# Switchgrass and corn contributions to deep soil C after 9 years: Soil fractions to plant biomarkers

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## Introduction

- Switchgrass (*Panicum virgatum* L.) is a perennial, cellulosic biofuel feedstock that could be grown on marginal cropland to improve soil quality and provide producer income.
- Increased SOC sequestration under switchgrass compared to corn is attributed to greater and deeper switchgrass root production.
- However, on degraded soils, dryland no-tillage continuous corn also resulted in positive SOC sequestration rates (Follett et al. 2012).

*Question: How does aboveground management (plant species, N fertilization & harvest) impact the depth and form of SOC?*

- We quantified switchgrass (Cave-in-Rock) and corn-derived organic C by physically fractioning the soils and measuring $\delta^{13}C$. We then measured plant-specific biomarkers using cupric oxide extraction and pyrolysis-GC/MS.

## Field Design & Sampling

| Species | N rate (kg N ha$^{-1}$) | Harvest/Residue treatments |
|---|---|---|
| Switchgrass (Cave-in-Rock) | 0<br>60<br>120 | August<br>October |
| Corn | 60<br>120<br>180 | No residue removal (NR)<br>50% residue removal (RR) |

Field setup: 9-yr old split-split plot design with three field replicates at the University of Nebraska's Agricultural Research and Development Center. Field soils were silty clay loams and silt loams.

Sampling: Depth increments of 0-5, 5-10, 10-30, 30-60, 60-90, 90-120, and 120-150 cm were sampled Apr 10, May 1 & 2 2007 in all plots.

Analyses: Physical fractionation into particulate organic matter (POM, >53µm) and silt+clay (S+C <53µm) & total soil C, N, and $\delta^{13}C$

Data Analysis: ANOVA mixed model with main treatment effects of plant, N(plant) and harvest(plant) within each depth. Replicate, replicate×plant and replicate×N(plant) were considered random effects.

## Root C

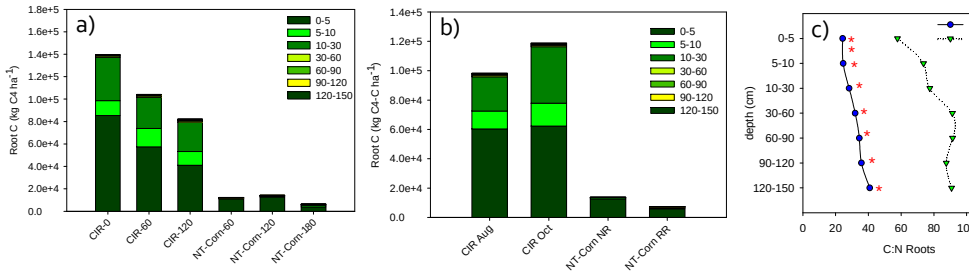


**Figure 1** Root biomass $C_4$-derived C from the soil 0-150cm profile for (a) N fertilizer treatments, (b) harvest treatments and (c) C:N ratio of NT-Corn and switchgrass root biomass. * indicates a significant difference between plant species.

## Soil Fraction C

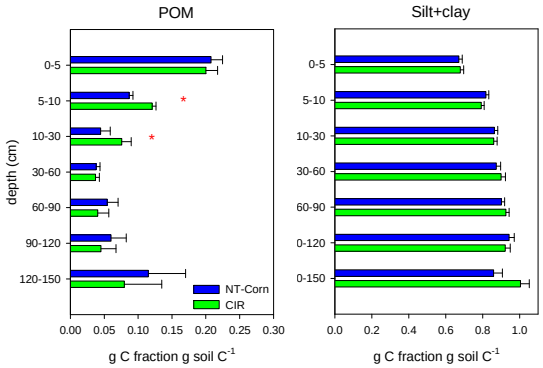


**Figure 2** Particulate organic matter (POM) and silt+clay C (g C fraction g soil C$^{-1}$) for NT corn and switchgrass. * indicates a significant difference between plant species.

