Procedure International Journal of Science and Technology

(International Open Access, Peer-reviewed & Refereed Journal)

(Multidisciplinary, Monthly, Multilanguage)

ISSN : 2584-2617 (Online)

Volume- 1, Issue- 2, January 2024

Website- www.pijst.com

Infectious Plant Diseases and Their Control

Dr. Dharmendra Singh

Assistant Professor, Department of Zoology, S.P.P.G College Shohratgarh, Siddharthnagar, UP, Email id- dharmendra.spdc@gmail.com

Abstract-

In managing plant diseases, biological control is seen to be a possible substitute for pesticides and plant resistance; nevertheless, support for this approach will require a deeper comprehension of the ways in which biological control interacts with society and the environment. Infectious plant diseases pose significant threats to global agriculture, impacting crop yield, quality, and food security. Plant pathogens, including fungi, bacteria, viruses, and nematodes, are responsible for a myriad of infectious diseases affecting crops worldwide. The complex interactions between pathogens, plants, and the environment create challenges for effective disease management. Understanding the physiological basis of plant-pathogen interactions is crucial for developing targeted control strategies. Integrated Disease Management (IDM) approaches offer a multifaceted strategy for controlling infectious plant diseases. Crop rotation, sanitation, and quarantine measures play pivotal roles in preventing the spread of diseases within and between agricultural systems. An increasing number of evolutionary biologists should be included in the strategy development process. The public and governments should collaborate on the creation and application of biological control techniques that provide positive externalities.

Keywords- Pathogen Evolution, Nematodes, Economic Gain, Disease Transmission, Functional trade-offs, Social interaction, Plant Pathogens, Plant-Pathogen Interactions.

Introduction-

Throughout human history, plant diseases produced by infectious viruses have had a significant negative impact on both human civilization 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 hunger and malnutrition of the Irish famine.[1] Infectious plant diseases represent a significant and persistent threat to global agriculture, posing challenges to crop health, yield, and overall food security. The intricate interactions between various pathogens and plants, coupled with environmental factors, create a complex web of challenges for effective disease control and prevention. Understanding the nature of infectious plant diseases, their mechanisms of transmission, and developing robust strategies for their control is paramount for sustaining agricultural productivity and ensuring a stable food supply. The economic impact of infectious plant diseases is profound, resulting in substantial losses in crop production globally. This underscores the urgency for comprehensive approaches to disease management that encompass prevention, early detection, and effective control measures. [2] Integrated Disease Management (IDM) has emerged as a holistic strategy that combines cultural practices, biological control agents, resistant plant varieties, and judicious use of chemical interventions. This multifaceted approach aims to reduce the reliance on any single method, promoting sustainable and environmentally friendly solutions to combat infectious plant diseases.

Methods for Controlling Plant Diseases-

Plants, pathogens, and the environment interact in complicated ways that lead to plant diseases. Throughout the lengthy history of agriculture, people have created a number of strategies to control interactions in order to produce a system but less than ideal for pathogen establishment, reproduction, and spread [3]. The viruses' 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 [4]. Certain resistances, like grapevine resistance to downy mildew, might still fail even when they were planted on a little amount of land [5]. This is especially an issue in contemporary agriculture, as monoculture and intensification foster the ideal environments for the growth of pathogens [6, 7]. Because each gene contributes slightly and cumulatively to the resistant phenotypes, the resistance is more persistent than vertical resistance even if it is imperfect and frequently needs extra disease control measures to assure higher harvests [8]. Fungicide treatment is unavoidable when host resistance is absent or insufficient to contain disease outbreaks. Fungicides are frequently abused in the free-disease agricultural paradigm that is presently widely employed to ensure crop productivity and quality, especially for vegetable and ornamental products in developed nations. In European potato production, for instance, up to 20 fungicide treatments are carried out [9], even though some of these applications may not always result in additional biological or financial benefits.

When comparing biological control to other plant disease management techniques, the following are some of the benefits it offers: Agents of biological control (1) typically target a particular group of pathogens, which makes them less harmful to the ecosystem than fungicides, though there are some ecological risks (discussed in Section 4.3) that should be taken into account, especially with the introduction of non-native species [10, 11]; (2) many BCAs are self-sustaining and can remain in place for a longer period of time without the need for extra work to keep the system functioning [12, 13]. Plants are able to devote more energy and resources to agronomic features that are significant to farmers because BCAs inhibit the host immune system from expressing themselves consistently. The agricultural community, especially in developing nations, has not yet recognized the economic benefit of the low commercial contribution, which is strongly linked to poor technological transfer. The use of BCAs is further limited by the fact that many of them are very susceptible to biotic and abiotic variables that also impact their longevity in the face of ongoing pathogen development. Gaining further insight into how BCAs interact with plants, diseases, and the environment within the frameworks of ecology, evolution, and economics is necessary to solve this conundrum.

