Climate adaptation and sustainability in switchgrass: exploring plant-microbe-soil interactions across continental scale environmental gradients

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Project Goals: Our collaborative project is focused on understanding switchgrass genetic diversity and adaptation across continental scale environmental gradients. Our goal is to improve the sustainability of switchgrass as a biofuel by gaining insight into the interaction of switchgrass diversity with its associated microbiome and environmental conditions. Our approach will involve 1) the collection and characterization of new switchgrass germplasm from across the species range, 2) the development of a genetic association mapping panel and extensive common gardens to evaluate switchgrass performance, 3) a detailed characterization of the switchgrass microbiome, 4) studies of the impact of switchgrass stands on ecosystem processes, and 5) extensive multiscale modeling to define conditions of sustainability and identify key tradeoffs between genetic diversity, productivity, and ecosystem services. Ultimately, these studies will identify critical plant-microbe-soil traits that may be manipulated, through breeding or agronomic management, to improve the sustainability of biofuel feedstocks.

Less carbon-intensive energy sources are needed to reduce greenhouse gas emissions and their predicted role in climate change. There is growing interest in the potential of biofuels for meeting this need. A critical question is whether large-scale biofuel production can be sustainable over the time scales needed to mitigate our carbon debt from fossil fuel consumption. The carbon balance and ultimately the sustainability of biofuel feedstock production is the result of complex climate-coupled interactions between carbon fixation, sequestration, and release through combustion. The long-term productivity of biofuels depends on the genetic and environmental factors limiting plant growth. These factors are often related to soil resources which involve complex interactions at the plant-microbe-soil interface impacting their availability and cycling.

Our collaborative project will address sustainable switchgrass (*Panicum virgatum*) production through a detailed characterization of plant growth and performance in both individual spaced and stand plantings. The project represents an unprecedented field-based experimental system for a bioenergy grass. We bring together diverse skill sets from plant and microbial genetics and genomics, physiology and ecosystem modeling. An underlying theme of the research is the use of locally adapted plant material to explore plant function, to understand the mechanistic basis of

environmental interactions, and to discover the plant genes important for adaptation and sustainability in the face of climate change. To this end, we have been collecting new genetic diversity in switchgrass from natural populations across the species range in North America. These new genotypes are being characterized through genome resequencing and clonally propagated for inclusion in experimental gardens at 14 field locations. This material will provide a detailed population genomic characterization of switchgrass along with resources for association mapping and genomic selection for future breeding programs.

Our plant-microbiome project will fully characterize the microbial communities associated with switchgrass at our planting locations using genomic tools. Specifically, we will sample field plantings of switchgrass for leaf and root microbial communities with 16S iTAG and metegenomic sequencing in collaboration with the DOE Joint Genome Center. Analyses will center on quantifying the relative importance of switchgrass host genotype, the planting environment, or their interaction on microbial community composition. Ultimately, these data will be linked with plant trait information to evaluate drivers of plant-microbiome interactions and their impacts on ecosystem processes.

Our ecosystem processes research will focus on carbon cycle responses at the ecosystem level using stand plantings of switchgrass diversity. We will couple plant growth and physiology measurements with measurements of key carbon pools and fluxes that integrate carbon dynamics across different temporal and spatial scales. Finally, our modeling will define conditions of a sustainable biofuel system and identify key tradeoffs between genetic diversity, productivity, and ecosystem services. Here, we highlight the background resources for our project, our progress establishing our new experiments, and plans for the coming field season.

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