P- ISSN 1991-8941 E-ISSN 2706-6703 2023,(17), ( 1 ):50– 61 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access

# Using Fungi and Bacteria as Biological Control Agents of Fungal Plant Diseases : A Review

**Rajaa Fadhil Hamdi , Khader Saker Alzawi**

Department of Biology ‹College of Science ‹University Of Anbar ‹ Al- Anbar ‹ Iraq ;

ARTICLE INFO

Received: 17 / 02 /2023
Accepted: 16 / 04/ 2023
Available online: 11 / 06 / 2023

DOI: 10.37652/juaps.2023.178865

**Keywords:**
plant diseases,
biological control,
BCA,
PDM,
bio resistance factors,
Fungi, bacteria,



ABSTRACT

Treating fungus-related plant diseases, biological control is an efficient and environmental friendly. It could be a substitute for addition to conventional pesticides, Plant diseases drastically reduced productivity and quality of agricultural yields by severely damaging or destroying crops all over the world. In this review, the antagonistic activity of bacterial and fungal biocontrol agents was discussed.The various fungal genera and bacteria have several use in both the natural and commercial worlds. In addition to their significant roles in the ecosystem, the antagonistic features of the fungal and bacterial species have been exploited as biological control agents (BCA) in the treatment of plant diseases. The ability of fungal biological control agents (FBCAs) to prevent disease is comparable to the use of synthetic chemicals, it is necessary to consider the availability of synthetic pesticides that are secured, environmentally friendly, and financially viable. It is thought that using microorganisms for biological management of pests is a practical strategy that can significantly reduce the negative effects of agrochemicals in soil. This study covers fungi and bacteria genera as BCA and calls for modifications to research and development to improve PDM. For increasing crop yield in sustainable agriculture.

## Introduction:

Plant pathogens, which include fungi, bacteria, viruses, and nematodes, seriously harm or destroy crops all over the world and drastically reduced the quality and output of agricultural products. Each year, these losses represent a serious danger to the world's food production [1]. Human and cattle health may be impacted by pathogenic infection in the field or during post-harvest storage, particularly if the disease releases toxins on or in consumable items [2].

Despite the fact that many common fungal illnesses kill mammals, given the prevalence of plant sapro phytes, pathogens, and mycorrhiza species in fungi, terrestrial plants have likely been the primary source of nutrition for fungi for a significant portion of their evolutionary history[3].

Fungi are the class of plant pests that collectively cause the most plant ailments, with over 8000 species known to be pathogenic (such as viruses and bacteria).

*Corresponding author at: Department of Biology, College of Science,University Of Anbar, Anbar ‹ Iraq;
ORCID:https://orcid.org/ 0000-0003-1401-7113
;Tel:+9647801909955
E-mail address: Sc.moh_n2002@uoanbar.edu.iq

Many of them have intricate life cycles that include two or more host plants.The symptoms of the plant diseases brought on by fungi are extremely diverse. In fact, harmful fungi can result in plant sterilization, lesions on leaf or flower, stem canker, root and fruits rot, or lesions. Because they target cultivated plants and their products, fungi pose a severe threat to agriculture because they lower crop production and lower product quality (seeds, fruits, grains). Almost all crops, including cereals, ornamental plants and trees, Corn, Rice, potato, Beans, peas, and Soybeans, as well as fruit trees (including Coffee and Cacao), have their own harmful fungi [4].

Plant illness require to be managed in order to preserve the high characteristics and availability of meal, nourish, and fiber produced by producers all over the globe.Several tactics can be utilized to protect , lessen, or eliminate crop diseases . Along with excellent horticultural and agronomic processes, farmers usually heavily rely on chemical compounds herbicides and fertilizers. Over the past 100 years, crop yield and quality have dramatically improved thanks in large part to such agricultural inputs. However, fear-mongering by certain pesticide opponents and the environmental damage brought on by improper and excessive use of agrochemicals have significantly altered people's views on insecticides used in agriculture.Today, the use of chemical pesti cides is strictly regulated, and political pressure is there to remove the most dangerous compounds from circulation. Additionally, because of the potential scale at which such treatments would be required, the transmission of plant diseases in natural environment may make it impossible to successfully apply chemicals. As a result, several researchers in pest management have concentrated their efforts on creating synthetic chemical-free alternatives to control pests and diseases. These possibilities include what are known as biological controls [5]. There are several biological controls that can be used, but their effective development will require a better comprehension of the intricate relationships between plants, people, and the environment. To that purpose, the nature and practice of biological control as it is used to control plant diseases are discussed in this article as an advanced survey.

**Plant Pathogenic Fungi:**

Some of the worst famines and human suffering in the history of the globe are caused by plant pathogenic fungus. When wheat harvests in the Middle Ages got afflicted with a dark, dusty powder that was subsequently identified as the spores of the fungus bunt or stinking smut, they were commonly destroyed (*Tilletia* spp.). Epidemics brought on by rust fungi have been recorded for ages. In the writings of Aristotle and Theophrastus, several plagues are recorded occuring in ancient Greece. To satisfy the Robigo and Robigus gods, whom the Romans ascribed responsibility for the rust epidemics, they held the Robigalia, a religious ceremony/festival [6]

The most important biotic barrier to potato production globally is the oomycete *Phytophthora infestans*, which causes potato late blight. In the 1840s, it produced epidemics that led to the evacuation of over 1.5 million people from Ireland and the deaths of over a million people from diseases linked to hunger or starvation. A more recent pandemic that resulted in a widespread famine was brought on by the same fungus that causes brown spot on rice; during the Great Bengal Famine of 1942, 2 million people perished from malnutrition[7].

In 1970, a related fungus that affects corn and produces southern leaf blight expanded rapidly throughout the United Regions, causing the loss of 15% of the whole corn crop and output reductions of up to 50% in some states. Stem rust has caused the loss of tens of millions of bushels of wheat just the United States during epidemic years (*Puccinia graminis tritici),* Rice burst, which is because of the pathogen *Magnaporthe oryzae*, is one of several disorders that affect people. It is always important, always dangerous, and it exists anywhere rice is grown, *Hemileia vastatrix*, which causes coffee rust, was responsible for epidemics of the disease on coffee plants in Ceylon (then-British-ruled Sri Lanka) throughout the nineteenth century. Due to restrictions on coffee exports from Ceylon, planters switched to tea instead of Arabian coffee, and tea eventually became the preferred alcoholic beverage among British society [4].

All ornamental plants are susceptible to powdery mildew infection, which is a frequent disease of greenhouse flower yields caused by *Botrytis* gray mold. These are only a few of the numerous patho genic fungus that destroy products.

