International Journal of Recent Research and Review, Vol. XIV, Issue 3, September 2021
ISSN 2277 – 8322

Application of Bio-control Agents in the management of Rhizome Rot in Zinger: A Review

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Abstract: The articleexplain the applications of Bio-control agents provide a sustainable and powerful approach to management of rhizome rot of ginger. By leveraging beneficial bacteria, fungi, and integrated techniques, it's far viable to lessen reliance on chemical pesticides and increase ginger production using bio-control agents like; *Trichoderma viridae*, *Trichoderma hargenum*, *pseudomonas spp.*etc. By continue studies and improvement in management practices involving bio-control agents for greater reliable and broadly promising management of rhizome rot of ginger could be developed.

Keywords: Bio-control agents (*T-viridae*, *T-harzenum*),ginger,rhizome,sustainable,

INTRODUCTION

Ginger (*Zingiberofficinale*) is a vital crop with big monetary and medicinal price worldwide. However, rhizome rot, brought on normally by pathogens together with *Pythium spp*., *Fusarium spp*., and *Rhizoctoniasolani*, poses a full-size danger to ginger cultivation. Traditional chemical approachhave raised environmental and health worries, prompting the need for sustainable and green biocontrol agents. This evaluation comprehensively explores the utility of biocontrol agents in reducing rhizome rot in ginger, that specialize in their mechanisms, efficacy, and included management strategies.

The utility of biocontrol agents for preventing rhizome rot in Zingiber (ginger) can be an effective approach to control this common and detrimental disease. Rhizome rot, often due to pathogens along with *Pythium*, *Fusarium*, and *Ralstonia solanacearum*, leads to huge yield losses. An outline of possible ways of biocontrol agents may be utilized to manage the rhizome rot of ginger as following:

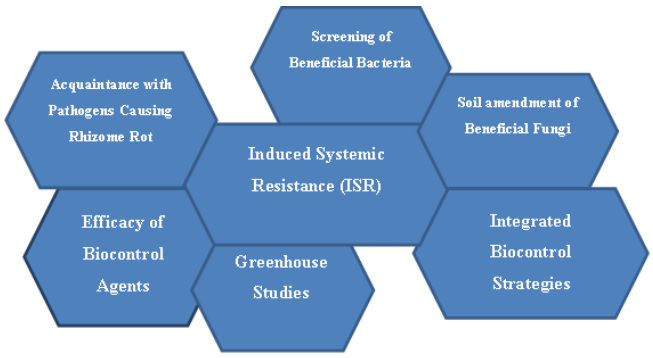

Fig.1. Application of biocontrol agents for preventing rhizome rot in Zingiber (ginger)

Pathogens of Rhizome Rot of Ginger

Pythium spp.

Pythium species belongs to oomycetes that thrive in moist and poorly tired soils. It is the common reason of rhizome rot in ginger, main cause for major yield losses in production of ginger rhizomes. *Pythium* infects young seedlings, inflicting damping-off and in mature plants, resulting in rhizome rot.

***Fusarium spp*.**

Fusarium oxysporum and *Fusarium solani* are primary culprits in causing wilt and decay in ginger. These fungi invade the plant's vascular system, inhibit the growths, yellowing of leaves, and eventual loss of life of the plants has been observed due to the fungus.

Rhizoctoniasolani

Rhizoctoniasolani is a soil-borne fungus accountable for damping-off and soft rot in seedlings. It disrupts the plant status quo and extensively reduces yield.

Biocontrol Agents

Biocontrol agentsinvolves beneficial micro-organism like; mycorrhizal fungi and bacteria that inhibit pathogen growth via using diversified mechanisms.

Beneficial Bacteria

Bacillus spp.

- *Bacillus subtilis* and *Bacillus amyloliquefaciens* are well-documented biocontrol agents.
- Mechanisms: They produce antibiotics, lipopeptides, and enzymes that inhibit pathogen growth. *Bacillus spp*. Additionally set off systemic resistance in vegetation.

Pseudomonas spp.

- *Pseudomonas fluorescens* and *Pseudomonas putida* are effective against soil-borne pathogens.
- Mechanisms: These micro organism produce siderophores, antibiotics and cellular wall-degrading enzymes. They also affect plant growth via hormone manufacturing.

Beneficial Fungi

Trichoderma spp.

- *Trichoderma harzianum* and *Trichoderma viridae* are extensively used biocontrol fungi.
- Mechanisms: *Trichoderma spp*. Act through mycoparasitism, opposition, and the manufacturing of antifungal compounds.

Gliocladium spp.

- *Gliocladiumvirens* (now called *Trichoderma virens*) is also effective other biocontrol fungus.
- Mechanisms: It produces antibiotics and competes with pathogens for area and vitamins.

