Rotational Tillage Assessment White Paper: Synopsis

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Background

To determine whether changing from conventional to rotational tillage in corn and soybean systems offers creditable greenhouse gas (GHG) benefits, ESMC technical partner, Regrow, conducted a factorial simulation study using the DNDC soil biogeochemical model to analyze the differences in GHG outcomes between multiple types of tillage practices across a range of soil and climate conditions. The study considered four factors thought to drive GHG emissions in corn/soy systems: 1) tillage practices; [3] 2) climate (temperature and precipitation) (Figure 1); 3) soil texture; [4] and 4) initial soil carbon content. [5] All combinations of each factor were simulated in DNDC, yielding 180 unique simulations. Simulations ran ten years with results reported as the average annual change in either direct N_2O emissions or SOC sequestration. SOC was accounted for to 30 cm depth in accordance with the ESMC Protocol.

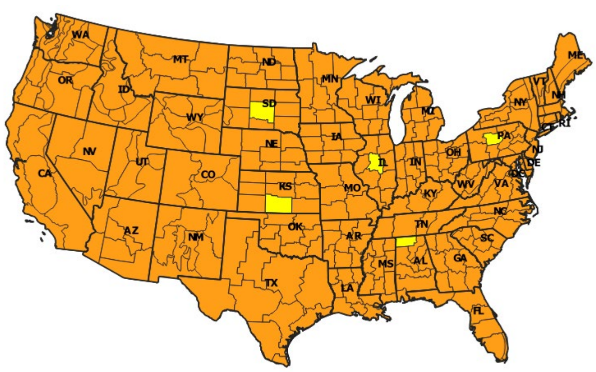

Figure 1. Location of climate scenarios representing five states across a warm/wet → cool/dry gradient. Simulations run in the Kansas climate were irrigated, adding 0 – 100 cm of water annually on top of ambient precipitation to meet crop moisture demand.

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[3] *CT*: Conventional tillage in both soy and corn (tillage to 10 cm before planting and to 20 cm after harvest); *CT-NT*: conventional tillage in corn (before and after planting), no-till in soy; *NT-CT*: no-till in corn, conventional till in soy (before and after planting); and *NT*: no-till in both corn and soy

[4] Sandy loam (9.5% clay), silt loam (14% clay), and silty clay loam (34% clay)

[5] Low (1% SOC), Medium (2% SOC), and High (3% SOC)

Results

- N_2O emissions were highest in high carbon, clay soils at warm and wet sites (AL and KS). These were also the conditions where changes to rotational tillage and no-till led to the greatest emissions reductions (0.2 – 0.4 tCO_2e/acre/year). In all other scenarios, tillage practice had minimal effects on N_2O emissions.
- SOC sequestration was greatest in low carbon, clay soils at cool, dry sites (PA, SD). Conversely, soil carbon was emitted in high carbon, sandy soils at wet sites (AL, IL, KS).
- Clay soils had higher SOC sequestration rates but higher N_2O emissions than sandy soils, resulting in larger GHG benefits on clay soils.
- Low initial soil carbon concentrations resulted in higher SOC sequestration and lower N_2O emissions compared to high initial soil carbon concentrations.
- Tillage had greater effects on SOC sequestration than N_2O emissions. Rotational tillage scenarios roughly doubled SOC sequestration compared to continuous conventional till (0.2 vs 0.1 tCO_2e/acre/yr), while no-till sequestered on average 0.3 tCO_2e/acre/yr.
- Switching from conventional to rotational tillage had the largest impact on SOC sequestration in silt or clay soils with high carbon at wet sites (AL, IL, KS). While no-till always sequestered more carbon than rotational tillage, the transition from conventional till to rotational till generally yielded a greater increase in SOC sequestration than the transition from rotational till to no-till.

Takeaways

This analysis yields several important takeaways regarding the impact of tillage practices in generating GHG credits:

- Factors beyond the control of a farmer, such as soil texture and initial soil carbon content, can have stronger impacts on SOC sequestration and N_2O emissions than tillage practice.
- The beneficial climate impact of SOC sequestration can at times be offset by N_2O emissions. Under carbon programs that require accounting for all GHGs impacted by on-farm practices, this can result in a lower-than-expected number of credits.
- Substantial practice changes (e.g., changing from conventional till to no-till) are more likely to generate the most climate benefit and, therefore, more GHG credits. Stacking additional practice changes, such as the adoption of cover crops or reductions in fertilizer applications, on top of improved tillage will further improve results and maximize a producer's return from participating in a carbon program.