EGU21-8198
https://doi.org/10.5194/egusphere-egu21-8198
EGU General Assembly 2021
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Regulation of fungal decomposition at single-cell level

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Ectomycorrhizal fungi use both extracellular enzymes and hydroxyl radicals to decompose soil organic matter (SOM) in a way that is similar to that of their saprotrophic wood decomposing ancestors. Although it are ultimately the individual hyphae that decompose SOM, it has remained unclear if it is also the local environmental conditions experienced by individual hyphae that control the decomposition activity of these hyphae or if it is the overall physiological status of the mycelium these hyphae are connected to that drives decomposition activity of hyphae. We set up an experimental system in which the decomposition activity of individual hyphae could be imaged using infrared (IR) microspectroscopy. Colonies of the ectomycorrhizal fungus Paxillus involutus were grown on solid, sterile lignin films which were amended with ferrihydrite minerals or not. The decomposition activity of individual hyphae was subsequently related to the local environmental conditions experienced by subsets of hyphae (presence or absence of ferrihydrite in lignin substrates) of a mycelial colony and the overall physiological status of the mycelium (difference in hydroxyl radical producing capacity of the mycelium and organic versus inorganic nitrogen nutrition). Using this experimental set-up, we have shown that the local conditions experienced by individual hyphae plays a key role in determining the decomposition activity of these hyphae, but the overall decomposition activity of the mycelium these hyphae were connected to also played a clear role. We also showed that hyphae which more actively oxidized the lignin substrate, also secreted more extracellular matrix materials, suggesting a functional involvement of fungal extracellular matrices in this decomposition process. We conclude that phenotypic heterogeneity occurring between genetically identical hyphal tips may be an important strategy for filamentous fungi to cope with heterogeneous and constantly changing soil environments.