Title: The Soil Lipidome is a Robust Indicator of the Microbial Community Response to Rewetting Following a Summer Drought

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Project Goals: PNNL's Phenotypic Response of Soil Microbiomes SFA aims to achieve a systems-level understanding of the soil microbiome's phenotypic response to changing moisture. We perform multi-scale examinations of molecular and ecological interactions occurring within and between members of microbial consortia during organic carbon decomposition, using chitin as a model compound. Integrated experiments address spatial and inter-kingdom interactions among bacteria, fungi viruses and plants that regulate community functions throughout the soil profile. Data are used to parametrize individual- and population-based models for predicting interspecies and inter-kingdom interactions. Predictions are tested in lab and field experiments to reveal individual and community microbial phenotypes. Knowledge gained provides fundamental understanding of how soil microbes interact to decompose organic carbon and enable prediction of how biochemical reaction networks shift in response to changing moisture regimes.

Abstract Text:

Extreme environmental change such as a severe drought followed by a precipitation event can trigger a complex cascade of microbial physiological responses, impacting soil microbial community structure and functions. Lipids are vital to microbial structural and signaling functions, yet the effect of environmental change on soil microbial lipids is only beginning to be explored. To reveal the importance of lipids in regulating microbial physiological responses to environmental stress, we used untargeted lipidomics, 16S rRNA gene and ITS region sequencing, to monitor an arid grassland soil microbiome for 3 hours following rewetting in a summer drought incubation experiment.

We show that the soil lipidome is rapidly remodeled following rewetting and the distinct changes in lipids are important for stress adaptation, substrate use, and recovery during drought and subsequent rewetting. Comprehensive coverage of a broad range of lipid classes combined with our ability to characterize the fatty acid compositions of the measured lipids is an important

advantage of our work, enabling the discovery of previously unknown responses at the lipid subclass and fatty acid level. Our findings suggest that lipids may be critical in orchestrating the broad differences in stress response strategies used by bacteria and fungi to survive environmental stress. Drought resulted in an increase in lipids implicated in mediating heat, osmotic and oxidative stress and nutrient deprivation. Drought also induced elevated levels of lipids containing fatty acid moieties that were characteristic of fungal metabolism. The increase in lipids with fatty acids typical of bacteria following wetting suggested rapid metabolic reactivation in the bacterial community as nutrient diffusion increased and conditions became more favorable for growth.

These results underscore the importance of the soil lipidome as a robust indicator of microbial community responses, even at short time scales. We demonstrate the immense potential for harnessing information from the soil lipidome to understand how soil microbiomes adapt and respond to stress.

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