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Role of Beneficial Microbes in Protecting Plants from Disease

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Abstract

Protective microbes such as bacteria, fungi and other microorganisms aid in defence against plant pathogens hence acting as bio control to chemical pesticides. These microbes are located in different plant environment of which includes; Rhizosphere, endophytic sites, and phyllosphere where they form strong relationship with the plants with an aim of promoting plant health. The compatible mutualistic partners benefit the plant by denying pathogens a chance to access nutrients and space on the plant tissues and by other means such as producing chemicals that are toxic to pathogens and cause the plant to harden up on diseases. This is perhaps one of the most effective methods by which helpful microbes shield plants from bad pathogens through resource rivalry. In the rhizosphere, the growth of growth promoting bacteria and mycorhyzal fungi results in intense competition with pathogenic microbes. Also, valuable microbes release bioactive chemicals including antibiotics and volatile organic compounds (VOCs) that pointedly curb microbial development and even prevent diseases. These microbes also trigger defense mechanisms in plants such as ISR, which prepares the plant to offer early and enhanced response to subsequent pathogen invasions. This part benefits plants besides protection from pathogens or parasites by mutual microbial association. For instance, mycorrhizal fungi include fungi that interact with the plant root system to aid in nutrient acquisition as well as to present protection against pathogenic organisms in the soil. Myocardial microbes living inside tissues give inside protection by synthesizing secondary products that minimize pathogenic action and improve plant resistance. There is growing interest in the application of beneficial microbes as biocontrol agents in the management of diseases in crop production systems. But, such constraints as the

variability in the environment and competition from microbes still remain factors inhibiting extensive use of bioadsorbents. Future investigations to microbial communities and their relationship with plants will reveal more applications of these microorganisms thus enhancing the improvement of efficient and sustainable agricultural systems. The strategies of the helpful microbes in shield plants, the position of the microbes in sustainable agriculture and prospect of more advance on plant healthy management are illustrated in this article.

Introduction

Plants as the so called 'bottom of the food chain' are obliged to deal daily with various pathogenic infections pretenders – bacteria, fungi, viruses and nematodes. Through the ages, they have adopted versatile mechanisms of security to combat the above mentioned impending calamities. Although the method of protecting plants has in the past involved the use of chemicals such as pesticides, there is an increasing concern on advanced, environmental friendly methods. Of these, the application of post-CRAMA beneficial microbes for developing a shield against plant diseases has been found to be a novel tactic. Mentioned bacteria, fungi and other microbes make crucial contribution to plant's growth promoting it and to its defense from a great number of plant pathogens. Symbiotic partners are always existing in so many sites of plants, such as, rhizosphere (root), endosphere (inside tissues of plant), and Phyllosphere (plant leaves). In these niches, these microorganisms positively interface with plants by suppressing the buffering of diseases as well as enhancing the health of plants. In these symbiotic interactions beneficial microbes protect the plant against pathogenic organisms using several strategies including nutrient competition, antimicrobial substance production, and plant immunization. In some cases, the microbes seem to trigger protective responses in plants and prepare them to act faster in the event of an infestation or invasion. However, PGP-burdened microbes are multitasking stress-protective agents that not only stress-protect plants but also enhance nutrient acquisition, beneficially alter root exudite concentrations, and modulate hormone homeostasis. That is why the concept of beneficial microbes is growing in importance as pivotal in sustainable practices in modern agriculture. Incorporation in the system provides an opportunity to replace chemical pesticides and fertilizers hence enhancing sustainability and environmental practices in agriculture. This article describes the various types of beneficial microbes and their modes of action as disease protectants as well as the role of such microbes in changing the current concept of plant disease management in sustainable agriculture.

Types of Beneficial Microbes

Premium microbes refer to beneficial microorganisms that help the plant and help it to stand up to diseases. These microbes can be broadly categorized into three main groups based on their habitat and interaction with plants: The plant-associated microbes that could be identified includes the rhizosphere microbes, the endophytic microbes and the phyllosphere microbes. All groups have their functions that contribute towards the strengthening of resistance of plants to pathogens besides improving their health.

