2017 Final Report Summary Sheet

Grantee Information

Project Title:	Understanding mechanisms and processes of dissolved reactive phosphate (DRP) loss in Illinois tile-drained fields
Institution:	University of Illinois
Primary Investigator:	Arai
NREC Project #	2016-4-360347-203

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Is your project on target from an IMPLEMENTATION standpoint? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

Is your project on target from a BUDGET standpoint? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

Based on what you know today, will you meet the objectives of your project on-time and on-budget? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

Have you encountered any issues related to this project? ☐ **Yes** ☒ **No**
If you answered "yes" please explain:

Have you reached any conclusions related to this project that you would like to highlight? ☐ **Yes** ☒ **No**
If you answered "yes" please explain:

Have you completed any outreach activities related this project? Or do you have any activities planned? ☒ **Yes** ☐ **No**
If you answered "yes" please explain and provide details for any upcoming outreach:

Luis Andino, Jennifer Fraterrigo, Lowell Gentry and Yuji Arai. 2017. The effect of closed depressions on dissolved reactive phosphorus losses in tile-drained fields. Agronomy Society of America meeting 2017 Tampa, FL

Lowell Gentry, Luis Andino, Yuji Arai, and Jennifer Fraterrigo. Understanding mechanisms and controls on nitrate and phosphorus loss from tile-drained fields. 2017 NLRS Workshop

2017 Watseka Iroquois county Farm Bureau

Additional Notes:

Annual NREC Project Report (Jan 2017-Jan 2018)

I. Understanding Mechanisms and Processes of Dissolved Reactive Phosphate (DRP) Loss in Illinois Tile-Drained Fields

II. Cooperators: This project will be conducted by an interdisciplinary team of faculty at the University of Illinois.

PI: Yuji Arai, Assistant Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, N-215 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. (217)244-3602. Cell: (650)444-4206. yarai@illinois.edu. Dr. Arai has extensive experience in soil phosphorus chemistry in predicting dissolved reactive phosphorus in various agricultural soils.

Co-PI: Mark B. David, Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, W-503 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. (217) 333-4308. mbdavid@illinois.edu. Dr. David has extensive experience in evaluating nutrient losses from tile drained fields in Illinois.

Co-PI: Jennifer M. Fraterrigo, Associate Professor, Department of Natural Resources and Environmental Sciences, University of Illinois, W-423 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. (217) 333-9428. jmf@illinois.edu. Dr. Fraterrigo has conducted extensive research in agriculturally dominated regions to understand relationships between landscape patterns and nutrient loss.

Co-PI: Lowell E. Gentry, Principal Research Specialist in Agriculture, Department of Natural Resources and Environmental Sciences, University of Illinois, W-503 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. (217) 333-1769. lgentry@illinois.edu. With more than 20 years of experience in agricultural monitoring, he has the knowledge needed for documenting and interpreting the loss of nutrients from tile-drained fields.

Locations: This project will leverage field and watershed infrastructure already in place in the Embarras River watershed of east-central Illinois supported by NREC, as well as additional agricultural fields in surrounding watersheds of this same area. East-central Illinois has poorly drained Mollisols, but with tile drainage supports intensive and extremely productive corn and soybean production. In addition, this watershed is relatively flat and surface runoff generally only occurs with major precipitation events, which are easily discernable with river flow events dominated by tile inputs. Much of our past work has focused on N, but we have completed three P studies (Xue et al., 1998; Royer et al., 2006; Gentry et al., 2007) that give us a good understanding of P loads and yields in this area. These studies have also shown the importance of tile drainage to DRP loads in the rivers, but have not explained the variation in P loss from tile system to tile system.

We will make use of a wide range of fields we are currently monitoring for various nitrate projects, but where we also measure DRP and total P and will add our additional studies to. Table 1 summarizes the 22 tiles on eight different farms that we now have fully instrumented with Agri Drain structures, Solinst pressure transducers, and ISCO automatic samplers.

In addition we, have the 36 instrumented tiles on the NREC supported farm in Douglas County (described below), for a total of 58 instrumented tiles. *This array of fields will allow us to conduct DRP research beyond what is available in most studies, and build on long-term data from the tiles and overall watershed in unprecedented ways.*

We have a unique field study near Tuscola, Illinois in Douglas County funded by NREC (David, Nafziger, and Gentry), where 36 individual tile laterals are being monitored in a N fertilizer timing study to examine nitrate losses. This is a typical farm that has a patterned tile system on 100 foot centers. We were able to locate individual laterals, and install monitoring systems on each lateral. Each lateral drains about 5 acres, and again has an Agri Drain structure, continuous flow monitoring, and ISCO automatic samplers. The study is half in corn and half in soybean each year, with each of the six N treatments (fall, spring, split, sidedress, reduced rate, cover crop) replicated 3 times for each crop type. As with our other tile work, we are measuring P in all samples and have already found great variability in concentrations across this 240 acre field. This variation in P will allow us to examine individual lateral variation as explained in our approach. This will give us a better understanding of controls on P concentrations and forms where a patterned tile system, so typical of what is currently in use, has in effect been separated piece by piece. We have information or can obtain information about the management of each field (or portion of a field) in this study. We will have a wide range of field conditions, farming practices, and other factors to explore. Each farm receives P fertilizer at variable rates as DAP according to fertilizer recommendations for agronomic crops in Illinois or the farmers own experience. The Douglas County site has six replicated N rate/timing/cover crop treatments that will allow us to look at the interaction of N fertilization on P loss, as well as cover crop effects. Some of the other fields have cover crops as well, and the Eric Miller farm has a corn/soybean/wheat rotation. Taken together, we have a wide range of agronomic practices typical for corn and soybean production on tile-drained soils in east-central Illinois.

