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CRITICAL ROLES FOR BIOCONTROL FACTORS AGAINST PLANT PATHOGENS: A REVIEW

Akmam Ali Habeeb
Department of Biological Sciences, College of Sciences, Wasit University, Kut, Iraq.
*Email address: ahmedaltai2277@gmail.com

Tayseer Shamran Al-Deresawi
Department of Biology, College of Education for Pure Sciences, University of Wasit, Kut, Iraq.
** Email: tshamran@uowasit.edu.iq

Abstract
The present review was carried out to show the importance of the biocontrol strategy in the control of plant pathogens, such as bacteria, fungi, and plant pests. Some microbial agents function in the increase of plant immunity by releasing some chemicals, such as antibiotic-like substances, secondary metabolites, which encourage positive defensive lines of the host plant against different pathogens. The review shows the importance of biological control in the management of plant pathogens, and that microbial-based beneficial agents are critical in this process, which provide the host with important roles to potentiate the host plants with some microbial bioactive metabolites that may increase the defense mechanisms against plant pathogens.

Keywords: Biocontrol, biological control, plant diseases.

Introduction

Plant diseases that are caused by pathogenic organisms have had a significant negative impact on human civilization as well as the natural world during the course of human history. These infections have produced harm to food supply, economic growth, ecological robustness, and geographical features. Hunger and malnutrition induced by the Irish famine, which was resulted by the potato late blight microorganism *Phytophthora infestans* (Mont.) de Bary, and the Bengali food shortages, which was induced by (*Bipolaris oryzae* (Breda de Haan)); the rice brown spot microorganism, directed to the loss of many lives and removed communities and social systems (1). The global outbreaks of chestnut blight, generated by Cryphonectria parasitica (Murrill) Barr and Dutch elm disease, induced by *Ophiostoma novo-ulmi* (Buism.) Nann., wiped out a substantial fraction of forestry in the United States and European countries, which resulted in an environmental disaster in those geographic areas. Furthermore, several plant diseases are responsible for the production of mycotoxins, which pose a direct or indirect risk to the wellbeing of both people and animals (2).

Plant diseases can happen anywhere along the complete crop manufacturing system, and they continue to be one of the biggest dangers to the viable advancement of social structure. This can outcome in a loss of yearly output that ranges from 13% to 22%, or financial consequences that amount to billions of dollars in staple foods such as rice, wheat, maize, and potato, in addition to the added expenses

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expended on advancement and education of control techniques. According to current calculations, there are around 800 million individuals throughout the globe who are starving or undernourished. These biological and financial damages at least largely contribute for this staggering statistic (3,4).

For the management of plant diseases, biological control is regarded as a potentially productive potential substitute to the use of pesticides and overcome resistance; however, prior to its approval, a greater comprehension of the engagement between the natural and sociological features of biological control is required. The use of biological control agents can change the way in which plants, pathogenic organisms, and surroundings interact with one another. This can result in physical and biological signaling pathways that have an effect on the wellness of pathogenic organisms, the wellbeing of crops, and the operation of ecosystems. These interconnections produce a landscape of advantages and disadvantages between the characteristic activities of biological control and the social functions. In order to guarantee the viable progression and implementation of the strategy, a critical analysis of the advantages and expenditures of the strategy from the viewpoints of both society and farmers is necessary (5).

Biological Control

Biological control, also known as biocontrol, appears to be the non-chemical strategy that is most suitable for organic farming when compared to other methods of insect and disease control. It is not harmful to the environment, it is healthy, it is financially feasible, and it is quite specialized. The utilization of naturally existing soil microorganisms, for example, is one of these approaches that is now being used to combat a wide range of different illnesses and pests. Previous to the deployment of biocontrol, especially in situations of a broad disease, a greater knowledge of the connections between plants and microorganisms as well as the environmental elements common in a given region has to be appreciated (6).

Biocontrol is the interplay of several environmental components with the purpose of limiting the adverse consequences of dangerous species while simultaneously boosting the development of useful crops, friendly pests, and bacteria. In the field of plant pathology, biological control is described as the interplay of multiple ecological factors. Biological management is reliant on a wide variety of interconnections, both agonistic and antagonistic, involving plants and microorganisms that live in the rhizosphere and the phyllosphere, as well as their deployment in order to reduce the risk of disease and bring harmful pests under control (7,8).

It is possible to collect microorganisms from the rhizosphere from the ecosystem around the plant (this is known as the black box technique), or they may be brought into the area from outside suppliers (silver bullet approach). Because microbial communities build-creates a steady rhizosphere that enables more efficient control over pathogenic microorganisms, it is desirable to use a community of microorganisms with collaborative features rather than depending on one species. This is because relying on a particular species might be risky. In addition to the use of microbes, biological control may also be accomplished with the assistance of other plant chemicals, such as extracts, biofertilizers, and biopesticides; natural predators of insects and diseases; and products of genes (9–11).

