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Special issue

Molecular Basics of Mycorrhizal Symbiosis

Editors: Alfred Pühler and Dieter Strack

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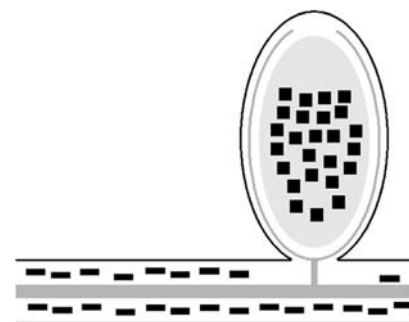
REVIEWS

Identification and expression regulation of symbiotically activated legume genes

pp 8–18

Helge Küster\*, Martin F. Vieweg, Katja Manthey, Marcus C. Baier, Natalija Hohnjec, Andreas M. Perlick

Legume root endosymbioses activate a common set of genes during microbial infection and the establishment of symbiotic structures. These genes can be traced by *in silico* and experimental transcriptome profiling. Symbiotic gene expression is regulated by promoter elements specific to the infected cells of root nodules or arbuscular mycorrhizal roots.

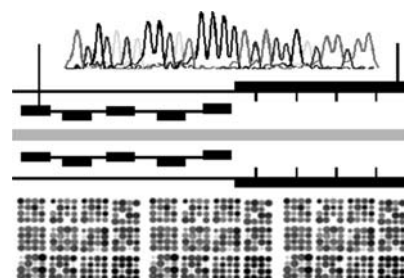


Development of bioinformatic tools to support EST-sequencing, *in silico*- and microarray-based transcriptome profiling in mycorrhizal symbioses

pp 19–32

Helge Küster\*, Anke Becker, Christian Firnhaber, Natalija Hohnjec, Katja Manthey, Andreas M. Perlick, Thomas Bekel, Michael Dondrup, Kolja Henckel, Alexander Goesmann, Folker Meyer, Daniel Wipf, Natalia Requena, Ulrich Hildebrandt, Rüdiger Hampp, Uwe Nehls, Franziska Krajinski, Philipp Franken, Alfred Pühler

The application of high-throughput genomics approaches relying on EST-sequencing, *in silico*-, and microarray-based transcriptome profiling has substantially widened our molecular understanding of mycorrhizal symbioses. This review summarizes recent activities in the field that apply bioinformatics tools to integrate transcriptome profiling experiments in model mycorrhizae.

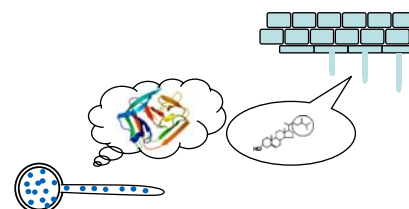


Plant signals and fungal perception during arbuscular mycorrhiza establishment

pp 33–40

Natalia Requena\*, Esther Serrano, Aurora Ocón, Magdalene Breuninger

Arbuscular mycorrhizal fungi and plant roots talk to each other in a language that has not been deciphered yet. Plant signals induce in the fungus the activation of the symbiotic program to overcome its preset growth arrest. Molecular components have been identified that could link plant signals with this fungal checkpoint.

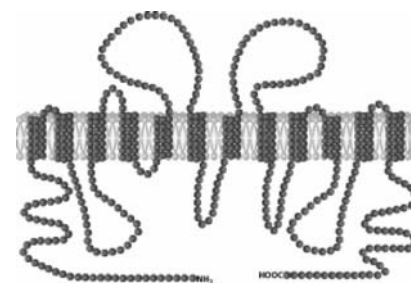


### Nitrogen transport in the ectomycorrhiza association: The *Hebeloma cylindrosporum*–*Pinus pinaster* model

pp 41–51

Tobias Müller, Meghan Avolio, Martin Olivi, Mariam Benjdia, Enno Rikirsch, Alexis Kasaras, Michael Fitz, Michel Chalot, Daniel Wipf\*

The function of mycorrhizal systems depends on the ability of the fungal symbionts to take up nutrients available in the soil and to translocate them (or their metabolites) to the symbiotic roots through transporter proteins (pictured). This review summarizes recent results obtained with the *Hebeloma cylindrosporum*–*Pinus pinaster* ectomycorrhizal association.

