74. Greenhouse gas emissions from fertilized plots of bioenergy crops in Eastern Washington

Manmeet Pannu[1], Kelley Meinhardt[1], Anthony Bertagnolli[1], **Sally Brown[2]**, **Steve Fransen[3]**, **David Stahl[1]** and **Stuart Strand[1]*** (sstrand@uw.edu)

Civil and Environmental Engineering[1] & College of Forestry[2], University of Washington, Seattle, WA 98195, Department of Crop and Soil Science[3], Washington State University at Prosser, WA 99350

Project Goals: The impact of an expanded bioenergy industry on soil and atmospheric chemistry remains unknown. Nitrogen fertilization is required for enhanced plant growth but nitrifying organisms in soil oxidizes ammonium to nitrate and produces greenhouse gases as a byproduct. Ammonia oxidizing Archaea (AOA) are often observed in high abundances in soils, and have been implicated as the dominant assemblages responsible for the first step of nitrification (ammonia oxidation to nitrite). However, information regarding their role in nitrification in soils impacted by biofuels cultivars remains unknown. The goals of this project were to assess whether differing soil types and nitrogen delivery strategies 1) altered the rates of differing greenhouse gas emissions 2) impacted the community abundance, structure, and diversity of nitrifying assemblages 3) altered broader components of microbial diversity and metabolic activity associated with the nitrogen cycle.

Cellulosic ethanol (biofuel) is proposed as an alternative to fossil fuels. Nitrogen fertilizer is the highest energy input for biofuel production and is often applied in excess to enhance crop yields. However, excess nitrogen application leads to nitrogen leaching and to increased emissions of atmospherically active nitrous oxide (N_2O) and nitric oxide (NO). Nitrous oxide is a greenhouse gas with a global warming potential 300 times greater than carbon dioxide. Nitric oxide has an indirect impact on earth's radiative balance by catalyzing tropospheric ozone formation. Thus, in order to minimize adverse environmental impacts of crop production, efficient nitrogen delivery is essential. Our primary research objective was to determine the influence of plant species, soil type, N source, and microbial community on greenhouse gas emissions. Our studies focused on two experimental plots of irrigated switchgrass, a potential biofuels feedstock, in Eastern Washington at two sites, near Prosser (PR) and Paterson (PatN), having different soil characteristics. Experimental treatments included varying rates of chemical and biosolids fertilizer application, and the passive delivery of nitrogen via intercropping with alfalfa (N-fixer). During the 2013 field season (April-October), gas samples were collected immediately after irrigation at roughly monthly intervals and the flux of nitrogen oxides calculated using Fick's law.

Nitrous oxide flux data for the 2013 season revealed distinctive site differences. A greater flux was measured at the PatN site (sandy, pH ~6) than at the PR site (silt loam, pH ~8), suggesting an effect of soil texture and/or pH on nitrous oxide emissions. Previous published studies also observed higher N_2O fluxes at sites with acidic soils. Average N_2O fluxes were elevated immediately after fertilization and irrigation: 12.5 g N_2O-N /ha/d at PR and 15 g N_2O-N /ha/d at PatN. Further, biosolids application (PatN site) contributed to much higher emissions (25 g N_2O- N /ha/d) than observed for inorganic fertilizer or in control plots. Intercropping with alfalfa resulted in a maximum flux of 4 g N_2O-N /ha/d. To mimic field treatments in a controlled laboratory environment, undisturbed soil cores (without switchgrass) from the PatN field site were analyzed using a dynamic chamber system. N_2O fluxes increased immediately after watering soils amended with biosolids and inorganic fertilizer at field rates, but returned to ambient concentrations over time as the soils dried. Higher emissions from biosolids (250 N_2O-N g/ha/d) and inorganic fertilizer (75 N_2O-N g/ha/d) than observed in the field site was likely due to the absence of switchgrass plants in these initial laboratory studies (now being replicated using switchgrass planted soils).

Our results clearly demonstrated that soil type, and the form and rate of nitrogen application, together greatly influence N_2O emission rates. Greater N_2O fluxes were observed with biosolids and in acidic soil (PatN) relative to slightly alkaline soil (PR). Complementary molecular studies have revealed that ammonia oxidizing archaea (AOA) are the dominant ammonia-oxidizing population in these intensively managed soils, greatly outnumbering ammonia-oxidizing bacteria. Since these molecular studies also revealed a distinctive shift in AOA population type - *Nitrososphaera* (54d9 clade) dominant at PatN and *Nitrosotalea* (subcluster 1.1) dominant at PR – physiological differences among AOA genotypes may also influence emission rates of atmospherically active gases.