**STReESS: Studying Tree Responses to extreme Events: a SynthesiS**
Cost Action FP1106

STSM Report:
The role of ectomycorrhizal traits in tree resource uptake under extreme soil resource conditions

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**The role of ectomycorrhizal traits in tree resource uptake under extreme soil resource conditions**

*Introduction*

A major part of tree resource uptake takes place through mycorrhizal symbioses: mycorrhizal fungi can colonize the larger part of tree fine root tips and produce mycelia that exploit the soil for resources transferred to the tree in exchange for carbon (Brundrett 1991; Aerts and Chapin 2000; Smith and Read 2008). The morphology of ectomycorrhizal fungi (EMF) varies across fungal species and is associated with the ecological functioning of EMF, and based on these morphological differences, EMF can be classified in different exploration types (Agerer 2001). For example, so-called contact exploration types include EMF with smooth mantles and few hyphae that require little carbon costs, whereas long-distance exploration types typically produce mycelia (to different extents) to search the soil for nutrients and water, and long rhizomorphs, i.e., bundles of mycelia equipped for the fast transport of resources over long distances (Agerer 2001).

Trees can thus rely on a variety of EMF species with different morphologies to capture their resources in different environments. For instance, on nutrient-poor sites, long-distance exploration types may be more beneficial to trees in acquiring and transporting scarce resources, while on rich sites, trees can e.g. reduce carbon expenses to EMF by hosting contact exploration types. These exploration types are therefore functionally related to, and provide further clues into tree resource uptake under various site conditions.

*Objectives*

The general objective of this STSM was to test whether the fine roots of *Picea abies* trees were colonized by different EMF exploration types growing on two extreme soils (i.e., a rich, moist clay soil vs. a poor, dry sandy soil), and across the vertical soil profile.

My specific aim for this STSM was to learn the techniques involved in morphotyping, i.e., distinguishing different EMF based on their morphological traits, as well as the DNA methods involved in determining EMF species composition.

*Work description:*

Root samples were collected at monospecific *Picea abies* study sites in the Netherlands up to 40 cm depth, and separated over 3 soil layers: 0 – 5, 10 – 20 and 30 – 40 cm depth. The roots were washed out, and sent to the host institute (Mycorrhiza group, WSL Birmensdorf, Switzerland).

Per sample – containing the roots present in each core and soil layer – I characterized each new morphotype observed (see Fig. 1 for examples) based on visually distinct properties using a stereomicroscope and an identification key by Agerer and Rambold (2007). These morphological properties included color of the mantle and mycelia, branching of the EMF root, and the presence and abundance of extramatrical mycelia and rhizomorphs, among others. Next, based on these properties, the morphotypes were further categorized into different exploration types (see Agerer 2001 for descriptions of each exploration type).

I estimated the proportion of dead root tips and the different morphotypes present per sample. I then sampled each morphotype by cutting off up to three root tips on which this particular morphotype was present, and stored each individual tip in a buffer for further DNA analysis. DNA from these mycorrhizal roots was extracted and amplified by PCR and currently to be sequenced in order to determine the EMF species present. We will use literature, if available, to confirm the exploration types of the different EMF species observed.

*Main results:*

The main results can be summarized as follows:

- Nine morphotypes have been identified across all six study plots. These were classified into three different exploration types: contact exploration, short-distance and medium distance exploration types, based on the following summarized criteria (Agerer 2001):
    - Contact exploration type: EMF with a smooth mantle, few or no emanating hyphae (e.g., Fig. 1a).
    - Short-distance exploration type: EMF with many emanating hyphae, no rhizomorphs (e.g., Fig. 1b).
    - Medium-distance exploration type, smooth subtype: EMF with rhizomorphs; the smooth subtype is further characterized by a smooth mantle and few hyphae (e.g., Fig. 1c).


**Figure 1.** Ectomycorrhizal *P. abies* roots of different morphotypes and exploration types: a, contact exploration types with smooth mantle and no (or few) emanating hyphae; b, short-distance exploration type (*Cenococcum geophila* sp.) with emanating hyphae but no rhizomorphs; c, medium-distance exploration, smooth subtype, with a smooth mantle, few hyphae and rhizomorphs.

- Comparing the two soil types, the spruce trees at the clay soil only hosted EMF of the contact exploration type, whereas at the tree roots from the sandy soil the short- and medium-distance types were also observed.
- Across the soil profile, similar morphotypes were observed. The abundance of EMF roots was lower at greater depth than at the top soil, due to a larger proportion of dead root tips at the 30 – 40 cm soil layer.
- Furthermore, at the sandy soil, an unusually large proportion of dead tips was observed. At one of the sandy soil plots, up to 80 % at the top soil (0 – 5 cm) and 85 – 100 % at greater depth (30 – 40 cm) of the root tips were dead. These dead tips could only be microscopically detected, and do not necessarily imply that all root mass was dead, as mortality gradually occurs throughout the root (Comas et al. 2000).
- The DNA analysis is yet to reveal whether the different morphotypes also reflect species diversity and whether species differ between soils and across the soil depth, but results are currently not yet available.

*Contribution to the Action:*

This STSM contributes to the general objective of this COST Action “STReESS”. The data collected and knowledge gathered on mycorrhiza exploration types during this STSM leads to greater understanding of forest responses to extreme climate conditions in several ways. Firstly, EMF contribute strongly to tree uptake of soil resources required for growth, whose availability may be strongly altered by climate change; hence, EMF uptake capacity, represented here by the different exploration types, determines tree resource availability. Furthermore, as the data generated here is aimed to be implemented in a whole-tree growth model, this STSM particularly agrees with, and adds to the objectives of WG2 to improve growth models to understand tree functioning under normal and stress conditions.

This STSM stimulated further collaboration between the chair groups I am involved in at Wageningen University and the WSL, specifically the Mycorrhiza group. The knowledge and facilities available at the WSL proved a very suitable and pleasant work environment. For me personally, this STSM at the WSL turned out a great opportunity to learn new methods and techniques, enhance my knowledge on mycorrhiza, discuss the results of my STSM but also previous results with experts, and to expand my professional network.

*The confirmation by the WSL of the successful execution of this STSM is provided separately.*

*This report may be posted on the Action website.*

*Literature:*

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