FINAL REPORT: REDUCTION OF NUTRIENT LOSSES FROM TILE-DRAINED CROPLAND USING DRAINAGE WATER MANAGEMENT

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INTRODUCTION

Subsurface tile drainage is critical to productive agriculture in nearly half of Indiana's cropland, allowing earlier field work and aeration of the root zone for. However, subsurface drains increase the loss of nitrate from cropped fields, and can also provide a direct pathway for phosphorus loss in some soils. Tile drains have been shown to be the major pathway for nitrate loads in the Mississippi Basin, and recent research has shown that phosphorus flow through tile drains has recently is a key source of phosphorus in streams (Smith et al., 2014; King et al., 2014a). King et al. (2014b) showed that phosphorus from tile drains, which we previously assumed was negligible, is responsible for about 50% of losses from drained agricultural land.

Drainage water management is one of the practices that shows the greatest promise for reducing nitrate losses from tile-drained land while maintaining drainage intensity during critical periods of the crop growth cycle (Frankenberger et al., 2007; Skaggs et al., 2012), but the potential for reducing phosphorus is not well understood. It uses water control structures to raise the effective height of the drain outlet, and thereby reduces the amount of subsurface drainage from a field (Figure 1). Unlike conventional drainage systems that remove excess water to the depth of the tile drain whenever it occurs, a drainage water management system conserves water by increasing the retention time of water in the soil profile. Removal of excess soil water can be delayed and/or reduced, creating opportunities for more optimum plant growth conditions for crop production while reducing annual drainage volumes.

In this project, we collected and analyzed drain flow at the Davis Purdue Agriculture Center (DPAC). Funding from Indiana Soybean Alliance added 6 months of data collection to 4 years funded by a previously-funded project that ended in early winter 2016, which gave us a total of five years of data for more robust results than we would have had without this funding. Funding from this project also allowed us to add phosphorus analysis of the drainage water, in order to start to assess potential effects of drainage water management on phosphorus.

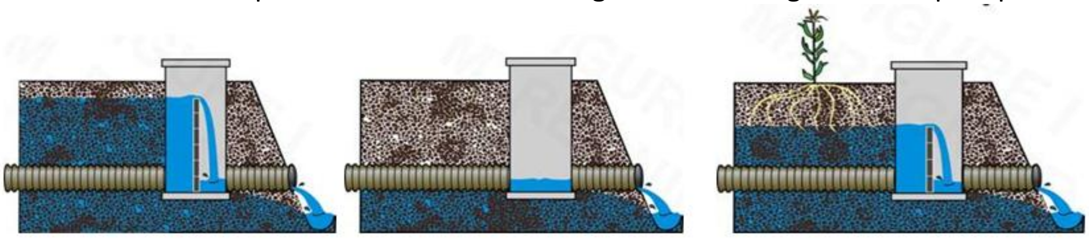

Figure 1: In drainage water management, the tile drainage outlet is raised after harvest to reduce nitrate delivery (left), lowered before planting and harvest to allow the field to drain fully (center) and raised again after planting to potentially store water for crops (right).

METHODS

Drainage monitoring *took* place in Field W at the Davis Purdue Agriculture Center (DPAC) in Randolph County, where we have a long-term drainage research site (Figure 2).

Four drained 10-acre subfields (two managed and two free-draining) were separately instrumented for collecting drain flow, soil moisture, water table level, and collecting samples for this research. Drain flow was collected at the outlet of each subfield using electromagnetic flow meters, Isco automated samplers, Decagon soil moisture sensors, and water table observation wells with Global Water level loggers and a datalogger with cellular modem for transmission to computers on campus. Instrumentation is shown in Figure 4 (page 3).

