**Plant-soil-microbial interactions in detritusphere and its impact on $N_2O$ emission**

Alyssa Kim[12,*] (kimkyu46@msu.edu), Jenie Gil[12], Nathaniel Ostrom[12], Hasand Gandhi[12], Maxwell Oerther[12], Yakov Kuzyakov[3], Andrey Guber[12], and **Alexandra Kravchenko[12]**

[1]Michigan State University, East Lansing, MI; DOE Great Lakes Bioenergy Research Center, East Lansing, MI; [3]Georg-August-Universität Göttingen, Göttingen, Germany

**Project Goals: Evaluation of the environmental performance in bioenergy cropping systems is an important part for sustainable bioenergy production. The goal of this project is to examine the contribution of decomposing switchgrass roots to nitroux oxide ($N_2O$) emission. We aimed to track the fate of switchgrass-driven nitrogen (N) in the microbial biomass, soil (organic and inorganic N), and atmosphere ($N_2O$) under different soil physical conditions. We also aimed to elucidate the temporal and spatial dynamics of microbial activity and $N_2O$ emission and find the key controls of them.**

**Abstract text:** Switchgrass (*Panicum Virgatum L.*) is a promising bioenergy crop that can preserve land from environmental disturbances and play a role in carbon (C) sequestration. For a comprehensive assessment of the ecological and environmental functions of the switchgrass production system, $N_2O$ emissions, especially at the decomposition stage of switchgrass roots (that often occurs after harvest), has to be thoroughly investigated.

We conducted a greenhouse study of switchgrass root decomposition, under various controlled soil conditions. We treated the soils of the same origin (thus expected to have the same microbial community) to have different moisture contents (40% and 70% water-filled pore space) and pore size distributions (dominant pores of >30μm Ø and < 10μm Ø, referred to as large and small pores). For a more realistic assessment, we used *in-situ* grown switchgrass roots instead of incorporating root fragments. It enabled us to include an indirect effect of the microenvironments and microbial community structures formed during the plant growth (rhizosphere). The switchgrass roots were subjected to dual-isotope labeling ($^{15}N$ and $^{13}C$) to track the fate of N and C. Isotopic levels were measured during the decomposition to estimate the size of the pools of microbial biomass, soil, and atmosphere. Microbial activity was measured using the zymography approach, which is a 2-dimensional mapping technique of extracellular enzymes. We mapped the distribution of N-acetyl-glucosaminide (chitinase) and separated the chitinase activity on the roots and soils to assess spatial dynamic.

In our results, up to 0.4 % of the switchgrass root-driven N was emitted as $N_2O$ gas, only within 21 days of the decomposition, suggesting the necessity of management practice to mitigate the formation of strong $N_2O$ hotspots after harvest in the bioenergy system. Approximately 21 ~35% of root N was transformed to dissolved organic N, while less than 1 % of the root N remained as ammonium ($NH_4^+$) and nitrate ($NO_3^-$) during the incubation. Decreasing $NH_4^+$ and increasing

$NO_3^-$ suggested nitrification. Surprisingly, inorganic and organic N, enzyme activity, and $N_2O$ emission were greater in the soil with the prevalence of large pores. However, there was no difference in microbial biomass between the soil pore size treatments. Higher chitinase activity in the soils with the prevalence of large pores suggests that the fungal activity was higher in those soils compared to the soils dominated with small pores. Root chitinase activity was positively correlated with the root driven $N_2O$ emission rate ($p< 0.01$, $R^2=0.22$), supporting that the microbial hotspot formed near the root is the hotspots of $N_2O$ emission. The ample supply of labile substrates degraded by extracellular enzymes might be a key control to the magnitude of the $N_2O$ hotspots in detritusphere.

Tracking the fate of N during the plant root decomposition provides a new perspective on the strategies to minimize $N_2O$ emissions in switchgrass bioenergy cropping systems. Our study also indicates that the intensity of root-driven $N_2O$ hotspots can highly depend on the soil's physical characteristics, being mediated by decomposed substances and enzyme activity.

**Funding statement:** This material is based upon work supported by the Great Lakes Bioenergy Research Center, U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research under Award Number DE-SC0018409.