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Mini Review

Interaction between Arbuscular Mycorrhiza and Rhizobacteria with Legumes : A Promising Strategy to Fight with Abiotic Stress

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Abstract

Symbiotic association of rhizobium with legumes plays a key role in biological nitrogen fixation while the arbuscular mycorrhizal (AM) association with high plants can increase the availability of poorly mobile nutrients such as phosphorous. In legumes both the symbiots can inhabit and synergistically affect each other in various stress conditions such as drought and mineral deficiency. Understanding the impact of tripartite interaction between AM and rhizobacteria under different abiotic stress can be a powerful strategy to improve the soil condition and plant yield in sustainable way.

Keywords: Arbuscular mycorrhiza; Drought; Legumes; Rhizobium; Symbiosis; Tripartite interaction

Abbreviation: Arbuscular mycorrhizal fungi (AMF); Biological nitrogen fixation (BNF); Nitrogen (N); Phosphorus (P)

Introduction

Legumes are agriculturally and ecologically important crop as they are the major source of food and feed worldwide. Legumes are also a key component of biological nitrogen fixation (BNF). Legumes form two types of symbiotic association with soil microorganisms. The symbiotic association established between legumes and diazotrophic bacteria is unique and exclusive to legumes only. In this association, the bacteria inhabit in the host plants' root nodules and fix the atmospheric nitrogen (N2) into biologically available form, i.e., ammonia [1]. The second association occurs between legumes and arbuscular mycorrhiza fungi (AMF) it is very common in majority of terrestrial vascular plants [2]. AMF colonize plant roots and reach the surrounding soil by creating extensive network of mycelium. This intense mycelium network reaches beyond the depletion zone where poorly mobile nutrients such as phosphorus (P) are present [3].

The effect of either AMF or rhizobium on host plants have been studied more intensively while the combined effect of AMF and rhizobium are less studied. The tripartite interaction of legumes with rhizobium and AMF is more complex than the symbiotic association of legume with rhizobium or AMF alone. Rhizobial and mycorrhizal association can synergistically affect the plant growth [4-6] but the interaction of these two symbionts can also reduce the growth of plant [7,8].

In tripartite interaction, the environmental factors and nutrient availability along with AMF and rhizobium may influence the

overall plant growth and yield. In different conditions of light, it has been found that AMF and rhizobium association can positively and negatively affect the seed production in lema bean [8]. In normal light condition the association of these two symbionts showed synergistic effect while in limited light AMF negatively affect the nitrogen fixating capacity of rhizobium inhabiting in lema bean [8]. In case of prairie legume Amorpha canescens, AMF and rhizobia together increased the biomass. Also, it has been reported that the decrease in nodulation due to addition of nitrogen can counter by the coinfection of AMF [5].

Maintenance of rhizobial symbiosis requires high level of P, probably because the concentration of P is significantly higher in microbial cell [9]. P deficiency not only affects the nodule formation but also affect the photosynthetic capacity of plant [9]. As AMF generally improve the P availability, the AMF symbiosis is expected to positivity affect the functioning of rhizobial association with host. It has been reported that AMF stimulates the nitrogen fixation in two Medicago species under low P availability [10]. The positive impact of AMF along with rhizobia on biological nitrogen fixation under low P availability have been reported in cowpea and prairie legume [5,11]. On the other hand, under P-sufficient condition, they compete for the carbon (C) and negatively affect the biomass production [7,12].

Tripartite interaction of legumes with rhizobia and AMF can improve plant growth and biomass production under drought stress [13,14]. The AMF association could stimulate the rate of nodule formation under stress conditions [14]. AMF could also reduce the oxidative stress and improve carbon metabolism of nodules [15,16].

These studies suggest that the benefit of the symbiotic relation of rhizobia and AMF is dependent upon the environment conditions. In stress conditions, such as drought, the presence of AMF along with rhizobia can be a significant strategy to improve the growth and production of legumes. Further, plant stress tolerance induced by these symbionts needs to studied under field conditions. For the sustainable crop production and maintenance of eco-physiological system, the cumulative effect of rhizobia and AMF along with the soil and environmental conditions should be studied in detail.

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Conflict of Interest

No conflict of interest.

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