Adaptive hydrophobic and hydrophilic surface response of fungi to changing growth conditions

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Project Goals: Bacterial-fungal interactions (BFI) drive a multitude of process in the environment. In the context of soil, fungi are able to cope with heterogenous environmental constraints thanks to their filamentous lifestyle. This has a crucial impact on *fungal highways*, a BFI describing the ability of bacteria to spread in soil by using the fungal filamentous network. The formation of an aqueous film at the surface of hyphae appears to be a key parameter for the fitness of fungal highways. It is assumed that hydrophilic surfaces are more conducive to this fungal-driven bacterial dispersal. Therefore, in this study, we aimed at assessing how hyphal growth in hydrophobic or hydrophilic conditions impacts hyphae surface properties (i.e. hydrophilicity) by comparing two methods: a colony-scale approach (contact angle measurements) and a hypha-scale approach (atomic force microscopy).

At the microbial scale, soil is a heterogeneous environment composed of air pores, liquid patches, and solid particles. This results in the co-existence of numerous micro-environments with contrasting physicochemical characteristics that vary over space and time. This clearly represents a major influence to the development and activity of microbial life. In soil, filamentous fungi build 3D networks that may represent up to 10^4 m per g of soil. In addition to this, due to their microscopic dimensions, fungal hyphae have a high surface:volume ratio. As a result, a large fraction of the soil volume consists in fungal surfaces interacting with both biotic and abiotic soil components. This represents a central aspect of soil functioning. To be able to cope with the ever-changing conditions of soil microenvironments, while building and maintaining an extensive network, fungi need to dynamically adapt their surface properties. For instance, it is known that fungal hyphae are able to escape the water-air interface with amphiphatic peptides known as hydrophobins. In this study, we assessed the influence of growth conditions (either on hydrophobic or hydrophilic surfaces) on three fungal strains with two different approaches: contact angle (CA) and atomic force microscopy (AFM). CA measures surface hydrophilicity at the scale of fungal colonies, while AFM allows assessing surface properties at the scale of a single hypha. Two different types of behaviors were observed with CA: some fungi had a mycelial network that remained hydrophobic (or hydrophilic), whatever the growth conditions; while others dynamically adapted to the growth conditions. AFM showed that on hydrophobic surfaces, fungal hyphae tended to minimize the contact with the surface. On the contrary, on hydrophilic surface, fungal hyphae tended to be flat by adhering to the surface and secreted EPS-like compounds. Likewise, the topographical surface characteristics of hyphae varied depending on the growth surface, but species-dependent patterns were still prominent. Overall, these results corroborate the ability of fungi to adapt their network to the highly dynamic conditions of soil by quickly adapting their surface properties. However, this adaptation occurs at the scale of single hyphae. Therefore, this aspect should be taken into account when considering fungal highways in which bacteria directly depend on the surface properties of fungal hyphae to spread.

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