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Issue Article

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PLANT DISEASES UNDER BIOLOGICAL CONTROL

***Abstract**: Plant diseases caused by infectious viruses have had a significant impact on human society and the environment, causing significant losses in food supply, economic growth, and ecological resilience. The Irish famine and the Bengali famine were caused by rice brown spot and potato late blight pathogens, while Dutch elm disease and chestnut blight caused devastating pandemics in North America and Europe. These diseases can cause annual yield losses of 13% to 22%, and billions of dollars in losses in staple crops. Biological control strategies, such as crop diversification and field hygiene, have been to control interactions between plants, pathogens, and the environment. Host resistance is a practical and environmentally beneficial plant disease control strategy, as it involves the release of effector proteins by pathogens that cause resistant responses in plants. Biological control, which originated in world 4,000 years ago, has evolved into numerous biological control mechanisms, including plant inducers, microbial metabolites, beneficial microbes, and plant extracts in crop diversification.*

***Key words**: plant diseases, biological control, resistance, developed, pathogens, environment.*
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Introduction

Throughout human history, plant diseases produced by infectious viruses have had a significant negative impact on both human society and the environment by harming natural landscapes, food supply, economic growth, and ecological resilience. Millions of people died and entire families and social structures were uprooted during the Irish famine, which was brought on by the rice brown spot pathogen Bipolaris oryzae (Breda de Haan) Shoemaker, and the Bengali famine, which was brought on by the potato late blight pathogen Phytophthora infestans (Mont.) de Bary. A significant amount of primary and secondary forestry in North America and Europe was devastated by the pandemics of Dutch elm disease (Ophiostoma novo-ulmi (Buism.) Nann. and chestnut blight (Cryphonectria parasitica (Murrill) Barr, which resulted in an ecological catastrophe in the affected areas. One of the biggest threats to society's ability to develop sustainably is plant diseases, which can affect the entire chain of crop production. They can cause annual yield losses of 13% to 22%, or billions of US dollars' worth of losses in staples like rice, wheat, maize, and potatoes, in addition to additional expenses for management strategy development and education. The estimated 800 million individuals who are starving or undernourished worldwide, according to recent estimates, can be at least partially explained by these biological and economic losses.

Plants, pathogens, and the environment interact intricately to cause lant illnesses. Over the lengthy history of agriculture, people have created a number of strategies to control interactions in order to create a system that is favorable to host plant growth and development but less than ideal for pathogen establishment, reproduction, and spread. These control strategies can be agronomic (such as crop diversification and field hygiene), regulative (such as quarantine and eradication), genetic (such as disease resistance and tolerance), physical (such as soil solarization and flooding), and chemical (such as pesticides and host-immunity inducer). They can be used singly or in combination (integrated disease management, IDM) to suppress the causative pathogen, promote host immunity, or alter the biotic and abiotic environment where host-pathogen interaction occurs.