Fungi create highly poisonous, hallucinogenic, and carcinogenic compounds that they donot cause only a negative impact on the lives of millions of people, but they are still as a problem till today additionally to serving as preharvest and postharvest agents illnesses and rots, numerous dogs were died in the U.S.A in 2006 from eating food that were contaminated with Alfa- toxin which is a substance that is release by *Aspergillus* species.These fungi can develop on maize and produce a toxin that is one of the most cancer-causing chemicals known to man that targets not just the liver but also the seed. Another illustration comes from the genus *Fusarium*, which has a large number of phyto pathogenic species, with *F. culmorum* and *F. graminearum* being especially significant cereal crop diseases in many parts of the world. They cause the ear and stalk rot of corn, the stem rot of carnations, and the head and seedling blight of minor grains like wheat and barley. These *Fusarium* diseases reduce yield in addition to producing" mycotoxins", they are extremely harmful to together plants and animals, including people [7].

Modern "agroecosystems" employ several techniques to manage fungal pathogens, including crop rotations, fungicide spraying, the development of resistant cultivars and other cultural practices that attempt to reduce plant infections. Fungicides and resistance may initially be quite effective, but they are also expensive, polluting, and frequently ineffective. One sick plant produces millions of spores, high dispersal ability, and many generations in a year. Fungi do actually have enormous effective sizes that allows them for rapid adaptation. Fungicide degradation frequently happens in a matter of years, just like resistance breakdown [8].

A" Top 10 fungal plant pathogen list for Molecular Plant Pathology includes, in rank order, (1) *Magnaporthe oryzae*; (2) *Botrytis cinerea*; (3) *Puccinia spp*.; (4) *Fusarium graminearum*; (5) *Fusarium oxysporum*; (6) *Blumeria graminis*; (7) *Mycosphaerella graminicola*; (8) *Colletotrichum spp*.; (9) *Ustilago maydis*; (10) *Melampsora lini*" [9].

**Biological Control on Plant Pathogens.**

Different branches of biology like entomology and pathology of plants have used the terms "biological control" and its short form synonym "biocontrol." the application of live insects that hunt prey to control the communities of various pest insects has been utilized in entomology, In the field of plant pathology, the phrase relates to both the employment of host-specific pathogens to manage weed populations and the use of microbial antagonists to suppress illnesses, organism that eliminates the infection or pest is also known as a biological control agent in both fields (BCA). Generall, the utilization of natural compounds that have been various sources extracted or fermented has also been referred to as biological control, These formulations could be extremely straight forward combinations of natural components with specified functions or sophisticated concoctions with various effects on both the target pest or pathogen and the host. to put a stop to the actions and populations of one or more biocontrol of phytopathogens entails the intentional use of newly introduced or locally existing living organisms other than disease-resistant host plants, this could include employing microbial inoculants to combat a specific type or group of plant diseases, or this may entail ground administration to encourage the interactions between local creatures connected with both plants and soil that help suppress everything else. The most specific definition of biological control is the eradication of one pathogen (or pest), by one antagonist, in one cropping system [5].

**Biological Control Agents:**

**1. Fungi :**

Over than 19,000 fungi have been discovered to cause disease in crop plants. Until conditions are right, they could stay active but latent on both living and dead plant tissues which favorable to their growth. Several fungi grow within their host plant's tissues. Air, moisture, sand, insects, and other invertebrates can easily spread fungus spores, in this method, they may totally infest a crop. [10].

On the other hand, other fungus may even benefit the host plant by aiding in its growth and development. For instance, mycorrhizae establish a mutualistic relationship with the host plant's root systems**.** Fungi that promote plant growth have a variety of ways to manage fungal phytopathogens, including antioxidant molecules that recover from oxidative bursts and reduce the synthesis of mycotoxins [11]. An alternate method for controlling *Fusarium wilts* is biological control, which employs antagonistic nonpathogenic microorganisms with the ability to reduce or reverse the negative effects in a variety of situations crops [12].The physiological condition known as stimulated resistance is brought on by particular environmentally friendly stimuli that have antimicrobial effectiveness against a variety of plant diseases, including fungi [13].

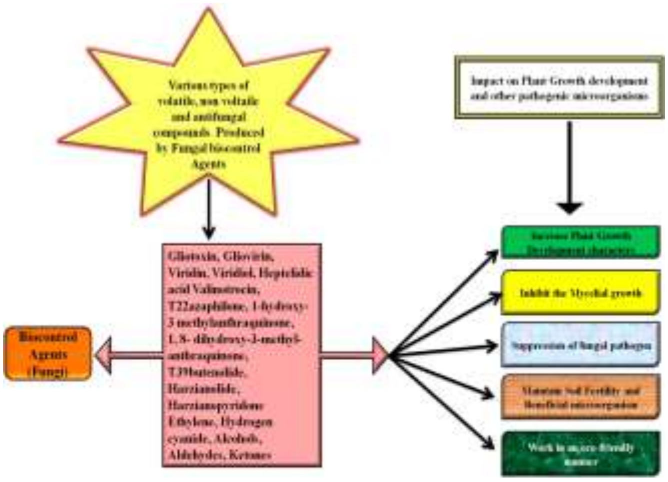


**Figure 1. effects of fungi as biocontrol agents on plant growth and other harmful microorganisms [14]**

- ***Trichoderma***

Trichodermal fungi are a huge category of microscopic creatures that have a big impact on the environment to occupy different ecological niches, they employ a number of strategies. Numerous *Trichoderma* species have a beneficial impact on plants by promoting plant growth and shielding them against bacterial and fungal diseases. Both bioremediation and biological plant protection use them as biofungicides. Trichodermal species are also used in a variety of industrial sectors, primarily for the synthesis of enzymes, antibiotics, and other metabolites, but also for the generation of biofuel [15].

Fungal *Trichoderma* species are distinguished from other species by Conidial spore generation is brisk and plentiful. together with their ability to create sclerotia. These type of fungi create a variety of colors from a greenish-yellow to reddish tint, conidia may also have a variety of coloration, from colorless to various shades of hints of brown, grey, or even green. In addition to the genus's significance for industry some species of *Trichoderma* can be antagonistic and pathogenic of plants [16]. The fungus is known for its ability to attack other fungi and produce antibiotics that affect other microorganisms, and thus it is considered a biological resistance agent [17]. *Trichoderma* strains added to the rhizosphere shield plants from pathogens such as viral, bacterial, and fungal pathogens that cause aerial infections, this suggests that resistance mechanisms similar to the hypersensitive response (HR), systemic acquired resistance (SAR), and induced systemic resistance (ISR) in plants have been induced [18]. [19] used his research on the bean foliage disease caused by Colletotrichum lindemuthianum and Botrytis cinerea to make the first demonstration of Trichoderma-induced resistance.

[20] used their research on cucumber seedling disease with T. harzianum to support the idea of inducing resistance. Perhaps MAMP-triggered immunity in the host plant may serve as a model system for Trichoderma-induced resistance. Several MAMPS, including hydrophobins, an expansin-like protein, secondary metabolites, and enzymes, are produced by different Trichoderma strains. They cause the body to produce defense metabolites and enzymes, such as the enzymes Phenyl Alanine Ammonia Lyase (PAL) and Chalcone Synthase (CHS), which are necessary for the biosynthesis of phytoalexins (HR response), chitinases and glucanases, which are vital pathogenesis-related proteins (SAR response), and enzymes that react to oxidative stress[21].

