Ancestral alliances: Plant mutualistic symbioses with fungi and bacteria

Contact: Francis M. Martin (francis.martin@inra.fr); Mitch Doktycz (doktyczmj@ornl.gov); (865) 574-6204
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Background

- Mutualistic fungal and bacterial symbionts are striking examples of soil microorganisms that have successfully coevolved with their plant hosts.
- Recent studies of these associations have identified key conserved features which characterize these mutually beneficial plant-microbe associations, including the molecular and cellular mechanisms which are involved in the successful colonization of plant roots by the respective fungal and bacterial symbionts.

Science

- Despite the very different nature of microsymbionts, many of the molecular and cellular mechanisms are remarkably similar during the earliest steps of root colonization. For example, the perception of microbial chitin-based signals by a specific plant signal transduction pathway which first appeared over 400 million years ago during the establishment of the arbuscular mychorrhizal symbiosis, was then recruited 60 million years ago to play a similar role during the rhizobial/legume nitrogen-fixing symbiosis.
- Other similar features, which are underscored in the article, are the various root developmental processes involving modifications in plant hormonal balances, as well as a number of complex mechanisms which have evolved to avoid the triggering of immune defense during different stages of symbiotic microbe colonization.

Significance

- This review highlights how modern technological advances and tools (*e.g.*, high-throughput sequencing, comparative genomics, metatranscriptomics, genome-wide association studies) have given unprecedented access to the diversity and composition of the plant microbiota.
- Future studies would involve investigating the heritability of beneficial microbiota and manipulating the plant micobiota in order to modulate plant development as well as promote sustainable growth of crop plants.

Apoplastic models of Root Entry. Top: AM fungal entry (Intracellular); **Middle**: ECM fungi (Intercellular entry); **Bottom**: Rhizobial (Intracellular). Circles represent point of entry into the cell.

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Francis M. Martin[1], Stéphane Uroz[1], and David G. Barker[2]

[1]Department of Tree-Microbe Interactions (IaM), INRA-Lorraine University, INRA-Nancy France, [2]Laboratory of Plant-Microbe Interactions (LIPM), INRA-CNRS-Toulous University, Castanet-Tolosan, France.

Abstract

Within the plant microbiota, mutualistic fungal and bacterial symbionts are striking examples of microorganisms playing crucial roles in nutrient acquisition. They have coevolved with their hosts since initial plant adaptation to land. Despite the evolutionary distances that separate mycorrhizal and nitrogen-fixing symbioses, these associations share a number of highly conserved features, including specific plant symbiotic signaling pathways, root colonization strategies that circumvent plant immune responses, functional host-microbe interface formation, and the central role of phytohormones in symbiosis-associated root developmental pathways.We highlight recent and emerging areas of investigation relating to these evolutionarily conserved mechanisms, with an emphasis on the more ancestral mycorrhizal associations, and consider to what extent this knowledge can contribute to an understanding of plant-microbiota associations as a whole.

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