2021 Final Report Summary Sheet

Grantee Information

Project Title: Integrating Tillage, Soil Carbon Dynamics, and Tile Nitrate Loss

Institution: University of Illinois at Urbana-Champaign

Primary Investigator: Lowell Gentry

NREC Project # 2021-4-360350-257

[redacted]

Is your project on target from an IMPLEMENTATION standpoint? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

Is your project on target from a BUDGET standpoint? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

Based on what you know today, will you meet the objectives of your project on-time and on-budget? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

Have you encountered any issues related to this project? ☐ **Yes** ☒ **No**
If you answered "yes" please explain:

Have you reached any conclusions related to this project that you would like to highlight? ☒ **Yes** ☒ **No**
If you answered "yes" please explain:
Winter barley ahead of strip-tilled corn lowered tile nitrate by 25% while maintaining grain yield.

Have you completed any outreach activities related this project? Or do you have any activities planned? ☒ **Yes** ☐ **No**
If you answered "yes" please explain and provide details for any upcoming outreach:
I introduced the project during my talk at the IFCA convention on 1-18-22.

Please write a detailed summary report that includes: Details of each objective and the progress made towards its competition, planned research activities for 2022, major accomplishments, any preliminary findings or data relevant to the project, relevant budgeting, and any publications or outreach accomplished from the research. Please **include a one page summary with relevant data tables or graphs and pictures related to the project that you would like included in the NREC end of the year report.**

Integrating Tillage, Soil Carbon Dynamics, and Tile Nitrate Loss

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Co-PI: Andrew Margenot (Assistant Professor, Crop Sci.),

Collaborators: Eric Miller, (Landowner and operator of the production farm where the research will be conducted) **and Dan Schaefer** (custom farming)

Location: Eric Miller's farm in Piatt County IL. Mr. Miller installed a replicated tile drainage study in 2020 by installing 16 laterals that are 80 ft apart with an Agri Dain structure on each tile.

Objectives:

This study aims to quantify the effect of tillage, residue management, and cover crop on crop yield, soil C, and tile nitrate.

The **objectives** are:

1. To determine tile nitrate loads under various tillage regimes (conventional tillage vs. no-till vs. strip-till with and without a cover crop) in a corn/soybean rotation.
2. To investigate C cycling by directly measuring annual C inputs (including below ground measurements of roots) from crop residues and the additional C added to the system with cover crops.
3. To evaluate deep banding versus broadcast application of phosphorus (P) and potassium (K) on crop yield, nutrient stratification, and tile nutrient loads.

Methods:

We are using 16 tile-drained plots (80 ft wide by approx.1700 ft long) to accommodate four treatments with four replicates in a randomized complete block design in a corn-soybean rotation. The four treatments are: conventional tillage (fall and spring) (CT); no-till (NT); strip-till (ST); and strip till with a cover crop (STCC). The cover crop is cereal rye after corn and a mixture of winter barley and rape after soybean. Fertilizer N rate for corn was 180 lbs/A following soybean, consisting of a 30:70 split (at planting and side-dress). In November of 2020, 150 lbs/A of 0-46-0 and 150 lbs/A of 0-0-60 for P and K fertilizers were broadcast applied in the conventional and no-till plots, and deep-banded in the strip-till plots. Winter barley and rape were drill planted on October 16, 2020, and cover crop biomass was sampled on April 4, April 14, and April 21 to provide cover crop growth rates to test the cover crop model project funded by NREC and conducted by Jonathan Coppess and Rabin Bhattarrai. Corn was planted on May 25.

Tile plow installing laterals for a replicated tile drainage study supporting 4 treatments with 4 replicates. Agri Drain structures were installed and fitted with a V-notch stoplog, and tile flow and nutrient concentrations (N, P, and K) have been monitored for a year.

Winter barley:

- Winter barley was terminated on April 22.
- Barley biomass accumulation attained 0.5 tons/A on April 21and was terminated the next day.
- See photo (left) of Dan Schaefer spraying the barley cover crop with a boom fitted to a Gator.
- This amount of biomass (0.5 tons/A) is sufficient to reduce tile nitrate loads.