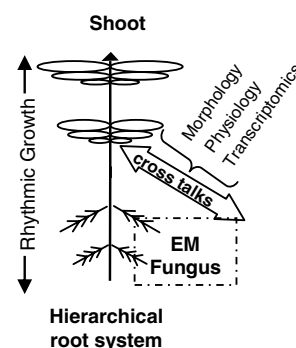


### Cross talks at the morphogenetic, physiological and gene regulation levels between the mycobiont *Piloderma croceum* and oak microcuttings (*Quercus robur*) during formation of ectomycorrhizas

pp 52–67

Sylvie Herrmann, François Buscot\*

Ectomycorrhiza (EM) represent a highly differentiated interface between soil fungi and tree rootlets enabling symbiotic exchanges of nutrients and water. Mechanisms ruling EM formation were analyzed on *in vitro* propagated oaks inoculated with the fungus *Piloderma croceum*. In early phases of the interaction at which EM were not yet differentiated, the fungus promoted plant development, triggered photoassimilation, and plant genes related to symbiosis were found regulated. These early cross talks at different levels were influenced by the plant endogenous rhythmic growth and it appeared that fully differentiation of EM tissues is conditioned by the reaching of a certain carrying capacity by the plant.

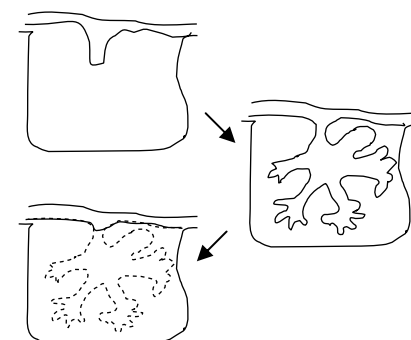


### Gene expression analysis of arbuscule development and functioning

pp 68–74

Philipp Franken\*, Katrin Donges, Ulf Grunwald, Gerhard Kost, Karl-Heinz Rexer, M'Barek Tamasloukht, Astrid Waschke, Dorit Zeuske

Arbuscules as the central structure of the arbuscular mycorrhizal symbiosis play a crucial role in the main functions of the interaction, the improved plant nutrition and the biocontrol of root pathogens. The review summarises the RNA accumulation studies concerning arbuscule development and functioning.

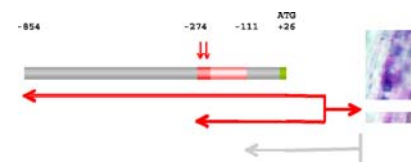


### Towards the elucidation of AM-specific transcription in *Medicago truncatula*

pp 75–81

Franziska Krajinski\*, André Frenzel

The identification and analysis of AM-specific genes represent further means to gain insight into the molecular background of the AM symbiosis and the molecular regulation of this tight symbiosis. Here, we describe the identification of AM-specific genes and the analysis of their transcriptional regulation.

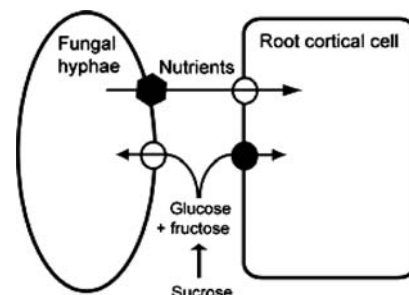


**Sugar for my honey: Carbohydrate partitioning in ectomycorrhizal symbiosis**

pp 82–91

Uwe Nehls\*, Nina Grunze, Martin Willmann, Marlis Reich, Helge Küster

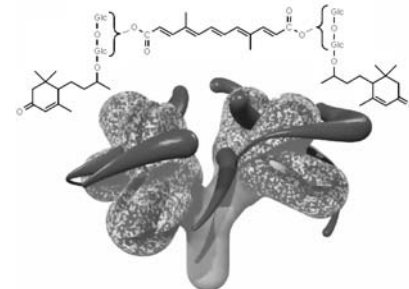
The focus of this contribution will be on the question how the fungal carbohydrate support is enabled by the host plant in ectomycorrhizas, its physiological consequences for both partners, and the questions of how carbohydrate drain might be controlled by the plant partner to ensure a reciprocal relationship and to avoid fungal parasitism.