Types of Biological Control and Their Mechanisms-

The idea of biological control, which is a potential plant diseases, originated in Egypt around 4,000 years ago. But it wasn't until the nineteenth century [14] that biological control became the subject of scientific research. The use of BCAs to treat plant diseases has increased dramatically when it was shown that many soil-borne illnesses were less severe when caused by antagonistic microorganisms such as Ampelomyces quisqualis Ces and Bacillus subtilis (Ehrenberg) Cohn [14, 15]. As will be covered in more detail below, these BCAs fall into three groups based on how they work.

Inhibiting Pathogens-

Pathogens, microscopic organisms that cause diseases in plants, animals, and humans, pose significant challenges to global health, agriculture, and ecosystems. The control and inhibition of pathogens are paramount for ensuring the well-being of living organisms. One of the most traditional methods for inhibiting pathogens involves the use of chemical agents. In agriculture, fungicides, bactericides, and virucides are employed to combat plant diseases. Similarly, in human medicine, antibiotics and antiviral drugs play a critical role in inhibiting the growth and spread of bacterial and viral infections. However, the overuse of these chemicals raises concerns about resistance development, necessitating a judicious and responsible approach. Harnessing the power of nature, biological control strategies involve introducing natural enemies of pathogens to limit their impact. Predatory insects or parasitoid wasps can serve as effective biological control agents in agriculture. In human medicine, the concept extends to the use of probiotics, where beneficial microorganisms are introduced to outcompete harmful pathogens in the body.

Inhibiting pathogens requires a comprehensive and integrative approach, recognizing the interconnectedness of health, agriculture, and the environment. By combining chemical, biological, genetic, cultural, and physical strategies, alongside education and research efforts, we can build a resilient defense against pathogens across diverse domains. In the face of evolving microbial challenges, a multifaceted approach ensures that we stay one step ahead in the ongoing battle against infectious diseases.

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 [16]. When pathogens infect host plants, these substances cause the observed systemic acquired resistance [17].

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, content, and structure of the local plant and microbial communities determine the spatiotemporal dynamics of these beneficial species in agricultural fields. 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.

Ecological Sustainability-

The interactions between organisms and their natural surroundings, facilitated by energy and nutrient cycles, form an ecosystem. It is subject to consistent dynamics in both space and time when any one of its biotic and abiotic constituents changes. The interactions between BCAs and farmlands, whether through the application of biological organisms or substances, invariably alter the ecosystem's composition and functioning, either temporarily or permanently. This might be accomplished by supporting functioning biota, beneficial species, natural enemies/competitors, and ecological efficiency [18]. Particularly in western nations, this worry over ecological safety has sparked a contentious discussion between environmentalists and practitioners and muddled the strategy for managing plant diseases. Ecological philosophers contend that in extreme circumstances, biological control might result in the extinction of a species, endangering ecological resilience and function, whereas agricultural pragmatists contend that no such repercussions have been demonstrated [19]. This is because invasive species have negative ecological and economic effects on natural sustainability and societal development [114]. These behaviors are primarily seen in systems where insects and animals are used as BCAs [20]. They have a special chance to survive and proliferate since they have no natural adversaries in their new surroundings. The idea cannot be ruled out, even if reports of the same events involving the use of helpful bacteria in plant pathology are rare.

The Creation of Economical and "Green" Biological Control Agents-

Many farmers, especially in poor nations, are hesitant to adopt the biological control strategy despite its potential future because of its ecological concerns, technical difficulties, or allure from an economic standpoint [21]. In order to satisfy the growing demand from society for more high-quality, diversified food production that has "green" benefits on ecosystems, it is also imperative to develop a new generation of BCAs. Nowadays, a large number of BCAs function as either a pathogen antagonist or a promoter of increased host immunity. The development of green BCAs that regulate ecosystems, such as those based on conservation or the micro biome, should receive more attention in the future. These approaches should emphasize the synthetic functions of sustainability, durability, efficacy, and complementation (with other approaches). The development is made feasible by advances in molecular screening technology and the body of information regarding the genetic and evolutionary factors behind ecological roles.