Corn yields:

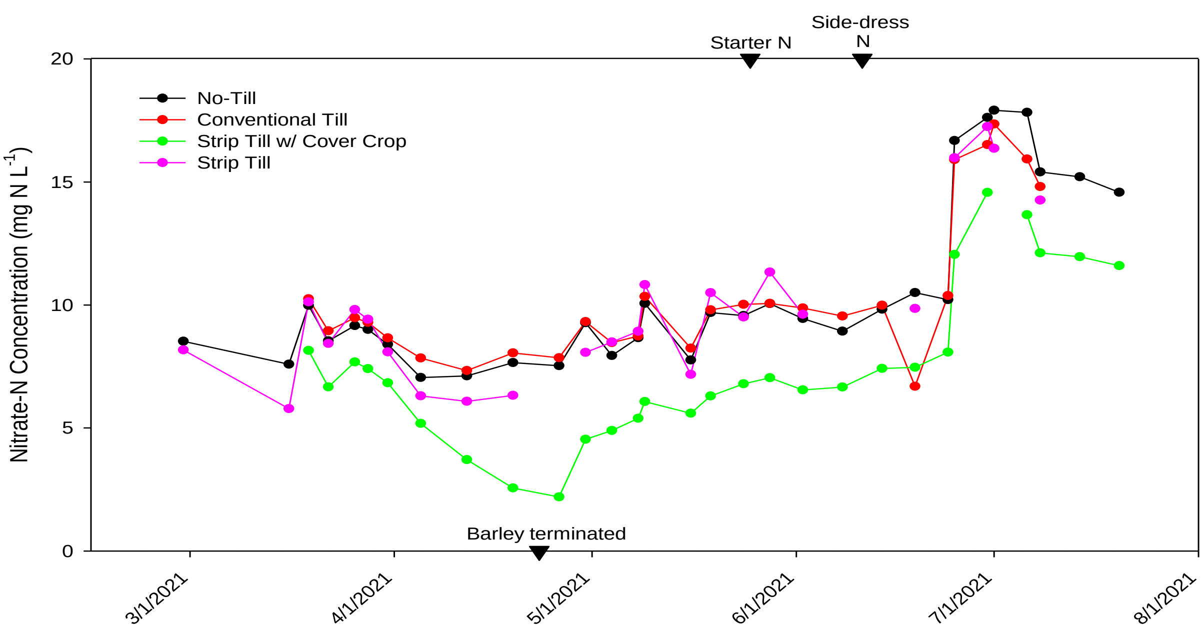
Corn yields were excellent in 2021, ranging from 249 bu/A with strip-till to 257 bu/A with no-till. We found no significant treatment effect on corn yields.

Corn yield in 2021 for the four treatments: Conventional till, no-till, and strip till with and without a cover crop.

Treatment	Corn Yield
	bu/A
Conventional (CT)	249.2
No-till (NT)	256.8
Strip-till (ST)	249.2
Strip-till/cover crop (STCC)	251.1

Tile nitrate:

For baseline comparisons across tiles, full width tillage in CT was not performed in the fall and was conducted the day before corn planting. It is important to show that tile nitrate concentrations were similar among CT, NT, and ST treatment in the first year of this research prior to imparting the fall tillage treatment. It is clear from this data that tile nitrate was reduced (>25%) by the presence of winter barley (green dots).



