Northern NY Agricultural Development Program
2010 Project Report

Estimating Phosphorus Losses from Tile-Drained Fields in Northern New York

Project Leader(s):
Eric Young, Research Agronomist; Stephen Kramer, Director of Laboratory Studies, Catherine Ballard, Director of Research; Rick Grant, President; Laura Klaiber, Research Technician; and Lisa Klaiber, Research Technician (all work at Miner Institute)

Collaborator(s):
Larry Geohring, Senior Research Associate, Dept. of Agricultural and Biological Engineering, Cornell University; Quirine Ketterings, Associate Professor, Dept. of Animal Science, Cornell University.

Background:
Tile drainage of poorly drained crop fields is a critical management practice for dairy and field crop producers in NNY. Research in NNY during 1970's and 1980's clearly demonstrated the economic benefits of tile drainage and showed a quick return on investment. Benefits of tile drainage compared to an undrained condition include decreased surface runoff, increased crop yield/quality, lower compaction risk, warmer soils in the spring, and earlier planting.

While the benefits of tile drainage are clear, there is evidence that tile drains can transport nitrogen (N) and phosphorus (P) in effluent under some conditions. In the Lake Champlain Basin, P is considered a priority nutrient due to its role in eutrophication. Increasingly, water quality managers in the Lake Champlain Basin and NNY are asking questions about tile drains and their potential impact on surface water quality. More information is needed on the factors that influence the risk of P leaching to tile drains and to what extent P is lost in effluent over the growing season. Ultimately, controlled field studies need to be designed that compare P loading between drained and undrained field conditions so that the full impact of tile drains on both surface and subsurface P runoff can be established under differing management schemes.

Because little work has addressed the issue of P loss in tile drainage in NNY, research on tile drainage water quality benefits both farmers and resource managers. Tile drainage is an invaluable tool for farms in NNY and producers need to understand how soils, weather and management affect tile drainage water quality. The objective of our project was to monitor P concentrations in tile drainage effluent to better understand the potential for P losses over the growing season.

Methods:
The site for this research was an 18-acre field at Miner Institute. The field is an alfalfa-grass mix (4^{th} year) and the dominant soil type is a poorly drained silty clay (Ajiduamo). In June 2009, inline water control structures (Agri Drain Corporation, Adair, IA) were installed in each of eight tiles that run the full length of the field (tile spacing is roughly

50 ft. on center). In addition, a water control structure was installed in the main tile outlet that drains the field. Tile drainage water from this water control structure was sampled for P concentrations during the 2010 season. Approximately 4,000 gal/ac of liquid dairy manure was applied after the second (last week of June) and third cutting harvest of alfalfa-grass (last week of July).

The original objective of this study was to compare P loading from free-flowing tiles to tiles that have a portion of their flow restricted by *stoplogs*, which act as dams in the drainage pipe and artificially raise the water table in the vicinity of the tile (Fig. 1, Appendix). The hypothesis being that the restricted flow reduces the flow rate of water exiting the field through the tile drain (e.g., increased residence time of water), which permits greater P fixation (chemical binding of P to the) and thus a lower P concentration in the tile effluent. After installation of the water control structures and subsequent rainfall events in 2009 and 2010, it was apparent that our original experimental design was untenable due to inherent water table variation in the field. This contributed to a very large variation in tile flow across the eight tile lines during base flow and high flow conditions. We therefore could not 'pair' the tile lines and perform the original hypothesis as planned in the proposal. In addition, drainage capacity from the main outlet for this field saturates under moderate to high flow events and precludes the use of Agri Drain's published equations for calculating water flow. Given these limitations, we revised our original objective and focused on sampling tile effluent from the main outlet to capture field-level changes in P concentrations over the season (note the project title was also changed to reflect this).

In an effort to provide more information in light of the above limitations, we also report here on data collected at the same time from another tile drainage monitoring site located on a private nearby dairy farm. This site is part of a tile drainage water quality study led by Larry Geohring. At this site, a 3 acre cornfield with a somewhat poorly/poorly drain ed sandy loam soil (Swanton) was monitored. All drainage from the field exits a tile main fitted with an inline water control structure (Agri Drain Corp.). Manure is generally applied in the spring prior to planting and again after corn silage harvest in the fall. Water samples were collected from this structure and drainage reflects the entire field. This site is referred to as the 'Ashley Rd. site' in this report.

Tile drainage water samples were collected either by hand or by an autosampler. Water samples were returned to the lab and stored at 5º C until P analysis was performed. Total P was measured on unfiltered water samples using standard methods. Soluble reactive P (orthophosphate) was filtered through 0.45 μm glass fiber filters and analyzed within 48 hours using standard methods.

