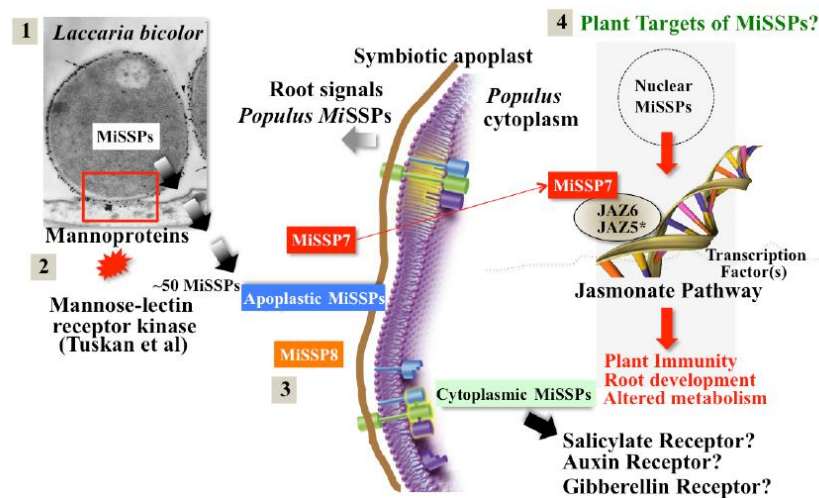


## ERESY



### Elucidating the Role(s) of Effector-like proteins in the ectomycorrhizal Symbiosis

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Collaboration: OakRidge National Laboratory (Plant Microbe Interfaces project)

**Context** — Ectomycorrhizal mutualistic symbiosis between tree roots and fungal hyphae, are essential for tree health and thus forest sustainability. In exchange for carbohydrates, ECM fungi improve mineral supply of the trees. To facilitate nutrient exchanges, root morphology is strikingly altered and a mixt symbiotic organ (ectomycorrhiza : ECM) is formed. The signals from the two partners that promote and mediate the ECM symbiosis have remained mainly uncharacterized. Recent studies highlight the importance of fungal small-secreted proteins/peptides (SSP)-based communication (dialogue) between plants and their symbionts. These SSPs are called effectors as a reference towards effectors produced by plant pathogenic microbes to suppress or inactivate plant immunity thereby allowing access to plant nutrient stores.

**Objectives** — Understanding the roles of effector proteins (such as Mycorrhizal induced Small Secreted Proteins : MiSSPs), and the targeted hormone signalling pathways used to restructure the plant host cell to promote mutualism is the fundamental aim of this project.

**Approach** — We propose (i) to describe the secretome diversity among fungi with different life-styles (ii) to elucidate the plant cellular processes targeted by fungal effectors using a multidisciplinary approach and (iii) to identify fungal effectors able to target hormone-receptor or hormone-mediated signalling such as Salicylic Acid (SA) and Giberrellic Acid (GA).

**Key results** — The secretome from ECM fungi is characterized by a restricted number of secreted CAZymes, but their repertoires of secreted proteases and lipases are similar to those of saprotrophic fungi.

- The secretome of ECM fungi is enriched in SSPs compared with other species. Most of the SSPs are coded by orphan genes with no known PFAM domain or similarities to known sequences in databases.
- Based on the clustering analysis, we identified shared- and lifestyle-specific SSPs between saprotrophic and ECM fungi.
- The protein PtJAZ6 of *Populus* is stabilized through its interaction with the effector MiSSP7 of *Laccaria bicolor*.
- The PtJAZ6 is interacting with several transcription factors either activator or repressor (PtMYC2.1, PtMYC2.2 and PtJAM1), and TOPLESS protein.

- The PtJAZ6 protein is able to interact with PtDELLA protein, a receptor for GA-signalling pathway.

### **Main conclusions including key points of discussion —**

- Our results highlight that the presence of SSPs is not limited to fungi interacting with living plants as the genome of saprotrophic fungi also code for numerous SSPs and support support the concept of a continuum from saprophytic to ECM fungi. The fact that ECM fungi are enriched in SSPs compared with the other lifestyles might reflect the conservation of SSPs from saprotrophic ancestors and the expansion of symbiosis-specific SSPs dedicated to the molecular cross-talk between partners, the accommodation of hyphae in planta, the establishment and functioning of the symbiosis.
- The protein complex including PtJAZ6 is very similar to the complex identified in the model plant *Arabidopsis thaliana*, suggesting a conserved way of regulation.

### **Future perspectives —**

- ECM fungi shared lifestyle-specific SSPs likely involved in symbiosis that are good candidates for further functional analyses.
- The genes targeted by the identified transcriptional factors remained to be identified. As of today, it is not known whether the JA-pathway inhibition by MiSSP7 has a long-lasting effect and whether a systemic response is also perceived in other parts of the roots or the shoots

### **Valorisation —**

#### **Publications**

Clement Pellegrin, Emmanuelle Morin, Francis Martin and Claire Veneault-Fourrey (2015). Comparative Analysis of Secretomes from Ectomycorrhizal Fungi with an Emphasis on Small-Secreted Proteins. *Frontiers in Microbiology* (section Plant-Microbe Interactions) 6: 1278.

#### **Book Chapter**

Yohann Daguerre, Jonathan Plett and Claire Veneault-Fourrey. (2016, in press) Signalling pathways driving the development of ectomycorrhizal symbiosis. Section Cellular, genetic and molecular mechanisms in the establishment of mycorrhizal symbioses. *The Molecular Mycorrhizal Symbiosis*. Wiley-Blackwell; John Wiley & Sons, Inc.

#### **Presentations at conference**

Veneault-Fourrey C, Daguerre Y, Pellegrin C, Zhang F, Schellenberger R, Kohler A, Martin F. Mutualistic ectomycorrhizal fungus: a delicate edge between saprotrophic and biotrophic plant-pathogenic fungi ? (3-6 Avril 2016) 13th European Conference of Fungal Genetics, Paris

Jonathan M. Plett, Yohann Daguerre, Sebastian Wittulsky, Romain Schellenberger, Annegret Kohler, Claire Veneault-Fourrey\* and Francis Martin. 36th New Phytologist Symposium. Cell biology at the plant-microbe interface (29 nov-01 Dec 2015, Munich) How mutualistic fungi are taking the control over jasmonic-acid signaling?

Claire Veneault-Fourrey, Yohann Daguerre, Romain Schellenberger, Sebastian Wittulky, Jonathan Plett, Francis Martin INRA/UPSC/CRAG meeting on Plant Integrative Biology (6-8 oct 2015 ; INRA-Nancy, France) JAZ proteins in poplar roots: a checkpoint for establishment of mutualistic interactions?