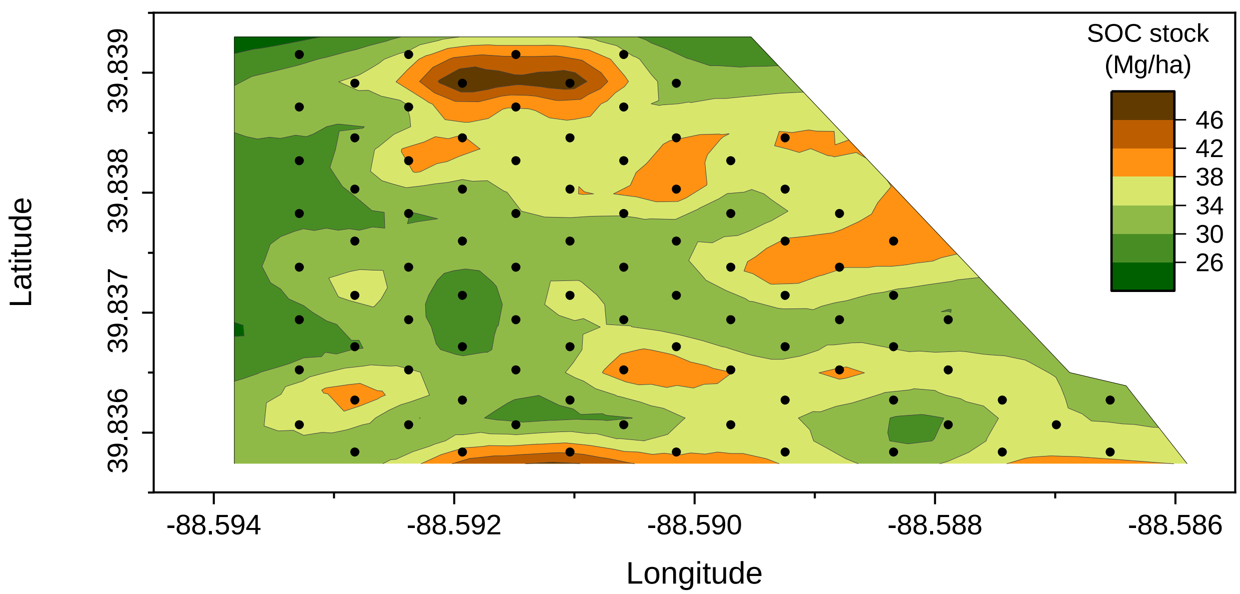
Tile nitrate concentrations in 2021 for the four treatments: no-till, conventional till, and strip till with and without a cover crop.

All four treatments showed a spike in tile nitrate concentration with heavy rains in late June, following side-dress application of UAN (32%) on June 11. It is interesting to note that tile nitrate in the cover crop plots quickly began to increase following termination, suggesting that winter barley may not hold onto the N as tightly as cereal rye, which would be desirable ahead of corn.

Carbon investigation:

Baseline deep soil sampling to 105 cm to determine initial carbon stocks across our study area were conducted in November of 2020.

	Piatt					
Depth	Carbon %	CV	BD g/cm3	CV	SOC stock Mg/ha	CV
0-15	2.2	12.3	1.1	10.3	34.4	12.8
15-30	1.7	16.3	1.1	5.7	27.1	15.9
30-45	1.1	25.4	1.1	4.9	18.2	24.2
45-60	0.8	23.4	1.1	4.6	12.5	23.1
60-75	0.6	24.2	1.1	4.5	9.4	23.9
75-90	0.5	37.7	1.1	6	8.3	35.2
90-105	0.4	48.4	1.2	15.1	5.2	49.7

