Soil Biology & Biochemistry 87 (2015) 25–33

Contents lists available at ScienceDirect

Soil Biology & Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Review paper

Microbial consortium-mediated plant defense against phytopathogens: Readdressing for enhancing efficacy

Birinchi Kumar Sarma [a, *], Sudheer Kumar Yadav [b], Surendra Singh [b], Harikesh Bahadur Singh [a]

[a] Department of Mycology and Plant Pathology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005, India
[b] Department of Botany, Banaras Hindu University, Varanasi 221005, India

ARTICLE INFO

Article history:
Received 25 November 2014
Received in revised form
31 March 2015
Accepted 1 April 2015
Available online 24 April 2015

Keywords:
Microbial consortium
Compatible strains
Plant defense
Phenylpropanoid pathway
Antioxidant activities
Induced systemic resistance (ISR)

ABSTRACT

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. The current research trend has therefore oriented towards investigating the role of small microbial consortia in promoting plant growth and health against various invading pathogens. This is a paradigm shift from the original investigations involving a single microbe. 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 signaling 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 this review, we have 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.

1. Introduction

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 (Jain et al., 2012). Rhizosphere microbiome plays a significant role in reprogramming the defense responses of plants (Spence et al., 2014). 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 (Berendsen et al., 2012). Further the plant species and prevailing environmental conditions also play a crucial role in shaping the microbiome (Zachow et al., 2014). Even plant age has an impact on the rhizosphere microbiome (Micallef et al., 2009; Chaparro et al., 2013). 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

* Corresponding author. Tel.: +91 542 6702578 (Office), +91 9454350649 (Cell); fax: +91 542 2368993.
E-mail addresses: birinchi_ks@yahoo.com, birinchi@bhu.ac.in (B.K. Sarma).

http://dx.doi.org/10.1016/j.soilbio.2015.04.001
0038-0717/

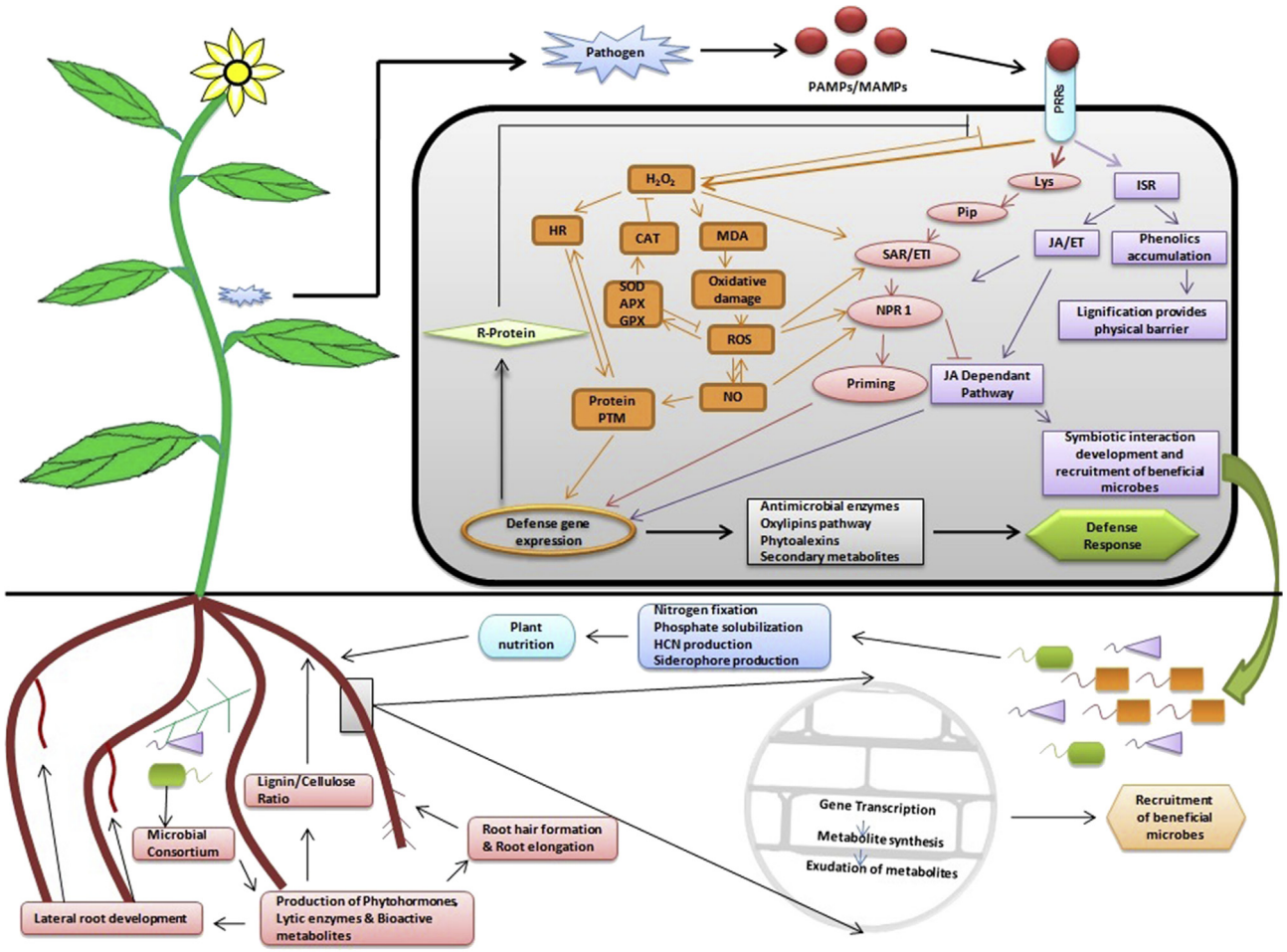

Fig. 1. Mechanisms of rhizosphere microbe-mediated defense responses in plants against pathogenic stresses.

protective cover that enhances pathogen suppressiveness in the rhizosphere (Mendes et al., 2011). 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 (Berendsen et al., 2012). 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 (Xu et al., 2011). 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 were 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) (Jain et al., 2012), a condition of enhanced defense capability of a plant in which the innate defense responses are raised against incident biotic challenges (Bakker et al., 2007). 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. In this review we focused on the issues such as 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, and prospects of biotechnological interventions for development of effective microbial consortia.

2. Plant recruitment of beneficial microbes in the rhizosphere

Rhizosphere facilitates growth, development and functioning of diverse microbial communities including plant growth-promoting rhizobacteria (PGPR). PGPR colonizes the root surfaces, promotes plant growth (Vacheron et al., 2013), protect plants from phytoparasites (Lugtenberg and Kamilova, 2009), and also help plants to