Results and Discussion:

Phosphorus Concentrations in Drainage Water

The 2010 growing season in Chazy was marked by above average precipitation (Fig. 2). Tile water flow from both fields was greater during the late winter/early spring, decreased during the growing season (May-September), and increased again later in the fall when soil moisture was abundant. With the exception of one rainfall event near the end of June, rainfall events at both sites during the growing season did not generate a sufficient drainage water volume to permit sampling.

Total P and SRP concentrations from field R20w and the Ashley Rd. site varied depending on flow conditions. In general, P concentrations were lower under low flow conditions and increased with higher water flow (Fig. 3). Total P and SRP concentrations in drainage water averaged 305 μg L^{-1} (*n* =25; SD=319) and 206 μg P L^{-1} (*n*= 19; SD=243), respectively. The high standard deviation reflects the influence of water flow conditions on P concentrations and the need for careful water flow measurements if the goal is to estimate P loading from individual fields. Our results suggest an episodic leaching of P to tile drains in this field, but further study is needed better quantify actual losses. To accurately measure water flow and an actual P loss, the outlet in this field must be modified to permit free drainage from the field to enable flow estimates. This is critical for calculating actual P loss (e.g., P mass/time/area).

The influence of tile water flow rate on P concentrations was also apparent at the Ashley Rd. site. In general, higher flow conditions (spring/late fall) were associated with greater P concentrations in drainage water (Fig. 4). This suggests that P derived from manure and/or weakly adsorbed soil P was mobilized from macropores during high flow conditions. It is possible that P from manure applied in the fall contributed to the two events with the greatest P concentrations. Episodic P leaching has been observed in previous field studies, particularly when macropores are present. However, it is important to note that average P concentrations were very low over the season at this site. For example, average total P and SRP at the Ashley Rd. site was 65 μg L^{-1} (SD=119; *n* =700) and 31 μg P L^{-1} (SD=68; *n*= 713), respectively. These are very low P concentrations with respect to surface water quality, particularly when compared to wastewater treatment plants, which typically discharge wastewater with 1,000 μg total P L^{-1}. With the exception of the late January 2010 thaw event and the early December event, both total and SRP concentrations remained very low (Fig. 4).

Estimating Drainage Flow and Phosphorus Loss

Due to the restricted free drainage through the outlet in field R20w, drainage flow estimates were not possible. Without good water flow estimates, it is not possible to estimate a mass of P lost from the field. At the Ashley Rd. site, flow through the tile main outlet was not restricted and water table elevations were recorded by a data logger. We are currently applying recently published equations for the v-notch weir used at this site which will enable water flow estimates. We also calculated water flow directly using a simple velocity-area method at differing flow levels (*n* = 23). These measurements will be used to calibrate/validate the published flow equations. Estimates of P loss from the field (lb P/acre/yr) will be made after water flow estimates are completed.

Conclusions/Outcomes/Impacts:

With respect to P loss and management recommendations, we cannot draw definitive conclusions from our research at this point. It is clear that P from manure application and/or weakly adsorbed soil P can be episodically mobilized by tile drainage water, particularly under high flow conditions. However, the overall magnitude of P loss from the field may be very small when the drainage volume for the entire year is considered. It is critical for tile drainage studies to accurately characterize both P concentrations and water flow over the season. Without both of these components, realistic P loss estimates are not possible. Accurate estimates of P loss in tile drainage are important for placing P losses into perspective, particularly when comparing to P losses that can occur in surface runoff, which are generally much greater than P losses from tile drainage. In addition, P loss studies require several years of data collection before definitive conclusions can be made due to the strong influence of weather and management on results.

To the extent possible, producers should apply manure to crops when they can utilize the applied nutrients. While spring applied manure may be ideal from an agronomic and water quality perspective, it may not be practical for some farms. For example, if fields are mostly poorly drained, applying manure in the spring is not plausible due to the extended wetness in the spring and the risk of compaction. Farms operating under a nutrient management plan (e.g., CAFO farms) must apply manure according to the NY P index, which accounts for both surface and subsurface P loss potential based on soil test P level, hydrology, and manure management (e.g., timing, incorporation). Thus, these farms have been following best management practices for P management. Once data are collected from a sufficient number of sites and under a range of weather and management conditions, more definitive conclusions and recommendations will be possible.

Outreach:

Some of the data reported here were presented in a preliminary fashion to farmers/researchers/consultants at meetings in New Brunswick, New Hampshire, and New York this spring. However, due to the preliminary nature of these data, only broad trends were discussed. Management recommendations from this work will not be made until additional data is collected and more definitive conclusions can be made.

