

# Mitigating the Soil Carbon Deficit of Annual Agriculture with Perennial Bioenergy Crops in the U.S. Midwest

## Background/Objective

Nearly two centuries of maize-based agriculture in the U.S. Midwest has halved soil organic carbon (SOC) stocks compared to tall-grass prairies native to this region. Replacement of annual maize/soy cropping with perennial bioenergy grasses may partially reverse these incurred SOC deficits. This work explores the ability of perennial bioenergy crops to restore agricultural soils to pre-cultivation prairie conditions by comparing SOC under perennial bioenergy crops planted on former corn/soy fields to maize-based annual cropping and native prairie.

## Approach

Researchers quantified SOC stocks by depth to 1m among native remnant prairie, maize cropping systems, and seven recently (<11 years) established perennial bioenergy cropping systems (miscanthus and switchgrass) across Illinois. They then quantified SOC stock change after 5 years in miscanthus and switchgrass and used carbon isotopes ( $\delta^{13}\text{C}$ ) to determine the origin of new C entering the soil.

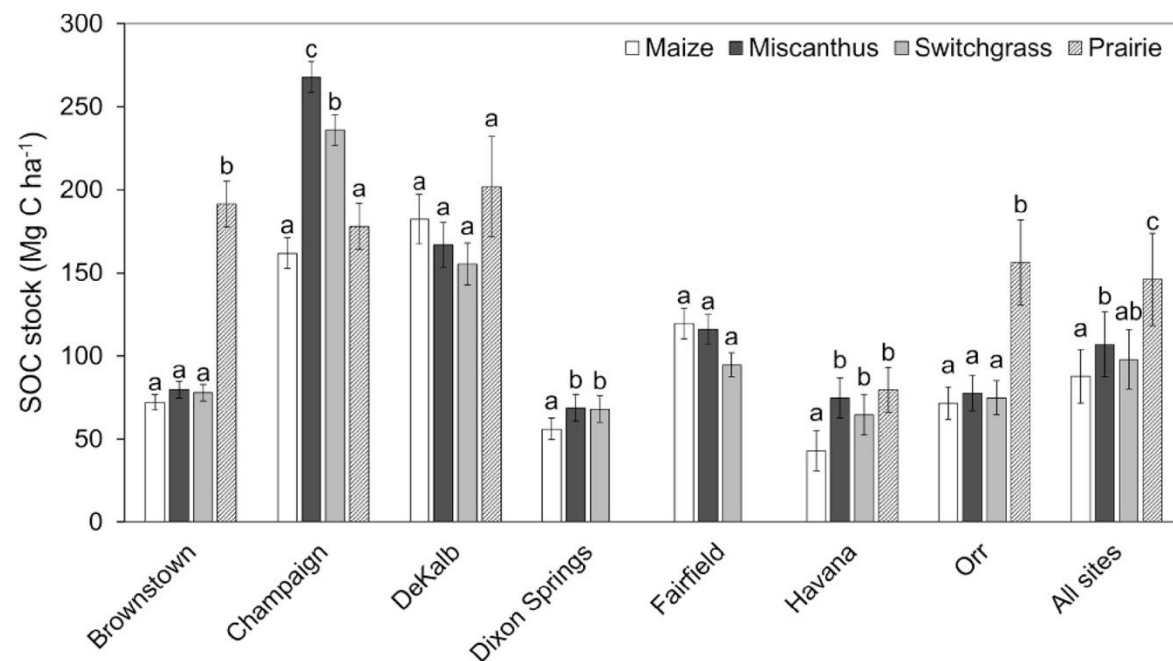
## Results

Across sites, average SOC stocks to 1m depth on an equivalent soil mass basis were 146 MG C ha<sup>-1</sup> (prairie), 107 MG C ha<sup>-1</sup> (miscanthus), 97.9 MG C ha<sup>-1</sup> (switchgrass), and 87.7 MG C ha<sup>-1</sup> (maize). SOC increased in the first 5 years under mature bioenergy crops at four of seven sites.  $\delta^{13}\text{C}$  analyses of surface depths confirmed SOC increases to be derived from miscanthus and switchgrass.

## Significance/Impacts

This work demonstrates the potential of perennial bioenergy crops to rebuild SOC over time, even with annual harvesting, and address the SOC deficit caused by annual maize cropping.

Kantola et al. 2026. "Mitigating the Soil Carbon Deficit of Annual Agriculture with Perennial Bioenergy Crops in the U.S. Midwest." *Geoderma*. DOI: 10.1016/j.geoderma.2026.117830.



**Comparison of SOC stock on equivalent soil mass basis between cropping systems across all sites and within each site. Error bars represent  $\pm$  standard error of the mean. Lower case letters represent differences among crop types within each site or across all sites ( $p < 0.05$ ).**