Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 02 (MAR-APR, 2022)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Microbial Consortia in Plant Disease Management

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A consortium is an association of two or more individuals, companies, organizations or with the objective of participating in a common activity or pooling their resources for achieving a common goal. A microbial consortium is two or more microbial groups living symbiotically, consortiums can be endosymbiotic or ectosymbiotic. Microbes in small consortia enhance the defense signalling cascades leading to enhanced transcriptional activation of several metabolic pathways. Application of microbial consortium consisting of efficient strains for biological control may be a superior technique compared to application of individual microbes for managing plant diseases.

Introduction

A consortium is an association of two or more individuals, companies, organizations or (any combination of these entities) with the objective of participating in a common activity or pooling their resources for achieving a common goal. Consortium is a Latin word, meaning "partnership", "association" or "society" and derives from consors 'partner', itself from con- 'together' and sors 'fate', meaning owner of means or comrade. Consortium two or more members of a natural assemblage in which each organism benefits from the other. The group may collectively carryout some process that no single member can accomplish on its own.

Microbial Consortia Definition

A group of different species of microorganisms that act together as a community. A microbial consortium is two or more microbial groups living symbiotically, consortiums can be endosymbiotic or ectosymbiotic: An endosymbiont is any organism that lives within the body or cells of another organism, i.e., forming an endosymbiosis (Greek: ἔνδονendon "within", σύν syn "together" and βίωσις biosis "living"). Examples are nitrogen-fixing bacteria (called rhizobia), which live in root nodules on legume roots, single-cell algae inside reef-building corals, and bacterial endosymbionts that provide essential nutrients to about 10–15% of insects. Ectosymbiosis is symbiosis in which the symbiont lives on the body surface of the host, including internal surfaces such as the lining of the digestive tube and the ducts of glands.

Role of Microbial Consortium

Microorganisms under natural habitats live in communities and some provides benefits to plant. Further, microbes when introduced to soil as consortium and interact with a host plant, partially mimic the natural soil conditions. In the recent past, information on various mechanisms by which microbial consortia promoted plant growth and triggered defense responses in host plants during pathogen ingress have become available. It was also unveiled that microbes in small consortia enhance the defense signalling cascades leading to enhanced transcriptional activation of several metabolic pathways. However, an additive or synergistic effect is not achieved every time a microbial consortium is used. With progress in time a sizable understanding on microbial consortium-induced plant defense responses had been reached. Further generation of information on host's responses to pathogenic challenge in the presence of diverse microbial consortia at functional level is underway. In review of presented the outcomes of small microbial consortia used so far to protect crop plants from various pathogens. We have also provided possible explanations for reduction in diseases when a microbial consortium was used, compared the effects of microbes when used alone as well as in consortium, possible shortcomings for not obtaining desired outcome from the introduced consortia, and provided the rationale for development of effective microbial consortia capable of inducing enhanced systemic resistance. Finally, we have suggested some potential biotechnological applications to sustain the effect of microbe-induced defense responses in host plants.

Introduction to Microbial Consortia

Plants generally overcome the threats caused by pathogenic microbes by their innate ability to perceive signals from potential pathogens. Thereafter, the plants reprogram the defense systems appropriately to overcome such threats. Rhizosphere microbiome plays a significant role in reprogramming the defense responses of plants. Microbes associated with plant's root are enormously diverse. The complex microbial communities associated with plant species is cited as the second genome of the plant which is considered to be highly important for the plant's health and development. Recent studies on plant microbe interaction have revealed that plants shape their rhizospheric microbiome by secreting root exudates. Further the plant species and prevailing environmental conditions also play a crucial role in shaping the microbiome. Even plant age has an impact on the rhizosphere microbiome. Plants help beneficial soil microbes by giving an auxiliary environment in the rhizosphere, and microbes in return also provide several benefits to plants such as growth promotion and stress relief (Fig. 1). Plant roots ooze different organic nutrients such as sugar, vitamins, organic acids, amino acids, mucilage, phytosiderophores, nucleosides, phenolic compounds and other signals. Such compounds attract microbes which have the ability to initialize these compounds and multiply in the same habitat. The ability of plants to recruit beneficial microbes is viewed as building of a protective cover that enhances pathogen suppressiveness in the rhizosphere (Sarma *et al*., 2015).