Reports and/or articles in which the results of this project have already been published. Data reported here have not been published elsewhere.

Person(s) to contact for more information:

Eric Young, William H. Miner Agricultural Research Institute, Chazy, NY; (518) 846-7121, ext. 113; young@whminer.com.

Appendix

Figure 1. Agri Drain inline tile drainage water control structures.

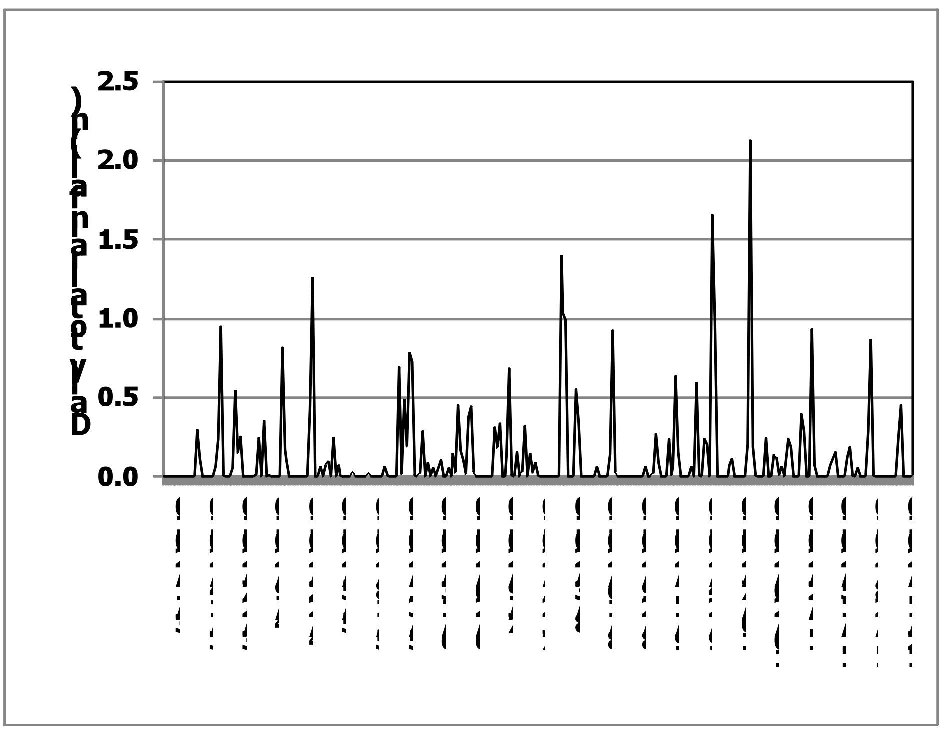

Figure 2. Daily total rainfall (in) from March to December 2010 at Miner Institute.

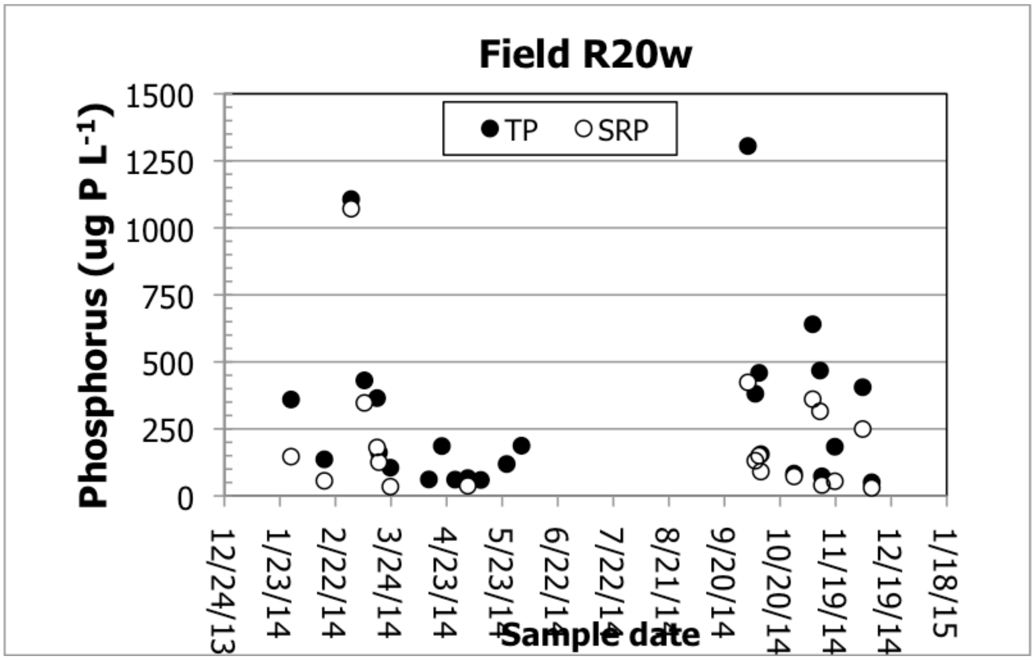

Figure 3. Total P (TP) and soluble reactive P (SRP) in drainage outlet water for R20w.

