Minnesota Department of Agriculture
Agricultural Fertilizer Research & Education Council

Annual Project Report for 2021 Cropping Season (Year 2)

PROJECT TITLE: **Quantifying soil carbon, nitrogen, and phosphorus after subsurface drainage installation**

PRINCIPAL INVESTIGATORS: **Drs. Lindsay Pease, Anna Cates, Fabian Fernandez, and Jeff Strock**
Department of Soil, Water, and Climate
University of Minnesota Twin Cities

PROJECT NUMBER: **SWIFT 191419, CON000000090560**

EMAIL: lpease@umn.edu

Project Objectives

This project has three primary objectives:

1. *Quantify SOM depletion over two years in drained and undrained fields.*
2. *Measure nitrogen (N) losses via mineralization and nitrous oxide (N_2O) emissions over two years in drained and undrained fields.*
3. *Monitor total phosphorus (P) and plant-available P in the soil over two years in drained and undrained fields.*

Plots Established

We collected data on four 15-acre plots (two drained and two undrained) were established in October 2019 at the University of Minnesota Northwest Research and Outreach Center (NWROC) in Crookston, MN (Figure 1). These plots were maintained throughout the 2020 and 2021 growing seasons.

Data collection took place throughout the growing season on the four drainage plots to support Objectives 1, 2, and 3 of this project. We met project goals for quarterly soil sampling, weekly greenhouse gas sampling, biweekly in-situ nitrate mineralization, and daily water sample collection.

We collected approximately 1440 GHG samples, 260 soil samples, and 240 water samples during the 2021 growing season. These samples were analyzed for nitrogen, carbon, and phosphorus.

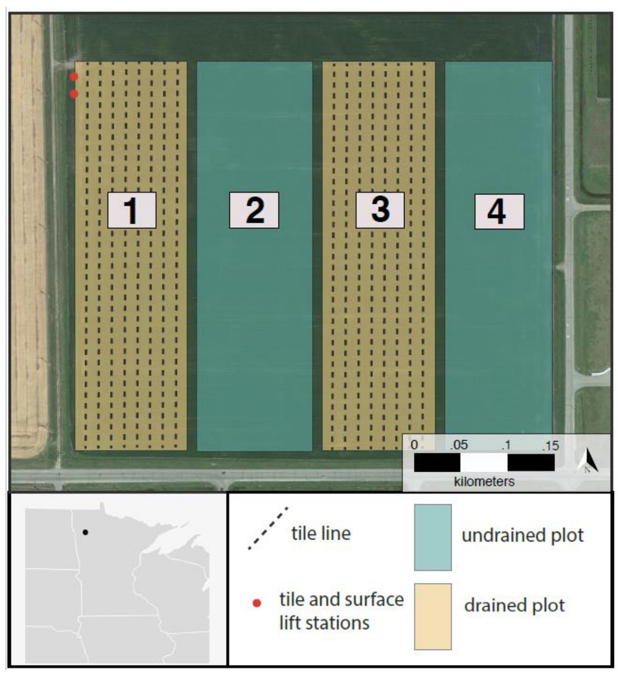

Figure 1: Diagram of plot layout at NWROC

Measurements Collected

Greenhouse gas sampling

In Q1, weekly greenhouse gas (GHG) samples were collected from five locations in each plot beginning in mid-April. Weekly sampling continued through the end of the growing season and until soil temperatures dropped below 4°C in October.

Quarterly Soil Sampling

Spring soil sampling occurred pre-planting in April, summer soil sampling occurred in June, and fall soil sampling occurred post-harvest in October. We collected soil samples at 64 locations (16 locations per plot) to a depth of 90 cm.

Water Sampling

Daily water samples were collected from surface and subsurface drainage lift stations throughout the growing season (April through October). Water samples were processed and analyzed for nitrate, total nitrogen, dissolved phosphorus, and total phosphorus.

Project Results

Nitrogen – Analysis by Graduate Research Assistant Aaron Frankl

Soil temperature, soil moisture, and barometric pressure all significantly affected nitrous oxide emissions in 2020. However, drainage did not have a statistically significant effect on Nitrous Oxide Flux during 2020 (the first year following installation) (Figure 1).

