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Review Article

Fungal Antagonists Mode of Action

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Abstract: Fungal plant pathogens are the primary factors responsible for significant losses to agricultural products annually. The predominant method of controlling fungal diseases has been the use of fungicides; however, there is a global shift towards reducing their application. Biocontrol agents offer a viable alternative to chemical control for the eradication of fungal diseases. Throughout their life cycle, plants interact with diverse pathogens that impact their health through various mechanisms. Fungal biocontrol agents employ multiple modes of action, including antibiosis, competition for nutrients and space, and mycoparasitism, with the specific mechanism varying according to the pathogen-host combination. While competition for space and nutrients is the primary mode of action for fungi, bacteria often produce antibiotics. These mechanisms may act consecutively, making it challenging to identify the association with specific antifungal actions. This summary provides an overview of the modes of action of fungal antagonists.

Keywords: Antagonists, Biocontrol, Eradication, Antibiosis, Competition

Introduction

Fungi the most devastating biotic agent causes serious losses to the quality and the quantity of various agricultural products. Disease cause by fungi is considered the most important microbial agents that cause serious pre and postharvest losses on different plants annually (Agrios, 1988). Fungus needs to be controlled to ensure good food production. There are different strategies being employed to control the disease of plants. Apart from good agronomic and cultural practices farmers rely on fungicide application. Excessive use of chemical fungicides which are hazardous to environment and cause

pollution, resistance in pathogen and have adverse effect on consumer's health. Therefore, there is need of non-chemical or biological alternative to control plant disease (Agrios, 1988). Biological control is a viable alternative to manage the disease caused by fungus. Biological control is a management strategy to inhibit the growth, reproduction and infection of an organism using another organism. This strategy is environmentally friendly and is the only option available to control the plant against pathogen (Cook, 1993). Biological control employs natural enemies to eradicate and control the population of pathogens. Some fungal pathogens are being controlled by using fungal antagonists that includes *powdery mildew* cause disease on leaves and flowers, *Botrytis* that cause diseases on fruits and vegetables. Antagonistic fungi show a wide range of modes of actions against pathogens; sometime different modes act sequentially and create

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difficulty to identify the mechanism that has contributed to a specific antifungal action. The antagonistic fungi protect the plants, pre and postharvest vegetables, fruits and crops with different mechanisms includes antibiosis, competition for nutrients and space, Mycoparasitism. These mechanisms are considered as the main mode of action by which antagonistic agent control the main causal agent. The most suitable environment for successful application of biological control agents is postharvest phase because of its constant temperature, high humidity and offers more chances to increase their antifungal activity (Magan, 2001). Antagonistic strategy of the pathogen is depending upon host, environment and the pathogen; therefore, to understand their mode of action to enhance their viability and potential in disease control is necessary (Chanchaichaovivat et al., 2008).

Fungus Interaction with Antagonistic Agent

During the life cycle, the plant and fungus interact with other microorganism that significantly affects plant health in various ways (Agrios, 1988; (Bull et al., 2002). Plant directly or indirectly interact with antagonistic agents i.e., *Trichoderma* control the pathogenic fungus indirectly by producing antibiotics that stops the growth of pathogen and directly compete with the fungus for resources such as space, oxygen, enzyme substrate (Sanchez et al., 2007). During the interaction between the fungus, host and antagonist several factors play a significant role in determining the success of biocontrol such as oxidative stresses, oxygen composition and water activity (Chanchaichaovivat, 2008).The type of interaction between plant and microorganism are mentioned as mutualism, neutralisms and parasitism (Bankhead, 2004; Bulet al., 2002; Katska, 194; Chisholm et al., 2006; Fitter & Garbaye, 1994; Hoitink, 1999).

Mutualism

It is an interaction among various species in which all the pathogens get benefited from each other and in general it is a facultative and an opportunistic association. Sometimes it is obligatory association that involve physical and biochemical contact among two organisms, such as between the plant and mycorrhizal fungi (Bull et al., 2002; katska, 1994; Chisholm, 2006;(Fitter & Garbaye, 1994). Rhizobium bacteria produce in greater number in soil due to this association with legume plants by providing improved nutrients (Chisholm, 2006; Fitter & Garbaye, 1994).