Table 1. Farms in or near the Embarras River watershed that currently have tile monitoring by our team as part of other projects, and will be used in this study.

	Tile # and type	Tillage	Cropping	Drainage area
				Acres
Salt Fork Watershed				
Farm 1	3 patterned fields	chisel	corn/soybean and corn/corn, one with cover crop	20-60
Farm 2	2 patterned fields	no-till (25+ years)	corn/soybean	25-55
Farm 3	3 random drainage fields	no-till and strip till	corn and soybean	40-60
Embarras Watershed				
Farm 4	2 patterned fields	chisel	seed corn/soybean	15 each
Farm 5	4 patterned fields	chisel	corn/soybean	20-250
Farm 6	1 patterned field	chisel	corn/soybean	50
Farm 7	1 patterned field	chisel	corn/soybean/wheat	12
Lake Shelbyville Watershed				
Farm 8	6 patterned tiles	no-till and strip till	corn/soybean/wheat with cover crops	25-70

III. Objectives

The overall goal of this project is to evaluate physicochemical factors (e.g., soil test P, landscape topography, infiltration rate, and soil chemistry) influencing the seasonal distribution and movement of DRP in tile drainage systems. We will more fully understand the fate of DRP in relation to soil test P in current P management systems at long term tile-drained experimental fields in Illinois.

The objectives are to:

1. fully understand tile DRP losses in relation to soil test P (i.e., labile P in surface soils) for fields in east-central Illinois under typical corn and soybean production;
2. assess tile DRP losses in relation to spatial variability (i.e., fine scale topography) across fields and landscapes;
3. determine the relationship between land surface topography and tile DRP losses, examining soil physical properties (e.g., infiltration rate, hydraulic conductivity, soil P extraction relevant to soil test P);
4. examine the processes responsible for seasonal DRP release to tile lines, including physicochemical properties (e.g., depth sequence distribution of DRP and agronomic P soil test P) of subsurface soils; and
5. include a final report at the conclusion of this project that will address each of the objectives stated above and evaluate both the yield response and the tile losses of DRP/changes in soil test P.

IV. Justification Statement

Phosphorus loss from agricultural fields has long been an environmental issue due to its effects on aquatic ecosystems (Carpenter et al., 1998; Sharpley et al., 1994), but not an agronomically important one. Compared to nitrogen, little P is typically lost from fields, unusually on the order of 0.2 to 2 kg P ha^{-1} yr^{-1} (Gentry et al., 2007). Larger amounts of DRP can be lost during major erosion events, and recently DRP losses at high concentrations have been reported through tile drainage in the Lake Erie watersheds of northwestern Ohio (King et al., 2015b). Concentrations of DRP can range from just detectable to many tenths of a mg L^{-1} in tile lines, and can be many mg L^{-1} in surface runoff, the two methods of P transport from fields to streams (King et al., 2015a). These concentrations and loads of DRP are more than enough to lead to eutrophication and algal production in downstream water bodies. However, this loss of P is small compared to N losses, which in tile drained watersheds can be 8-50 kg N ha^{-1} yr^{-1} (David et al., 2010; Gentry et al., 2014). Without a crop yield response to P loss (i.e., importance of soil test P), economics alone will not solve this problem. Therefore, it is a major challenge to reduce P losses from agricultural fields by the large percentage called for in most states as part of the Gulf of Mexico Hypoxia Action Plan. Illinois has recently developed a nutrient loss reduction strategy that calls for 45% reductions in P losses (in addition to 45% nitrate reductions) from both point and non-point sources (Illinois Nutrient Loss Reduction Strategy, 2015). This will be a major challenge for Illinois, as well as other states in the agricultural Midwest. Phosphorus loss has long been known to be transported primarily with sediment erosion through surface runoff. Many scientists downplayed tile drainage losses following early reports of little P in tile water (e.g., Logan et al., 1980), although Co-PI David's research group published their first paper on P and tile drainage losses in 1998 (Xue et al., 1998), and followed that up with work by Royer et al. (2006) and Gentry et al. (2007). This body of work demonstrated the importance of high flow events (i.e., during rainfall event and or snowmelt) in leading to losses of DRP, clearly pointing out the importance of tile P loads. More recently there has been great interest in tile drainage losses of DRP due to algal problems in Lake Erie, and a special issue of 17 papers in the 2015 March-April issue of the *Journal of Environmental Quality* (JEQ) on "Phosphorus Fate, Management, and Modeling in Artificially Drained Systems" was just published. Review papers on transport by subsurface drainage (King et al., 2015a) and modeling of P losses through tiles (Radcliffe et al., 2015) summarized our current state of knowledge on understanding DRP losses by this transport method. These papers built on the older review by Sims et al. (1998). In addition, papers such as King et al. (2015b) showed the importance of tile drainage to watershed scale P transport. While these papers acknowledged that tile transport has been overlooked as an important transport pathway, we don't know about how and when DRP is released in tile flow in relation to the landscape surface topography, the subsurface networks of solute transport and the depth sequence of soil properties. **Our proposal will help to fill some of those gaps.**