The in vitro antagonistic ability of *Trichoderma viride* towards phyto pathogens "(*Sclerotium rolfsii*, *Fusarium oxysporum* f.s.p. *ciceri*, *Fusarium oxysporum* f.s.p. *udum*)" was studied and it was found to be maximum towards *F. oxysporum* f.s.p. *ciceri* (62.85% mycelial growth inhi bition) followed *by F. oxysporum* f.s.p. *udum* (59.37% hyphae growth inhibition) and S. rolfsii (58.03% hyphae growth inhibition) [22].

- ***Aspergillus***

*Aspergillus* species exhibited effective suppression against a variety of nematodes, bacteria, and plant harmful fungi [23]. Indirect inhibitory secretome components including hydrolytic chitinase and -glucanase enzymes [24] and organic acids [25], direct mycoparasitism, and other mechanisms have all been proposed to explain the suppressive impact of *Aspergillus* [26] .

The *Aspergillus* genus has numerous species with various morphological, biological, and ecological traits. *Aspergillus* species are common in the agricultural environment and can be found growing in soil, decomposing organic materials, plants, and animals. The ability of *Aspergillus* species to exploit a wide range of organic substrates and successfully adapt to a wide range of environmental conditions is connected with their diversity [27]. *A. niger* considered the common soil fungus and can survive in a variety of soil types with pH values ranging from extremely acidic to extremely alkaline [28].

Likewise, *A. Japonicus* may adapt to agricultural settings and domesticated animals and is typically found in the soil [29]. The beneficial effects of *Aspergillus* species extend beyond their propensity for conflict. The fact that many *Aspergillus* species coexist in symbiotic relationships with their host plants makes them plant endophytes. The symbiont *Aspergillus* partner promotes host plant growth and offers defense against a variety of pathogenic plants [30]. Other *Aspergillus* species members by converting dangerous chemical molecules into ecologically friendly compounds, they act as bio-remediators for the agricultural environment. limiting the buildup of heavy metals and taking on benign forms [31].

Numerous species of *Aspergillus* have commercial value for producing lipids, proteins, enzymes, and purified organic acids in large quantities [32]. As a result, *Aspergillus* is a prominent genus that contains highly useful species that provide both direct and indirect benefits to industry and agriculture.

It has long been known that the genus *Aspergillus* is a vast origin of Substances containing lead with intriguingly varied biological and structural functions [33]. Notably, between 2015 and 2019, 362 secondary metabolites, including alkaloids, butenolides, and cytochalasins, were identified from several *Aspergillus* species. These compounds have shown a variety of biological activity, including antibacterial, anti-inflammatory, and anticancer properties [34]. According to the researchs on the anti microbial activity, aspetritones and derivatives of the candidusin found in *Aspergillus tritici* SP2-8-1 showed anti bacterial action against methicillin-resistant strains of *Staphylococcus aureus* [35].

Experiments conducted in vitro The bacteria *S. aureus*, *Bacillus cereus*, and *Candida albicans* discovered two new compounds, aspergillethers A and B, from the endophytic fungus *A. versicolor* had strong antibacterial and antifungal effects [36]. Although efforts have been made to identify secondary metabolites with antibacterial action, relatively several *Aspergillus* species have been evaluated as bio-logical plant defense factors to date [37].

- ***Penicillium***

The well-known mold genus *Penicillium*, which has more than 350 species, plays a range of roles in biotechnology, agriculture, and natural ecosystems. There are two sides to them: a positive, productive side and a dreadful, harming side from an economic perspective. Several *Penicillium* species, such as *P. albocoremium* (Andrastin A), *P. decumbens*, the anti bacterial antibiotic penicillin from *P. chrysogenum*, and the anti fungal antibiotic griseofulvin from *P. griseofulvum*, produce anti-cancer chemicals (Bredenin). Roquefort and Camembert cheese are produced using *P.* roqueforti and *P. camemberti*, respectively [38a,b].

Several *Penicillium* species produce industrially useful enzymes, including as cellulases and xylanases, which have numerous uses in the pulp and paper, textile, and food and feed sectors [39]. *Penicillium* species can be employed to restore an environment that has been harmed by oil as well as to biodegrade oil. The *Penicillium* species' peroxidase enzyme has the capacity to biodegrade substances including amaranth color, "orange G, azure B, and lip dye" are examples of heterocyclic dyes. . Additionally, certain animals have the ability to recycle waste by acting as decomposers of dead materials.

*Penicillium aurantiogrisum*, *P. citrinum*, and *P. waksmani* are just a few of the *Penicillium* species that have recently been employed for the environmentally benign biosynthesis of gold nanoparticles from an AuCl solution. The Z-average diameter of the three species of gold nanoparticles—153.3 nm, 172 nm, and 160.1 nm—are all reasonably homogeneous and spherical in shape.

On the other hand, certain species have a history of transmitting diseases after harvest. *Penicillium expansum*, for instance is one of the most common post-harvest decay that damage apples ,There are many hosts from which this plant disease can be isolated, including pears, strawberries, tomatoes, corn, and rice, despite the fact that it represents a significant economic issue in apples. Additionally, this mold creates the neurotoxic patulin, a carcinogenic metabolite that is dangerous in apple juice and apple-derived goods. Because many food products are ingested by young children, patulin in them raises health concerns. A second secondary metabolite called citrinin is also formed, Citrus fruit storage mold growth is a persistent issue that costs businesses money. Although a number of other fungi have been identified as contributing to the deterioration of citrus products, *P. digitatum* (green mold) and *P. italicum* (blue mold) are the main pathogens [40].

Many *Penicillium* species have been identified as plant pathogen antagonists, and their mode of action relies on the induction of resistance [41], the synthesis of antibiotic substances[42], as well as the development of mycoparasitic interactions[43].

## 2. Bacteria

Bacterial biocontrol factors use a variety of tactics to protect plants from Infections caused by pathogens. Through one or a mixture of processes, they may interact with the pathogen directly or indirectly to prevent or limit plant illness. [44]. BCA can contend with pathogens for resources and space, hinder their ability to spread, and engage with them directly by secreting anti microbial substances. Many B.C.A. produce and release metabolites such as lipo peptides, bacteriocins, antibiotics, bio surfactants, enzymes that dissolve cell walls, or volatile compounds produced by microbes that have antimicrobial properties by delaying the development or metabolic activity of infections. By inhibiting the creation of signal molecules or by enzyme-degrading them, BCA may also interfere with the quorum sensing (QS) system of pathogen, which is employed to start infections. For instance, creating QS inhibitors that break down QS signal molecules, like lactonase, pectinases, and chitinases, can hinder pathogen invasion and lessen the symptoms of plant diseases [45].

