Quantifying the impact of no-till and cover crops on soil carbon flux in a corn-soybean rotation

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Intro

- Preserving soil carbon stocks is important both to increase crop yield and mitigate greenhouse gas emissions.
- No-till, cover crops, and expanded crop rotations are all strategies to increase carbon storage in soils, but it is unknown which is most effective.
- Measuring changes in soil carbon storage is difficult, soil samples must be taken years apart and eddy covariance does not specifically measure soil carbon.
- We leverage both techniques to assess the impact of climate smart practices on soil carbon storage.

Methods

1. Two agricultural fields, are instrumented with eddy covariance from 2016 to 2022.
2. The Business as Usual (BAU) field has conventional tillage, no cover crops, and a maize-soybean-soybean rotation.
3. The Aspirational (ASP) field has no-till, cover crops, and an expanded crop rotation including wheat and hay.
4. Soil organic carbon content was measured with deep soil core samples in 2016 and early 2022.

Results

- The ASP field has a net carbon uptake over the 6-year period while the BAU field is likely carbon neutral. (Figure 1).
- The eddy covariance (EC) and soil sampling methods agree that the ASP site has carbon uptake, but the approaches do not converge at the BAU site.

There are three main hypotheses for what could lead the ASP system to having more carbon uptake than the BAU site:

1. Reduced respiration from no-till at the ASP site.

- No. Respiration is higher at ASP (1,248 g m^{-2} yr^{-1} vs 935 g m^{-2} yr^{-1})

2. Different crop types (wheat and hay are included in ASP).

- No. Wheat has more uptake than maize or soybean. But in the ASP system this is balanced by hay that has more carbon emissions, largely because the whole plant is harvested and leaves no crop residue. (Figure 3).

3. Increased biomass production from the inclusion of cover crops.

- Yes. At the ASP site, cover crop periods have essentially no NEE, whereas at BAU the NEE is ~500 g m^{-2}. This is not due to respiration; it is primarily due to the higher GPP from cover crops (Figure 4).

Cover crops are the key component of an agricultural system designed to **maximize carbon storage in soils.**

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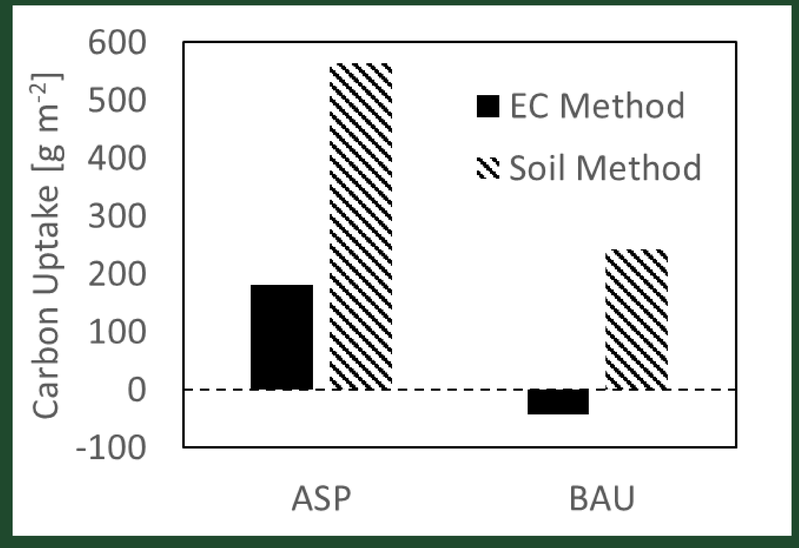

Figure 1: Carbon uptake from 2016-2022 estimated by eddy covariance (EC) and soil samples at each field.

Extra Figures & Tables

Figure 2: Aerial photo of the ASP field with locations where soil cores were extracted to measure soil carbon (left). Photo of the eddy covariance tower at the ASP field (right). The BAU field is approximately 2.5 km to the West.

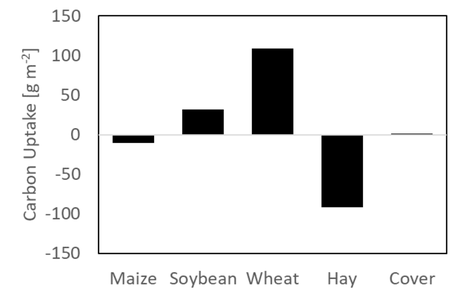

Figure 3: Average growing season carbon uptake from each of the crops at the ASP site. Net carbon uptake is measured with eddy covariance (EC) and carbon content in the crop yield is removed from the EC measurement.

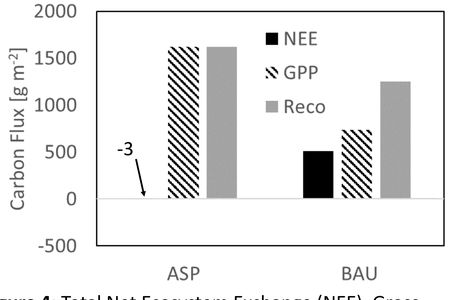

Figure 4: Total Net Ecosystem Exchange (NEE), Gross Primary Production (GPP) and Ecosystem Respiration (R_{eco}) measured at the ASP and BAU sites from 2016 to 2022 for the time period with cover crops at ASP and fallow ground at BAU. Note that negative values of NEE indicate carbon uptake by soils.