Project Summary: 2018 Annual Report of Edge-of-Field Water Quality Monitoring

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Introduction

Miner Institute initiated an NRCS Edge-of-Field water quality-monitoring project in the fall of 2014. The objective of the project is to compare edge-of-field water quality between a tile-drained field with free (uncontrolled) drainage and a tile-drained field with drainage water management (DWM). Drainage water management is a national conservation practice (Code 554) that allows for the management of the water table level in fields equipped with tile drainage systems. By raising the level of the water table in the non-growing season and reducing the drainage capacity, the total volume of outflow from the tile drainage system can be reduced. This reduction in subsurface runoff has been demonstrated to reduce nitrogen (N) losses in previous research. However, there has been limited research on the impact of DWM on phosphorus (P) losses. The objective of this report is to present the baseline data (both fields freely drained) over the first two years of monitoring and results from the first year of the treatment period (DWM implemented in field T5). Interpretation of a possible treatment response will be limited due to the early stage of the treatment period.

Methods

Nutrient and sediment loads in surface runoff and subsurface tile drainage in two paired fields managed as corn for silage (4.6 ac field referred to as T5; 8.1 acre field referred to as T9) were monitored using a small-paired watershed approach. Tile drainage was installed in both fields (fall 2014) at an average depth of 4 ft. with a 35 ft. lateral spacing between tiles. Subsurface flows from each field are routed to separate manholes where flow-based samples are collected using automated water samplers. Tile flows are gauged where they outlet into a 55-gallon drum equipped with a v-notch weir and an ultrasonic sensor that continuously records water level every 15 min. Flows are estimated using a nonlinear regression between measured flows and water levels. Surface runoff is routed to interceptor ditches and gauged with pre-calibrated H-flumes and ultrasonic sensors. Water samples are taken from surface flumes and subsurface drainage outlets for every 0.35 mm of runoff. The composite samples are collected in 16-liter plastic containers and nutrient content represents event mean concentrations (i.e., average concentration for the duration of an event) which are multiplied by the flow volume to calculate nutrient loads.

Fully operational monitoring began in October 2015. Fields T5 and T9 have been monitored for a period of three years. On 22 December 2017, DWM was implemented in field T5. Two additional years of monitoring are planned (through 2020) to conclude the treatment phase of study. The tile outlet elevation was set to a level of 30 inches below the soil surface, rather than the recommended 12 inches for the 2017-2018 non-growing season. This may have reduced the ability to detect a significant response in the first year of treatment implementation. Following manure application and tillage activities in fall 2018, the outlet elevation will be raised to the recommended level of 12 inches below the soil surface. Data reported here include runoff events occurring between 29 October 2015 and 1 November 2018.

Results and Discussion

Clinton County experiences an average of 31.5 inches of annual precipitation and a growing season of 130 d. From 2016 to 2018, the study location has experienced a water year (October-September) of average precipitation (2016 = 28.5 in), above average precipitation (2017 = 37.7 in), and below average precipitation (2018 = 22.6 in). Annualized runoff followed this pattern with approximately two times more total runoff occurring during the 2017 monitoring year than during 2016 or 2018. The proportion of annual precipitation occurring during the growing season (GS, May 1 – October 31) and the non-growing season (NGS, November 1 – April 30) has been fairly consistent with NGS precipitation accounting for 39-44% of annual precipitation during the three years of monitoring data. Despite slightly higher precipitation during the GS, runoff from both surface and tile systems in fields T5 and T9 predominantly occurs during the NGS. Runoff during the NGS has comprised approximately three-quarters of runoff from both surface and subsurface pathways during both the baseline period and the first year of treatment. The quantity and magnitude of surface runoff events was far less during the 2018 monitoring season than in 2016 and 2017. Whereas tile flow accounted for 47-75% of total flows in the fields during the 2016 and 2017 monitoring periods, it accounted for 95% of total runoff in 2018 from both fields.