BCA may also reduce the stress of pathogen infection via competitive exclusion over pathogens by inhibiting their development without actually eliminating them. Having an improved nutrition uptake mechanism than the pathogen, such as low-molecular-weight siderophores having an affinity for ferrous iron, highly competitive bacterial BCA may colonize and persist in the infected site. In addition to direct interactions, BCA can shield plants in a more indirect way by bringing on a defense response or encouraging plant development [46].

## • Biocontrol agents of plant diseases:

### Bacteria:

Numerous bacterial species have been found to exhibit plant disease protection action against fungi and bacteria, including *Agrobacterium*, *Alcaligenes*, *Arthrobacter*, *Bacillus*, *Enterobacter*, *Erwinia*, *Pseudomonas*, *Rhizobium*, *Serratia*, *Stenotrophomonas*, and *Xanthomonas*. Bacteria have a variety of techniques they can employ to prevent the spread of plant diseases. These methods of action include plant resistance induction, antagonistic activity based on colonization of infection sites, competitive exclusion of the pathogen, and the release of highly effective antimicrobials like antibiotics or cell wall lytic enzyme. [47].

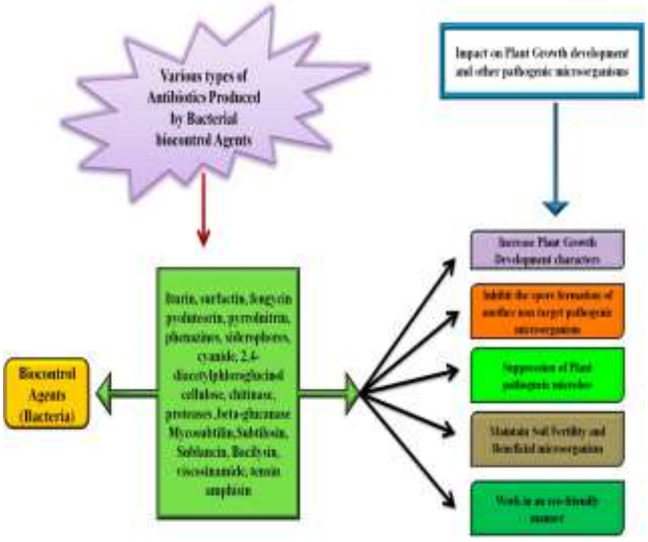


**Figure2. Effects of bacterial biocontrol agents on plant development and other harmful microorganisms (14).**

- ***Pseudomonas spp.***

Fluorescent *pseudomonads* are frequently found in plants habitats and have a number of essential characteristics that contribute to their efficiency in preventing plant illness. High ecological fitness is one of these qualities, a potent ability to incite an immunological response in plants, and a significant antagonistic activity toward numerous plant diseases.

Numerous *Pseudomonas* species are proficient endosphere and plant surface colonists (rhizosphere and phyllosphere). They have a rapid growth rate and the capacity to utilize a variety of plant exudates as nutrients, which are necessary for them to effectively compete with other microbes for resources and space in the plant habitats [48]. For instance, *P. pseudoalcaligenes* AVO110 and *P. fluorescens* EPS62e's effectiveness in reducing *Erwinia amylovora* and *Rosellinia necatrix* infections, respectively, is founded on their high fitness for colonizing plant tissues and their superior ability to use nutrients compared to the target pathogens [49]. Competition for limited nutrients has also been identified as a crucial Pseudomonas spp. tactic, while it only works when the concentration of a specific limited resource is low, as in the instance of *P. fluorescens* biological control of *Pythium ultimum*. [50], or in the prevention of *Fusarium* wilt of carnations by *P. putida* WCS358 by competition for iron that is mediated by siderophores [51]. Another significant feature of *Pseudomonas* spp. is their high bioactive chemical production, which includes antibiotics, cyclic peptids, and enzymes that play critical environmental roles. They generate a number of anti- microbial compounds, including as phenazines, phloroglucinols, dialkylresorcinols, pyoluteorin, and pyrrolnitrin, whose participation as a method of action in biological control has drawn a lot of interest. [52], and PCA create by *P. fluorescens* EPS894 inhibits *Phytophthora cactorum* in strawberry plants[53]. *Pseudomonads* are also capable of producing lytic extracellular enzymes such cellulases, glucanases, and chitinases, which are essential for biocontrol activity by breaking down glucan, glucosidic bridges, and chitin, which are parts of cell walls. For instance, *Pseudomonas* sp. hydrolytic enzymes promote chickpea growth and have antifungal properties against *Rhizoctonia solani* and *Pythium aphanidermatum* in vitro [54].

- ***Bacillus***

The genus *Bacillus* considers the most frequently used beneficial bacteria as bio pesticides.They have a wide range of physiological abilities and the capacity to generate endospores, which confers resistance to unfavorable climatic conditions. They are extensively distributed in many environments, including soil and plant surfaces. They can create antagonistic relationships with a variety of bacterial and fungi that cause plant diseases. The most noteworthy aspect of *Bacillus* spp. is their ability to create a variety of bioactive compounds important for agricultural requirements, such as metabolites with antibacterial activity, surface-active, and associated with the development of plant defensive responses. [55].

Bacteriocins and compounds that like them are peptides produced by the ribosome that attack goal cells by preventing the production of the cell wall or by creating gaps within a cellular membranes . Numerous bacteriocins having antimicrobial activity, including amylolysin, amylocyclicin, amysin, subtilin, subtilosin A, and subtilosin B, are produced by *Bacillus* species [56]. Some of them have experience in plant pathogen biocontrol. For instance, thuricin Bn1 from *B. thuringiensis* subsp. kurstaki Bn1 has activity against *Pseudomonas savastanoi* and *P. syringae* [57] and Bac- GM17 produced by *B. clausii* GM17 has activity against *Agrobacterium tumefaciens* [58].

Cyclic lipopeptides (CLPs), which are extensively distributed in *Bacillus* species, are non-ribosomally synthesized amphiphilic molecules made up of a fatty acid tail connected to a short oligo peptide that forms a macro cyclic ring structure. Iturins, fengicins, and surfactins are three of the most significant CLPs made by *Bacillus*. They interact with the target pathogens' cell membrane, creating holes and disrupting transmembrane ion fluxes [59].

There are numerous strains of the bacterium *Bacillus spp*. that produce CLPs, which oversee the antifungal action that shields plants against disease. Key components of the antagonism against fungal diseases include the fengycin, iturin A, and surfactin generated by *B. amyloliquefaciens* PPCB004 and the bacillomycin, fengycin, and iturin A produced by *B. subtilis* UMAF6614 and UMAF6639 [60]. Additionally, *Bacillus* strains that produce CLPs also have antibacterial activity For example, *B. amyloliquefaciens* A17 (currently B. velezensis) produces bacillomycin, fengycin, iturin, and surfactin, which work in concert to combat a number of bacterial plant pathogens [61], and *B. amyloliquefaciens* KPS46 produces surfactin, which is necessary [62]. Some of these substances function indirectly as elicitors of defensive mechanisms in the host plant or have a significant role in promoting colonization [63] in addition to their antibacterial activity.