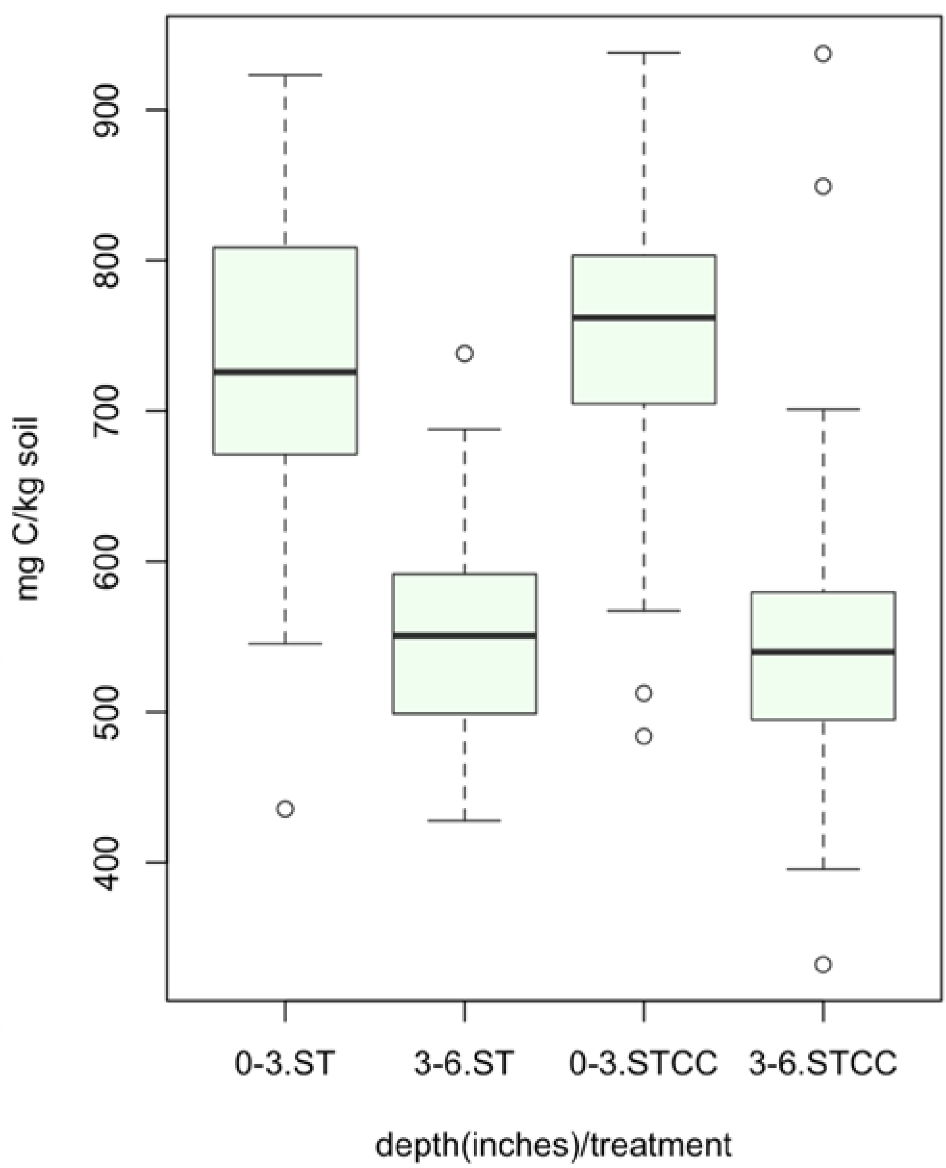


Interpolation map of surface (0-6" depth) soil organic carbon (SOC) stocks across our study area from November baseline soil sampling. To 36" depth, stocks range up to 140 Mg/ha.