Neutralism

An association in which population of one specie has no effect on the other (Berg et al., 2005; Chisholm et al., 2006). A competition among or within the species decreased the growth by suppressing the fecundity of interacting organisms. When a non-pathogen interacts with a pathogen for nutrients in a host, then this interaction directly benefits one population (Cook, 1993).

Parasitism

A relationship between two coexisting organisms for a prolong period in which the pathogen (parasite) get benefit by harming another organism (Lo et al., 1997). Through direct parasitism interaction the antagonist and pathogen secrete lytic enzymes and play a vital role in a biocontrol activity (Spadaro & Gullino, 2005). Biocontrol agents break down the cell wall of pathogen

through enzymatic activity such as β-1,3 –glucanase and chitinase. The Bacillus species and Pseudomonas species are most effective antagonists of fungal pathogen due to their parasitic effect of chitinase (Yu et al., 2008).

Mechanisms of Biocontrol

Fungus is controlled by using biocontrol agents and these antagonists kill the pathogenic agents with different kind of mechanisms which are mentioned as under.

Mycoparasitism

A mechanism, in which a fungus is killed by using a biological control agent that feeds on it, resulted in lysis of fungal structures. Mycoparasitism is a complex and combined mechanisms. The best example of this mechanism is *Trichoderma* which interact with other soil borne pathogens. This fungus parasite other fungi by producing chemical signals on the expense of cell wall degrading enzymes (Cortes, 1998; Vinale, 2008). Upon the contact with host *Trichoderma* coils around the host hyphae and form hook like structure known as haustoria and help in penetration to host's cell (Elad, 1983). With the help of scanning electron microscope degradation of cell wall was observed that remain as a hole where mycoparasite had been attached. The lectin-carbohydrate interaction facilitates the attachment and recognition between Trichoderma and other soil borne plant pathogen (Tu, 1984).

Antibiosis

Mechanism in which antagonists are produced by pathogens that inhibit the potential of harmful pathogens to grow. In general antibiosis is the production of antibiotics which at low concentration kill the harmful microorganism. The most effective antibiotics produced by Bacillus species are iturin which is helpful against postharvest fungal pathogens. Bacillus species show antifungal activities by producing bacillomycin, surfactin and fengycin (Arrebola et al. 2010). Effective antibiotics suppress the growth of the targeted pathogen in vitro condition, and the antibiotic must be produced in a sufficient dose near the pathogen. Due to heterogeneous distribution of plant associated microbes it is difficult to detect the expression of antibiotics when and where they produce (Thomashow et al., 1990). Abiotic factors also influenced the production of antimicrobial compounds such as temperature, microelements, oxygen, carbon and nitrogen source, for example P. syringae produces syringomycin in vivo condition depends upon the nutrient availability (Tampakaki et al. 2009).

Competition for Nutrients & Space

Pathogen in soil is always in competition for nutrient and space, Rhizosphere known as a source of nutrient is not sufficient for microorganism to colonized because of the competition among the pathogen for available nutrients. Host supplied nutrients includes exudates, leachates along with that pathogen obtained the nutrient supply from waste product of other microorganisms in soil. Competition for nutrient and space between pathogens and non-pathogen is always an important issue in biocontrol. Competition for nutrient and space is a critical issue for soil borne pathogen

such as *Fusarium* and *Pythium* than foliar pathogens. Soil borne pathogen infect the plant with their mycelia interaction while the foliar pathogen that infect the plant surface directly with the help of appressorium (Elad and Baker, 1985; Keel et al., 1989; Loper and Buyer, 1991).

Conclusion

Fungicides remain primary method of controlling plant diseases; the world is now shifting towards the reduction of their use. To manage the plant disease there is a need of alternate method, like bio-fungicides. Although a lot of research has been done on bio control agents, but there is need of more development to understand the mode of action, interaction and activity between the pathogen and its environment. The basic mode of action of fungal pathogen is competition for space and nutrient, while for bacterial agents it could be antibiotics. Application of different biocontrol agents has been successfully used in green houses to enhance the production of agricultural products. Various modes of actions can interact with each other by supporting the affectivity of bio control agents to bring innovative solutions for sustainable agriculture.

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