*Bacillus spp*. strains also produce large amounts of hydrolytic enzymes such "chitinases, chitosanases, glucanases, cellulases, lipases, and proteases". These substances have been used to effectively hydrolyze the main parts of bacterial and fungal cell walls and to inhibit plant pathogens. For instance, them hydrolases activity (protease, chitinase, cellulase, and glucanase) [64] shown to be essential component of *B. velezensis* in the management of pepper gray mold caused by *Botrytis cinerea* and showed success in the biocontrol of *Fusarium oxysporum* [65].

- ***Streptomyces spp.***

*Streptomyces spp*.are more investigated bacterial genera , they are create bioactive compounds that, in vitro, prevent plant diseases and are helpful in treating a variety of bacterial and fungal plant diseases [66],These metabolites include aminoglycosides, polyenes, nucleosides, and macrolide benzoquinones. The ability of certain *Streptomyces* strains to produce extracellular enzymes useful in the breakdown of fungal cell walls is also well documented. *Phaseolus vulgaris* infections with *Macrophomina phaseolina* and *Rhizoctonia solani* were reduced by several strains of *Streptomyces* CBQ-EA-2 and CBQ-B-8, which have chitinolytic, cellulolytic, and proteolytic activity. , may have a mycoparasitic potential, and these hydrolases may also play a role in the limitation of plant diseases [67].

The endosphere and rhizosphere of plants, as well as the soil, are the main habitats for these bacteria. For example, the Streptomyces sp. rhizosphere strains VV/R1 and VV/R4 shown anti-fungal activity and decrease nursery fungal graft infections on grapevine plants. [68].

- ***Pantoea spp.***

Because *Pantoea spp.* are widespread and produce antimicrobial chemicals, several of their strains have BCA abilities. In Canada, the United States, and New Zealand, there are registered and commercially accessible biopesticides based on *Pantoea* species. Through a variety of processes, such as competitive colonization, the synthesis of antimicrobials, and/or the stimulation of host systemic protection, they have biocontrol activity. Through the release of antimicrobial substances including pantocins, herbicolins, microcins, and phenazines, There is evidence that specific strains of the *Pantoea* species can kill a variety of plant diseases, including bacteria, fungus, and oomycetes [69]. Another illustration is the ability of *Pantoea* species to create N-acyl-homoserine lactone (AHL), which has an impact on pathogen quorum sensing and may help to prevent the spread of diseases by enhancing plant environmental fitness [70].

- ***Lactic acid bacteria (LAB).***

Lactic Acid bacteria (LAB) are good candidates as BCAs because they involve some strains that have been classified as Generally Regarded as Safe (GRAS) by the U.S. Food and Drug Administrations (FDA) and as having Qualified Presumption of Safety (QPS) status by the European Food Safety Authority (EFSA), as well as because they have been widely reported as bio preservatives of vegetable and fruits [71].

Due to the formation of one or more antimicrobial metabolites, LAB exhibit antimicrobial action. These include proteinaceous substances like bacteriocins and antifungal peptides, organic acids, carbon dioxide, diacetyl, and hydroxide peroxide. They may also prevent pathogens from colonizing plant tissues that are vulnerable to infection, by competing for resources and available space, or by triggering defensive mechanisms in plants. The bacterial plant diseases *L. plantarum* PM411 and TC92, for instance, can be avoided. Established on antimicrobial metabolites and the inhibition of pathogen population on plant surfaces, their broad spectrum of antagonistic activity against microorganisms that cause plant disease is based [72].

**Conclusions:**

Plants are exposed to many diseases, whether in the field or inside the greenhouse, due to the presence of many fungal, bacterial and viral pathogens in the environment, which leads to economic loss in field crops and a lack of yield in quantity and quality, and use of insecticides that are chemical leads to damage to the environment and the plant in addition to the consumer, whether human or animal. It causes many diseases, which prompted researchers to use biological control agents or biopesticides represented in fungi and bacteria as vital control agents to get rid of plant pests and diseases and reduce the bad effects of chemical pesticides on the environment, plants, and the consumer. Beneficial microorganisms (biocontrol and/or plant biostimulant micro-organisms), which are found in natural goods, seem to be the most promising means of ensuring the health of plants as well as the quality and safety of vegetal products. There are now derived BCA-based bioformulates on the market as a result of the extensive research (thousands of published scientific articles) that has been conducted over the past few decades on analyzing the performance of different selected BCAs against various hazardous fungal diseases. Despite the technical and administrative challenges associated with the development of microbial BCAs, there is a strong tendency to shift to the control of plant diseases with a lower environmental impact and fewer risks for human health. Additionally, there is growing political support from various governments to find solutions and funding of research on new technologies to solve the more general problems related to climate change and the conservation of biodiversity and the environment. Therefore, in this review, we discussed the role of bacterial and fungal biocontrol agents in control on plant fungal diseases.

**References :**

[1] O'Brien, P. A. (2017). Biological control of plant diseases. Australas. Plant Pathol.46 (4), 293–304. doi: 10.1007/s13313-017-0481-4.

[2] Menzler-Hokkanen, I. (2006). "Socioeconomic significance of biological control," in An ecological and societal approach to biological control (Dordrecht: Springer), 13–25.

[3] James, T., et al. (2006). Reconstructing the early evolution of fungi using a six-gene phylogeny. Nature 443, 818-822.

[4] Staples, R.C. (2000). Research on the rust fungi during the twentieth century. Annu. Rev. Phytopathol. 38, 4969.

[5] Pal, K. K. and B. McSpadden Gardener. (2006). Biological Control of Plant Pathogens. *The Plant Health Instructor* DOI: 10.1094/PHI-A-2006-1117-02.

[6] Agrios, George. N. (2005). Plant pathology. Fifth edition , printed in united state of America. Pp : 12-15.

[7] Desjardins, A.E., Hohn, T.M., McCormick, S.P. (1993). Trichothecene biosynthesis in *Fusarium* species: chemistry, genetics and significance. Microbiol. Rev. 57, 595604.

[8] Brown, J.K.M., (1994). Chance and selection in the evolution of barley mildew. Trends Microbiol. 2, 461501.

[9] Dean R. , Jan A. L. Vankan , Zacharias, A. Pretorius , E. Hammond, K. , Antonio, P. , Pietro, D. SPANU, Jason, J. , Marty, D. , Regine, K. , JEFF,E. and Garyd, F. (2012). The Top 10 fungal pathogens in molecular plant pathology. molecular plant pathology 13(4). Pp 414- 430.