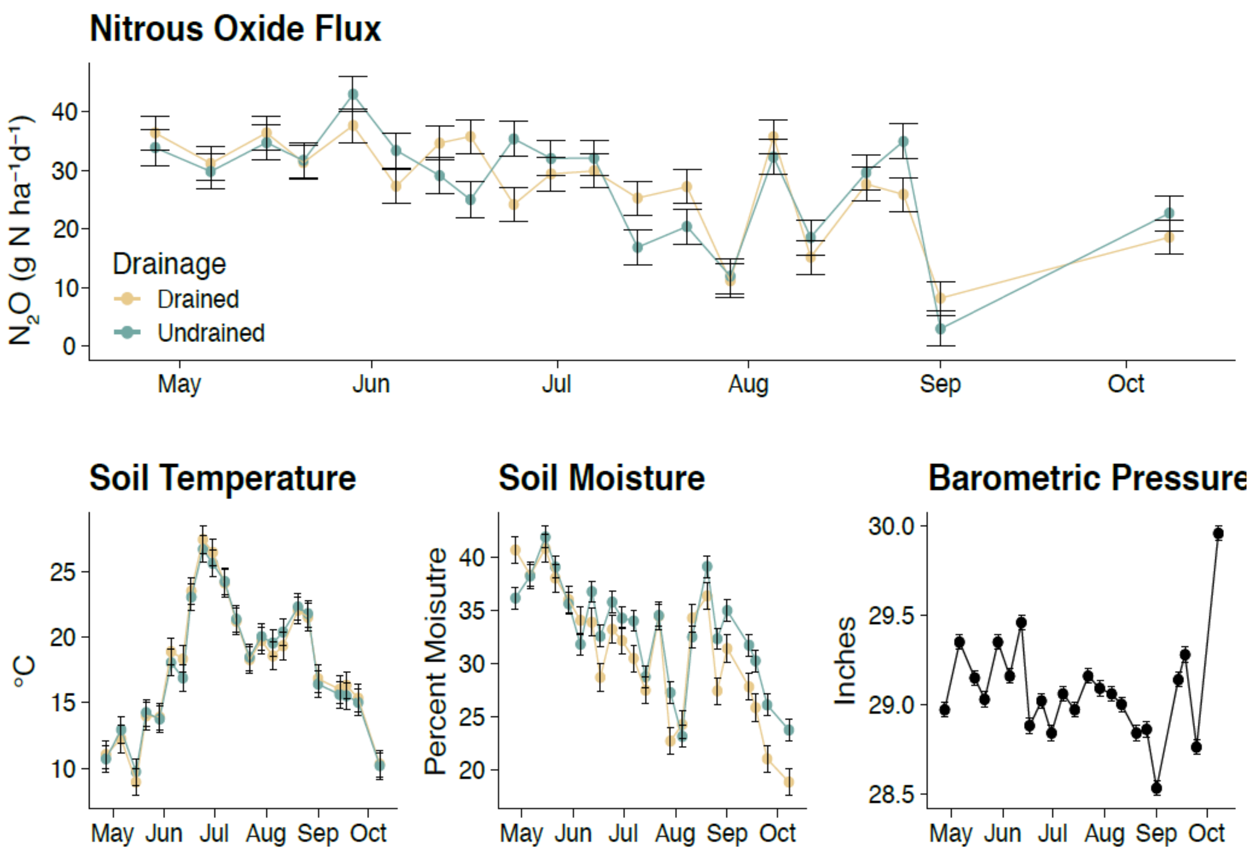

Figure 2: Nitrous Oxide (N2O) monitoring during the 2020 growing season. In blue, measurements from the undrained sections. In yellow, measurements from the drained sections.