**“Chromoplast” development in arbuscular mycorrhizal roots**

pp 92–100

Thomas Fester\*, Swanhild Lohse, Kristine Halfmann

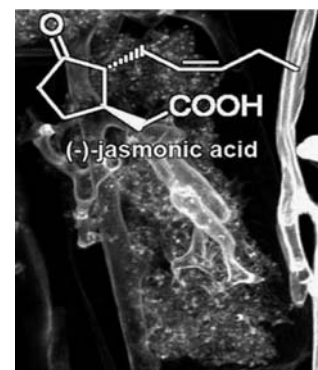
Plastids are key biosynthetic organelles in the formation of the symbiotic interface of the AM symbiosis. Their role during arbuscule decomposition is less understood, although they are involved in marked cytological and metabolic changes during this phase. These changes include the activation of carotenoid biosynthesis, resulting in the accumulation of carotenoid degradation products in many plants and the formation of large tubular structures arranged in a network-like fashion.

**Jasmonates in arbuscular mycorrhizal interactions**

pp 101–110

Bettina Hause\*, Cornelia Mrosk, Stanislav Isayenkov, Dieter Strack

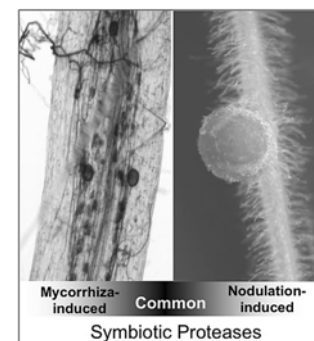
The review summarizes the current knowledge about the role of phyto-hormones in roots colonized by an arbuscular mycorrhizal fungus. It focuses, however, on jasmonates, which have been shown to be involved in the establishment of the symbiosis.

**Proteases in plant root symbiosis**

pp 111–121

Naoya Takeda\*, Catherine Kistner, Sonja Kosuta, Thilo Winzer, Andrea Pitzschke, Martin Groth, Shusei Sato, Takakazu Kaneko, Satoshi Tabata, Martin Parniske

Symbiotic protease genes are transcriptionally activated during arbuscular mycorrhiza and/or nitrogen fixing root nodule symbiosis. The widespread occurrence of AM-induced proteases in angiosperms suggests important functions. The isolation and predicted roles of symbiotic proteases are discussed in this review.

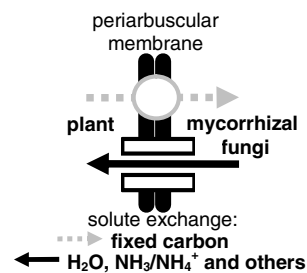


**Arbuscular mycorrhizal symbiosis and plant aquaporin expression**

pp 122–129

Norbert Uehlein, Kerstin Fileschi, Martin Eckert, Gerd Patrick Bienert, Adam Bertl, Ralf Kaldenhoff \*

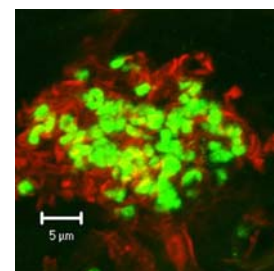
Establishment of the symbiosis between plants and mycorrhizal fungi is accompanied by structural changes in the plant root. During arbuscule formation fungal hyphae penetrate the root apoplast and install highly specialized interfaces for solute transport between plant and fungus. The periarbuscular membrane surrounding arbuscular structures contains a high density of transport systems. Among these also aquaporins, which potentially can act as a low affinity transport system for ammonia or ammonium.

**Apocarotenoid biosynthesis in arbuscular mycorrhizal roots: Contributions from methylerythritol phosphate pathway isogenes and tools for its manipulation**

pp 130–138

Michael H. Walter \*, Daniela S. Floß, Joachim Hans, Thomas Fester, Dieter Strack

The accumulation of 1-deoxy-D-xylulose 5-phosphate reductoisomerase (DXR) protein involved in apocarotenoid biosynthesis accompanies the degeneration of fungal arbuscules in mycorrhizal roots. The DXR protein is visualized by immunolocalization (green channel) overlaid to the red staining of the fungal structure, which represents a collapsing arbuscule.

**Arbuscular mycorrhiza and heavy metal tolerance**

pp 139–146

Ulrich Hildebrandt\*, Marjana Regvar, Hermann Bothe

Arbuscular mycorrhizal fungi (AMF) have repeatedly been demonstrated to alleviate heavy metal stress of plants. This review summarizes results obtained so far on the colonization of plants by AMF in heavy metal soils, deposition of heavy metals in plant and fungal structures, differential gene expressions and the potential to use AMF-plant combinations, with emphasis on pennycresses (*Thlaspi* spp.) in phytoremediation.



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