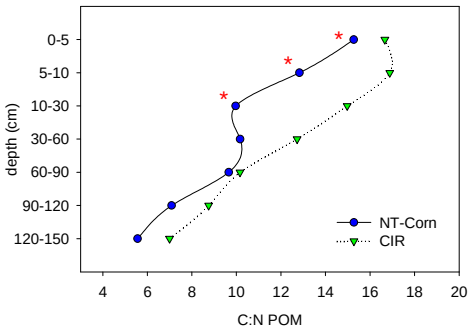


**Figure 3** Particulate organic matter (POM) C:N ratio for NT corn and switchgrass. * indicates a significant difference between plant species.

## Lignin Biomarkers

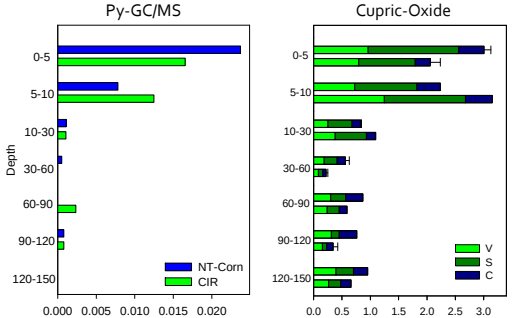


**Figure 4** Lignin biomarkers from the cupric-oxide extraction and py-GC/MS for the NT-corn 120 kg N ha$^{-1}$ and switchgrass under 60 kg N ha$^{-1}$. V=vanillyl, S=syringyl and c=cinnamyl phenols.

## Lignin Degradation

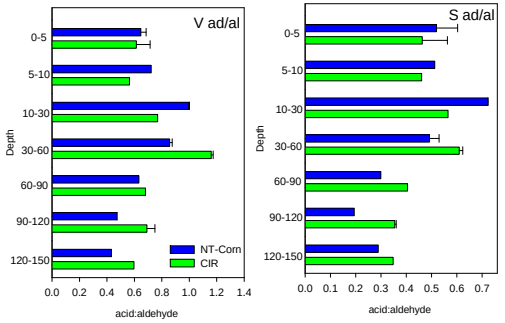


**Figure 5** Acid to aldehyde ratios of vanillyl and syringyl biomarkers from the cupric-oxide extraction for NT-corn 120 kg N ha$^{-1}$ and switchgrass under 60 kg N ha$^{-1}$. Larger ratios indicate more decomposed lignin.

## Summary


- In 2007, switchgrass had 7 times more root C and nearly twice the plant C:N of corn (Fig. 1a, 1c) and the Oct. harvest increased switchgrass root C (Fig. 1b).
- After 9 years POM C was greater in switchgrass soils (10-15%) in the 5-10 and 10-30cm depths, but silt+clay held 85% of soil C (Fig. 2).
- The higher switchgrass C:N ratio was incorporated into the POM from 0-30 cm --indicating that root-derived soil C is structural (lignin) rather than root exudates (Fig. 3).
- Switchgrass had more lignin in the 5-30 cm depths, while corn had more below 30cm (Fig. 4).
- Lignin biomarkers were more decomposed in corn in 10-30cm, and in switchgrass 30-150cm, indicating depth-specific root turnover (Fig. 5).


## Conclusions

- Switchgrass soils had more root C that was more recalcitrant compared to corn.
- Lignin biomarkers were evident throughout the soil profile and greater under NT-corn deeper than 30cm, reflecting root turnover.
- Less lignin under switchgrass from 30-120 cm reflects large root longevity but the greater ac/ad, more fine root decomposition.
- Root C is an important source of deep soil C in both dryland NT-Corn and switchgrass biofuel production systems, where water-stress promotes deep rooting.


### Acknowledgements

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### References


Follett, R.F., Vogel, K.P., Varvel G.E., Mitchell, R.B. & Kimble, J. 2012. Soil Carbon Sequestration by Switchgrass and No-Till Maize. Grown for Bioenergy. Bioenerg. Res. DOI 10.1007/s12155-012-9198-y.