Comparing the Carbon Sequestration Potential of Winter Wheat Under Conventional and No-Till Systems

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Abstract

- Soil processes, such as soil respiration play a crucial role in the global carbon cycle and the evolution of greenhouse gases into the atmosphere.
- The soil carbon storage in cropping systems is notably affected by intensive tillage practices that modify soil conditions.
- Soil physical properties control several processes including the storage and flow of water and gases from the soil, the oxidation of organic matter and microbial activity that contribute importantly to soil respiration.
- **The objective of this study was to investigate the potential of agroecosystems in sequestering or releasing carbon through measurement and comparison of soil CO_2 flux under conventional and no-till practices implemented continuously over 33-years in College Station, Texas.**

Hypothesis

- The availability of carbon and nitrogen in soils determines the amount of carbon release through soils respiration.
- CT increases CO_2 flux from soils compared to NT that reduces evaporation and oxidation of organic matter via respiration.

Soil properties

- The experiment was performed at a long-term study initiated in 1982 in southcentral Texas to evaluate different cropping systems and tillage practices.
- The winter-wheat rotation under conventional tillage (CT) and no tillage (NT) was selected to measure soil properties and soil CO_2 flux.
- CT treatment consisted in disking at 25 cm three or four times after harvest. NT treatment received only band fertilizer application.

- The soil is characterized as a Weswood silty clay loam.
- Bulk density was determined using the core method at 10, 20, and 30 cm.
- Soil total carbon (STC), soil organic carbon (SOC), and total nitrogen (STN) were analyzed.
- Soil CO_2 flux was measured at 30-minute interval using a automated soil gas flux system (Figure 1).
- Soil CO2 flux was compared to soil analysis.

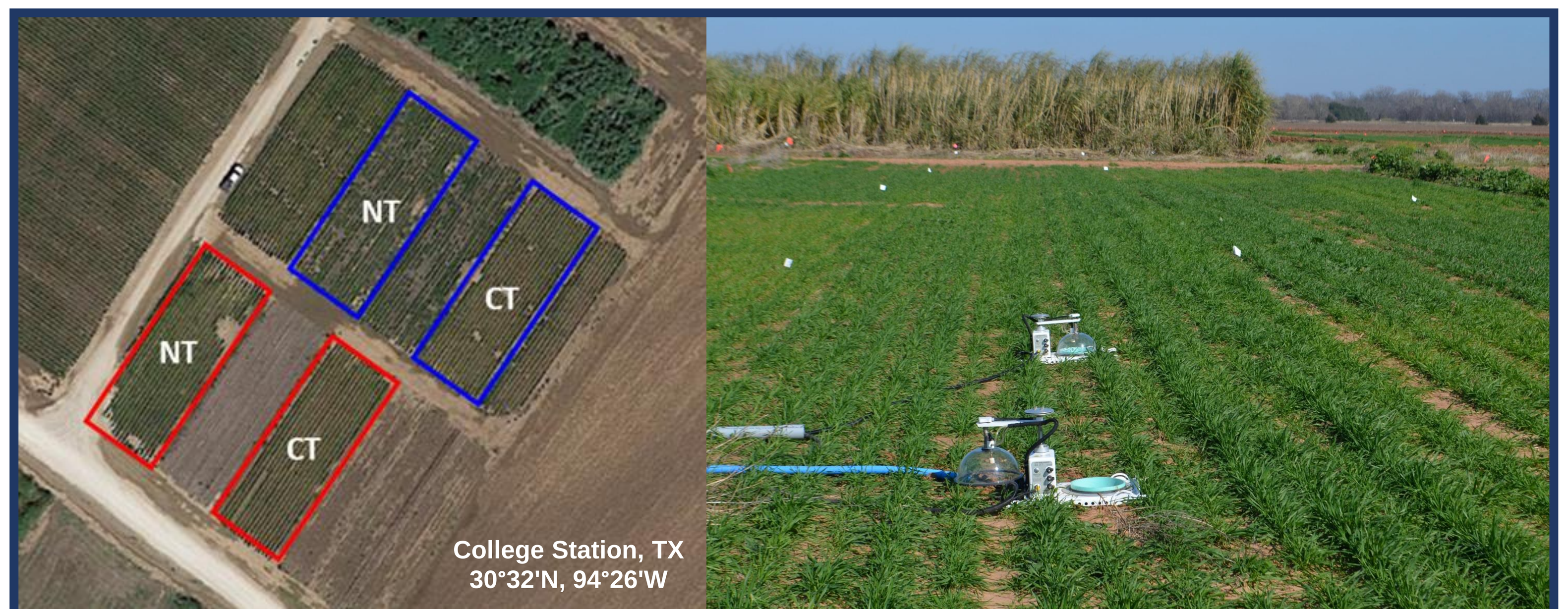

Figure 1. Agroecological long-term study located at the Texas A&M University, Brazos Farm (left) and the Li-8100A automated soil gas flux system (right).