Rhizosphere Microbes

Rhizosphere is that area of the soil surrounding the root of the plant and is densely populated by bacteria, fungi, and actinomycetes. These microbes play an important role in plant health since they enhance nutrient acquisition especially nitrogen, phosphorous and micro nutrients. Soil beneficial rhizobacteria including Pseudomonas and Bacillus have ability to inhibit the soil-borne pathogens through competition exclusion, production of antimicrobial substances or inhibition of nutrient utilization by pathogenic microorganisms. Mycorrhizal fungi associated with roots of most large groups of plants increase nutrient uptake and offer plants defense mechanisms against root pathogens by acting as a barrier to pathogen infection.

Endophytic Microbes

Some of the microbes are found to live within plant tissues without being pathogenic to the plants. Saying that, these microbes may be bacteria or fungi or in some cases even algae. Endophytes have shown ability to combat diseases affecting plants through release of bioactive compounds including antibiotics and antifungal metabolites that negatively impact the pathogens. Besides, they can sensitize the plant to other future pathogen invasions by increasing immunity to certain diseases in the plant. There is also evidence that endophytes may stimulate enhanced production of plant hormones or alter nutrient acquisition or stress resistance. Promising endophytic bacteria include Bacillus spp and Azospirillum which fix P, K, and other nutrients in the plant tissue leading to increased disease resistance and plant growth.

Phyllosphere Microbes

Phylosphere to means the plant surface; more precisely, the leaf surface which supports bacteria, yeasts and fungi. These microorganisms cover the surface of the leaves with a layer that denies pathogenic microorganisms' access to the plant. Phyllosphere microbes may also make antimicrobial substances, or compete for nutrients with other microbes, or even trigger systemic resistance in plants. Some of the vital fungi which have been found to protect foliar diseases include Trichoderma have been known to control harbour pathogenic fungi including; Alternaria and Fusarium.

Protection against disease by Beneficial Microbes

Plant beneficial microbes serve to impede deleterious organisms through several methods aimed at supporting plant defense and thereby relieve pathogenic burden. Hence the strategies include; resource competition, production of antimicrobial compounds, induction of systemic resistance and mechanically through biofilm formation.

Competition for Resources

An essential way through which advantageous microbes defend plants is through occupying nutrients and space from pathogens. Microorganisms, especially bacteria and fungi; Pseudomonas and Bacillus lock the pathogenic microorganisms from accessing nitrogen, phosphorus, and organic carbon as found in the rhizosphere. These mutualists exert antimicrobial effects by occupying ecological spaces, which pathogens would normally use to invade the host organism. This type of competition exclusion lowers the possibilities of pathogen settlement and infection.

Syntheses of Antibiotic Substances

Nutrient-savoring microbes have been reported to synthesize antibiotic substances, ant fungal metabolites and volatile organic compounds (VOCs) which arrest the growth of pathogens. For instance Bacillus species release bacteriocins and lipopeptides which inhibit bacterial pathogen growth while Trichoderma species release enzymes that degrade fungal pathogen cell walls. These antimicrobial compounds serve as inherent biochemical barriers against colonization by, and growth of, pathogens on plant organs and in plant tissues.

ISR for its short form stands for Induction of Systemic Resistance.

Some rhizosphere beneficial microbes can elicit SAR or ISR, both of which are a part of the plant defense stimulation. Some of these microbes produce a chemical signal such as JA or SA within the plant to help alert it to potential threats so the plant is better prepared for any future invasions. Such primed immune response helps a plant to its rapid and effective mode of identification of pathogenic invasion.

Biofilm Formation

Beneficial microbes, for instance those living on the surface of the plant or in the vicinity of the roots, usually inhabit the phyllosphere or rhizosphere respectively, combines to form a film on the plant which has the effect of shielding against pathogens. These biofilms prevent attachment of unwanted microorganisms and also make it unfavorable for pathogens to grow due to some changes made to the physical characteristics of tissues of plants and elaboration of compounds that discourage pathogen attachment.