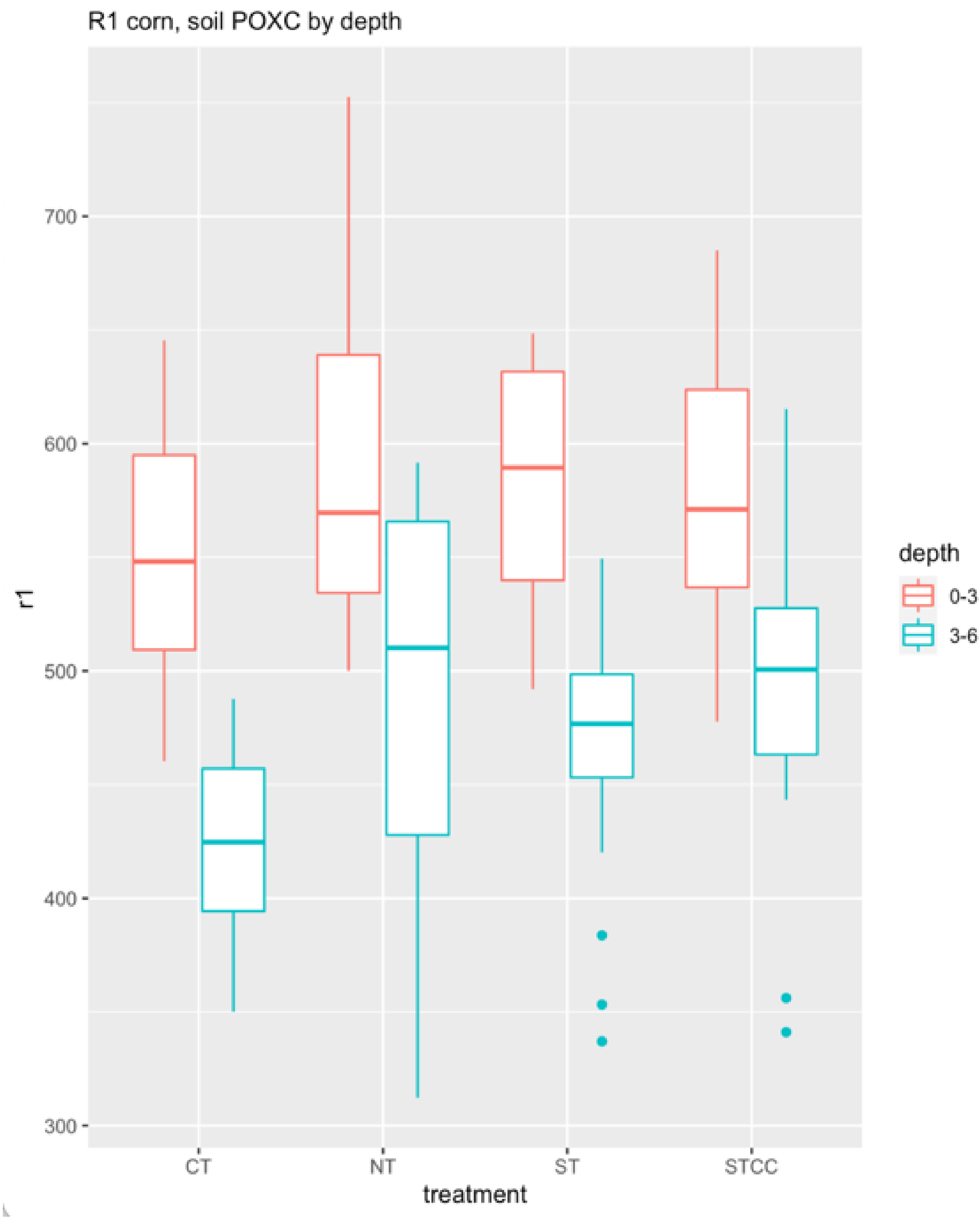
An accurate assessment of the beginning soil C stocks in our study area is critical for C accounting and soil C accrual in this intensive C cycling evaluation. We conducted a very high density (128 cores in the 44 A field = 3 samples per acre) to ensure accuracy of soil C stock baselines, which is essential to accurate monitor changes at short (<5 year) timespans. This also positions the field to be a ripe location for future on-farm soil C sequestration research.

Labile C:

Additionally, we evaluated labile C as assayed by permanganate oxidization (POXC). At spring, when cover crop was at peak biomass before termination, POXC was similar between cover cropped and non-cover crop strip till treatments in surface soils (See below).



POXC (mg/kg) under strip-till (ST) and strip-till with cover crop (STCC), spring 2021.



POXC (mg/kg) under the four replicated treatments at 0-3” and 3-6” depth.

At R1 corn stage (July), strip tilled treatments had slightly higher POXC than conventional or no-till, and POXC varied most in no-till (See above).

Plant and soil measurements:

- Beginning on April 20, soil inorganic N as well as microbial biomass C, N, and P were measured every two weeks throughout the growing season at 32 microplots (2 per each of the 16 plots).

- As part of the AI FARMS grant, 55 soil moisture, electrical conductivity, and temperature probes have been installed at 3 depths and data can be accessed via the ZENTRA Cloud website.

- Crop biomass was sampled throughout the growing season every two weeks when soil samples were collected.

- Crop root measurements were included at VT and PM corn growth stages. Additionally, we compared two competing methods for determining root biomass, developed at Iowa State (root transect method) or the Kellogg Biological Station (in-ground root core method).