Carbon sequestration

- Soil bulk density measured at the end of the growing season was 1.48 ± 0.13 g cm^{-3} in NT and 1.43 ± 0.08 g in CT (Table 1).
- Both tillage practices showed a decrease in bulk density with depth that was explained by changes in texture along the soil profile.
- STN was significantly affected by tillage only at the top 5 cm.
- Average soil organic carbon under CT and NT were 7.91 g/kg and 10.11 g/kg, respectively.

Table 1. Bulk density (g/cm^3) measured at three soil depths (Sampling: 5/25/16).

Depth (cm)	Conventional till (CT)	No till (NT)
10	1.68 (±0.13)	1.49 (±0.18)
20	1.44 (±0.01)	1.53 (±0.08)
30	1.21 (±0.10)	1.39 (±0.13)

- The distribution of STC along the soil profile did not change with tillage (Figure 2).
- Tillage decreased the total soil organic carbon at all the soil depths evaluated.
- Conversion from CT to NT increased carbon sequestration in the soil.
- Continuous soil tillage reduce soil organic carbon in 22% compared to NT.

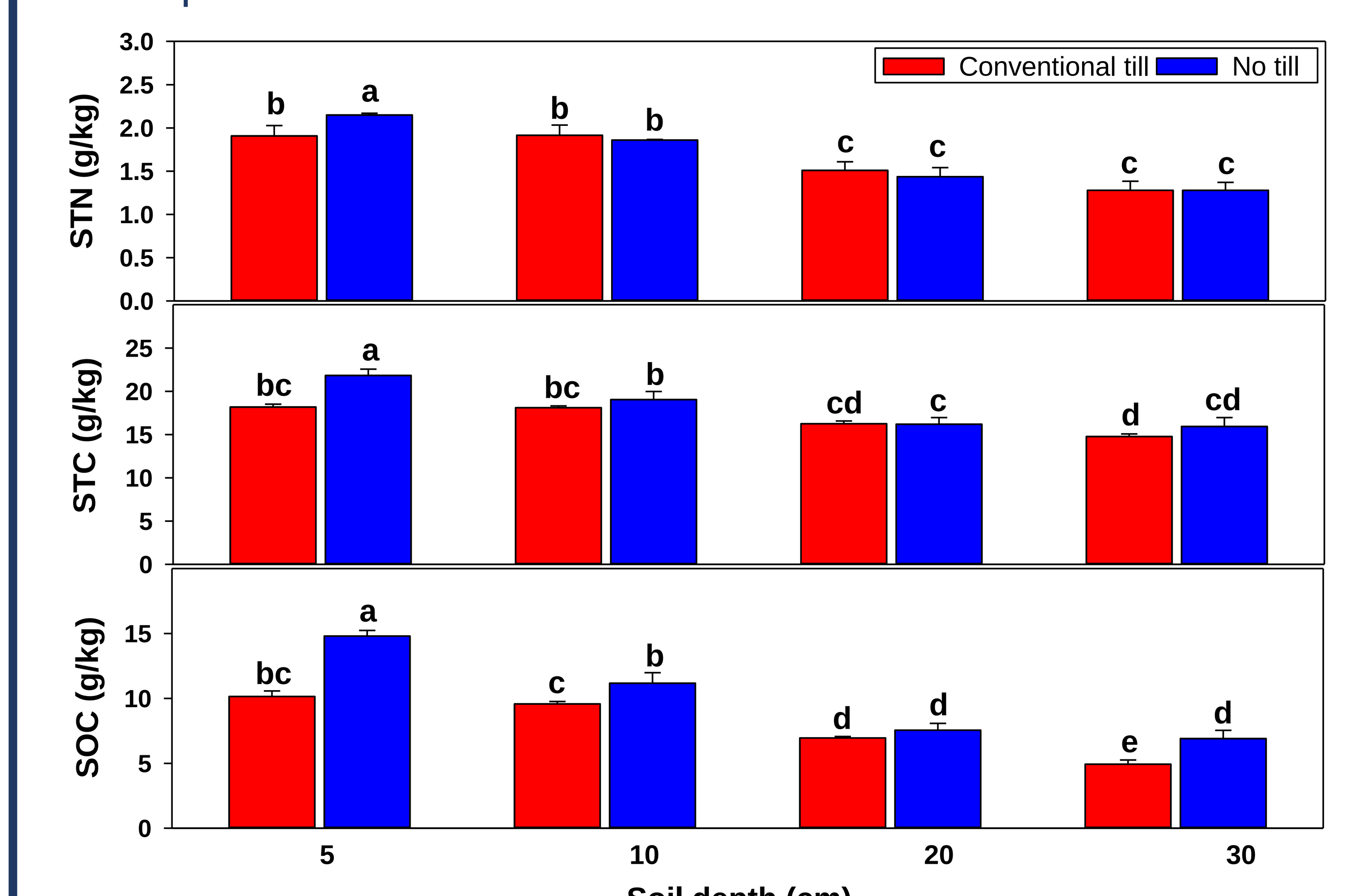

Figure 2. Soil total nitrogen (STN), total carbon (STC), organic carbon (SOC) under conventional tillage and no-tillage.

