Fungal Trait Tradeoffs in a Southern Californian Grassland

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Project Goals: Integrating functional responses of soil microorganisms with genomic information is a fundamental challenge in understanding decomposition dynamics, especially with global change altering our predictions. Trait-based approaches offer a way to overcome this challenge by connecting organismal phenotypic responses with genomic information. In this project we focus on linking fungal trait responses under temperature and moisture manipulations to explore how fungal species and their resulting ecosystem functions are structured by tradeoffs among traits. Specifically, we measured growth yield, resource acquisition, and drought tolerance traits to identify potential tradeoffs in resource allocation under environmentally stressed conditions. We will incorporate these fungal trait responses into the DEMENT model to better predict decomposition rates under drought conditions.

Abstract Text:

Fungi play a critical role in decomposition in terrestrial ecosystems, with major consequences for ecosystem processes and biogeochemical cycling. Yet, little is known about how fungal traits will respond to climate change and how that will impact terrestrial biogeochemical cycling. To better understand the mechanisms involved in fungal stress tolerance and connect these traits to functional differences to carbon and nitrogen cycling, we measured fungal trait responses under climate stress from several diverse strains of fungi in Southern California. Because microbial communities and their resulting functions are structured by tradeoffs among traits, we asked the driving question of what tradeoffs exist for fungal traits subjected to environmental change.

To test this question, we designed an experiment that manipulated moisture and temperature and measured three fungal traits: growth yield, resource acquisition, and drought tolerance. We chose these traits because they are relevant traits for decomposition and valuable overall indicators of microbial growth and survival. In order to isolate the effects of the different fungi, we sterilized grassland litter, and then inoculated the litter with 15 different fungal strains (Ascomycota and Basidiomycota) isolated from the same site. These microsocms were then subjected to one of nine different moisture and temperature combinations in the lab for five weeks. We measured CO_2 production rate, fungal hyphal biomass, and four different extracellular enzymes at the end of the incubation period to calculate the fungal traits. Growth yield was calculated as the inverse of mass specific respiration (a function of fungal hyphal biomass and CO_2 production rate), resource acquisition was determined through the extracellular enzyme assays, and drought tolerance was calculated as the relationship between fungal hyphal biomass and moisture level.

Our analyses revealed some distinct fungal trait tradeoffs. First, we found that as growth yield increases, there is less enzyme activity ($P < 0.01$; $R^2 = 0.64$), indicating a tradeoff between resource acquisition and growth yield (Fig. 1). Second, we also found a tradeoff between resource acquisition and drought tolerance (Fig. 1), with more enzyme activity correlating with less drought tolerance ($P < 0.001$; $R^2 = 0.73$). These results suggest that metabolic investment into resource acquisition is made at the expense of growth and investment towards drought tolerance. Third, we did not find a tradeoff between growth yield and drought tolerance (Fig. 1), since lower growth yield was correlated with less drought tolerance ($P < 0.001$; $R^2 = 0.75$); this perhaps indicates that growth yield is coupled with traits selecting for drought tolerance. Our work simultaneously improves mechanistic understanding of fungi in ecosystems and advances trait-based modeling, which is part of additional work from our group under this funding opportunity, in order to further predict fungal impact on biogeochemical cycling.

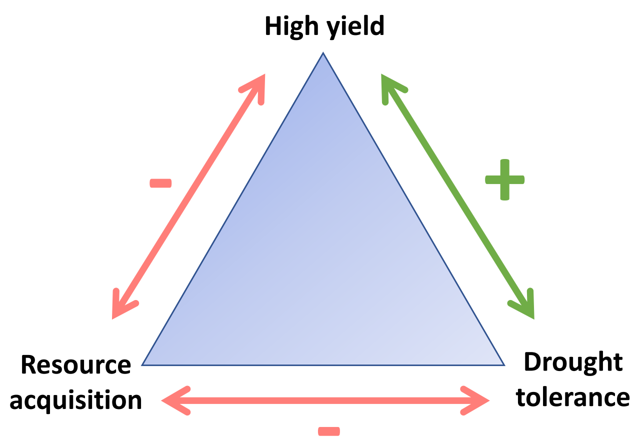

Figure 1. Schematic indicating the positive and negative relationships between high yield, resource acquisition, and drought tolerance traits observed in our study for soil fungal species.