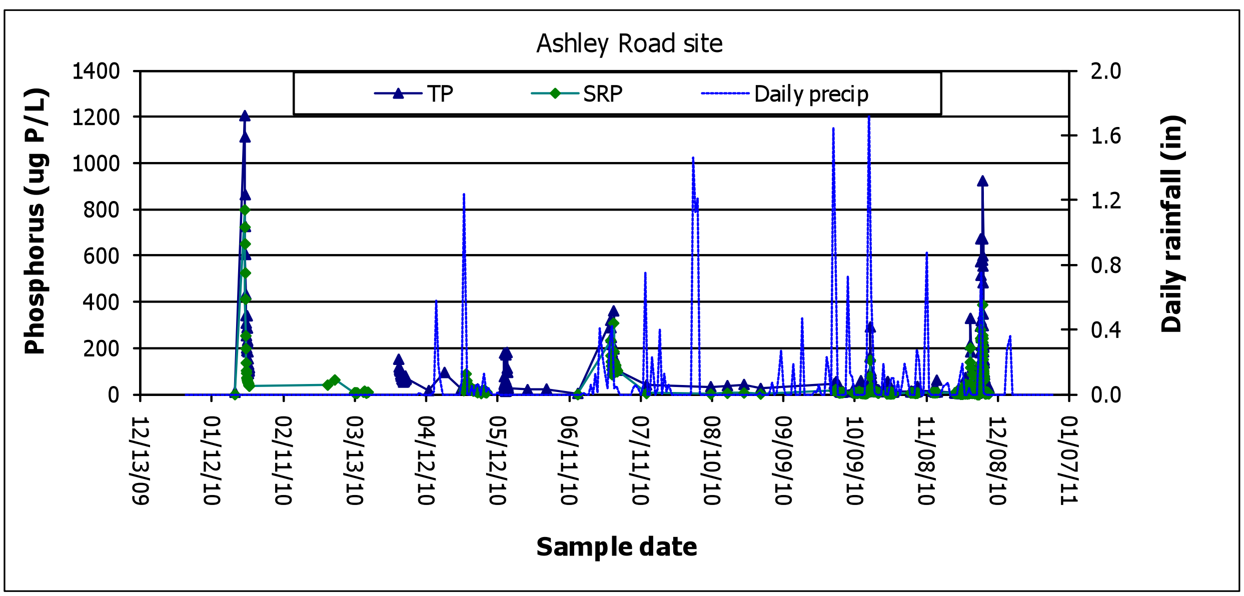

Figure 4. Total P (TP) and soluble reactive P (SRP) in tile drainage outlet water for the Ashley Rd. field site. Daily average rainfall (in) is also plotted on the second y-axis.

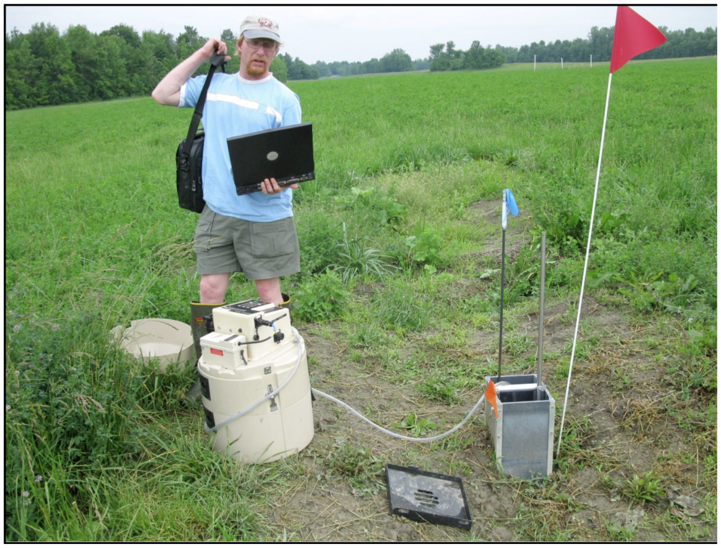

Photo 1. Steve Kramer downloads water table data and retrieves tile drainage water samples from an autosampler in a research field (R20w) at Miner Institute (photo by Eric Young).

Photo 2. Water control structure on the tile drainage main outlet at the Ashley Rd. field site (photo by Steve Kramer).