Symbiotic Relations of Plants and Microbes and Disease Management

Plant-microbes interactions are important in disease protection because the interaction between plants and microbes is a mutual one. These relationships assist plants to grow under harsh conditions, and offer protection from multiple pathogens. Of the three major types of plant-microbe mutualism, rhizobacterial, endophytic, and mycorrhizal, all three play a role in bringing about disease protection in different ways.

Rhizobacterial Symbiosis

For example, Pseudomonas, Bacillus, and Azospirillum species invade the root zone of the plant and form mutual beneficial conspicuous myricks that safeguard the plants against pathogenic infections from the soil. Such beneficial bacteria assist in competing with undesirable microbes for both food and space and they release antimicrobial substances including antibiotica that restrict the ‘growth’ of pathogenic microbes. Moreover, some forms of rhizobacteria bring out systemic defense mechanisms that acts an alarm to the plant in case of any pathogen attack in future. The form of protection is called induced systemic resistance (ISR); what this does is to sensitize the plant tissues so that they are able to detect the pathogen and defend themselves much more effectively.

Endophytic Symbiosis

They are those microorganisms which exists within the tissues of plants being beneficial in protecting plants against diseases without harm. These microbes for instance bacteria and fungi deliver substances such as antifungal metabolites that act to pause the proliferation of pathogens in the interior of plant tissue. Endophytes can also cause a systemic level of resistance in plant organisms, which make them better reaction to attacks of pathogens. Certain healthy bacteria like Bacillus subtilis and Pseudomonas fluorescens, activate systemic immunity defence in plants, and enhance their health to both pathogens and environmental stress. Some of the functions of endophytic microbes encompass; boosting plant immunity and manufacturing defensive chemicals in order to shield plants from pathogens.

Mycorrhizal Symbiosis

In endothelial cells, mycorrhizal fungi are beneficial both in nutrient absorption and in protection against root pathogens. Mycorrhizal fungi form a physical barrier to pathogens by forming a sheath over the plant roots, and can elaborate antifungal substances that inhibit pathogenic fungi as for example, Fusarium and Rhizoctonia. Further, mycorrhizal fungi aid in plant’s disease vigor by making a plant healthier in general, and this makes a plant to be strong enough against stresses; stress which includes attack by pathogens.

Effect of Microbes in Sustainable Control of Diseases

Since disease control through microbial inoculants in plants is an eco-friendly technique, it is slowly picking up as a substitute for chemical insecticides. These micro-organisms includes bacteria, fungi, yeasts and actinomycetes are of tremendous use in managing the plant diseases without use of chemical agents and hence having minimal effect on the environment. Useful microbes provide diverse biological control methods to combat disease incidence, and improve the health of plants or farming practices.

Biological Control Agents

Used to reduce the prevalence of disease affecting a plant, a common function that has been attributed to beneficial microbes is biological control where they act against pathogen. This symbiosis acts against soil borne diseases because these categories of beneficial microbes release extracellular enzymes and are useful in suppression of importance pathogenic fungi and fungi like Trichoderma, Bacillus and Pseudomonas secrete antifungal and antibiotics necessary in the suppression of pathogenic microbes. And using these microbes as biocontrol agents, the farmers have an opportunity to protect their plants from diseases without using toxic chemical fungicides and bactericides, which are dangerous for the environment and useful organisms.

Stimulated Defense of the Plant

Numerous plant growth-promoting microbes can help in increasing the plant immune system through systemic resistance. When plants are colonized by these good microbes, the plants intense defense mechanisms that ready them to combat future infections. This process mantled as the induced systemic resistance (ISR) enables the plants to respond aggressively to disease causing pathogen. By the help of ISR, beneficial microbes make a plant to be resistant to a wide range of pathogens such as fungi, bacteria, and viruses.