[10] Lazarovits G., Turnbull A., Johnston-Monje D.(2014). Plant health management: biological control of plant pathogens. In: Van Alfen NK, editor. Encyclopedia of agriculture and food systems. New York, NY: Academic Press; p. 388–399.

[11] Kour, D.; Rana, K.L.; Yadav, A.N.; Yadav, N.; Kumar, M.; Kumar, V.; Vyas, P.; Dhaliwal, H.S.; Saxena, A.K.(2019). Microbial biofertilizers: Bioresources and eco-friendly technologies for agricultural and environmental sustainability. Biocatal. Agric. Biotechnol.,23, 101487.

[12] Glick, B.R.(2012). Plant Growth-Promoting Bacteria: Mechanisms and Applications. Scientifica , 963401.

[13] Mohammed, B.L.; Hussein, R.A.; Toama, F.N.(2019). Biological control of *Fusarium* wilt in tomato by endophytic rhizobactria. Energy Procedia , 157, 171–179.

[14] Tariq, M. ; Khan, A.; Asif, M.; Khan, F.; Ansari, T.; Shariq ,M.; and Siddiqui,M.(2020). Biological control: a sustainable and practical approach for plant disease management. ACTA Agriculture Scandinavica, Section B — Soil & Plant Science , vol. 70, No. 6, 507–524; https://doi.org/10.1080/09064710.2020.1784262

[15] Blaszcyk, L.; Siwulski, M.; Sobieralski, K.; Lisiecka, J.; Jedryczka, M.(2014). Trichoderma spp. - application and prospects for use in organic farming and industry. Journal of Plant Protection Research ;54(4):309–317

[16] Schuster A., Schmoll M.( 2010). Biology and biotechnology of *Trichoderma*. Appl. Microbiol. Biotechnol. 87 (3): 789−799.

[17] Harman, G.E. (2006) "Overview of mechanisms and uses of *Trichoderma* spp."
Phytopathology 96 (2): 190.

[18] Harman, G.E., Howell, C.R., Viterbo, A., Chet, I. and Lorito, M. (2004). Trichoderma species - Opportunistic, Avirulent Plant Symbionts. Nature Reveiws, 2: 43-56.

[19] Bigirimana, J., De Meyer, G., Poppe, J., Elad, Y. and Hofte, M. (1997). Induction of systemic resistance on bean (Phaseolus vulgaris) by Trichoderma harzianum. Med Fac Landbouww University Gent, 62: 1001–1007.

[20] Yedidia, I., Benhamou, N. and Chet, I. (1999). Induction of defence responses in Cucumber plants (Cucumis sativus L.) by the Biocontrol agent Trichoderma harzianum. Applied Environmental and Microbiology, 65: 1061-1071.

[21] Mohiddin, F.A., Khan, M.R., Khan, S.M. and Bhat, B.H. (2010). Why Trichoderma is Considered Super Hero (Super Fungus) Against the Evil Parasites? Plant Pathology Journal, 9(3): 92-102.

[22] Puyam, A., Shahid, M., Srivastava, M. and Singh, A. (2013). Effect of different physiological parameters on growth and sporulation of Trichoderma viride. Plant Disease Research, 28(2) :146-151.

[23] Boughalleb-M'Hamdi, N.; Salem, I.B.; M'Hamdi, M.(2018). Evaluation of the Efficiency of Trichoderma, Penicillium, and Aspergillus Species as Biological Control Agents against Four Soil-Borne Fungi of Melon and Watermelon. Egypt. J. Biol. Pest Control, 28, 25.

[24] Jin, N.; Liu, S.M.; Peng, H.; Huang, W.K.; Kong, L.A.; Wu, Y.H.; Chen, Y.P.; Ge, F.Y.; Jian, H.; Peng, D.L.(2019). Isolation and Characterization of Aspergillus Niger NBC001 Underlying Suppression against Heterodera Glycines. Sci. Rep., 9, 591.

[25] Idan, A.A.; Sijam, K.; Kadir, J.; Rashid, T.S.; Awla, H.K.; Alsultan,W.(2017). Biological Control of Pyricularia Oryzae Using Antifungal Compounds Produced by Aspergillus Niger. Am. J. Plant Sci. , 08, 2445–2460.

[26] Hu, X.;Webster, G.; Xie, L.; Yu, C.; Li, Y.; Liao, X.(2013). A New Mycoparasite, Aspergillus sp. ASP-4, Parasitizes the Sclerotia of Sclerotinia
Sclerotiorum. Crop. Prot., 54, 15–22.

[27] Cray, J.A.; Bell, A.N.W.; Bhaganna, P.; Mswaka, A.Y.; Timson, D.J.; Hallsworth, J.E.(2013) The Biology of Habitat Dominance; Can Microbes Behave asWeeds? Microb. Biotechnol., 6, 453–492.

[28] Šimonoviˇcová, A.; Vojtková, H.; Nosalj, S.; Piecková, E.; Švehláková, H.; Kraková, L.; Drahovská, H.; Stalmachová, B.; Kuˇcová, K.; Pangallo, D.(2021). Aspergillus Niger Environmental Isolates and Their Specific Diversity Through Metabolite Profiling. Front. Microbiol., 12, 658010.

[29] Nadumane, V.K.; Venkatachalam, P.; Gajaraj, B.(2016).Aspergillus Applications in Cancer Research. In New and Future Developments in Microbial Biotechnology and Bioengineering; Gupta, V.K., Ed.; Elsevier: Amsterdam, The Netherlands; pp. 243–255, ISBN 978-0-444-63505-1.

[30] Hamayun, M.; Hussain, A.; Iqbal, A.; Khan, S.A.; Lee, I.(2018). Endophytic Fungus Aspergillus Japonicus Mediates Host Plant Growth under Normal and Heat Stress Conditions. Biomed Res. Int., 3, 7696831.

[31] Gulzar, T.; Huma, T.; Jalal, F.; Iqbal, S.; Abrar, S.; Kiran, S.; Nosheen, S.; Hussain,W.; Rafique, M.A.(2017). Bioremediation of Synthetic and Industrial Effluents by Aspergillus Niger Isolated from Contaminated Soil Following a Sequential Strategy. Molecules, 22, 2244.

[32] Yang, L.; Lübeck, M.; Lübeck, P.S.(2017). Aspergillus as a Versatile Cell Factory for Organic Acid Production. Fungal. Biol. Rev., 31, 33–49.

[33] Sadorn K., Saepua S., Boonyuen N., Laksanacharoen P., Rachtawee P., Prabpai S., et al.. (2016). Allahabadolactones A and B from the endophytic fungus, *Aspergillus allahabadii* BCC45335. *Tetrahedron* 72, 489–495. doi: 10.1016/j.tet.2015.11.056.

[34] El-hawary S. S., Moawad A. S., Bahr H. S., Abdelmohsen U. R., Mohammed R. (2020). Natural product diversity from the endophytic fungi of the genus Aspergillus. RSC Adv. 10, 22058–22079. doi: 10.1039/D0RA04290K.

