

Molecular interactions of the plant-soil-microbe continuum of bioenergy ecosystems

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Project Goals: The overall goal of this project is to identify the factors regulating plant-microbe-soil interactions to determine the extent to which biofuel feedstock production can confer environmental benefits. We aim to test if plant-microbe interactions are limited to influencing the rate of C accrual, while mineralogy regulates the sink capacity of biofuel cropping systems. To accomplish this goal, we are (1) identifying how microbial community composition and function relate to the production of microbial necromass that contribute to soil C accumulation, (2) characterizing microbial dynamics that contribute to necromass accumulation in situ in response to crop selection and edaphic factors and (3) generating long-term, cross-site data that can be used to model C cycling in bioenergy cropping systems under different soil conditions.

Abstract text. Crop selection and soil texture influence the physicochemical attributes of the soil, which structures microbial communities and influences soil organic matter formation, cycling and long-term storage. At the molecular scale, microbial metabolites and necromass alter the soil environment, which creates feedbacks that influence ecosystem functions, including soil organic matter accumulation. Yet the generalizable mechanisms regulating the accrual and long term stabilization of soil organic matter are still unclear. By integrating lab to field studies we aim to identify the molecules, organisms and metabolic pathways that control the formation of molecules that contribute to long term organic matter stabilization in bioenergy soils.

We investigated the relative influence of crop and site selection on microbial community composition, enzyme activity and soil chemistry at the Great Lakes Bioenergy Research experiment. Sites in WI and MI, USA have been in corn and switchgrass cropping systems for a decade, resulting in pronounced differences in soil structure. By comparing soil aggregate ecology across sites and cropping systems we are able to test the relative importance of plant, microbe, and mineral influences on soil organic matter dynamics. Soil bacterial and fungal community structure (Bray-Curtis) differ with crop selection, and are even more strongly influenced by site selection. Crop and site effects in microbial community structure were consistently apparent in all aggregate fractions and treatment effects were more pronounced in large compared to small aggregate fractions. Similarly crop and site selection influenced potential enzyme activity with strongest site effects in enzymes that liberate carbon molecules (betaglucosidase, betaxylidase) and more pronounced crop effects in enzymes that release compounds containing carbon and nitrogen (aminopeptidase, nagase). FT-ICR MS revealed differences in the molecular composition of water-soluble fraction of soil organic matter. Similar to microbial activity, we found that bioavailable substrate pools were more strongly influenced

by plant inputs compared to soil origin. For example, we observed more molecules classified as amino sugars, carbohydrates, proteins, and lipids in switchgrass plots, while condensed hydrocarbons and lignins were more prevalent in the corn cropping systems. These data are consistent with cropping system effects on potential enzyme activity, where betaglucosidase, betazylosidase, aminopeptidase and nagase activity was greater in soils under switchgrass compared to corn. These results suggest that although soil origin influences the bacterial and fungal community structure, plants have a stronger influence on microbial activity which is consistent with the soluble soil chemistry. While cycling of organic compounds is reflective of bioenergy cropping systems, the differences in microbial community structure may have long lasting effects on the stabilized carbon remaining in the soil. Ongoing research aims to characterize the persistent organic compounds that are hypothesized to reflect microbial necromass more than recent plant inputs.

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