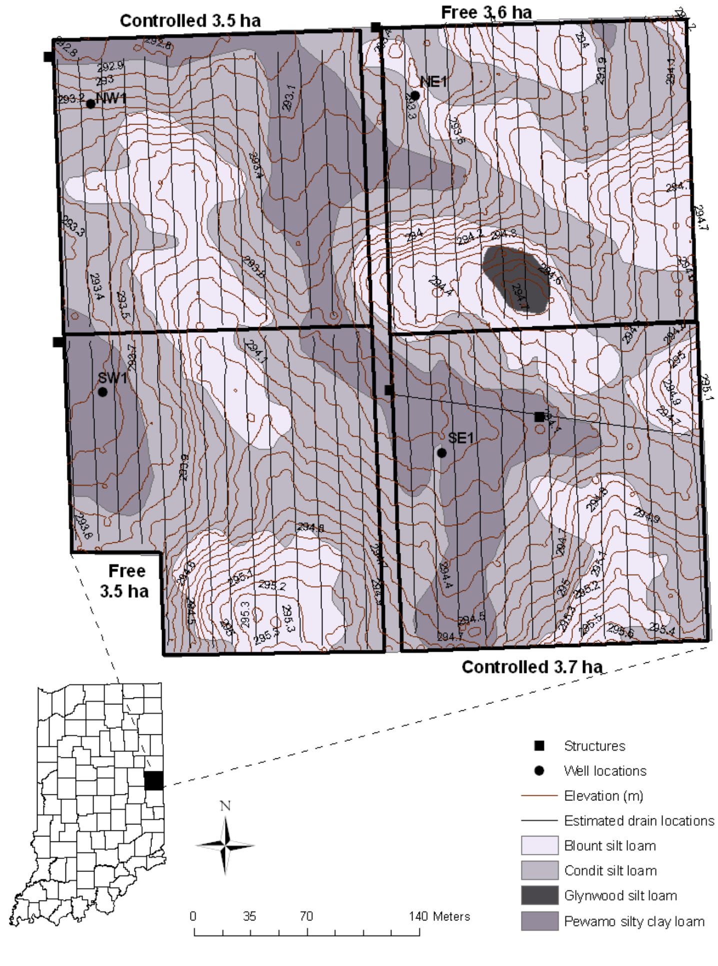

Figure 2: Research site at Davis Purdue Agriculture Center (DPAC) in Randolph County

Figure 4: Samaneh Saadat, Graduate Student funded by this project, prepares sample bottles for analysis .

A water table well was installed in each sub-field, and equipped with an automatic water level meter. Soil moisture was also monitored at five depths (10cm, 20 cm, 40 cm, 60 cm, and 100 cm) in each of the four sub-fields.

Analysis of nitrate and phosphorus in drain flow samples was done in the McMillan Laboratory in the Department of Agricultural and Biological Engineering (Figure 4). All analysis of drainage water management impacts was done by comparing it to conventional (free) drainage.