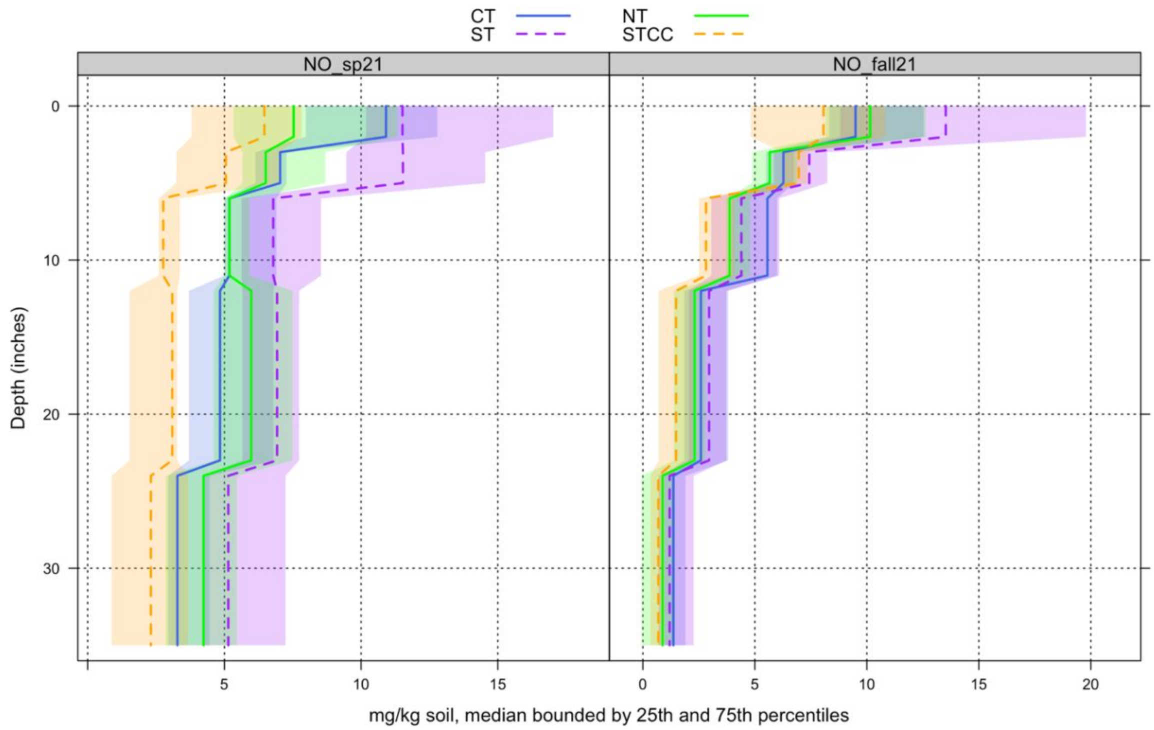
- Soil health measurements were made every two to three weeks (POXC, b-glucosidase, phosphomonoesterase, leucine aminopeptidase) from late April through mid-November.

Soil inorganic N:

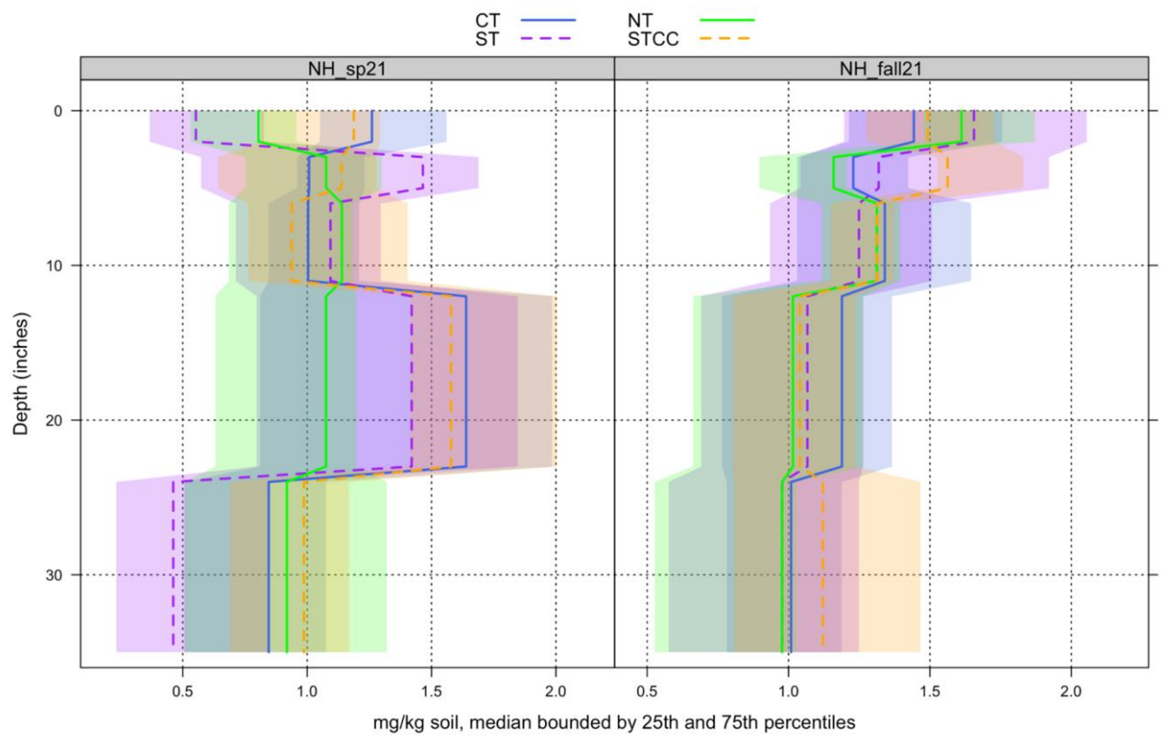
Soil inorganic N concentration by depth (0-3", 3-6", 6-12", 12-24", and 24-36") in the four treatments on April 20 (2 days prior to cover crop termination).

Depth	CT	NT	ST	STCC
inches	ppm	ppm	ppm	ppm
0-3	54	37	59	30
3-6	34	31	54	23
6-12	28	24	32	15
12-24	24	24	31	12
24-36	17	17	24	15

Soil inorganic N in early June was greatest in CT and ST, intermediate in NT, and least in ST. This data suggests tillage (either CT or ST) increased soil nitrate compared with no-till, while the winter barley cover crop decreased soil nitrate in STCC. Although this early season effect was observed, corn yield was not reduced. Soil ammonium concentration was never greater than 3.5 ppm for any treatment at any depth, which indicates the affinity soil microbes have for consuming and retaining the ammonium ion.