Overall, both drained and undrained plots had lower soil nitrate levels in 2021 compared to in 2020 (Figure 2). This is likely partially explained by cropping system. Inorganic nitrogen in 2020 is residual nitrate from wheat production in 2019. Inorganic nitrogen in 2021 is the residual from soybean production in 2020. Although both drained and undrained had lower levels of inorganic N, the difference is greater in our drained plots. Because we did not see a difference in soil emissions between the two plots, loss of N in subsurface drainage discharge is likely the cause of this difference. Of note is that this difference between nitrate levels in drainage treatments is greater at more shallow depths. There is very little difference in soil nitrate from 60-90 cm between drainage treatments. Similar results for water-extractable organic nitrogen have also been observed.

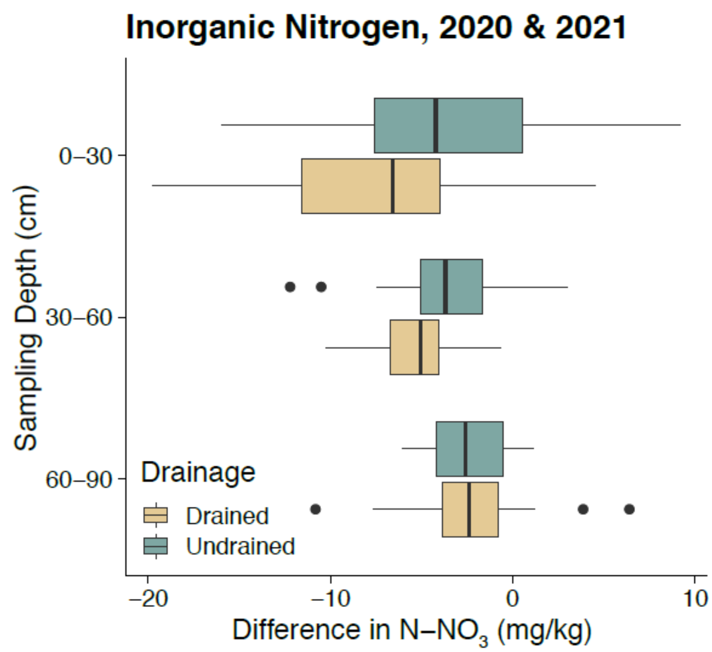

Figure 3: Differences between Spring 2020 and Spring 2021 soil nitrate concentration.

Carbon – Analysis by Graduate Research Assistant Kyle Sherbine

Some soil organic matter (SOM) cycles slowly, and some quickly, and increasing aeration is likely to shift the balance between the two, with consequences for soil fertility and long-term carbon storage. One important fraction of SOM is particulate organic matter (POM). POM is readily available to microbes and easily susceptible to disturbance. Additionally, POM has a relatively large C/N ratio compared to other SOM fractions and plays a crucial role in SOM's ability to store carbon. After one year of drainage, the change in particulate organic matter (POM) varies by depth with the largest decrease in POM occurring at the deepest depths (Figure 4). Presumably, the change in water table affected soil at deeper depths and allowed microbes to migrate deeper into the soil profile to previously uninhabitable regions.

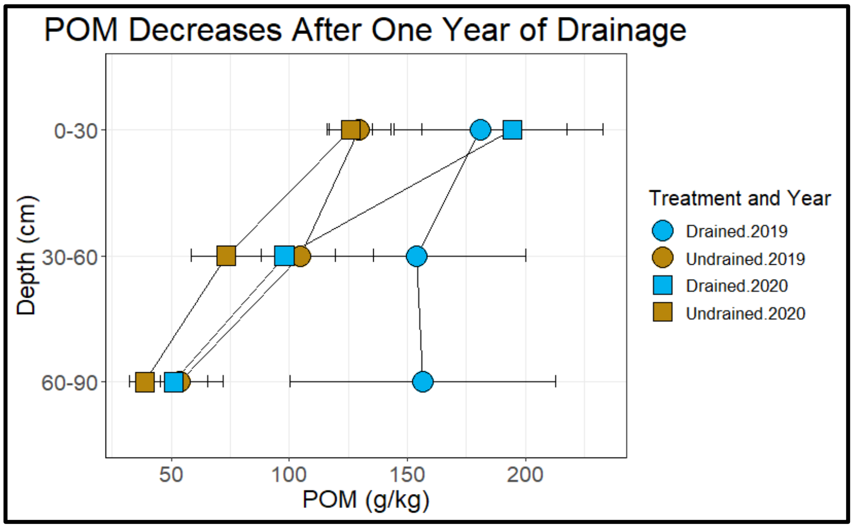

Figure 4: Differences in particulate organic matter (POM) concentration.