Many BCAs are environment-sensitive, especially those that involve beneficial microbes. The observed response of Botrytis bunch rot to different commercial BCAs has been used to demonstrate the two key environmental parameters influencing the efficacy of BCAs: temperature and relative humidity [22]. As a result, it's critical to assess BCAs in light of particular climatic circumstances, community makeup, host and pathogen populations, and agricultural techniques.

Utilize in addition to other disease-control strategies-

The management of tomato and cucumber diseases caused by Botrytis cinerea Pers has been proven to benefit from this integration. However, information on pathogen compositions in farmlands is provided by population surveys [22], which may be utilized to choose the best BCAs for optimum control. The microbiota, ecological variety, and state of plant health all influence how effective BCAs. The effectiveness of biological control can be increased by allocating resources optimally to coincide with plant phenology by controlling resource availability through sensible fertilizer and water applications, cropping system adjustments, and/or intensified cultivation. Therefore, while applying BCAs, we should consider the composition and structure of the community, including interspecific connections, geographical heterogenicity, and plant genetics and physiology.

Create a Program for Dynamic Disease Management-

In reaction to environmental stressors including those caused by climate change and disease-control strategies, plant pathogens rapidly and continuously evolve. The emergence of resistance in pathogen populations is a significant obstacle to the commercialization of BCAs, and many pathogen–BCA interactions have documented this occurrence. By using this dynamic strategy, pathogen populations are subjected to a diverse selection that stops the formation of mutants that can defeat the BCAs. Because diverse selection produced by many phages might prevent the target bacteria from becoming resistant to any of them, cocktails have been employed to preserve the effectiveness of bacteriophages [108]. Biological control, no matter how successful, is deemed unsuccessful if local populations do not accept it. Therefore, it is necessary to make an effort to comprehend how societies see biological control and their views about it [23]. Outreach initiatives may include involve educating the public about the government's involvement in BCA regulation and research as well as how to utilize BCAs safely.

Conclusion-

Historically, the use of pesticides, the introduction of resistant genes, and other methods have been used to meet the desire for high agricultural yields. Nonetheless, the all-encompassing advantage of these methods has been contested because of their effects on the environment or their durability. Biological management seems to be the most promising option among the possibilities for environmentally friendly and sustainable agriculture to preserve food and agricultural plants [24]. The management and control of infectious plant diseases represent a critical aspect of ensuring global food security, agricultural sustainability, and environmental well-being. The multifaceted nature of plant-pathogen interactions necessitates a comprehensive approach that integrates various strategies and technologies.

Throughout this exploration, it is evident that advancements in science, technology, and agricultural practices have significantly enhanced our ability to combat plant diseases effectively. Integrated Disease Management (IDM) strategies, encompassing cultural practices, biological controls, resistant plant varieties, and judicious chemical interventions, form the cornerstone of modern plant disease control. The synergistic combination of these approaches not only minimizes the reliance on any single method but also promotes sustainable and environmentally friendly solutions. The emergence of genetic resistance through breeding and biotechnology provides a promising avenue for developing crops that can withstand pathogenic threats. Precision agriculture, empowered by data-driven technologies, enables early detection, rapid response, and optimized resource allocation in the face of potential disease outbreaks. Biological control techniques must be technologically feasible and economically appealing for farmers to use. Education, policy support, and the supply of practical and inexpensive BCAs are all desperately needed. This emphasizes how critical it is to use the ecological evolutionary principle to assess biological control's effectiveness, efficiency, longevity, and environmental safety in concert.

References-

1. Rigling, D.; Prospero, S. Cryphonectria parasitica, the causal agent of chestnut blight: Invasion history, population biology and disease control. Mol. Plant Pathol. 2018, 19, 7–20.
2. Brasier, C.M. Ophiostoma novo-ulmi sp. nov., causative agent of current dutch elm disease pandemics. Mycopathologia 1991, 115, 151–161.
3. Awuchi, C.G.; Ondari, E.N.; Ogbonna, C.U.; Upadhyay, A.K.; Baran, K.; Okpala, C.O.R.; Korzeniowska, M.; Guiné, R.P.F. Mycotoxins affecting animals, foods, humans, and plants: Types, occurrence, toxicities, action mechanisms, prevention, and detoxification strategies-A revisit. Foods 2021, 10, 1279.
4. Oerke, E.C. Crop losses to pests. J. Agric. Sci. 2006, 144, 31–43.
5. Savary, S.; Willocquet, L.; Pethybridge, S.J.; Esker, P.; McRoberts, N.; Nelson, A. The global burden of pathogens and pests on major food crops. Nat. Ecol. Evol. 2019, 3, 430–439.
6. McGuire, S.; FAO, IFAD, and WFP. The state of food insecurity in the world 2015: Meeting the 2015 international hunger targets: Taking stock of uneven progress. Rome: FAO, 2015. Adv. Nutr. 2015, 6, 623–624.
7. Bisht, N.; Mishra, S.K.; Chauhan, P.S. Bacillus amyloliquefaciens inoculation alters physiology of rice (Oryza sativa L. var. IR-36) through modulating carbohydrate metabolism to mitigate stress induced by nutrient starvation. J. Biol. Macromol. 2020, 143, 937–951.
8. Denes, T.E.; Molnar, I.; Rakosy-Tican, E. New insights into the interaction between cultivated potato and Phytophthora infestans. Studia Univ. Babes-Bolyai Biol. 2015, 60, 165–175.