V. Work Plan

As described above, in year 1 we will conduct the spatial distribution analysis of terrain, and continue monitoring the seasonal tile flow and DRP at each of the fields in east-central Illinois listed in Table 1. Frequent saturation at topographic depressions with low permeability is known to accumulate DRP (Tomer and Liebman, 2014). However, it is not clearly understood how drain tiles may exacerbate ponding-induced subsurface DRP loss and changes in soil test P. Understanding how terrain variability might affect the translocation of DRP from surface to sub soils will allow us to predict how the DRP loss to tile lines affect soil test P. Terrain analysis will be performed using high-resolution (6 in.-2 ft.) digital elevation models (DEMs) derived from LiDAR (light detection and ranging) and combining terrain metrics with geospatial SSURGO data (NRCS) to develop a probabilistic map of ponding severity for our study fields. Following ground-truthing with aerial imagery, we will use the map together with tile maps to prioritize tiles for soil and water sampling. We will take soil test P data at each field following Agronomy Handbook recommendations. All production information, including corn and soybean planting dates, soil moisture conditions at planting, plant stands, and yield response will be recorded.

Each tile line requires equipment to allow for continuous measurement of flow and for automated collection of water samples for measurement of DRP, total P and others, but is already installed from previous projects. We are using a small Agri Drain structure with a pressure transducer and datalogger to gage flow on 15-min intervals on each tile lateral. ISCO automatic water samplers are used to collect flow proportional solution samples as frequently as every 15 min during runoff events, but from our experience a sample every 2-3 hours during flow events provides adequate sampling. Water samples will be analyzed for pH, DRP, total P, and DOC. Samples for dissolved constituents will be filtered through a 0.45 µm membrane. All sample processing and preservation follows standard methods (APHA, 1998).We use a Lachat QuikChem 8000 continuous flow analyzer for ammonium, DRP, and total P (following digestion with sulfuric acid and ammonium persulfate). Our flow monitoring and water quality measurements will allow us to determine the lb/acre loss of DRP from each tile line for each day, month, and season, as well as annually. We will be able to show producers how much and when DRP is released through tile lines in response to weather and the fluctuating tile flow.

In year 2, prior to soil sampling (i.e., disturbance of terrain), infiltration and/or saturated hydraulic conductivity will be measured. Examination of the hydrological pathways (e.g., macropore flow) is critical in enabling transport of DRP from agricultural land during the rainfall/snowmelt events. Specific sites will be selected according to the results of high resolution terrain maps and the distribution of DRP in tile flow in year 1.We are particularly interested in sites that had high DRP with high or low flow and low DRP with high or low flow. This will allow us to examine how the terrain characteristics contribute to the DRP loss in tile flow. The double ring infiltrometer (DRI) can be used to measure the infiltration rate (Reynolds et al. 2000). A total of eight-nine locations in each farm, adjacent to the GeoProbe sampling sites, will be used for the DRI experiments and the fresh surface soil core sampling for porosity measurements. Two replicate DRI infiltration measurements will be performed on the surface soil with tap water. To prepare the surface soil for the DI experiments, any plants with > 30 in. will be carefully trimmed to the soil surface. The inner and outer steel rings of 8 and 16 in. diameter, respectively, will be secured about 4-8 in. deep into the soil, with minimum soil disturbance. The steady-state vertical water flux below the inner ring will be kept at the same hydraulic head as the outer ring. The vertical water flux under these conditions corresponds to the infiltration rate. If the sites are saturated due to excess precipitation, we will conduct the saturated hydraulic conductivity measurements using core samples. Other measurements will include surface soil sampling after the infiltration measurements to better understand soil P levels and physicochemical properties and how they relate to tile P losses. Samples will be taken with a tractor-mounted probe to a depth of 30 inches, and divided into 0-6, 6-12, 12-20, and 20-30 inch depth increments. Samples will be processed and sent to a commercial lab for soil nutrient testing in addition to the porosity test. Analysis of mobile P speciation (e.g., DRP and soluble organic P) is important since they are influenced by the soil properties (e.g., organic carbon content, particle size distribution) and transport pathway.