A comprehensive understanding on the mechanisms that govern recruitment and activity of the recruited microbes may open up opportunities to utilize the phenomenon in increasing crop productivity. It is thus documented that in nature various factors shape the microbial community in the rhizosphere. However, when microbial mixtures or consortia are developed artificially to treat plants such factors are often overlooked. Artificially mixed microbial combinations may lead to increased, reduced or similar pathogen suppressive effects. One of the major observations made while going through most of the earlier publications on use of microbial consortia for plant disease management was that no proper selection criteria was adopted while selecting the microbial components in most of the studies. Negative impacts of the microbial consortia in such studies may be due to the negative impacts of the microbial partners on each other leading to reduced biocontrol efficacies against the phytopathogens targeted. It was also observed that in most cases selection of microbial partners was made only on the merit of their individual biocontrol potentials. There was no mention in most of the cases whether the microbial partners used have suppressive or antagonistic effects on the other partner(s). Moreover, only few microbial species with limited mode of actions against phytopathogens were explored and used to develop microbial consortia until recently. However, it is only recently attention has been given to identify and utilize the rhizospheric microbes in consortia that can mediate induced systemic resistance (ISR), a condition of enhanced defense capability of a plant in which the innate defense responses are raised against incident biotic challenges. Since microbes in natural habitats live in communities and they are recruited by the plant species in the rhizosphere, it is believed that each microbial component provides specific benefit to plants. Therefore, it has become obligatory to develop comprehensive understandings on the microbial components of a consortium so that desired benefits can be provided to plants especially under the pathogen challenged conditions. So, Plant recruitment of beneficial microbes. Microbial consortia used for disease suppression. Mechanisms of disease suppression by the microbial consortia. The impact of microbial consortia on disease suppression over individual microbes (Mishra *et al.*, 2021).