Mycorrhizal Fungi

Arbuscular Mycorrhizal Fungi (AMF)

- *Glomus spp.* Form symbiotic relationships with ginger roots.
- Mechanisms: AMF beautify nutrient uptake and result in systemic resistance against pathogens. They improve soil shape and fitness, developing a less favorable environment for the pathogen.

Mechanisms of Biocontrol

Antibiosis

Antibiosis includes the production of antimicrobial compounds through biocontrol agents that inhibit pathogen growth. For example, *Bacillus spp*. Produce antibiotics like iturins and fengycins, which disrupt fungal permeable membranes.

Competition

Biocontrol agents compete with pathogens for area, nutrients, and other sources. This mechanism is especially powerful in the rhizosphere, where beneficial microbes outcompete pathogens, thereby lowering their population and impact.

Mycoparasitism

Mycoparasitism entails direct assault on pathogenic fungi by biocontrol dealers. *Trichoderma spp*are recognised for their mycoparasitic activity, wherein they coil round pathogen hyphae, penetrate them and launch

enzymes that degrade fungal permeable membrane.

Induced Systemic Resistance (ISR)

Some biocontrol dealers result in systemic resistance in plant life, making them extra resilient to pathogen attacks. This entails the activation of plant protection mechanisms, consisting of the production of pathogenesis-associated proteins and phytoalexins. *Bacillus* and *Pseudomonas spp* are regarded to trigger ISR in ginger.

Advantages of Biocontrol

Environmentally Friendly: Reduces the need for chemical fungicides, which could have harmful environmental results.

Sustainable: Promotes biodiversity and may be part of an IntegratedDisease Management (IDM) strategy.

Resistance Management: Decreases the probability of pathogens developing resistance in comparison to chemical treatments.

Efficacy of Biocontrol Agents

FIELD STUDIES

Field research have verified the efficacy of numerous biocontrol agents in controlling rhizome rot in ginger:

- *Bacillus subtilis*: Significant decrease in sickness occurrence and advanced yield while implemented as a soil amendments or seed remedy.
- *Trichoderma harzianum*: Effective in reducing rhizome rot severity and promoting plant increase while used as a soil amendment agents or seed remedial.
- *Pseudomonas fluorescens*: Shown to enhance plant growth and reduce ailment occurrence whilst implemented as a soil drench or foliar spray.

Greenhouse Studies

Greenhouse research provides situations to test the efficacy of biocontrol retailers:

- *Gliocladiumvirens*: Demonstrated sizable decrease in rhizome rot severity in greenhouse situations.
- *Glomus spp*.: Promote plant boom and decreased ailment incidence in greenhouse trials when used as a soil amendment.

Integrated Biocontrol Strategies

Combining multiple biocontrol agents and different practices can increase efficacy. Integrated tactics can also encompass the usage of microbial consortia, natural amendments and cultural practices to create a holistic management strategy.

Microbial Consortia

Using a combination of beneficial bacteria and fungi can offer a broader spectrum of protection in opposition to pathogens. For instance, combining *Bacillus spp.*with *Trichoderma spp.*can exploit their complementary mechanisms for of IBS movement.

Organic Amendments

Adding natural sources, such as compost or green manure, can enhance soil health and microbial range by suppressing pathogens. Organic amendments also enhance soil structure and water-retaining capability, creating a less favorable environment for pathogens.

Cultural Practices

Crop rotation, proper drainage, and sanitation can lessen the occurrence of rhizome rot. These practices help in minimizing the pathogen load within the soil and enhancing plant health, making them less liable to infections.

CHALLENGES AND FUTURE DIRECTIONS

Consistency and Reliability

The efficacy of biocontrol agents can range because of environmental conditions, soil type, and pathogen variability. Further research is needed to recognize those interactions and enhance the consistency and reliability of biocontrol agents.

Formulation and Delivery

Developing effective formulations and transport systems for biocontrol agentsare critical for itssurvival and success. This consists of making sure the viability and balance of the agents during storage and transport.

Regulatory and Adoption Issues

Regulatory approvals and farmer adoption of biocontrol practices may be difficult. There is a need for guidelines to guide farmers using biocontrol agents and teach farmers on their advantages and utilization.

FUTURE RESEARCH

Future research should cognizance on:

1. Understanding the complex interactions among biocontrol agents, pathogens and the plant host.
2. Identifying and growing new biocontrol agents (local isolates) with wide-spectrum pastime and environmental adaptability.
3. Enhancing the formulations and transport structures to make certain the practical software of biocontrol agents in diverse farming conditions.

CONCLUSION

This article discuss approximately all the criteria and applications of biocontrol agents which offers a sustainable and effective method for handling rhizome rot in ginger. By leveraging beneficial micro-organism, fungi and integrated strategies, it might possible to reduce reliance on chemical pesticides, and to enhance ginger production. Continued research and improvement in this discipline will pave the way for greater reliable and extensively adopted biocontrol solutions.

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