Time-Dependent Tradeoff In Microbe-Plant Interactions Under Drought: Short-Term Stress Dampening Versus Long-Term Accelerated Mortality

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http://www.lanl.gov/org/padste/adcles/bioscience/bioenergy-biome-sciences/soil-carbon.php

Project goal:
Identify soil microbial community traits that influence ecosystem sensitivity to climate stress.

Abstract

The LANL Genomic Science SFA aims to inform climate modeling and enable carbon management. The SFA uses genomics approaches to reveal microbial processes affecting biogeochemical cycling (e.g. C and N cycling) in terrestrial ecosystems. This involves discovery of fundamental principles driving the organization and interactions of soil microbes at multiple scales.

The work presented here addresses BER Grand Challenge 4.1: *characterize biogeochemical exchanges driven by plant-microbe interactions and evaluate their process-level impacts and sensitivity to climate change*. We are attempting to identify microbial community traits that influence plant function because the production and longevity of plant biomass carbon in terrestrial ecosystems is a key component of climate feedbacks. Discovery of microbial-plant interactions that influence cycling of C and N is a step towards inclusion of microbial processes into earth system models (e.g. BER Grand Challenge 4.4).

Although soil microbial communities can improve plant productivity and survival, the interaction is not well-understood. A major knowledge gap is how soil microbial communities alter plant responses to drought. To address this gap, we examined plant responses to drought as a function of soil microbial community composition. We hypothesized that microbial community composition will affect plant functions including germination, growth, drought tolerance, photosynthesis, stomatal conductance, and wilting.

To test this hypothesis, seeds of a fast-growing C4 grass, blue grama (*Bouteloua gracilis*), were planted in sterilized sand (the control treatment) or in sterilized sand inoculated with soil microbial communities from 15 geographically distinct soils. The 15 soil microbial communities were selected to inoculate plants because they exhibited functional differences in carbon cycling. After substantial growth (14 weeks), drought was imposed. Measurements of plant physiology and soil microbial communities were taken before, during, and after drought.

One month after planting, germination and shoot height were significantly greater in inoculated plants compared to controls. During the initial stage of drought, inoculated plants were more productive (indicated by greater growth and rates of photosynthesis) than controls because the

inoculated plants maintained higher soil moisture. This delayed the onset of drought but also caused inoculated plants to have lower drought tolerance than controls. As drought persisted and soil moisture declined to zero, inoculated plants were more susceptible to drought as indicated by significantly lower stomatal conductance, greater wilting, and faster mortality compared to controls. Among the inoculated plants, plant functional differences (plant height and drought tolerance) were linked to the composition of the soil communities used for inoculation.

These data suggest that soil microbes promote *B. gracilis*' opportunistic growth strategy—i.e., fast plant growth when water is available and dieback when water is scarce. **In this system, microbes initially enhanced plant productivity and dampened drought stress, but accelerated mortality over longer timescales of persistent stress, suggesting tradeoffs linked to patterns of stress oscillation.** This work provides an unexpected insight into plant-microbe-soil interactions. The underlying mechanisms are relevant to understanding responses of terrestrial ecosystems to climate change. Investigation of microbial community traits linked to differences in plant susceptibility to drought is ongoing.

Funding Statement: The information presented in this poster was supported by the U.S. Department of Energy Biological System Science Division, through a Science Focus Area Grant (2015LANLF260) to Los Alamos National Laboratory, the Los Alamos National Laboratory Center for Space and Earth Science Chick Keller Post-Doc Fellowship to DM, and LDRD-ER project number 20160373ER.