Northern NY Agricultural Development Program
2014-2015 Project Report

Project Title: Assessing Agronomic and Environmental Aspects of Tile Drainage in the Northern New York Region

Project Leader:
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Collaborators:
- New England Interstate Water Pollution Control Commission and Lake Champlain Basin Program: Myra Lawyer
- Miner Institute: Laura Klaiber, Stephen Kramer, Catherine Ballard, Richard Grant
- Miner Institute/UVM: Keegan Griffith
- Champlain Valley Agronomics: Eric Bever and Mike Contessa

Background:
Tile drainage (TD) has been a critical agronomic practice for Northern NY farms for more than a century. Installing TD in poorly drained agricultural soils continues to be a profitable soil management option, with return on investment ranging from 7 to 12% (approximate payback of five to 10 years). While the economic return on investment and potential erosion-saving power of tile drainage is often well known to farmers and agronomists, the potential environmental and conservation benefits are not well documented in the NNY region, and the impact on water quality is not fully understood due to interactions among soil type, fertility, management, weather, or other factors.

A review of the literature indicates tile-drained fields generally produce less surface runoff and erosion compared to naturally poorly-drained fields. Since most phosphorus (P) loss is due to surface water runoff and erosion, tiling tends to reduce total P loss due to a reduction in surface runoff volume.

Given the importance of tiling to the continued profitability and sustainability of dairy, crop, and other agricultural enterprises in NNY, a careful documentation of the agronomic and environmental benefits from TD use would help to initiate a data-driven, proactive approach to guide current and future best management practices for tile-drained systems in NNY.

Objectives:

The objectives of our 2015 project were to:

- sample a wide range of tile-drained dairy crop production fields in the NNY region to measure instantaneous flow rates, total P (TP), soluble reactive P (SRP; i.e., orthophosphate), and nitrate-N concentrations to compare with typical thresholds used to define surface and ground water quality, and
- compare TP, SRP, and nitrate-N concentrations in tile drainage water to concentrations found in ponded surface water from the same fields.

Methods:

A total of five farms (four in Clinton and one in St. Lawrence) and 14 fields were represented as part of the sampling effort. Farms were selected based on producer willingness to have sampling performed and in consultation with Eric Bever of Champlain Valley Agronomics, Peru, NY.

For the purpose of this study, data are presented as averages by sampling date and farm names remain confidential. Crop field size ranged from 5 to >80 acres with lateral tile spacing ranging from 35 to 50 ft. and a depth below the soil surface of 3 to 4.5 ft. Only fields with known tile specifications and functioning outlets were included in this study.

Due to a cold winter and deep soil freezing in 2014, tile drainage flow was slow to occur in spring 2015. Measurable flows did not start in most fields until mid May due to frozen soil layers near the water table.

Flows were first measured on 5/28, however, since many tiles were not flowing, samples were not collected for nutrient analysis. Only sampling dates where the majority of tiles were flowing were included for water quality analysis.

At each sampling, instantaneous flow rates were recorded in duplicate for each tile outlet by measuring the time to fill a known volume (4 graduated plastic liter beaker). Flow was expressed as the mean of the duplicate rates in liters per second (L/s). Water samples were collected in 250 mL polyethylene beakers and placed on ice.

Soluble reactive P (SRP) was measured within 48 hours using a standard colorimetric technique.

TP was measured colorimetrically after digesting in an autoclave using the persulfate oxidation method.

Nitrate-N was also measured using a standard colorimetric procedure.

When significant surface ponding occurred (substantial ponding only occurred on four of the fields during sampling events), grab samples were taken so that nutrient concentrations could be compared numerically with tile drainage flow nutrient concentrations.

Results and Discussion:

Due to the relatively large range in field size, tile drainage flow rates spanned over two orders of magnitude for some of the events sampled (Table 1). Average flow rates ranged from 0.2 to >4 L/s (4 to >73 gallons/minute). The month of June was wetter than normal (almost twice the 30 yr mean monthly rainfall at Miner Institute) and tiles flowed much of June.

The relatively high flow rates from mid-June to July 2 illustrate the amount of subsurface water that is removed by these tiled systems. For example, one day of drainage at a rate of 2.5 L/s equates to about 65,845 gallons/day of subsurface water. The relatively fast removal of this excessive ground water by the tile systems permits more oxygen in the crop-rooting zone, reduces the prevalence of ponded water in the field, permits trafficking sooner, among other agronomic benefits.

Table 1. Mean, range, and standard deviation (SD) for tile drainage flow rates in NNY trials in 2015.

