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 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 the microbial functions and biopolymers of microbial necromass that contribute to soil C accumulation under controlled conditions, (2) characterizing microbial necromass accumulation in response to crop selection and edaphic factors in situ 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. To be competitive in the biofuel energy market, cellulosic feedstocks need to be high yielding and carbon neutral or negative. Generating sustainable feedstock production systems in marginal lands depends on the plant-microbe-soil interactions controlling the formation and stabilization of soil organic C. While some systems seem to show substantial increases in soil organic C under perennial cropping systems, others have more moderate increases that cannot be explained by relationships with climate or soil texture alone (Lemus and Lal 2005). Instead, microbial residues have come to light as a substantial source of soil organic C. Still there is limited knowledge of the complement of molecules that comprise microbially derived soil organic C. While many studies invoke microbial necromass as a key contributor to soil organic matter, only a few studies have investigated the chemical composition soil fractions by sensitive mass spectrometric methods (Golchin et al. 1997, Sleutel et al. 2011). To manage biofuel cropping systems in a sustainable manner, it is essential that we understand how plant-microbe-soil interactions regulate the accrual and stability of soil organic matter, and in particular the relative contribution of microbial biopolymers to soil organic C pools of different stability (Ludwig et al. 2015). This Early Career research program addresses soil organic matter biogeochemistry at the molecular scale, focusing on the production and stabilization of microbial metabolites and residues in soil. Through lab and field experiments I aim to reveal the microbial mechanisms that regulate carbon (C) stabilization in soils dedicated to biofuel crops, and test identified mechanisms in ecosystem-scale field experiments. After identifying microbial signatures in lab trials, I will evaluate necromass moieties under field conditions, to advance a systems-level understanding of the plant-microbiome-soil continuum for bioenergy feedstock production.

References

1. Lemus, R., and R. Lal. 2005. Bioenergy crops and carbon sequestration. Critical Reviews in Plant

Sciences 24:1-21.
2. Golchin, A., J. A. Baldock, P. Clarke, T. Higashi, and J. Oades. 1997. The effects of vegetation and burning on the chemical composition of soil organic matter of a volcanic ash soil as shown by 13 C NMR spectroscopy. II. Density fractions. Geoderma 76:175-192.
3. Sleutel, S., P. Leinweber, E. Van Ranst, M. Kader, and K. Jegajeevagan. 2011. Organic matter in clay density fractions from sandy cropland soils with differing land-use history. Soil Science Society of America Journal 75:521-532.
4. Ludwig, M., J. Achtenhagen, A. Miltner, K.-U. Eckhardt, P. Leinweber, C. Emmerling, and S. Thiele-Bruhn. 2015. Microbial contribution to SOM quantity and quality in density fractions of temperate arable soils. Soil Biology and Biochemistry 81:311-322.

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