Subsurface drainage is the primary hydrologic pathway in both fields, with 58-70% of total runoff occurring through the tile drains during the baseline period. However, surface runoff contributed 90-95%, 91%, and 90-95% of soluble reactive phosphorus (SRP), total phosphorus (total P), and total suspended solids (TSS, a measure of erosion) losses, respectively. The elevated risk of surface runoff with regards to P and TSS exports was also demonstrated during the first year of treatment, with surface runoff contributing 33-38% of SRP, 26-35% of total P, and 31-48% of TSS to field level losses, despite representing only 5% of the total runoff volume in both fields. With regard to N losses, this pattern is reversed, with the majority of losses (91%) occurring through the tiles due to the high solubility of nitrate-N. As with runoff volumes, the majority of nutrient and sediment losses occurred during the NGS. Over the three year monitoring period, non-growing season losses of total P represented 84-88% of tile drainage exports and 87-98% of surface runoff exports.

The level of P loss in this study has remained relatively low during the first three years of monitoring. Total P losses from the two fields averaged 0.43 lb/ac/yr during the baseline period. Likely due to below average precipitation and therefore lower runoff rates relative to the baseline period, the total P losses were even lower during the first year of treatment, with losses of 0.05 and 0.03 lb/ac/yr from fields T5 and T9, respectively. These levels of P export indicate a high efficiency of nutrient retention in field, with an average of 99.3% of applied nutrients (manure and inorganic fertilizer) remaining in the field over the duration of the study. Although previous research has indicated the potential for tile drains to be a significant source of P export, the data summarized here indicate that with sound nutrient management practices, tile drainage systems also have the potential to reduce P export from agricultural fields by reducing the incidence of surface runoff events. As previously discussed, the high solubility of nitrogen renders it a much more difficult nutrient to retain within field and this is reflected in the lower retention rates of N relative to what was applied to the fields during the baseline (91.5%) and treatment (82%) periods.

The low levels of P export from both fields are reflected in the flow-weighted mean (FWM) concentrations of the subsurface runoff. Flow-weighted mean concentrations represent the average concentration over a period of interest based on the nutrient load and runoff volume. Averaged over the first three years of monitoring data, the FWM concentrations of SRP in tile flows for fields T5 and T9 were 0.004 mg/L and 0.005 mg/L, respectively; well below eutrophication thresholds for freshwater systems (0.02-0.03 mg P/L). The subsurface FWM concentrations of total P were slightly higher at 0.02 mg/L in field T5 and 0.03 mg/L in field T9, but these levels are also well below the EPA recommended limit of 0.1 mg/L total P for water discharging to surface water bodies.

Preliminary analysis of the first year of treatment data indicate that DWM appears to be producing the intended effect of reducing tile flow in field T5, with a similar magnitude of reductions in both N and P loads. The 2018 monitoring year experienced below average precipitation and the lowest rates of both precipitation and runoff since the study began. As a result, there was a very low occurrence of surface runoff and conclusions based on this first year of treatment data should be made with caution. Raising the water table during the NGS in field T5 could result in both increased rate and magnitude of surface runoff events which carries the risk of increasing P losses. However, DWM is expected to reduce the rates of N export by reducing the drainage capacity of the field and therefore decreasing the transport of N.

Conclusion

Many of the patterns of loss observed during 2016 and 2017 continued during the 2018 monitoring year. The majority of surface and subsurface runoff and nutrient export continues to occur in the NGS. Surface runoff continues to be the major risk factor for TSS and P losses. Although TSS and P losses from surface and subsurface runoff from fields T5 and T9 during the 2018 monitoring year were similar, surface runoff contributed only 5% of the total flow in both fields, indicating that surface runoff has much greater potential to mobilize TSS, SRP and total P losses. Nitrogen continues to be predominantly lost from both fields through subsurface leaching to tile drains. The fraction of N and P lost relative to total inputs in 2018 remained in a similar low range compared to baseline monitoring in 2016 and 2017.