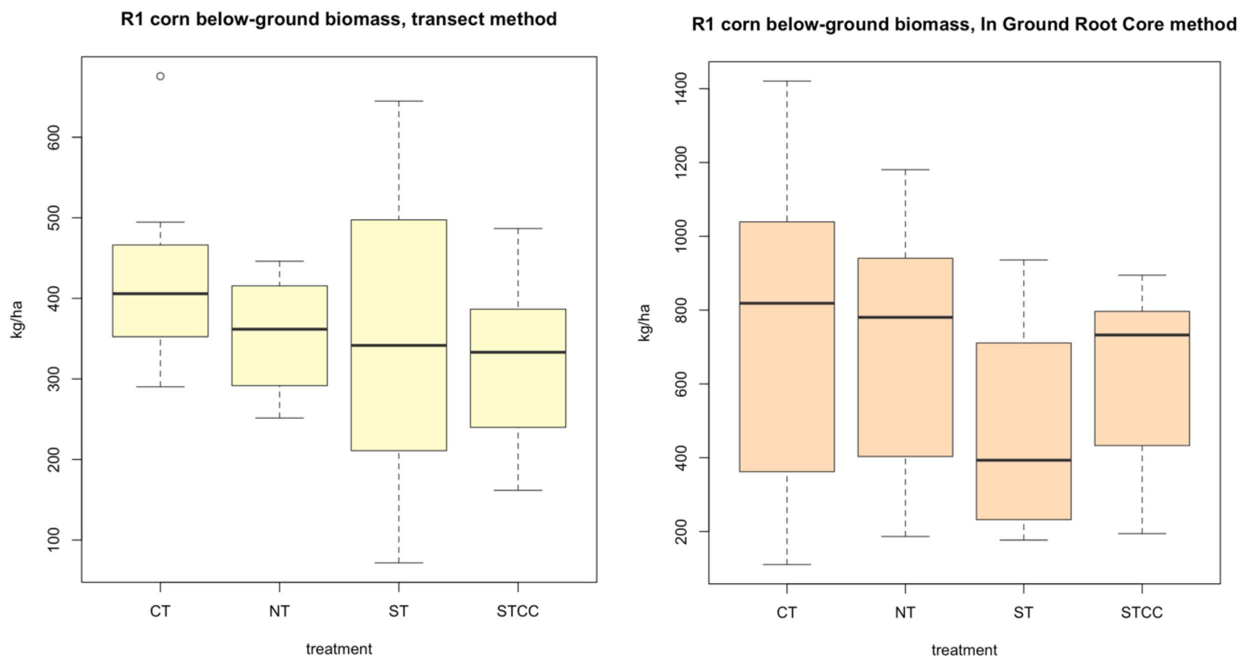


Soil profile of nitrate concentration to 36" in the four treatments.



Soil profile of ammonium concentration to 36" in the four treatments.

Corn root coring method comparison:



Below-ground corn root biomass (kg/ha) at R1 by the root transect method (left) and growth root core method (right). Note: Y axis scale change between graphs.

We found similar trends among treatments in root biomass of corn at R1 for both methods; however, we found twice as much root biomass using the in-ground root core method (See above).

Importance of this study:

The inherent fertility and overall quality of a given soil largely depends on the level of soil organic matter (SOC), and over time soils are slowly losing C stocks. Tillage exacerbates the loss of soil organic matter by enhancing soil aeration and energizing the microbial consumption of carbon (C) (both crop residues and soil organic matter). One of the clear outcomes of losing soil organic matter is the loss of overall soil fertility (i.e., tile nitrate loss) and system productivity. We contend that tile nitrate loss, especially following soybean production, is indicative of short-term soil C limitations and symptomatic of a declining soil organic matter reserve. Currently, there is great interest in modelling the impact of agricultural management on C cycling and C sequestration in agricultural soils in hopes of identifying systems that can increase soil organic matter; however, long term empirical evidence is lacking, especially for today's conservation tillage systems. This study aims to quantify the effect of tillage, residue management, and cover crop on crop yield, soil C, and tile nitrate.

Maintaining or increasing soil organic matter has always been a goal of agronomists in order to maintain or improve soil fertility. Today we call it soil health, but the goal was the same (to build soil organic matter; i.e., soil fertility). Nutrient and soil C management strategies that curtail N losses can also increase soil C. Tile nitrate loss is indicative of soil C losses, especially tile nitrate loss following soybean. This study will help understand how to manage N immobilization to tighten the N cycle and reduce leaks via reduced tillage/no-tillage systems, timely fertilizer N application (no fall N), and overwintering cover crops. N immobilization is synonymous with C sequestration, and this study will demonstrate that tile nitrate can be reduced with less tillage and C additions from am overwintering grass cover crops. This study will provide invaluable empirical data to address the effect of tillage, previous crop, and cover crop on soil C dynamics and tile nitrate loss.

We believe this work is critically needed at this time as producers strive to enhance soil health and the industry assesses the benefits of C accounting and C trading to reward and offset conservation costs. Even more far reaching is the idea that improvements in agricultural management that leads to enhanced soil C (C sequestration) may be one of the best mitigation efforts to combat increasing global atmospheric CO_2. Getting ahead of the curve with the quantification of management practice impacts on soil C – and trade-offs for NUE and yield – could be a way for Illinois producers to be more competitive in emerging ecosystem service markets, in particular C markets that appear to be gaining traction.