In years 3 and 4, we will use the results of terrain data, seasonal DRP in tile flow, and physicochemical properties of surface and subsurface soils to select the sites to excavate established tile lines where high/low soil test P is associated with high/low DRP in tile flow. Depending on the size of field, 4-8 tile lines will be evaluated. Soil samples along with or away from tile lines will be collected to evaluate the soil chemistry of tile lines. This includes the particle size distribution, agronomic soil test, organic carbon, DRP, total P and sequential P wet chemical extraction. Corn and soybean yields will be determined by machine harvest. All data will be statistically analyzed using proper software described below.

All endpoints will be statistically evaluated using MS excel, Statistical Analysis Software, and Origin graphic software. The statistical relationship of physiochemical parameters of surface and subsurface soils during the rainfall/snowmelt events may have critical role in assessing the movement of DRP in tile systems in IL agricultural soils. Finally, the distribution and translocation of DRP will be statistically evaluated with respect to agronomic soil test P and crop yield. In evaluating the statistical significance, T-test and ANOVA will be used. As a part of master thesis projects, the graduate students will be responsible for interpreting the overall data, statistical analysis and trends that will be supported by extensive literature reviews.

We will use field days, web pages, and fact sheets for outreach. We will hold one field day per year at each site to attract farmers and outreach specialists to understand our results and their implications. Presentations will be made at local, regional, and national conferences, including the American Society of Agronomy annual meetings. This will allow us to inform a wide variety of audiences.

Our written products will include fact sheets, a webpage, and scientific publications. Fact sheets will use information from a variety of sources along with the results from our research and place it in a form that can readily be used by farmers and their advisors to understand P management systems and possible DRP losses from tile lines. Information on field days, workshops, research results, and fact sheets will be placed on the webpage for The Bulletin (http://bulletin.ipm.illinois.edu/).

We will evaluate Extension and other educational activities using simple survey instruments at meetings to measure increases in awareness of nitrogen management systems and how they can (or should not) be used in cropping systems. We will count page hits for websites and articles written form results of this project. While we will not be able to claim full credit for increases in nitrogen management systems in Illinois, we do think that this project will help expand their use if we find that nitrate reductions from tile lines can be documented.

VI. Impact of the Research

This study will improve our understanding of DRP loss from surface soils to tile systems and from tile-drained fields and watersheds using detailed geostatistical analysis of terrains, monitoring of seasonal tile flow and DRP, soil physiochemical analysis of surface and subsurface soils including soil test P. Growers should be able to better interpret the variability of soil test P through the understanding of temporal and spatial variability of DRP in tile systems. In the report, we will highlight the importance of DRP loss in tile flow events vs. variability of terrains and precipitation, soil physical properties events in transporting various forms of P from fields to streams throughout the year, testing each of our hypotheses. We will make use of Co-PIs David and Gentry's large monitoring network of tiles where we can put the geography, physics and chemistry of DRP loss into the overall context of how readily DRP is transported to tile systems. Our results will inform the Illinois Nutrient Loss Reduction Strategy that is now being implemented across the state, and help to both target and refine possible conservation practices to reduce DRP losses and improve the understanding of soil test P.

The impact of this research is clear, as it will show for tile-drained fields what are "expected" DRP losses in relation to soil test P, as well as the effects on corn/soybean yield. The potential beneficiaries of the project will first and foremost be the agricultural producers of Illinois, followed by all citizens of the state who will benefit from improved water quality. Through our field days, educational materials, and other outreach methods, we will communicate the science-based results summarized from across the state.

The primary beneficiaries of this work will be crop producers, who are in need of answers about sustainable P management systems, crop yields, and corresponding tile-drainage P losses. Agriculture professionals, including NRCS personnel, will gain knowledge about how to work with producers to optimize their use of P management systems while minimizing the environment impacts.

VII. Date of Initiation and Completion

We will initiate this project beginning January 1, 2016. We anticipate this will be at least a 4-year project, in order to be sure that we have a wide range in weather conditions and tile flow.

Our timetable is a follows:

	2016				**2017**				**2018**				**2019**			
Task	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F
Spatial distribution of terrain analysis		X	X	X												
Agronomic soil test, water sampling and analysis and tile flow measurements		X	X	X	X	X	X	X	X	X	X	X				
Infiltration and or hydraulic conductivity analysis						X	X	X		X	X	X				
Surface soil sampling and physicochemical analysis of surface soils							X	X	X	X						
Excavation of tile systems and subsurface soil sampling and analysis										X	X	X	X	X		
Write up reports and research papers									X				X	X	X	X
Presentation & talks at conferences/meetings w/ target audiences/field days								X			X	X	X	X	X	X

VIII. Project Budget Update for continuing project

There is no change in the budget.

Our budget for farms in or near the Embarras River watershed for 2016-2019 can be supported with the following funds. The inflation rate of 3% was applied to the salary and other direct costs excluding the permanent equipment cost.

PI Arai requests one month of summer salary in years 1-4, and Co-PI Fraterrigo requests three weeks of summer salary in year 1 and two weeks of summer salary in year 2.

