Monitoring fluxes of atmospherically-reactive gases (CO_2, CH_4 and N_2O) during the conversion of grasslands into a biofuel crop (*Panicum virgatum*)

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Project Goals: Our project, *Establishment to senescence: plant-microbe and microbe-microbe interactions mediate switchgrass sustainability*, aims to understand the bases of switchgrass productivity in marginal soils by dissecting key molecular mechanisms that differentiate soil organisms associated with superior switchgrass genotypes adapted to a range of resource limitations. We hypothesize that successful establishment and sustainable cultivation of switchgrass in marginal soils is in part enabled by beneficial plant-microbial interactions, and that key ecosystem services ranging from C sequestration, increased soil fertility, and reduced trace gas production result from networks of plant–microbial interactions. We seek a mechanistic understanding of the interaction networks occurring within the switchgrass rhizosphere and their effects on ecosystem sustainability.

Switchgrass (*Panicum virgatum L.*), a perennial grass native to the tallgrass prairie, is one of the most promising bioenergy crops in the U.S. It's successful cultivation on marginal soils unsuitable for traditional agricultural crops has been identified as an important goal to meet the US Department of Energy's goal to replace 30% of petroleum-based transportation fuels with biofuel by 2030. In order to fully evaluate the sustainability of switchgrass-based biofuel production, we need to assess the consequences of transforming "natural" ecosystems such as grasslands into bioenergy crops. To that end field measurements of greenhouse gases (GHG) are needed to estimate the net GHG balance of biofuel production. Bioenergy crops in general are known for influencing the soil in which they grow and switchgrass in particular has been shown to potentially increase carbon sequestration in soils. Ultimately, this can further reduce GHG emissions associated with substituting renewable energy for fossil energy.

We present the results of 6 months of monitoring trace gas (CO_2, CH_4 and N_2O) fluxes during the establishment of switchgrass in two sites characteristic of the US southern plains. In each site, we compared background grassland with growing switchgrass cultivated using low-management practices. Additionally, we are interested in characterizing the effects of switchgrass establishment on the soil physical-chemical parameters along with soil microbial communities (bacterial and fungal). Thus, the main objectives of this study are to determine the effects of transforming a low-productivity grassland into a switchgrass field in terms of (i) soil physico-chemical characteristics, (ii) fluxes of GHG (CO_2, CH_4 and N_2O) and (iii) structure of the soil microbiome (bacteria and fungi). Ultimately, we will relate these three components to better understand and characterize the dynamics of GHG during the conversion of grassland into bioenergy crops.

Our two study sites, located in southern Oklahoma, represent marginal lands and exhibit differences in soil physical and chemical variables (***e.g.*** texture, organic matter content, pH). In both sites, two plots (27x22m) were delimited: one consists of a "fallow" in which natural vegetation is not disturbed and the other contains 500 switchgrass plants (Alamo variety) planted a meter apart in a honeycomb design. The fluxes of three major trace gases, carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) were measured using a recently developed cavity ring-down spectroscope (CRDS). This transportable instrument can measure concentrations down to part-per-billion for each gases species and provides high resolution measurements (every 2s). To capture both spatial and temporal variability, we used a non-steady-state chamber approach in a highly-replicated design (21 chambers per plot) along with a monthly sampling frequency. Simultaneously with trace gases sampling, we collected soil samples for physical-chemical characterization: moisture, pH, NH_4, NO_3, TN, TC, organic matter. Additionally, our two sites are located close to two meteorological towers from the Oklahoma Mesonet network, which provide us five-minute resolution data for more than twenty variables including precipitations, air and soil temperature and solar radiation. All these data will be combined with data characterizing composition of the microbial communities (by Illumina MiSeq sequencing of 16S and ITS marker genes for bacteria and fungi, respectively).

Preliminary results suggest differences in the trace gases flux dynamics across the two sites along with as well as a strong effect of the plant. Besides providing a better understanding of the effect of grassland transformation into switchgrass fields, our data will be used to estimate greenhouse gas budgets and model the switchgrass ecosystem.

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