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Types of plant pathogenic microorganisms

Biotrophs, necrotrophs, and hemibiotrophs, are the three main divisions that are used to classify plant pathogenic microorganisms according to the method in which they get their energy from the plants they infect. These linkages, in consequence, have an effect on the manner in which the plant reacts to the pathogenic organisms.

Biotrophs

With the assistance of complicated systems that allow them to gain entry to plant resources, biotrophic pathogens are able to get their nutrition from the live cells of the plant that they infect. They have such a strong association with the live tissue of the plants that some of the biotrophic pathogens have lost the capacity to develop on artificial media which is not living and have basic structures into obligatory biotrophic features as a result of this close connection. For instance, *Uromyces fabae*, which is responsible for rusts, and *Blumeria (Erysiphe) graminis*, which is responsible for powdery mildews (12).

But from the other side, non-obligate biotrophic agents, which are able to develop on artificial media, do not exhibit saprophytic activities, and cause damage exclusively to the host cells. The host cell wall is damaged by the hyphae and haustoria formed by biotrophs, but the plasma membrane is left untouched. At these sites, the unbroken membrane protrudes and provides a perihaustorial/peri arbuscular membrane, which is where nutrition transfer occurs. Pathogens are known to secrete trigger chemicals, which are thus able to assist more in the infiltration of the host genotypes. Other instances are the fungus Ustilago maydis, while that is responsible for corn smut, and *Cladosporium fulvum*, which is responsible for tomato leaf mold. Neither of these fungi generate haustoria, thus nutrition transfers between the plant and the microorganisms takes place via the apoplast (13,14).

Necrotrophs

Necrotrophic microorganisms, as opposed to biotrophs, are opportunists and unspecialized organisms that destroy the host quickly and maintain themselves on its damaged tissues. They do not develop haustoria, but instead infiltrate the plant via naturally occurring holes or lesions, where they then release lytic enzymes and phytotoxins. They are quite responsive to cultivation on artificial medium. Necrotrophs consist of bacterial and fungal organisms, and oomycetes, and they are able to live in a saprotrophic state as well. Necrotrophs mostly target young, weak, and injured plants. Necrotrophic bacteria and fungi both engage in infection processes that are quite similar to one another. These processes include attachment to the host, host penetration, and the eventual necrosis and degradation of plant cells (15).

Necrotrophic fungi include species such as *Cochliobolus*, which is responsible for corn leaf blight; *Alternaria*, which is responsible for potato early blight; and *Botrytis*, which is responsible for grey mold. Phytohormonal components, pathogenetic proteins, and bioactive components are the three components that make up the immune defense mechanisms that plants use to combat these diseases. Wheat, maize, and rice are examples of some of the most significant commercial crops that are

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susceptible to infection by necrotrophic fungal agents like *Fusarium* and *Rhizoctonia*. Even if a certain proportion of the crop genotype is resistant to the poisons that are generated by the necrotrophs and avoids necrosis, these diseases are still potential of causing a significantly larger loss of production and total damage when compared with biotrophs (16).

Hemibiotrophs

Hemibiotrophic pathogenic organisms are an attractive category of pathogens because they exhibit characteristics of both biotrophic and necrotrophic organisms and are potential of shifting between the two different forms. The symptomless biotrophic stage leads to the damaging necrotrophic stage, which is associated by the inhibition of the plant immune system at the proper moment. This results in substantial harm to the host, which ultimately leads to the plant decomposition and mortality. Hemibiotrophic features are displayed by fungi such as *Magnaporthe grisea*, *Phytophthora*, *Fusarium*, *Pythium*, *Venturia*, and *Colletotrichum*, as well as the bacterial microorganism; *Pseudomonas syringae*. These organisms are all proficient of a previous biotrophic presence with the host, but eventually transition to a necrotrophic configuration of feeding by damaging the host tissue (17,18).

Biocontrol system

Biocontrol using microbes

The region of soil that envelopes the roots is called the rhizosphere, and it is home to microorganisms that have the ability to inhibit the growth of plant pathogenic organisms. Consequently, it helps in supplying protective layer to plants against a range of microorganisms, either straightforwardly by the biosynthesis of metabolites that are oppositional towards the pathogenic organisms or indirectly by restricting the growth of pathogenic organisms and boosting the defense mechanisms of the affected plant. Antibiosis, which is induced by the release of antibiotics, chemical substances, toxicants, and numerous hydrolases such as beta-xylosidase, chitinase, pectin methylesterase, -1,3-glucanase, etc., is one of the strategies adopted by the microbial communities of rhizosphere to conduct the death of the pathogens, such as the breakdown of the glycosidic bonds in its cell wall (19).