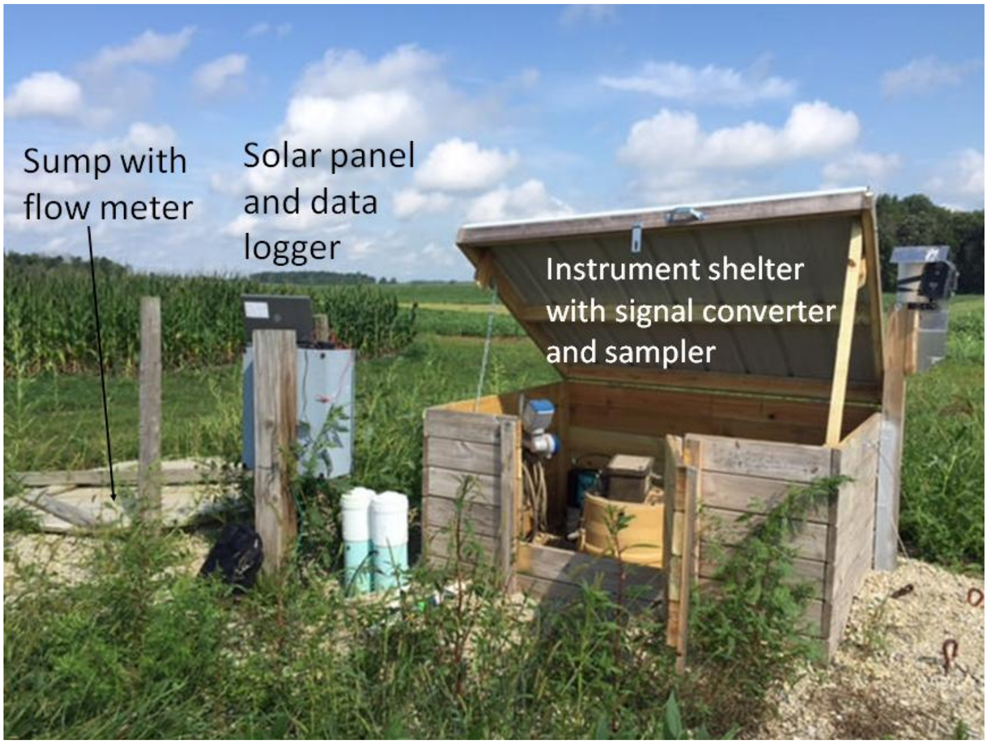

Figure 4: Research infrastructure for collecting drain flow, precipitation, wind speed, and water samples. Data are transmitted via a cellular modem. Soil moisture and water table measurements are also collected, but are within the field itself and are not shown here.

RESULTS

In this report, we have combined all the nitrate and phosphorus samples taken from January 2012 to February 2016 (funded by a previous project) with those funded by this project (spring 2016). However the annual load results are only through 2015, because that is the last year for which a full year was available. Figure 5 shows the concentrations of nitrate-N, soluble reactive phosphorus, and total phosphorus. The average of the 4-year concentrations, calculated for each nutrient for both free and managed quadrants, indicated that concentration was slightly higher under drainage water management for all 3 nutrients, but ANCOVA test results showed that the effect of management on concentration was not statistically significant.

