).
- *Ophiostoma novo-ulmi* hypovirus 1 (OnHV1): OnHV1 causes hypovirulence in its fungal host, *Ophiostoma novo-ulmi*, which is a fungus that causes Dutch elm disease (Kotta-Loizou, 2021).

Biotechnological potential of Mycoviruses

Mycoviruses are a fast expanding topic of research with important implications for a variety of industries and scientific advances. They provide distinct advantages for a wide range of biotechnological applications including as genetic engineering tools, enzyme manufacturing, medicines and biological control. Mycoviruses have the ability to insert or change genes in fungal hosts, increasing productivity in industries such as biofuel manufacturing. They can also boost fungal enzyme synthesis, making them more efficient and cost-effective enzyme suppliers. Fungi are also a source of bioactive substances such as antibiotics and medicines, which mycoviruses can alter to boost production or develop new bioactive molecules with therapeutic promise. Mycoviruses can be utilised as biopesticides against fungal infections in agriculture, lowering their virulence and reducing the demand for chemical fungicides.

Utilising mycoviruses in biotechnology has implications for sustainable production, economic gains, scientific innovation and disease management. Mycoviruses can eliminate the need for resource-intensive and polluting alternatives by increasing the efficiency of fungi in industrial applications (Larios *et al.*, 2023). Mycoviruses also provide a unique platform for investigating virus-host interactions, evolution and genetic modification, all of which contribute to our understanding of fundamental biological processes.

Insights into Mycoviruses evolution

Although mycoviruses only infect fungus, they provide a unique perspective on virus evolution. They have a high level of genetic variety, with different lineages exhibiting distinct traits. Mycoviruses have evolved to take advantage of many characteristics of fungal biology, such as their cellular machinery and life cycles. They are susceptible to intense selective pressures imposed by their fungal hosts, forcing them to change in order to avoid or counter these defences. Mycoviruses coevolutionary association with their fungal hosts provides useful insights into wider aspects of viral evolution and host-pathogen relationships. An continual arms race, genetic adaptability, and horizontal gene transfer are all examples of this. Mycoviruses have the ability to undergo fast genetic alterations, allowing them to adapt to different environments and host defences. Horizontal gene transfer affects fungal evolution and adaptation (Sato and Suzuki, 2023).

Understanding the dynamics of fungal ecosystems requires a knowledge of mycovirus-fungus coevolution because interactions between these viruses and their hosts can affect the population structures, competitive dynamics and nutrient cycles of the fungi they infect. Strategies for controlling fungal diseases in forestry, agriculture and natural ecosystems can be influenced by the knowledge acquired from studying mycovirus-fungus coevolution. Researchers can create ground-breaking strategies for disease control by better understanding how mycoviruses interact with their fungus hosts. Mycovirus evolution offers a special viewpoint on the coevolutionary dynamics between viruses and their hosts, with applications in virology and ecological management, among other areas.

Applications in Agriculture and Forestry

Mycoviruses have demonstrated potential in forestry and agriculture, providing creative methods for controlling fungi that pose a threat to crop growth. These viruses have the potential to replace chemical fungicides by acting as natural biological control agents against fungi that cause disease by lowering the frequency and severity of disease. Mycovirus-based disease management supports healthier and more resilient agricultural ecosystems and is consistent with sustainable agriculture concepts (Xie and Jiang, 2014).

In areas with a high reliance on agriculture, mycovirus techniques can also help lower yield losses in crops like wheat, rice and maize, boosting food security and economic stability. Mycovirus research in forestry is essential for maintaining forests and lessening the effects of fatal fungal infections. Mycoviruses, for instance, can be used to manage Dutch elm disease and the emerald ash borer, which both infect the fungus *Ophiostoma ulmi* (Adalia *et al.*, 2016).

By controlling fungal infections and preserving biodiversity, mycovirus research supports the maintenance of forest health. By shielding tree species from fungi, mycovirus-based techniques can also help sustainably produce lumber by maintaining a steady supply of high-quality wood products.

Challenges and Future Directions

Mycovirology is a growing discipline, however there are still many unanswered problems and challenges. These include mycovirus diversity across fungal species, transmission methods, coexistence tactics and the evolutionary dynamics of mycoviruses and fungi. Mycoviruses have a practical application in biotechnology and disease management, but it faces obstacles relating to delivery techniques, scalability and regulatory approval.

Despite these obstacles, mycovirology has a bright future thanks to new discoveries, biotechnology advances, ecological insights, disease management breakthroughs and fundamental virology. The research will identify novel mycoviruses with distinct features and possible applications, contributing to a better understanding of virus-fungus interactions. Biotechnology and genetic engineering advances will allow for more precise manipulation of mycoviruses and their fungal hosts, opening up new avenues for biotechnological applications.

Mycovirus research will provide light on nutrient cycling, fungal community dynamics and ecosystem health by providing greater insights into the role of viruses in fungal environments. Disease management technologies in agriculture and forestry have the potential to transform disease management practises, lowering dependency on chemical treatments and increasing sustainability.

Conclusion

Mycoviruses emerge as inconspicuous allies in nature's rich tapestry, acting behind the scenes to battle fungal threats. Mycoviruses, as specialised agents that only infect fungi, have opened up a new universe of possibilities and discoveries. They provide natural disease management alternatives in agriculture, lowering our dependency on chemical fungicides and supporting sustainable practises. Mycoviruses biotechnological potential opens the door to novel solutions in genetic engineering, enzyme synthesis and medicines. Their importance in moulding fungal ecosystems and nutrient cycle dynamics is highlighted by their function in ecological processes. Mycoviruses also provide an interesting look at virus evolution and virus-host interactions. In a world plagued by fungal infections and environmental degradation, mycoviruses serve as collaborators in fungus-fighting strategies, providing hope for a healthier, more robust future.

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