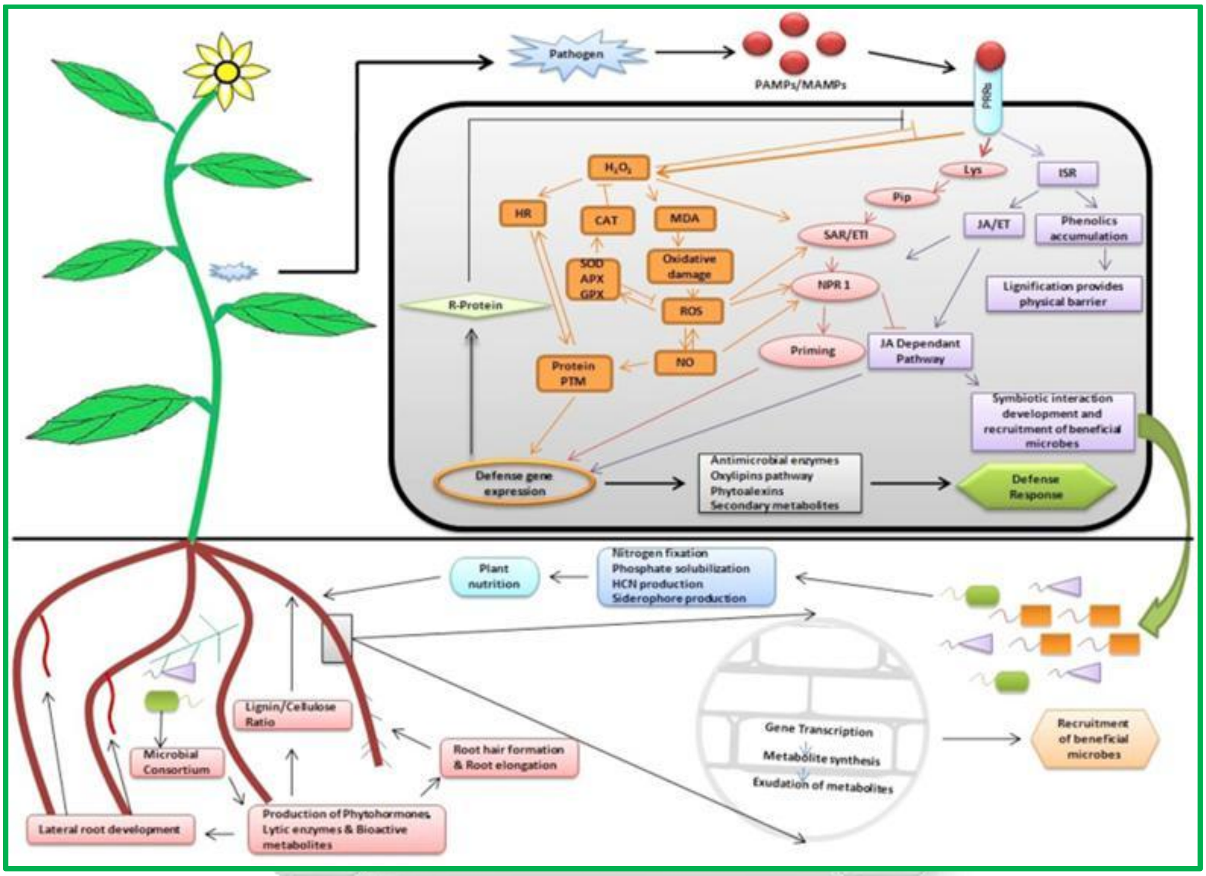

Fig. 1: Mechanisms of rhizosphere microbe-mediated defense responses in plants against pathogenic stresses

Microbial Consortium in Disease Suppression

Plant growth-promoting rhizobacteria (PGPR) or microorganisms (PGPM) either live together with non PGPR strains in soil or in the rhizosphere in different combinations. Considering this community-based living style of PGPR strains, the current trend is to mix biocontrol agents (BCAs) of diverse microbial species having plant growth-promoting activities to achieve desired agricultural outcomes. Application of microbial consortium consisting of efficient strains for biological control may be a superior technique compared to application of individual microbes for managing plant diseases. Moreover, application of microbes in a consortium may improve efficacy, reliability and consistency of the microbes under diverse soil and environmental conditions. Compatible microbes i.e., microbial strains that have no suppressive effect on other microbial strains when cocultured in a common medium, in consortium may therefore have an enhanced impact on plant growth promotion or disease suppression. Use of different species of microbes in combination may further have the advantage of enhancing biocontrol efficacies as different microbes occupy different niches in the root zone and thereby restrict competition among them. Additionally, diversity in biocontrol mechanisms offered by each microbial component may also help in enhancing disease suppressiveness. Some earlier studies showed that different microorganisms namely *Trichoderma*, *Bacillus*, *Pseudomonas*, *Rhizobium*, *Glomus*, etc. were used to develop microbial consortia. *Trichoderma koningii* when applied with some fluorescent Pseudomonad strains suppressed the take-all pathogen of wheat greater than *T. koningii* alone. Mixture of the *Bacillus* strains IN937a and IN937b increased superoxide dismutase and peroxidases activities by 25-50% in tomato and pepper against some soil and seed borne pathogens.

Combined application of *Trichoderma*, fluorescent *Pseudomonas* and Glomus suppressed Fusarium wilt incidence in tomato under field conditions by more than 50% over single application of Glomus. The rationale behind selection of the microbes that were used in consortia was mostly their ability to fix atmospheric N, solubilize phosphorous in soil, produce phytohormones, and antagonistic activities against the pathogens. Later on, microbes capable of inducing systemic resistance as well as enhancing nutrient use efficiency were also included in the microbial mixtures (Harman, 2011). These microbes are able to do their work individually. However, when compatible strains of these microbes are applied together as a consortium, the crop plants are expected to get a combined benefit of high N and P availabilities for uptake leading to better plant health and yield. Combining an antagonist bioagent may further facilitate disease free growth of the plants. Therefore, applying microbes as a consortium has great potentiality particularly in modern agriculture where minimization of chemical fertilizers and pesticides is one of the priorities. Enhanced N and P uptake along with biocontrol of soil-borne pathogens were reported in chickpea when Rhizobium, PSB and Trichoderma were applied as a consortium.

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