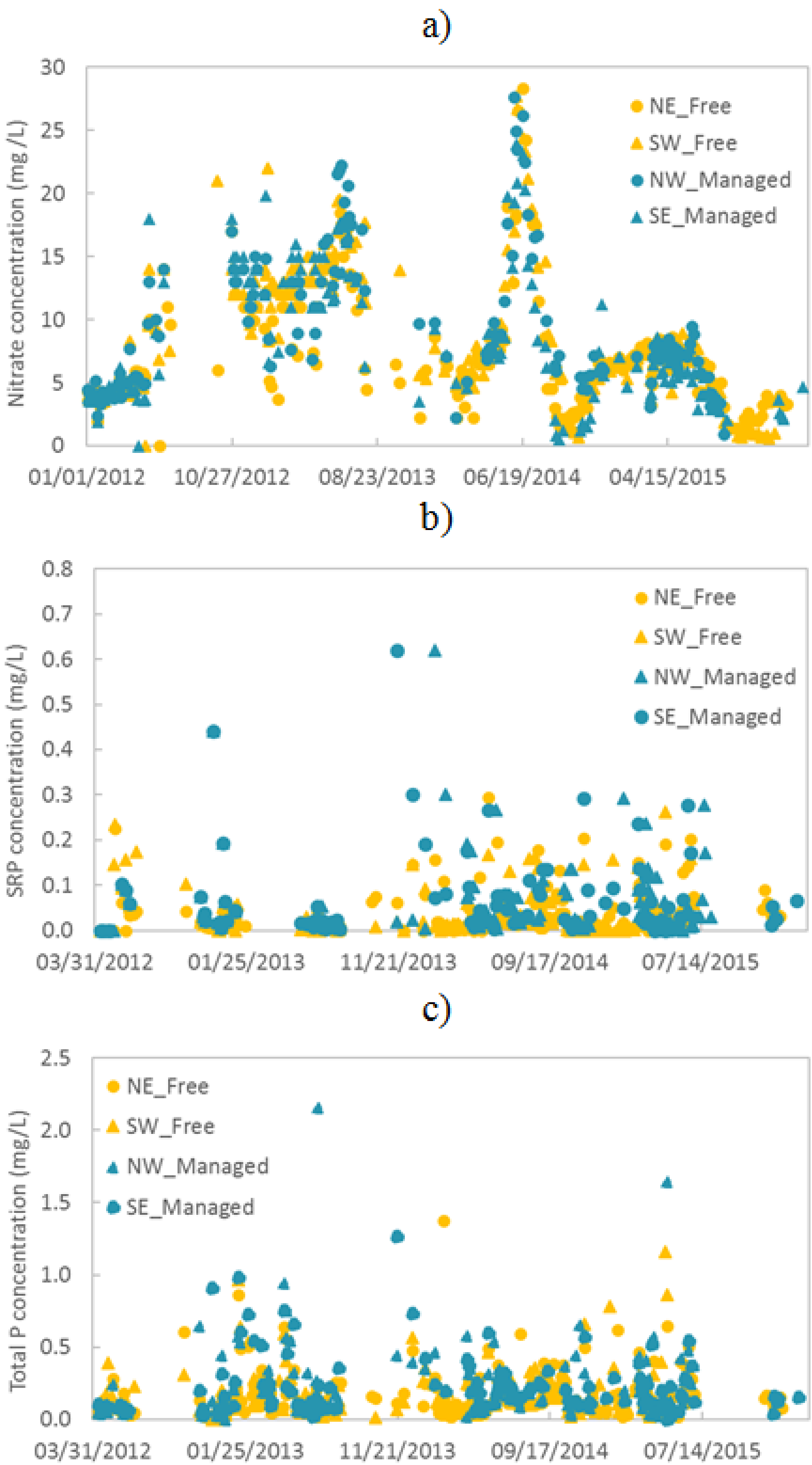

Figure 5. a) Nitrate concentration, b) soluble reactive phosphorus (SRP) concentration and c) total phosphorus concentration for free draining and managed quadrants from 2012 to 2015

Of more interest than nutrient concentrations, however, is the **load** or total pounds of nitrate-N and phosphorus lost through the system per acre. Load was calculated by multiplying our continuous (6-minute) flow data by the concentrations, and dividing by the drained area of each quadrant. Figure 6 shows loads in the free and managed quadrants for these three nutrients. Annual nitrate-N loads ranged from approximately 10 lbs/acre in 2012 (a dry year) to nearly 40 lbs/acre in one quadrant in 2014. Phosphorus loads were generally low (0.02 to 0.28 lb/acre of soluble reactive phosphorus, and 0.05 to 1.2 lb/acre of total phosphorus) with most loads less than a target of about 1 lb/acre often recommended to prevent eutrophication in lakes and streams.

Statistical analysis showed that drainage water management decreased nitrate-N by 2.3 and 4.0 lbs/acre (13% and 23%) in the two pairs of quadrants. This is significant and emphasizes the potential of drainage water management. However it is less than has been found in other locations. The reason may be the restrictions in flow at this site due to inadequate downstream drainage.

Phosphorus loads increased very slightly under drainage water management (0.06 to 0.09 lbs/acre) and this is not a significant concern. However it does indicate that drainage water management is not an effective practice for reducing phosphorus loads.

