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Minnesota Department of Agriculture
Agricultural Fertilizer Research & Education Council

Annual Project Report for 2022 Cropping Season (Year 3)

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

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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 2020-2022 growing seasons.

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

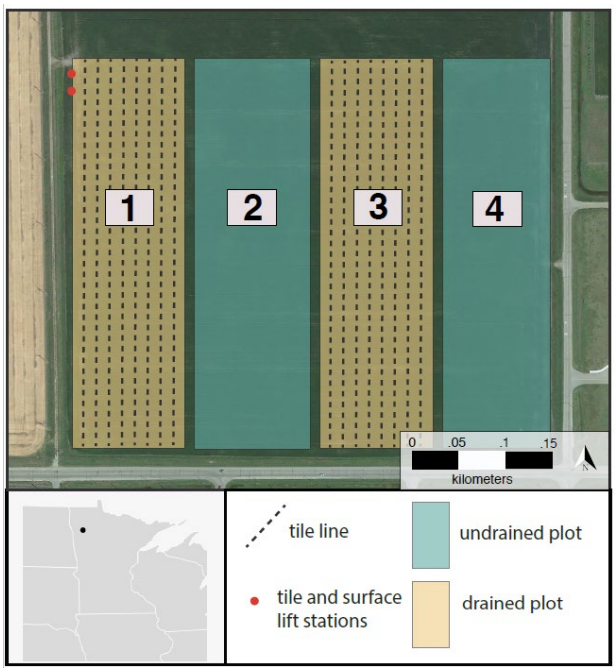

Figure 1: Diagram of plot layout at NWROC

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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.

Soil Sampling

Spring soil sampling occurred pre-planting in April 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

Two publications based on findings and results from this work were submitted for publication in 2022. These publications are summarized below.

1. Sherbine, K., A. Frankl, F. Fernandez, **L. Pease** & A. Cates (2023). Haney Soil Health Test changes with season, not subsurface drainage. Agricultural & Environmental Letters, 8, e20098. https://doi.org/10.1002/ael2.20098

    - This study used the Haney Soil Health Test (HSHT) to monitor changes in soil health following subsurface drainage installation, evaluate seasonal variability in soil nutrient pools, and calculate a potential N fertility credit.
    - Subsurface drainage did not significantly affect the three soil biological indicators used in the HSHT (potentially mineralizable carbon, water-extractable organic carbon, water-extractible organic nitrogen). These indices changed seasonally and annually, but not by drainage treatment. This suggests that variability in environmental factors such as rainfall and temperature have a stronger influence on soil biology than subsurface hydrology.
    - Calculated N credits were highly variable (ranging from 1 to 187 kg N ha^{-1}) but were also unaffected by the presence or absence of subsurface drainage.
    - Soil biological indicators did not change abruptly following subsurface drainage installation. Further long-term tracking of these metrics will help to quantify whether these indicators change gradually over time.

2. Frankl, A.*, K. Sherbine*, J. Strock, F. Fernandez, A. Cates, and **L. Pease** (*In Press*). Comparing the short- and long-term impacts of subsurface drainage installation on soil physical and biological properties. *Journal of Soil and Water Conservation* (Submitted: 10/30/22; Accepted: 07/17/23).

    - This study quantified changes to soil properties over time in six subsurface-drained fields in Northwest Minnesota. These fields were grouped into two timescales: three fields were drained prior to 2006, and three fields were drained in 2016 or later.

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- We evaluated three soil physical properties: saturated hydraulic conductivity (Kfs), bulk density, and aggregate stability, and three soil health metrics: water-extractable organic carbon (WEOC) and nitrogen (WEON), and potentially mineralizable carbon (PMC).
- The fields with older drainage systems had greater Kfs, WEON (all depths), WEOC (15 to 30 cm), and PMC (15 to 30 cm). There were no differences in bulk density, aggregate stability, WEOC (0 to 15 cm), and PMC (0 to 15 cm). We suspect that the increased Kfs resulted from development of preferential flow pathways in fields with older drainage systems. These preferential flow paths could also be areas with increased microbial diversity and activity, indicated by the higher biological indicators in the fields with older drainage systems.
- Our findings suggest that nutrient losses, soil physical properties, and soil health metrics evolve over time. This knowledge will improve the information provided to growers and help them more effectively manage their soil's health and reduce nutrient losses into waterways.

Presentations of Project Results

11.	"A Research Update from Minnesota's Coolest Drainage Plots" Annual Joint Conference of the Red River Watershed Management Board and the Red River Basin Flood Damage Reduction Work Group, Moorhead, MN	02/21/23
10.	"A tale of two extremes: Drainage tile in both a historic drought and wet spring" Best of the Best in Wheat & Soybean Research, Grand Forks, ND & Moorhead, MN	02/08/23 - 02/09/23
9.	"Do Newly Drained Fields Need Revised Fertility Recommendations?" North American Conservation & Drainage Expo, Des Moines, IA	01/17/23 - 01/19/23
8.	"Cutting Edge Drainage Research" Annual General Meeting & Conference, Saskatchewan Farm Stewardship Assoc., Yorkton, SK, Canada	12/15/22
7.	"Environmental implications of phosphorus losses to recently installed drainage" ASA, CSSA and SSSA International Annual Meeting, Baltimore, MD	11/06/22 - 11/09/22
6.	"Phosphorous and Tile Drainage at the Field Scale" Eastern South Dakota Water Conference, Brookings, SD	10/12/22
5.	"Subsurface Drainage Research in the Red River Valley" 2022 Red River Basin Partnership Summer Tour, Crookston, MN	08/24/22
4.	"Do newly drained fields need revised fertility recommendations?" 11th International Drainage Symposium, Des Moines, IA	08/29/22 - 09/01/22
3.	"P Management Challenges in the Northern Great Plains" SERA-17 Phosphorus Task Force Annual Meeting, Crookston, MN	08/09/22 to 08/10/22
2.	"Performance of NWROC's New Subsurface Drainage Installation" NWROC Crops & Soils Field Day, Crookston, MN	07/20/22
1.	"Drainage Research in Northwest Minnesota" Area 1 (Northwest MN) Soil and Water Conservation District Summer Meeting, Mahnomen, MN	06/21/22