Carbon stocks increase with increasing depth (Figure 5). Carbon concentrations used were collected prior to the use of the drainage system; this data will be used as a baseline to examine future changes in C stocks.

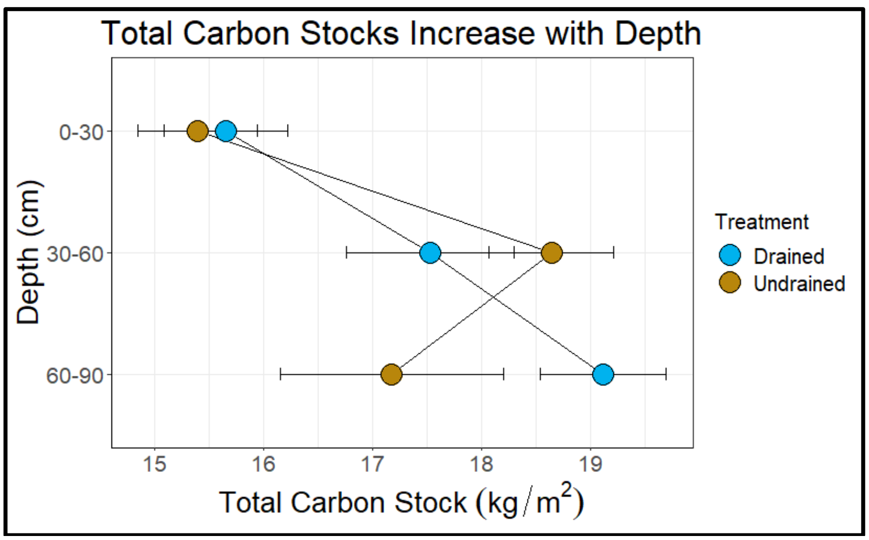

Figure 5: Total Carbon stocks in drained and undrained plots

An increase in SOM mineralization due to drainage may have enduring and permanent implications for a soil's ability to support crops in the long run. Drainage has been shown to increase annual yield, and if residues are mixed back into the soil, carbon lost to mineralization may be offset.

Presentations of Project Results

- Jul 2021: Update on field activities were given during the NWROC Crops and Soils Field Day in Crookston, MN
- Oct 2021: MN Crop News blog post comparing field conditions during 2020 and 2021
- Nov 2021: Two 5-minute rapid presentations followed by poster presentations at the Tri-Societies (American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America) International Annual Meeting in Salt Lake City, Utah
- Feb 2022: Presentation on nitrogen results at the hybrid Nutrient Management Conference in Mankato, MN
- Apr 2022: Presentation on project findings at the hybrid Conservation Drainage Network Meeting in Fort Wayne, IN

Financial Information

		Grant Funding		
Category	**Project Budget**	**Previous Expenses**	**Q4 Expenses**	**Total Expenses**
Salary Costs	$ 67,505	$ 51233.12	$ 14,813.09	$ 66,046.21
Consulting & Prof. Services	$ 0	$ 0	$ 0	$ 0
Supply and Services*	$ 16,957	$ 19,394.68	$ 1,294.44	$ 20,689.12
Travel Costs	$ 4,001	$ 3,727.67		$ 3,727.67
Subcontracts		$ 0	$ 0	$ 0
Repairs & Maintenance		$ 0	$ 0	$ 0
Equipment	$ 0	$ 0	$ 0	$ 0
Communication	$ 2,000	$ 0	$ 0	$ 0
Research Plot Fees	$ 0	$ 0	$ 0	$ 0
Other Expenses	$ 0	$ 0	$ 0	$ 0
Total	**$ 90,463**	**$ 74,355.47**	**$ 16,107.53**	**$ 90,463.00**