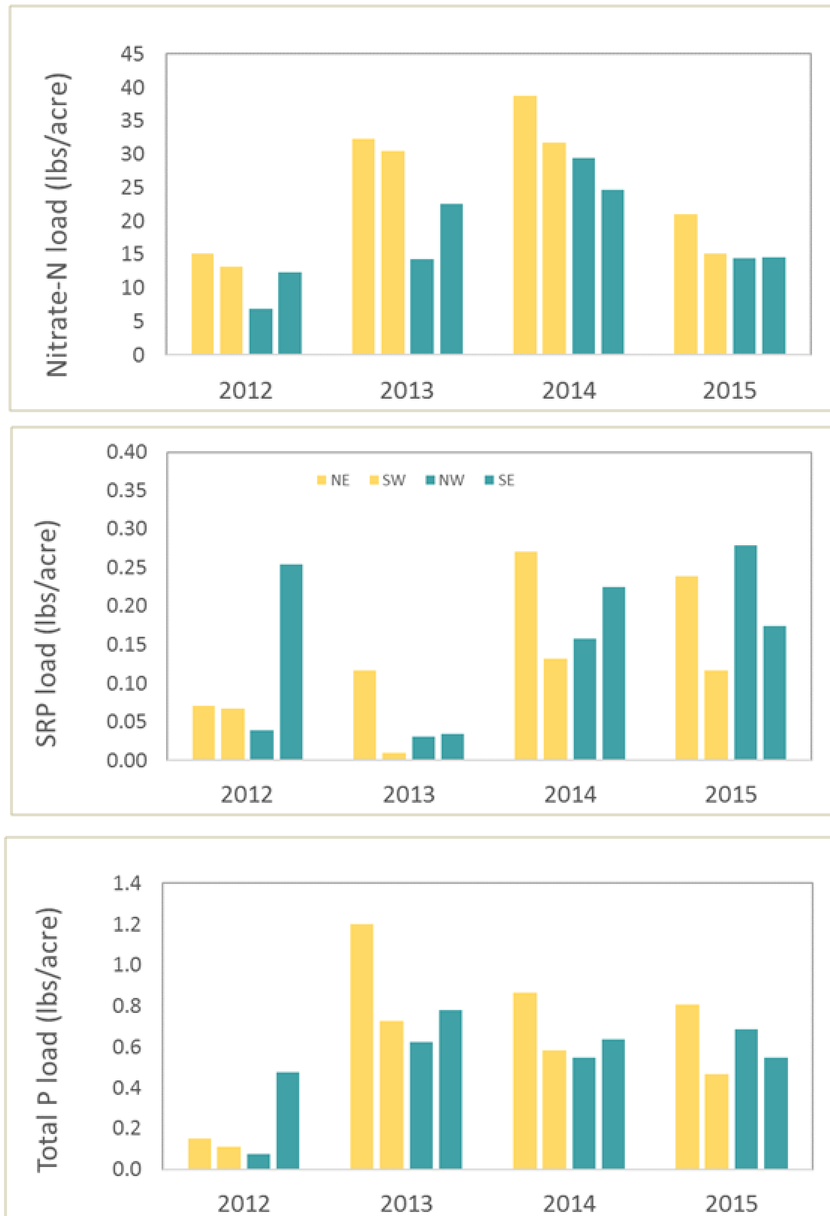

Figure 6: Loads of nitrate-N, soluble reactive phosphorus, and total phosphorus from free (gold) and drainage water management (aqua).

COMMUNICATION OF RESULTS

Results from this project have been communicated to other researchers in an oral presentation at the **American Society of Agricultural and Biological Engineers Annual International Meeting** in Orlando (July 2016), and in an oral presentation and paper written for the **International Drainage Symposium** (September 2016). The citation for the International Drainage Symposium paper, which can be found online, is:

- Saadat, S., J. Frankenberger, and L. Bowling, 2016. Quantifying Nutrient Loads with Estimated Drain Flow Using Water Table Observations. 2016 10th International Drainage Symposium Conference, 6-9 September 2016, Minneapolis, Minnesota. American Society of Agricultural and Biological Engineers, 2016, online.

A paper will be submitted soon to the peer-reviewed journal *Agricultural Water Management*.

Numerous presentations have also been made to Extension audiences. Results were also presented at the Corn Showcase at Purdue University on July 26, 2016 (Fig. 7). These results have also been included in Jane Frankenberger's presentation to more than 150 people at the Indiana Certified Crop Advisors meeting, December 13, 2016.