We requested (a) two graduate students in year 1-2 and one graduate student in year 3-4 at 50%-RA support (11 months), (b) hourly undergraduate summer worker(s) ($11/hr) in years 1-4, (c) part-time laboratory technician for all project years, (d) funds for general laboratory supplies, (e) travel to the research site and national meetings, (f) farmers' payment.

The materials and supplies budget line includes the cost of two sets of double ring infiltometers in year 2 ($7500). Under the ongoing NREC project led by Dr. David, Lowell Gentry is supported as the overall farm manager of the same site. Therefore no salary is requested.

IX. Reports

Semi-annual reports will be submitted every 6 months, on June 1 and January 1 of each year, assuming an initial funding date of 1/1/2017 for each year of the project. Reports on findings will be produced annually, by January 15 of the year following completion of each year's work. The project final report, covering all years in the study, will be submitted within 3 months of the end of the project.

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Annual NREC Progress Report (March 2017-Jan 2018)

Yuji Arai, Mark David, Jennifer M. Fraterrigo, and Lowell Gentry
University of Illinois at Urbana-Champaign

We are making steady progress toward the project goal. We completed objective 1, nearly completed objective 2 and made a progress in objective 3&4 according to the timetable. The annual progress report is summarized below.

Synopsis

Phosphorus (P) loss from agricultural fields is a pervasive problem generally associated with overland runoff following extreme precipitation events. Phosphorus concentrations and loads are more than enough to lead to eutrophication and algal production in downstream water bodies. Without a crop yield response to P loss (i.e., importance of soil test P), economics alone will not solve this problem. Illinois has recently developed a nutrient loss reduction strategy that calls for 45% reductions in P from both point and non-point sources (Illinois Nutrient Loss Reduction Strategy, 2015). This will be a major challenge for Illinois, as well as other Midwestern states. Phosphorus loss has long been known to be transported primarily with sediment, although several researchers reported P loss (dominantly dissolved reactive P) via tile drainage (Gentry et al., 2007; Royer et al. 2006; Xue et al., 1998). This body of work has been acknowledged in a recent special issue in the Journal of Environmental Quality which recognizes that tile transport has been overlooked and is an important P transport pathway (King et al. 2015a; King et al, 2015b; Smith et al. 2015). However it is not known how and when DRP is released in tile flow in relation to the landscape surface topography, the subsurface networks of solute transport and the depth sequence of soil properties. Our proposed study will help to fill some of those gaps. This study will improve our understanding of DRP loss from surface soils to tile systems and from tile-drained fields and watersheds using detailed geostatistical analysis of terrains, monitoring of seasonal tile flow and DRP, soil physiochemical analysis of surface and subsurface soils including soil test P. Growers should be able to better interpret the variability of soil test P through the understanding of temporal and spatial variability of DRP in tile systems.

Objectives

The overall goal of this project is to evaluate physicochemical factors (e.g., soil test P, landscape topography, infiltration rate, and soil chemistry) influencing the seasonal distribution and movement of DRP in tile drainage systems. We will more fully understand the fate of DRP in relation to soil test P in current P management systems at long term tile-drained experimental fields in Illinois.

The objectives are to:

1. fully understand tile DRP losses in relation to soil test P (i.e., labile P in surface soils) for fields in east-central Illinois under typical corn and soybean production;

2. assess tile DRP losses in relation to spatial variability (i.e., fine scale topography) across fields and landscapes;
3. determine the relationship between land surface topography and tile DRP losses, examining soil physical properties (e.g., infiltration rate, hydraulic conductivity, soil P extraction relevant to soil test P);
4. examine the processes responsible for seasonal DRP release to tile lines, including physicochemical properties (e.g., depth sequence distribution of DRP and agronomic P soil test P) of subsurface soils; and
5. include a final report at the conclusion of this project that will address each of the objectives stated above and evaluate both the yield response and the tile losses of DRP/changes in soil test P.

Site Information:
Site information is updated in Table 1.

Table 1. Farms in east-central Illinois that currently have tile monitoring by our team, and will be used in this study.

	Tile # and type	Tillage	Cropping	Drainage area (Acres)	Soil sampling for STP and tile map availability
Salt Fork Watershed					
Farm 1	3 patterned fields	chisel	corn/soybean and corn/corn, one with cover crop	20-60	X
Farm 2	2 patterned fields	no-till (25+ years)	corn/soybean	25-55	X
Farm 3	3 random drainage fields	no-till and strip till	corn and soybean	40-60	X (limited to field measurements, not tile map)
Embarras Watershed					
Farm 4	2 patterned fields	chisel	seed corn/soybean	15 each	X
Farm 5	4 patterned fields	chisel	corn/soybean	20-250	X
Farm 6	1 patterned field	chisel	corn/soybean	50	X
Farm 7	1 patterned field	chisel	corn/soybean/wheat	12	X
Farm 8	6 patterned tiles	no-till and strip till	corn/soybean/wheat with cover crops	25-75	X
Lake Shelbyville Watershed					
Farm 9	36 tile laterals	no-till and strip till	corn/soybean	4-5	X

Objectives 1& 2: Progress in Jan 2017 –Jan 2018

As we reported in the last annual report, we assessed tile DRP losses in relation to spatial variability in Farm 9. We worked on the analysis of Soil Test P and establishing the relationship between landscape topography and tile lines for Farm 6 and 8. The following figure shows that correlation between the surface topography and P in lbs/acre in two farms. Except for Farm 8 East, there is a positive correlation between STP and the depression depth. We will complete the assessment of tile DRP losses in relation to spatial variability in Farm 6 and 8 this summer.