9. Zhang, N.; Yuan, S.; Zhao, C.; Park, R.F.; Wen, X.; Yang, W.; Liu, D. TaNAC35 acts as a negative regulator for leaf rust resistance in a compatible interaction between common wheat and Puccinia triticina. Mol. Genet. Genomics. 2021, 296, 279–287.
10. Dodds, P.N.; Rafiqi, M.; Gan, P.H.P.; Hardham, A.R.; Jones, D.A.; Ellis, J.G. Effectors of biotrophic fungi and oomycetes: Pathogenicity factors and triggers of host resistance. New Phytol. 2009, 183, 993–1000.
11. Gassmann, W.; Bhattacharjee, S. Effector-triggered immunity signaling: From gene-for-gene pathways to protein-protein interaction networks. Mol. Plant Microbe Interact. 2012, 25, 862–868.
12. Stukenbrock, E.H.; McDonald, B.A. Population genetics of fungal and oomycete effectors involved in gene-for-gene interactions. Mol. Plant Microbe Interact. 2009, 22, 371–380.
13. Peressotti, E.; Wiedemann-Merdinoglu, S.; Delmotte, F.; Bellin, D.; Di Gaspero, G.; Testolin, R.; Merdinoglu, D.; Mestre, P. Breakdown of resistance to grapevine downy mildew upon limited deployment of a resistant variety. BMC Plant Biol. 2010, 10, 147.
14. Dodds, P.; Thrall, P. Recognition events and host-pathogen co-evolution in gene-for-gene resistance to flax rust. Funct. Plant Biol. 2009, 36, 395–408.
15. Zhan, J.; Thrall, P.H.; Papaïx, J.; Xie, L.; Burdon, J.J. Playing on a pathogen's weakness: Using evolution to guide sustainable plant disease control strategies. Annu. Rev. Phytopathol. 2015, 53, 19–43.
16. Kaur, B.; Bhatia, D.; Mavi, G.S. Eighty years of gene-for-gene relationship and its applications in identification and utilization of R genes. J. Genet. 2021, 100, 50.
17. Keane, P.J. Horizontal or generalized resistance to pathogens in plants. Plant Pathol. 2012, 327–362.
18. Kapsa, J.S. Important threats in potato production and integrated pathogen/pest management. Potato Res. 2008, 51, 385–401.
19. Burdon, J.; Barrett, L.G.; Yang, L.N.; He, D.C.; Zhan, J. Maximizing world food production through disease control. BioScience 2020, 70, 126–128.
20. Cai, J.Y.; Xiong, J.J.; Yu, H.; Ruifa, H. Pesticide overuse in apple production and its socioeconomic determinants: Evidence from Shaanxi and Shandong provinces, China. J. Clean. Prod. 2021, 315, 128–179.
21. Bragard, C.; Caciagli, P.; Lemaire, O.; Lopez-Moya, J.J.; MacFarlane, S.; Peters, D.; Susi, P.; Torrance, L. Status and prospects of plant virus control through interference with vector transmission. Annu. Rev. Phytopathol. 2013, 51, 177–201.
22. de Souza Vandenberghe, L.P.; Garcia, L.M.B.; Rodrigues, C.; Camara, M.C.;

de Melo Pereira, G.V.; de Oliveira, J.; Soccol, C.R. Potential applications of plant probiotic microorganisms in agriculture and forestry. AIMS Microbiol. 2017, 3, 629–648.

23. Burketova, L.; Trda, L.; Ott, P.G.; Valentova, O. Bio-based resistance inducers for sustainable plant protection against pathogens. Biotechnol. Adv. 2015, 33, 994–1004. Zhou, M.; Wang, W. Recent Advances in synthetic chemical inducers of plant immunity. Front. Plant Sci. 2018, 9, 1613.