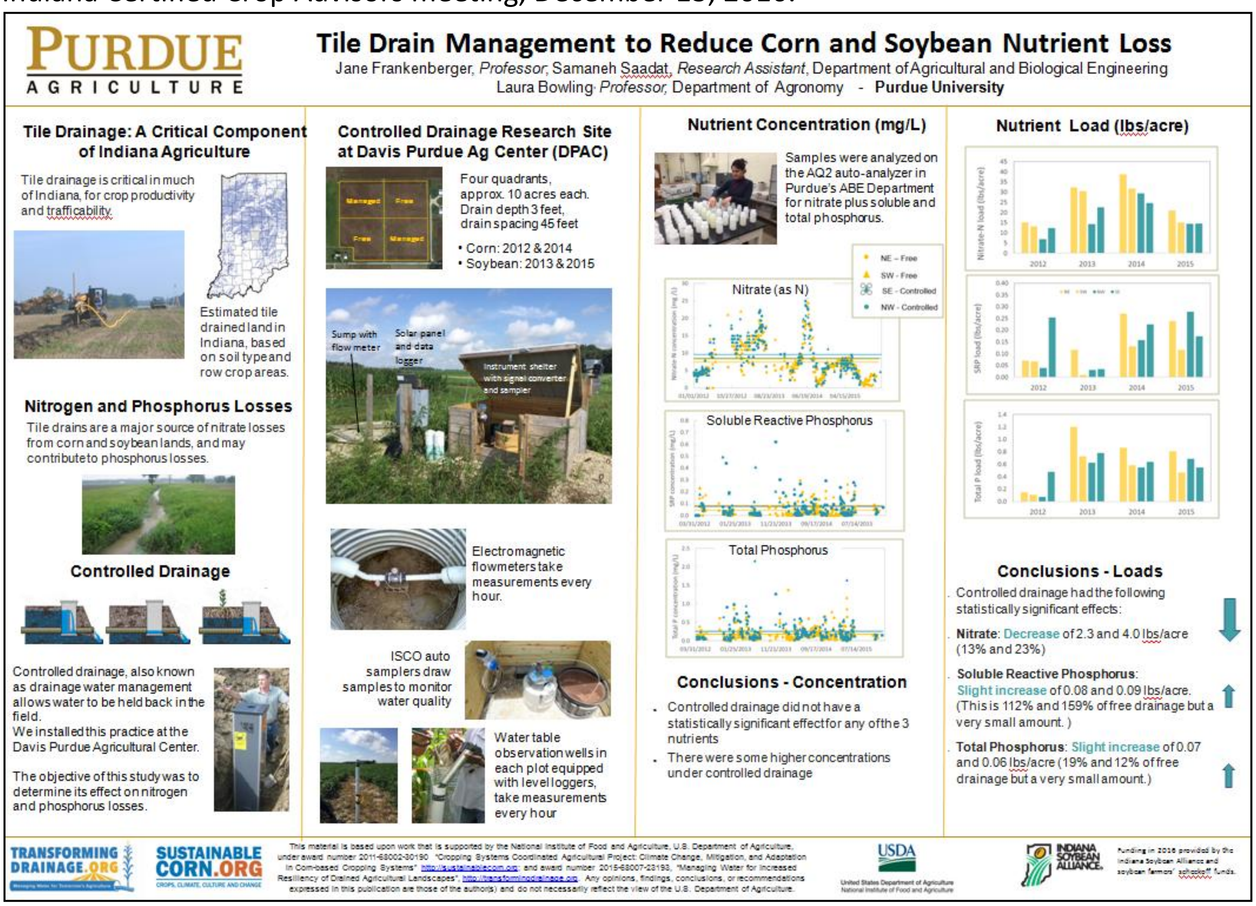

Figure 7: Poster presented at the Corn Showcase at Purdue University.

CONCLUSION

This project allowed us to complete long-term monitoring of drainage water management research site to determine the impacts on nitrate and also soluble and total phosphorus. The phosphorus analysis would not have been possible without Indiana Soybean Alliance funding. Results showed that the nitrate-N load decreased by 13-23%, while the phosphorus loads were not significantly different under drainage water management. The practice of drainage water management is one “tool in the toolbox” for reducing nutrient loads from drained agricultural land, but additional practices are also needed. Future work will explore how other practices with greater potential nutrient reductions, such as **drainage water recycling**, can be evaluated in Indiana.

REFERENCES

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