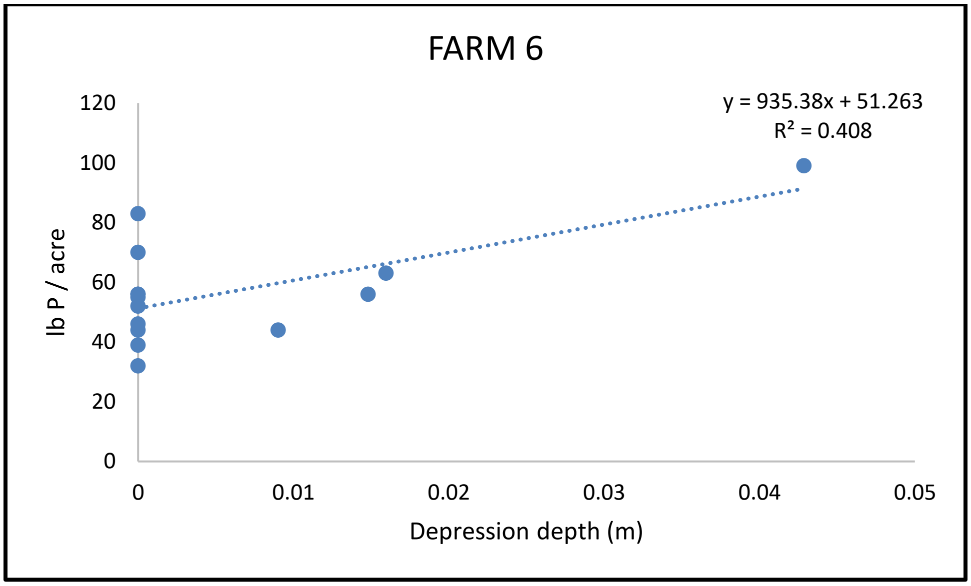

Figure 1: Relationship between depression depth and the results of soil test P in Farm 6.

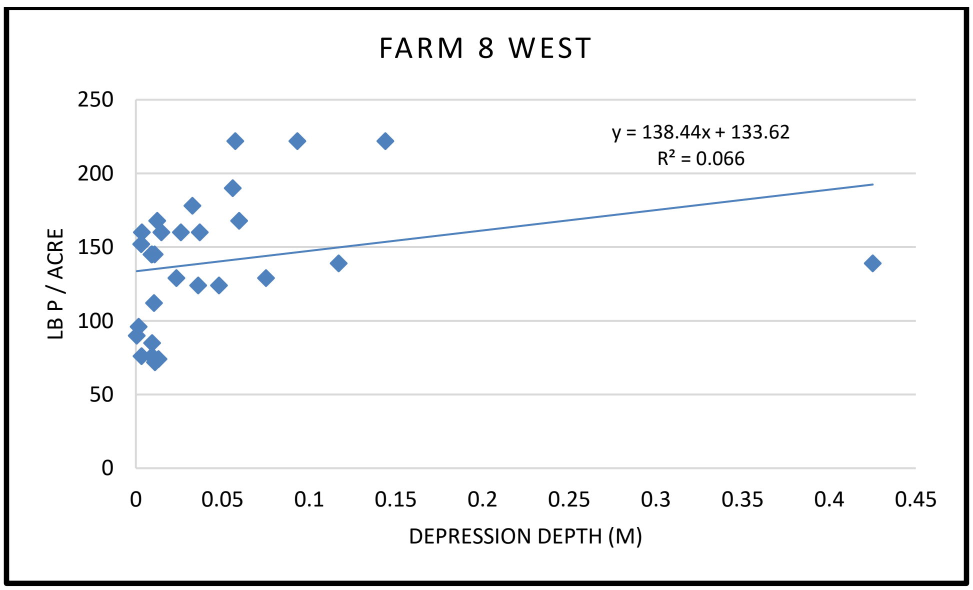

Figure 2: Relationship between depression depth and the results of soil test P in Farm 8 West.