[35] Wang W., Liao Y., Tang C., Huang X., Luo Z., Chen J., et al.. (2017). Cytotoxic and antibacterial compounds from the coral-derived fungus *Aspergillus tritici* SP2-8-1. *Mar. Drugs* 15, 348. doi: 10.3390/md15110348, PMID.

[36] Mohamed G. A., Ibrahim S. R., Asfour H. Z. (2020). Antimicrobial metabolites from the endophytic fungus *Aspergillus versicolor*. *Phytochem. Lett.* 35, 152–155. doi: 10.1016/j.phytol.2019.12.003.

[37] El-Sayed A. S., Ali G. S. (2020). *Aspergillus flavipes* is a novel efficient biocontrol agent of *Phytophthora parasitica*. *Biol. Control* 140:104072. doi: 10.1016/j.biocontrol.2019.104072.

[38a] Ali, I., Akbar, A., Anwar, M., Yanwisetpakdee, B., Prasongsuk, S., Lotrakul, P. and Punnapayak, H., (2014a). Purification and characterization of extracellular, polyextremophilic a- amylase obtained from halophilic Engyodontium album. Iranian J. Biotech., 12: 35-40.

[38b] Ali, I., Siwarungson, N., Punnapayak, H., Lotrakul, P., Prasongsuk, S., Bankeeree, W. and Sudip, K., Rakshit.,( 2014b). Screening Of Potential Biotechnological Applications From Obligate Halophilic Fungi, Isolated From A Man-Made Solar Saltern Located In Phetchaburi Province, Thailand. Pak. J. Bot., 46(3): 983-988.

[39] Belancic, A., Scarpa, J., Peirano, A., Díaz, R., Steiner, J. and Eyzaguirre, J.(1995). Penicillium purpurogenum produces several xylanases: Purification and properties of two of the enzymes. Elsevier, Journal of Biotechnology. Doi: 10.1016/0168-1656(95)00057- W.

[40] Refai M , Abo El-Yazid H. and Tawakkol W. ( 2015). Monograph On The genus Penicillium. Pp. 4 – 158.

[41] Hossain MM, Sultana F, Kubota M, Koyama H, Hyakumachi M. (2007). The plant growth-promoting fungus Penicillium simplicissimum GP17-2 induces resistance in Arabidopsis thaliana by activation of multiple defense signals. Plant and Cell Physiology 48, 1724-1736.

[42] Yang L, Xie J, Jiang D, Fu Y, Li G, Lin F. (2008) . Antifungal substances produced by Penicillium oxalicum strain PY-1—potential antibiotics against plant pathogenic fungi. World Journal of Microbiology and Biotechnology 24, 909-915.

[43] Sempere F, Santamarina MP .(2008). Suppression of Nigrospora oryzae (Berk. & Broome) Petch by an aggressive mycoparasite and competitor, Penicillium oxalicum Currie & Thom. International Journal of Food Microbiology 122, 35-43.

[44] Legein, M.; Smets, W.; Vandenheuvel, D.; Eilers, T.; Muyshondt, B.; Prinsen, E.; Samson, R.; Lebeer, S.(2020). Modes of action of microbial biocontrol in the phyllosphere. Front. Microbiol., 11, 1619.

[45] Kalia, V.C.; Patel, S.K.S.; Kang, Y.C.; Lee, J.K.(2019). Quorum sensing inhibitors as antipathogens: Biotechnological applications. Biotechnol. Adv, 37, 68–90.

[46] Elnahal, A.S.M.; El-Saadony, M.T.; Saad, A.M.; Desoky, E.S.M.; El-Tahan, A.M.; Rady, M.M.; AbuQamar, S.F.; El-Tarabily, K.A.(2022). The use of microbial inoculants for biological control, plant growth promotion, and sustainable agriculture: A review. Eur. J. Plant Pathol., 162, 759–792.

[47] Berendsen, R.L.; Pieterse, C.M.J.; Bakker, P.A.H.M.(2012). The rhizosphere microbiome and plant health. Trends Plant Sci., 17, 478–486.

[48] Oso, S.; Walters, M.; Schlechter, R.O.; Remus-Emsermann, M.N.P.(2019). Utilisation of hydrocarbons and production of surfactants by bacteria isolated from plant leaf surfaces. FEMS Microbiol. Lett., 366, fnz061.

[49] Pliego, C.; de Weert, S.; Lamers, G.; de Vicente, A.; Bloemberg, G.V.; Cazorla, F.M.; Ramos, C. (2008).Two similar enhanced root colonizing Pseudomonas strains differ largely in their colonization strategies of avocado roots and Rosellinia necatrix hyphae. Environ. Microbiol., 10, 3295–3304.

[50] Ellis, R.J.; Timms-Wilson, T.M.; Beringer, J.E.; Rhodes, D.; Renwick, A.; Stevenson, L.; Bailey, M.J.(1999). Ecological basis for biocontrol of damping-off disease by Pseudomonas fluorescens 54/96. J. Appl. Microbiol., 87, 454–463.

[51] Duijff, B.J.; Bakker, P.A.H.M.; Schippers, B.(1994). Suppression of fusarium wilt of carnation by Pseudomonas putida WCS358 at different levels of disease incidence and iron availability. Biocontrol. Sci. Technol., 4, 279–288.

[52] Haas, D.; Keel, C.(2003). Regulation of antibiotic production in root-colonizing Pseudomonas spp. and relevance for biological control of plant disease. Annu. Rev. Phytopathol., 41, 117–153.

[53] Agustí, L.; Bonaterra, A.; Moragrega, C.; Camps, J.; Montesinos, E.(2011). Biocontrol of root rot of strawberry caused by Phytophthora cactorum with a combination of two Pseudomonas fluorescens strains. J. Plant Pathol. , 93, 363–372.

[54] Sindhu, S.S.; Dadarwal, K.R.(2001). Chitinolytic and cellulolytic Pseudomonas sp. antagonistic to fungal pathogens enhances nodulation by Mesorhizobium sp. Cicer in chickpea. Microbiol. Res., 156, 353–358.

[55] McSpadden Gardener, B.B.(2004). Ecology of Bacillus and Paenibacillus spp. in agricultural systems. Phytopathology, 94, 1252–1258.

[56] Abriouel, H.; Franz, C.M.A.P.; Omar, N.B.; Gálvez, A.(2011). Diversity and applications of Bacillus bacteriocins. FEMS Microbiol. Rev., 35, 201–232.

[57] Ugras, S.; Sezen, K.; Kati, H.; Demirbag, Z.(2013). Purification and characterization of the bacteriocin Thuricin Bn1 produced by Bacillus thuringiensis subsp. kurstaki Bn1 isolated from a hazelnut pest. J. Microbiol. Biotechnol., 23, 167–176.