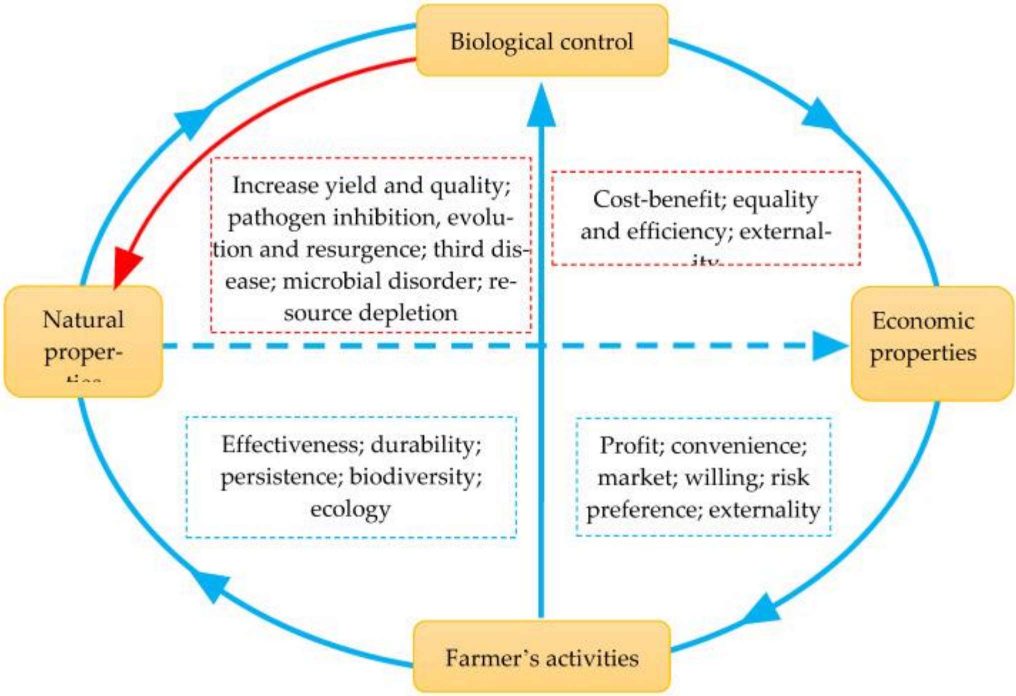

Figure 1. A diagram showing the interconnection of natural and economic properties of farmer adoption for biological control. Biological control of plant diseases can generate multifaced effects, including natural (e.g., pathogen inhibition, evolution, the third-party epidemics, nutrient supply, plant growth support, and resistance against biotic and abiotic stresses, saving yield and quality) and economic (e.g., cost, efficiency, benefit, externality) properties. In turn, these properties, particularly economic profit, convenience, and supply–demand market of technology and products, determine the choice of farmers in using biological control and other agricultural practices through the adaptation of their willingness, risk preferences, and expectations. (Dun-Chun He)

Host resistance is one of the most practical and environmentally beneficial plant disease control strategies available. A small set of proteins (called effectors) released by pathogens that were recognized by the corresponding receptor proteins made by host resistance genes cause resistant responses in plants in vertical resistance mediated by gene-for-gene interaction, as in the potato (P. infestans) and wheat (Puccinia triticina Eriks) systems. The infections' ongoing evolution allows for easy evasion of this total resistance, which causes resistant kinds to break down quickly once they are made available for commercial use.

Types and Mechanisms of Biological Control.

The idea of biological control, a potentially effective strategy for managing plant diseases, originated in Egypt some 4,000 years ago. But it wasn't until the nineteenth century that biological control became the subject of sophisticated research. The investigation into the use of BCAs to treat plant diseases was sparked by the finding that Bacillus subtilis (Ehrenberg) Cohn, Ampelomyces quisqualis Ces, and other antagonistic microbes reduced the severity of various soil-borne diseases. Since then, there has been a revolution in the study of biological regulation. Numerous BCAs have been created, including as the use of plant inducers, microbial metabolites, beneficial microbes, and plant extracts in crop diversification. As will be covered in more detail below, these BCAs fall into three groups based on how they work.

Certain microorganisms are hyperparasites that use antibiosis to kill pathogens directly, or they may depend on pathogens for their energy sources or habitats. Other microbes may act as rivals for nutrients and niches by secreting chemicals or antimicrobials. These characteristics are shared by some mycoviruses, bacteriophages, and fungus. Based on their biological characteristics and conditions, they may be BCAs enhanced against plant diseases and sprayed in fields once or several times. Without coming into direct touch with pathogens, several advantageous microorganisms work with plants to promote host immunity or develop host resistance. Plant extracts, microbial metabolites, synthetic chemicals, and gene products are a few examples of the natural products and chemical substances that fall under this category. Many chemicals, including nitric oxide, salicylic acid, and acetylsalicylic acid, as well as secondary metabolites involved in signal transduction, have characteristics that promote host resistance and stimulate host plant immunity. An unbalanced environment is frequently the cause of plant disease. The presence of competitors, promoters, predators, and other healthy species in an environment is necessary for biological management to be effective. The genetics, makeup, and structure of the surrounding plant and microbial communities determine the spatiotemporal dynamics of these beneficial species in agricultural areas. The healthy interactions between the microbiome and other soil community organisms are especially crucial for preserving the ecology that supports plant growth and immune development. Methanotrophs that cohabit with Hyphomicrobium spp. to form a rhizospheric microbial association—in which H. spp. can enhance efficient nutrient consumption and eliminate toxic methanol from the rhizosphere—can be suppressed by methanol.

Concluding Remarks

Historically, the use of pesticides, the introduction of resistant genes, and other methods have been used to meet the desire for high agricultural yields. But these methods' overall benefits have been called into question because of their long-term efficacy or ecological effects. Biological management seems to be one of the most promising methods among the possibilities for environmentally friendly and sustainable agriculture to preserve food and crop plants. However, there is not enough data available at this time to conclude that the use of biological control could enhance agricultural productivity and disease management in a way that is more convenient, profitable, and efficient. Biological control techniques must be technologically feasible and economically appealing for farmers to use. Education, policy support, and the provision of practical and inexpensive BCAs are all desperately needed. Complex interactions between crop plants, pathogens, BCAs, and physical environments can result in biological invasion, endangering the local ecosystem and raising the possibility that, if applied in a single, static way over an extended period of time, the efficacy of biological control techniques will be eroded or completely lost. This emphasizes how crucial it is to use the ecological evolutionary principle in concert with other assessment methods to jointly assess the effectiveness, efficiency, robustness, and environmental safety of biological control. In order to comprehend the ecological tolerance, societal acceptance, and financial accessibility of biological control techniques, efforts should be made to develop conceptual frameworks.

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