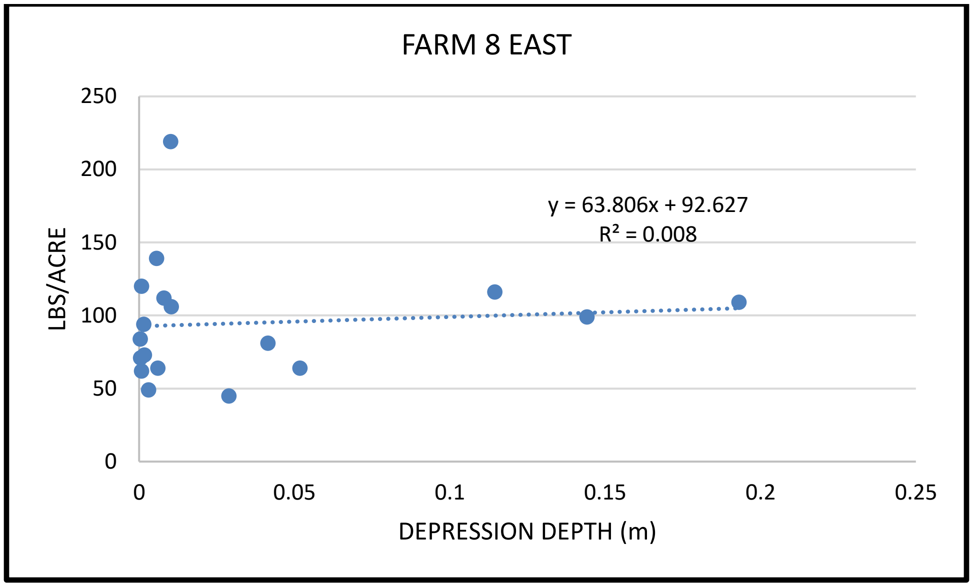

Figure 3: Relationship between depression depth and the results of soil test P in Farm 8 East.

We also conducted a detailed soil Bray P1 test (6 m grid) across the largest closed depression (near plot 4) in Farm 9/Douglas County. Piecewise regression revealed a critical threshold in the depression gradient at 0.38 m, at which soil P content abruptly shifted. Above this value, there was a strong positive association with soil P (R^2=0.91).

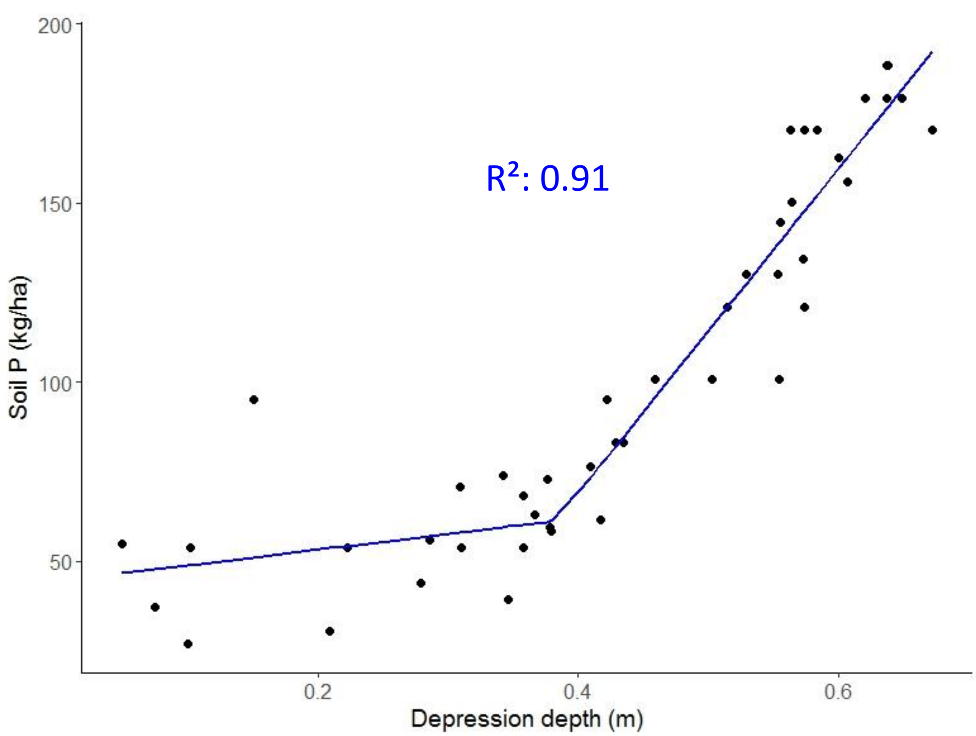

Figure 4: Piecewise linear regression between soil test P and depression depth in Farm 9.

Objective 2&3: Progress in Jan 2017-Jan 2018

The objective 2 is to assess tile DRP losses in relation to spatial variability (i.e., fine scale topography) across fields and landscapes. After assessing the surface topography of farms that we originally proposed, we chose Farm 9 and 8 west for the assessment of tile DRP and the depression index.

