The Impacts of N Fertilizer Management on Nitrous Oxide Emissions in Switchgrass

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Introduction

- Switchgrass (*Panicum virgatum* L.), a native warm-season, perennial grass, has been identified as a promising cellulosic biofuel crop.
- Perennial cellulosic crops do not have high fertilizer requirements, but producers may apply more N fertilizer than minimum recommended levels especially if the price of biofuel crops yield is much higher than fertilizer costs.
- N input can directly increase soil N_2O emissions, which offsets the effects of reduced greenhouse gas (GHG) emissions of biofuels.
- Currently, most studies use the linear IPCC (2006) emissions factor to estimate soil N_2O emissions in assessing biofuels GHG balance, which is based on the assumption that 1% of the fertilizer N converts to N_2O during cultivation.

Objective and Hypothesis

Objective: We studied the response in soil N_2O emissions to the input of N fertilizer in switchgrass.

Hypothesis:

- The response in soil N_2O emissions to the inputs of N fertilizer in switchgrass will be non-linear; in particular, fluxes will increase sharply after biomass yields no longer increase. Two corollaries follow:
  - a) the linear IPCC emission factor of 1% may be used to predict soil N_2O emissions only when N inputs are less than or equal to those required for maximum yields, after which emissions will increase significantly
  - b) cumulative N_2O emissions may be predicted by soil available N

Acknowledgements: we thank Emma Robertson, Poonam Jasrotia , Neville Millar, Stacey VanderWulp, Kevin Kahmark, Cathy McMinn, Joe Simmons, Julie Doll , Sven Bohm, Suzanne Sippel , Sara Syswerda, Ilya Gelfand, Ajay Bhardwaj, Iurii Shcherbak ,Terenzio Zenone and many lab technicians for assistance in the field and lab and insightful comments. We would also thank Wei Wang and Sasha Kravchenko for the help with statistical analysis. We are particularly grateful to Steve Hamilton for many suggestions and insightful comments.

Materials and Methods

- **Site Location :** The Great Lakes Bioenergy Research Center (GLBRC) main site at the Kellogg Biological Station in southwest Michigan.

- **Experimental design and treatments:** Eight treatments (0-196 kg N ha^{-1} nitrogen fertilization) were established in Spring 2009. Plots were arranged in a randomized complete block design with four replications.

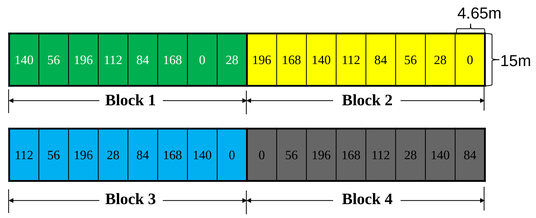

Figure 1. Experimental design for switchgrass N rate trial plots. Values in boxes indicate N rates in each plot (kg N ha^{-1}).

- **Gases measurements and analysis:**

Results

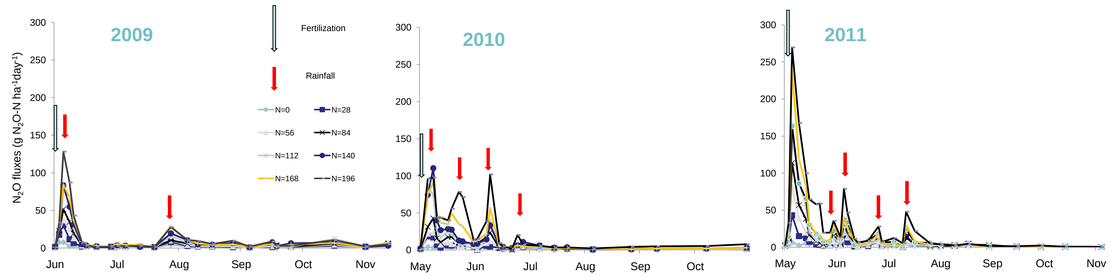

Figure 2. Daily soil N_2O fluxes in switchgrass during 2009-2011 (g N_2O-N $ha^{-1}d^{-1}$)

From 2009 to 2011, mean daily N_2O emissions ranged between 1.86 and 20.0 g N $ha^{-1}d^{-1}$ for the low fertilizer (0 kg N ha^{-1}) and high fertilizer (196 kg N ha^{-1}) N rates, respectively, with a maximum daily N_2O flux of 312 g N $ha^{-1}d^{-1}$ in the highest N rate plots and a minimum daily flux of 0 in plots that received no fertilizer N.

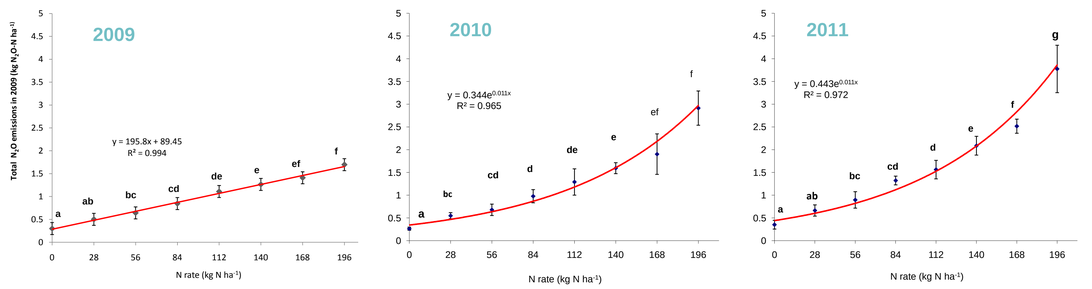

Figure 3. Relationship between N rates and cumulative N_2O emissions in switchgrass during 2009-2011

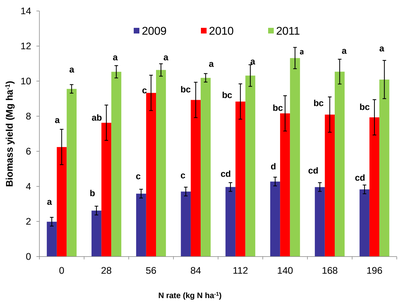

Figure 4. Biomass yield in switchgrass during 2009-2011. The treatments marked with the same letters are not significantly different from each other (α<0.05) in each year.

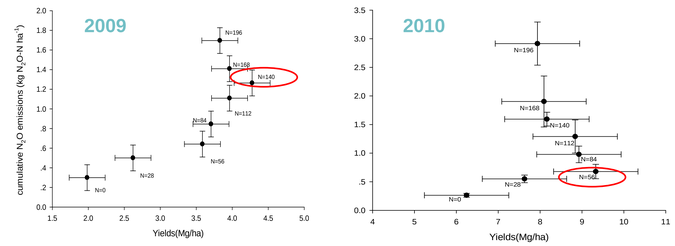

Figure 5. Relationship between biomass yield and cumulative N_2O emissions in switchgrass during 2009 and 2010

Conclusions

1. A linear relationship between N input and cumulative N_2O emissions occurred in the establishment year 2009 but a non-linear relationship occurred in 2010 and 2011.
2. N_2O fluxes were strongly correlated with precipitation.
3. Most of the N fertilizer-associated N_2O increase occurred within 40 days following fertilization.
4. Switchgrass yields were responsive to N fertilizer in 2009 (to 140 kg N ha^{-1}) and 2010 (to 56 kg N ha^{-1}) but there were no significant yield differences among treatments in 2011.