Rhizobacteria that are beneficial to plant development and reside in the rhizosphere are referred to as plant growth-promoting rhizobacteria (PGPR). These bacteria conduct biocontrol by lowering the occurrence of plant diseases, which helps plants develop. The PGPR also encourage antibiosis, competitive pressure, manufacturing of bioactive compounds that stimulate structural acquired immunity and upregulation of systemic resistance, parasitism, generation of hydrolases including cellulase, chitinase, glucanase and protease that destroy the cell wall including a range of antibiotics including oomycin A, 2,4-diacetyl phloroglucinol (DAPG). For instance, the genus Serratia, which is a member of the family Enterobacteriaceae, is a PGPR that generates bioactive substances that have desirable biocontrol qualities (20).

Rhizobia are symbiotic microorganisms that are located on the roots of leguminous plants. Rhizobia not only serve a significant part in the process of nitrogen fixation, but they also act as a vital function in the process of biocontrol. They do this by injecting antibiotics, siderophores, mycolytic enzymes, and

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hydrocyanic acid (HCN), all of which inhibit the development of harmful fungus related to genera such as *Fusarium*, *Sclerotium*, *Rhizoctonia*, and *Macrophomina*. This, in turn, encourages the growth and development of plants. They do this by inducing systemic resistance and elevating the expression of genes involved in resistance mechanisms. This results in a stronger immune response from the plant (21,22).

Seed condition may be enhanced by bacterization with the appropriate rhizobial strains in order to promote engagement of several enzymes engaged in the isoflavonoid and phenylpropanoid pathways, development of phenolic substances and isoflavonoid phytoalexins that boost the biocontrol potential of the cultivars, consequently enhancing plant growth and production. In order to combat the late blight of potato, which is resulted by *Phytophthora infestans*, scientists utilized a colloquium of Pseudomonas varieties that had been obtained from both the *phyllosphere* and the rhizosphere of the potato plant. This is an instance of the safeguard that can be provided by rhizobia. When comparing with the usage of individual species, the utilization of a colloquium consisting of many strains showed to be quite successful (23). The use of endophytes as biological control is another component of plant illness control. These microorganisms are able to live in a plant's shoot, leaves, or roots without causing any visible symptoms. Because different strains of endophytes have different levels of activity, it is possible to test different strains of endophytes for their capacity to operate as a biocontrol agent. This was demonstrated by Gonthier et al. (24) on the usages of *Suillus luteus* to fight the fungus; *Heterobasidion irregular* and *Heterobasidion annosum* that invade Scots pine (Pinus sylvestris). The use of Suillus luteus caused in reduced vulnerability to only *H. annosum*, but not to *H. irregular*. They also have the potential to be used as techniques of pest management against dangers such as the spotted lanternfly, which is responsible for significant financial damage in North America. Endophytes fight off infections through a wide variety of defensive mechanisms, including lysosomal enzymes, the stimulation of host defensive lines, the manufacture of antibiotics, and mycoparasitism (25,26).

Biocontrol utilizing fungi

Fungi, in addition to their capacity to increase plant nutrient absorption and nitrogen usage, also have the potential to biocontrol pests and diseases. They have the ability to help in the battle against plant diseases and pests such as nematodes and other microbes that attack different areas of the plant containing the roots, leafs, and fruits. They give defense against illnesses with the assistance of mechanisms such as mycoparasitism, competing for nutrients with pathogenic organisms, antibiosis, applying systemic immunity to the plant host. The species of *Trichoderma*, *Ectomycorrhizas*, *Arbuscular mycorrhizas*, yeasts, and endophytes are only few of the well-known organisms that function as biological control agents for plant pathogens (27)(28)(29).

Also the nonvirulent variants of some pathogenic organisms have the potential to make utilization hypovirulence-associated mycoviruses in particular to operate as biological control fungal agents. It is now feasible, thanks to developments in biotechnology and genetics, to not only incorporate advantageous fungal genetic materials into the genetic sequences of the plant species but also to disturb or genetically manipulate these genetic traits in attempt to enhance biological control capacity. A study

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written by Thambugala and colleagues (30) presents a full list of fungal biocontrol operators that were utilized against fungal plant infections due to new taxonomic definitions. They provide information on about 300 fungal opponents that belong to 13 groups and 113 genera (31).

Conclusion

The review shows the importance of biological control in the management of plant pathogens, and that microbial-based beneficial agents are critical in this process, which provide the host with important roles to potentiate the host plants with some microbial bioactive metabolites that may increase the defense mechanisms against plant pathogens.

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