Tile drain flow discharge rate				
Sampling date	**Mean flow rate (L/s)**	**Range (L/s)**	***n***	**SD**
5/28/15	0.1	0.01 - 0.2	7	0.1
6/2/15	2.1	0.2 - 10	9	3.1
6/9/15	0.8	0.04 - 5.94	13	1.6
6/17/15	2.4	0.3 - 9.2	13	2.5
6/22/15	2.8	0.4 - 9.4	13	2.8
6/28/15	2.3	0.03 - 10	12	2.9
7/2/15	4.1	0.2 - 4.2	14	4.2

Concentrations of TP, SRP and nitrate-N were generally below thresholds typically cited for water quality. A concentration of 30 μg/L of SRP is cited as the level of concern for eutrophication of freshwater lakes. A level of 100 μg/L is used by EPA as a guideline for TP, while the drinking water standard for nitrate-N is <10 mg nitrate-N/L. Only one sampling date resulted in a mean TP concentration >100 μg/L (6/9).

Concentrations of SRP were very low and the grand mean was <30 μg/L (Table 2).

Importantly, average nitrate-N was much lower than EPA's 10 ppm threshold for drinking water, while the grand mean was 4.0 mg nitrate-N/L (Table 2).

Table 2. Mean and standard error of the mean (SEM) for TP, SRP, and nitrate-N concentrations in tile drainage water flows in NNY trials in 2015. The number of fields sampled per event is represented by *n*.

Mean tile drain flow concentration				
Sampling date	**TP (μg/L)**	**SRP (μg/L)**	**Nitrate-N (mg/L)**	***n***
6/9/15	175	15	3.4	13
SEM	44	5	1.2	
6/17/15	86	21	4.6	13
SEM	23	9	1.2	
6/22/15	69	28	5.1	13
SEM	19	10	2.1	
6/28/15	87	41	1.8	12
SEM	31	18	0.4	
7/2/15	73	16	5.0	14
SEM	24	4	0.8	
Grand mean	**98**	**24**	**4.0**	
SD	**44**	**11**	**1.4**	

Compared to tile drainage flows, TP and SRP concentrations were much higher in ponded surface runoff from fields. Previous and more recent research has also shown that P concentrations, both dissolved and total, tend to be lower in tile drainage flows compared to surface runoff from the same field. Since most P is tightly bound in surface soils, surface runoff tends to produce runoff with greater P compared to tile drainage flows, where groundwater interacts mainly with subsoils, which are lower in P.

Using the grand means, our results showed that TP concentration in surface water was >10-fold greater than TP in tile drainage flow (Tables 2, 3).

In addition, the grand mean for surface water SRP was >14-fold greater than the grand mean for SRP tile drainage flow, providing further support that P concentrations tend to be much lower in tile drainage water compared to surface water runoff from the same field.

It should be noted that only a few fields produced sufficient ponded water to be sampled during our field visits.

Table 3. Mean and SEM for TP, SRP, and nitrate-N concentrations in surface water in NNY trials in 2015.

Mean surface water concentration				
Sampling date	**TP (μg/L)**	**SRP (μg/L)**	**Nitrate-N (mg/L)**	***n***
6/9/15	1864	580	0.3	3
SEM	227	6	0.4	
6/17/15	1460	349	0.1	3
SEM	728	158	0.03	
6/22/15	471	111	<detection limit	3
SEM	154	59	-	
6/28/15	702	549	8.6	5
SEM	299	267	4.1	
7/2/15	618	199	0.6	5
SEM	233	68	0.4	
Grand mean	**1023**	**358**	**2.4**	
SD	**606**	**207**	**4.1**	

Conclusions/Outcomes/Impacts:

Our results showed that P and nitrate-N concentrations measured in tile flows were lower than cited water quality thresholds.

Soluble reactive P concentrations, the most bioavailable form of P, were below cited eutrophication thresholds.

In addition, nitrate-N concentrations were well below EPA's drinking water standard of 10 mg nitrate-N/L.

Rainfall and tile flow rates were relatively high during June 2015, yet N and P concentrations still remained relatively low, suggesting low N and P losses from an agronomic and environmental standpoint.

Importantly, our results showed that P concentrations in surface runoff were 10 to 14-fold greater than concentrations in tile drainage flow. While this represents a substantial and important difference, total subsurface flows and surface runoff flows would have to be measured in order to provide field-scale estimates of total P losses.

Future work should focus on hydrologic characterization and edge-of-field measurements of N and P loss.

Outreach:

Results from this project will be summarized in a Miner Institute Farm Report article and presented at regional extension meetings.

Next Steps:

The next steps for this work will be to perform more site-specific investigations, including more robust measurements of flows to permit more accurate event-based and annual N and P loads in relation to crop nutrient inputs and yields.

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For More Information:

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