Conservation of Diseases Management Approaches

Incorporation of beneficial microbes in disease management is aligned with the holistic concepts of sustainable agriculture because it hampers the usage of chemical pesticides, raises consciousness on soil health and increases the biological divergence. Microbial ineoualants and bio based products are being synthesized in IPM and farmers can obtain effective means of controlling diseases affecting plants. Furthermore, such microbial solutions can work for reasonable periods sometimes lasting for years enhancing the protection against pathogens.

Further Research and Future Direction

How beneficial microbes have served in plant disease management or how more research has to be done in areas of microbial ecology, need to improve the efficiency of microbial-based products, and incorporate identified beneficial microbes into efficient plant disease management? With increased focus on plant-microbe interactions, several areas of development are likely to define the next milestone innovations in plant protection.

Microbial genomics & Metagenomics

Genomics and meta genomics in the analysis of microbial communities in the vicinity of plants will give improved understanding of genetics of beneficial microorganisms. Knowledge of the regulatory genes for pathogen suppression, activation of plant immune system and stress tolerance will go a long way in selecting better biocontrol agents. With newer sequencing platforms, it is possible to decipher complicated interactions of microbes in the rhizosphere, phyllosphere, and endosphere and to fashion functional microbial communities that can afford better protection to plants against diseases. Synthetic microbial communities are complex systems that involve microbial consortia and microbial communities, but are distinct from them in that they are more developed and better defined. The idea of cooperation in form of known beneficial microbes being put together in a single population known as synthetic microbial communities (SMCs) is gradually materializing. Scientists are able to increase disease protection and promote plant growth up to the desired level by accordantly combining certain selected strains that have significant disease-suppressing activities. These SMCs could be employed as biocontrol agents or microbial inoculants which provides better solutions to disease control problems rather than a single microbial culture.

Microbial Inoculants and Commercial Products

Since the targets are often difficult to reach or too dispersed to hit directly with microbial inoculants and biopesticides, a new trend is observed in the field – the stability and uniformity of novel microbial inoculants and biopesticide products applied in agricultural systems. The development of better microbial products for various applications continues together with enhancing the shelf life, stability, and performance of the products under different environment conditions. It will further extend the possibility to improve microbial delivery systems including seed treatments, soil treatments, and foliar application of microbial products to farmers.

Categories of factors that influence their distribution include environmental and host plant characteristics.

The future studies will also involve how different environmental factors (the environmental factors which include the PH level of the soil, the temperature and the moisture level in the environment) and the characteristics of the hosts plants will affect beneficial microbes. This way, knowledge of how these factors affect microbial colonization, survival and protection against diseases will enhance formulation of appropriate microbial products and for specific crop types and climates.

Conclusion

Beneficial microbes are considered as a leap forward in organic plant disease control rather than chemical control. Due to their multi-functional and complex forms of actions such as competition for resources, production of antimicrobial metabolites, activation of plant defense responses and lastly formation of biofilm-substrate for plant growth, these microbes increase plants' resistance against multiple pathogens. Rutgers' rhizobacterial, endophytic, and mycorrhizal interactions: the role of plant Microbes in the Plant Health and Disease Resistance. With increasing problems associated with pesticide resistance, increased environmental consciousness, and consumer awareness for a better form of farming, beneficial microbes exploits the opportunity in fixing a better proven method for the agriculture industry. They help in disease avoidance apart from improving soil standards, nutrient acquisition, and plant growth enhancement. Through smart use of functional microbes, farmers can decrease the use of toxic chemicals and at the same time increase microbial complexity of the agroecosystem. The future prospect of microbial based disease management is in research and development. The development of new techniques in microbial genomics, metagenomics and especially microbial consortiums is expanding the possibilities to enhance the efficacy of these biocontrol agents. Also, the improved microbial inoculants and biopesticides, crop, and the environment-specific varieties of microbes will boost the use of microbes in various agricultural operations. , the successful inoculation of beneficial microbes into the IPM represents one of the most effective methods of agriculture sustainability, long-term protective cover against diseases that affects our plants without polluting the environment. As we progress in defining and optimizing the potentials of these microorganisms, the world scales toward the realization of microbial based solutions for sustainable, production resilient and disease secure agricultural model.

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