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Soil Carbon Decomposition in Grass Based Biofuels

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Abstract

Biofuels from cellulosic bioenergy crops, which include perennial prairie grasses such as switchgrass (*Panicum virgatum L.*) and big bluestem (*Andropogon gerardii Vitman*) pose as a promising potential resource to help mitigate climate change. Ecological sustainability necessitates that growing these crops for bioenergy production promotes soil carbon (C) sequestration, such that their production contributes to removing CO_2 from the atmosphere. Soil C sequestration is driven by the quantity of C that plants release into soil and by the quantity of this C that is decomposed by soil microorganisms and subsequently respired back into the atmosphere. Our previous research has ascertained that the quantity of C released into soil differs between switchgrass and big bluestem, but we are uncertain about loss of this C from soil through decomposition processes. This knowledge gap makes it difficult to predict long-term soil C sequestration in these biofuel cropping systems. This project asks if there are significant differences in soil C decomposition dynamics between two grass based biofuels? We are performing a long-term controlled laboratory incubation study with soils derived from switchgrass and big bluestem bioenergy cropping systems which were collected in 2018. The field experiment was initiated in 2008 at the Fermilab National Environmental Research Park, in northeastern Illinois, USA. Soils will be homogenized by sieving, weighed (20g) into airtight incubation chambers, wetted to 60% of water holding capacity and stored in a dark environment at 20oC for 480 days. We will quantify decomposition of soil C by measuring microbial CO_2 respiration on days 1, 3, 7, 15, 30, 60, 120, 240, and 480. We will be able to disentangle whether respired C was derived from switchgrass or big bluestem versus the soil C that was present in the soil prior to planting these crops, by using the natural isotopic difference between C4 plants and the soil in which they had grown for 10 years, which was reflective of C3 plants. Understanding differences in the decomposition of C derived from switchgrass and big bluestem will help us determine which one of these species will offer a more promising solution to mitigating climate change.

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Introduction

- A significant portion of ethanol production in the United is derived from cellulosic bioenergy crops, which include perennial prairie grasses such as switchgrass (*Panicum virgatum L.*) and big bluestem (*Andropogon gerardii Vitman*) (Fig. 2).
- Ecological sustainability necessitates that the production process (Fig. 1) removes more CO_2 from the atmosphere than is released in the process of bioenergy production.
- If big bluestem and switchgrass promote soil C sequestration, then their growth will contribute to removing CO_2 from the atmosphere.
- Soil C sequestration is driven by the quantity of C that plants release into soil and by the quantity of this C that is decomposed by soil microorganisms and subsequently respired back into the atmosphere.
- We have ascertained that soil C differs between switchgrass and big bluestem (Fig. 3) , in-part owing due to differences in C input but we are uncertain about decomposition of this C, making it difficult to predict long-term soil C sequestration in these biofuel cropping systems.
- Understanding differences in the decomposition of C derived from switchgrass and big bluestem will help us determine which one of these species will offer a more promising solution to mitigating climate change.

***Figure 1**. Feedstock harvest*

***Figure 2.** Big Bluestem (native) grass*

Question

Are there differences in soil carbon decomposition between switchgrass and big bluestem bioenergy cropping systems?

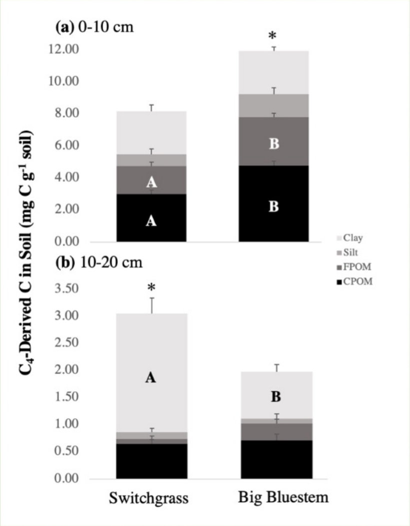

Figure 3a. Big bluestem soil displayed significantly higher C in the uppermost (0-10cm) layer. This type of C tends to be more vulnerable to decomposition.

Figure 3b. Switchgrass soils contained significantly more C in the lower 10-20 depth. The higher clay C in switchgrass tends to persist more long-term. (Kelly-Slatten et al, 2023).

Predictions

- Decomposition of soil C is higher in the shallow (0-10 cm) than deeper depths in big bluestem.
- Decomposition of C is higher in big bluestem than in switchgrass soils.
- Greater C association with the clay fraction in switchgrass compared to big bluestem soils will lead to less C loss from switchgrass soils in the long-term, and this leads to greater soil C storage.

Methods

- Experimental field site: Argonne National Laboratory's Sustainable Bioenergy Crop Production Research Facility, established at Fermilab, Batavia, IL, in 2008. Previously C3 plants had grown for 36 years, prior to establishment of C4 grasses.
- Samples of Big Bluestem and Switchgrass (three cultivars for each) were taken with a 4.8cm soil corer (0-10 cm, 10-20 cm depths) on the plant crown, in 2018.
- 20g Soil samples were homogenized and placed in sealed chambers for long-term incubations.
- CO_2 samples will be extracted on days 1,3,7,15,30,60,120, 240 and 480 from sealed incubation chambers then transferred to exetainer vials for analysis. The natural difference between C3 and C4 allows us to determine how much of the CO2 was respired from the grasses.

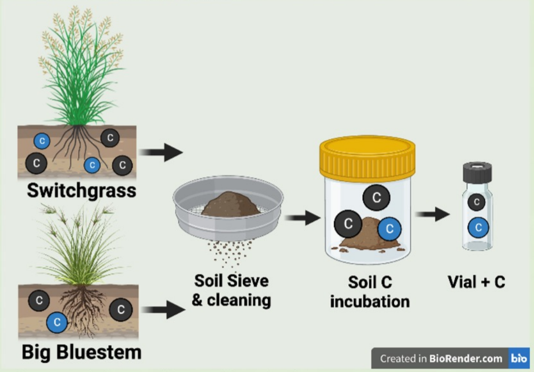

Figure 4. Soil sampling and incubation

Future Work

- Continued analysis of soil carbon decomposition in switchgrass and big bluestem.
- Analysis of soil C generated by big bluestem in comparison to switchgrass systems, and details of the chemical components (specific to each species) which may impact soil C decomposition dynamics.

Acknowledgements: Kelly-Slatten, M. J., Stewart, C. E., Tfaily, M. M., Jastrow, J. D., Sasso, A., & de Graaff, M. A. (2023). Root traits of perennial C4 grasses contribute to cultivar variations in soil chemistry and species patterns in particulate and mineral-associated carbon pool formation. GCB Bioenergy