[58] Mouloud, G.; Daoud, H.; Bassem, J.; Laribi Atef, I.; Hani, B.(2013). New bacteriocin from Bacillus clausii strainGM17: Purification, characterization, and biological activity. Appl. Biochem. Biotechnol., 171, 2186–2200.

[59] Raaijmakers, J.M.; De Bruijn, I.; Nybroe, O.; Ongena, M.(2010). Natural functions of lipopeptides from Bacillus and Pseudomonas: More than surfactants and antibiotics. FEMS Microbiol. Rev., 34, 1037–1062.

[60] Zeriouh, H.; Romero, D.; Garcia-Gutierrez, L.; Cazorla, F.M.; de Vicente, A.; Perez-Garcia, A.(2011). The iturin-like lipopeptides are essential components in the biological control arsenal of Bacillus subtilis against bacterial diseases of cucurbits. Mol. Plant Microbe Interact., 24, 1540–1552.

[61] Mora, I.; Cabrefiga, J.; Montesinos, E.(2015). Cyclic lipopeptide biosynthetic genes and products, and inhibitory activity of plantassociated Bacillus against phytopathogenic bacteria. PLoS ONE, 10, e0127738.

[62] Preecha, C.; Sadowsky, M.J.; Prathuangwong, S.(2010). Lipopeptide surfactin produced by Bacillus amyloliquefaciens KPS46 is required for biocontrol efficacy against Xanthomonas axonopodis pv. glycines. Kasetsart J. Nat. Sci., 44, 84–99.

[63] Ongena, M.; Duby, F.; Jourdan, E.; Beaudry, T.; Jadin, V.; Dommes, J.; Thonart, P.(2005). Bacillus subtilis M4 decreases plant susceptibility towards fungal pathogens by increasing host resistance associated with differential gene expression. Appl. Microbiol. Biot.,67, 692–698.

[64] Jiang, C.-H.; Liao, M.-J.; Wang, H.-K.; Zheng, M.-Z.; Xu, J.-J.; Guo, J.-H.(2018). Bacillus velezensis a potential and efficient biocontrol agent in control of pepper gray mold caused by Botrytis cinerea. Biol. Control, 126, 147–157.

[65] Guleria, S.; Walia, A.; Chauhan, A.; Shirkot, C.K.(2016). Molecular characterization of alkaline protease of Bacillus amyloliquefaciens SP1 involved in biocontrol of Fusarium

oxysporum. Int. J. Food Microbiol., 232, 134–143.

[66] Viaene, T.; Langendries, S.; Beirinckx, S.; Maes, M.; Goormachtig, S.(2016). Streptomyces as a plant's best friend? FEMS Microbiol. Ecol., 92, fiw119.

[67] Díaz-Díaz, M.; Bernal-Cabrera, A.; Trapero, A.; Medina-Marrero, R.; Sifontes-Rodríguez, S.; Cupull-Santana, R.D.; García-Bernal, M.; Agustí-Brisach, C.(2022). Characterization of actinobacterial strains as potential biocontrol agents against Macrophomina phaseolinaand Rhizoctonia solani, the main soil-borne pathogens of Phaseolus vulgaris in Cuba. Plants, 11, 645.

[68] Álvarez-Pérez, J.M.; González-García, S.; Cobos, R.; Olego, M.Á.; Ibañez, A.; Díez-Galán, A.; Garzón-Jimeno, E.; Coque, J.J.R.(2017). Use of endophytic and rhizosphere actinobacteria from grapevine plants to reduce nursery fungal graft infections that lead to young grapevine decline. Appl. Environ. Microbiol., 83, e01564-17.

[69] Walterson, A.M.; Stavrinides, J.(2015). Pantoea: Insights into a highly versatile and diverse genus within the Enterobacteriaceae. FEMS Microbiol. Rev., 39, 968–984.

[70] Smits, T.H.M.; Rezzonico, F.; Pelludat, C.; Goesmann, A.; Frey, J.E.; Duffy, B.(2010).Genomic and phenotypic characterization of a non-pigmented variant of Pantoea vagans biocontrol strain C9-1 lacking the 530 kb megaplasmid pPag3. FEMS Microbiol. Lett., 308, 48–54.

[71] Trias, R.; Badosa, E.; Montesinos, E.; Bañeras, L. (2008). Bioprotective Leuconostoc strains against Listeria monocytogenes in fresh fruits and vegetables. Int. J. Food Microbiol., 127, 91–98.

[72] Trias, R.; Bañeras, L.; Badosa, E.; Montesinos, E.(2008). Bioprotection of Golden Delicious apples and Iceberg lettuce against foodborne bacterial pathogens by lactic acid bacteria. Int. J. Food Microbiol., 123, 50–60.

# الفطريات والبكتيريا كعوامل سيطرة حيوية لأمراض النباتات الفطرية: مراجعة

**رجاء فاضل حمدي ، خضر صكر هاشم**

قسم علوم الحياة ، كلية العلوم ، جامعة الانبار ، الانبار ، العراق

Sc.moh_n2002@uoanbar.edu.iq

**الخلاصة :**

**بالنسبة لإدارة أمراض النباتات الفطرية ، تعتبر المكافحة البيولوجية بديلاً فعالاً وصديقاً للبيئة ،تسبب مسببات الأمراض النباتية خسائر أو أضراراً بالغة للمحاصيل في جميع أنحاء العالم وبالتالي تقلل بشكل كبير من جودة وكمية السلع الزراعية. في هذه المراجعة تمت مناقشة النشاط المضاد لبعض عوامل المكافحة الحيوية البكتيرية والفطرية الطبيعي والتجاري، اذ تم استخدام الصفات التضادية للأنواع الفطرية والبكتيرية كعوامل سيطرة بيولوجية (BCA) في إدارة أمراض النبات (PDM) بالإضافة إلى دورها المهم في النظام البيئي. إن قدرة عوامل المكافحة البيولوجية الفطرية (FBCAs) على الوقاية من الأمراض يمكن مقارنتها باستخدام المواد الكيميائية الاصطناعية ، فمن الضروري النظر في توافر مبيدات الآفات الاصطناعية الآمنة والصديقة للبيئة بالاضافة الى كلفتها المالية. أن استخدام الكائنات الحية الدقيقة للإدارة البيولوجية للآفات هو استراتيجية عملية يمكن أن تقلل بشكل كبير من الآثار السلبية للمواد الكيميائية الزراعية في التربة. اذ تغطي هذه الدراسة بعض الأجناس الفطرية والبكتيرية كعوامل سيطرة حيوية وتدعو إلى إجراء تعديلات على البحث والتطوير لتحسين عملية ادارة امراض النبات الفطرية وزيادة غلة المحاصيل في الزراعة المستدامة.**

**الكلمات المفتاحية : امراض نبات ، السيطرة البيولوجية , عوامل السيطرة الحيوية , عوامل المقاومة الحيوية , الفطريات , البكتريا .**