Soil carbon release

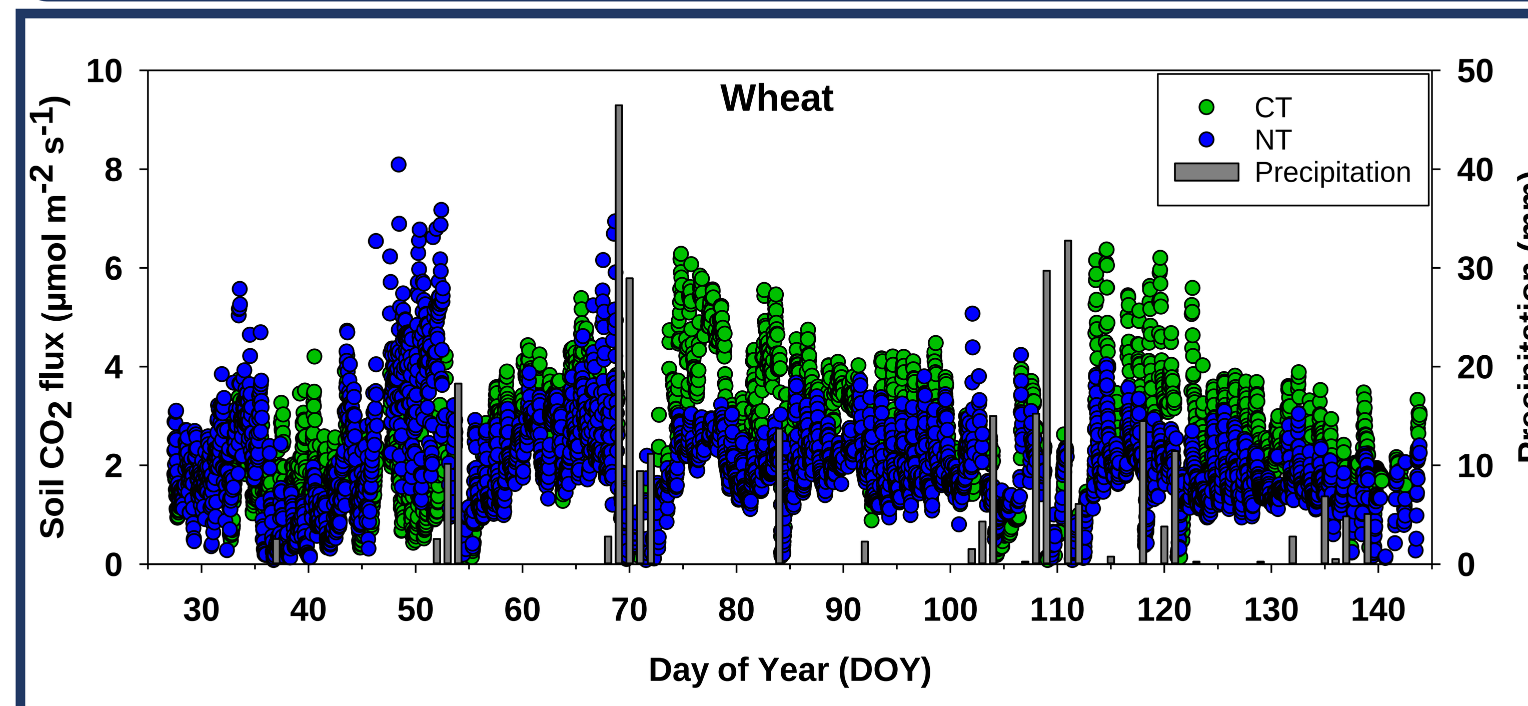

Figure 3. Daily soil CO_2 flux under conventional tillage (black) and no tillage (white) during the growing season of winter-wheat.

- After 32-years of the beginning of the experiment, average soil CO_2 flux was affected by tillage practices.
- Mean soil CO_2 flux was greater under CT with 2.43 µmol m^{-2} s^{-1} compared to NT with 2.03 µmol m^{-2} s^{-1} (Figure 3).
- This results differ from findings observed 13-years after the experiment started, in which NT emitted more CO_2 than CT.
- The estimated annual carbon emission for the rotation winter-wheat/soybean was 204.6 g C m^{-2} in CT and 171.15 g C m^{-2} in NT.
- Soil CO_2 flux was not related to SOC in winter-wheat. For instance, NT had the greater SOC, but released the less amount of carbon.
- In this study, a greater SOC content did not result in a greater emission of carbon, which can be explained by differences in the distribution of carbon along the soil profile.
- Also, it is possible that soil CO_2 measurements performed at the soil surface did not represent the carbon content at deeper layers.

Summary

- Land-use change and crop management control the carbon sequestration potential of agroecosystems.
- Soil tillage drives the accumulation of soil organic matter (SOM).
- Soil conservation practices like tillage enhance the storage of carbon, but did not reduce CO_2 emissions from agricultural systems.
- The greater potential of NT cropping systems to sequester carbon compared CT also open a window to evaluate the stability of carbon in soil and its sensibility to environmental conditions.
- Study the soil environmental conditions that control the soil carbon dynamics can reduce uncertainty in estimating the carbon sequestration potentials in agroecosystems.