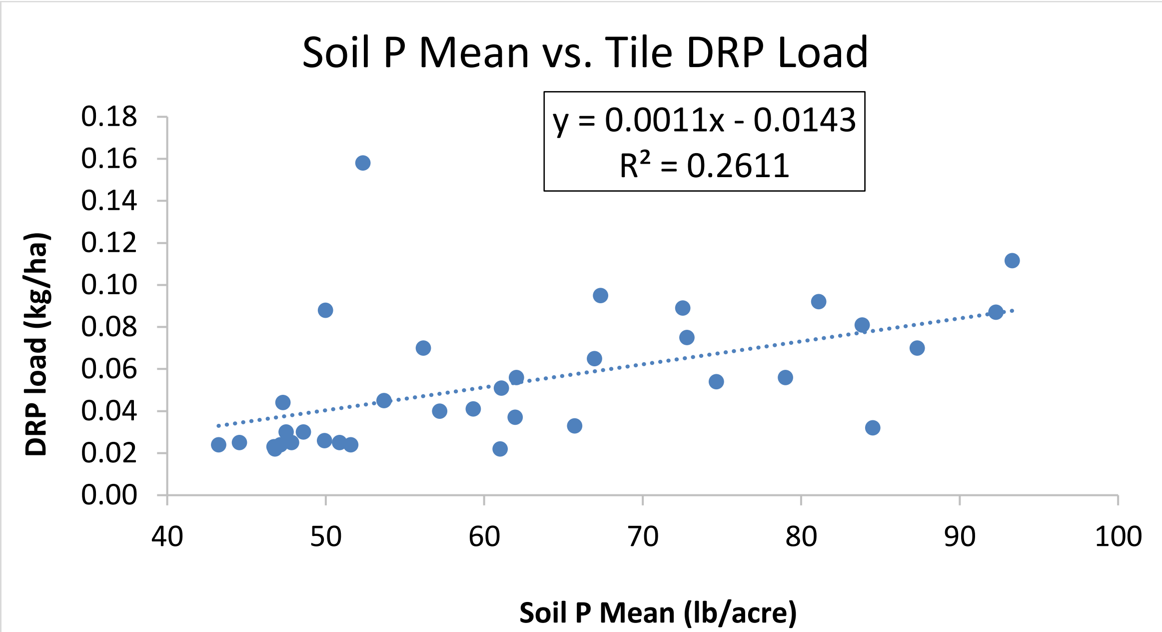

Figure 5. Regression of soil Bray P1 interpolated mean values and tile DRP load in 2016 for 36 tile laterals from Farm 9.

The R^2 value suggests there is a positive relationship between soil P and tile DRP load (Figure 5).

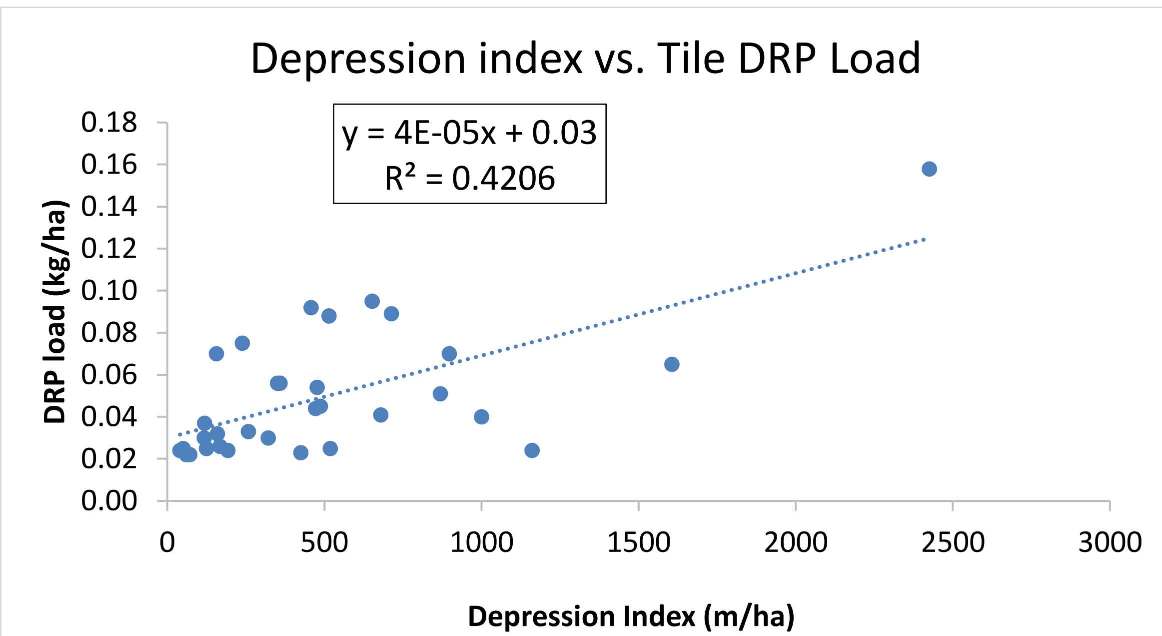

Figure 6. Regression of depression index values and tile DRP load in 2016 for 36 tile laterals from Farm 9.

The R^2 value suggests there is a positive relationship between depression index and tile DRP load, however, tile #4 (2425 m/ha; 0.158 kg/ha) is influencing the relationship (Figure 6).

For Farm8, we obtained the DRP data for the west part of the farm 8, which was the first one to be monitored. Preliminary flow data that do not account for by-pass flow in the AgriDrain structure of the woodchip bioreactors were used to estimate tile DRP yields and depression index/soil test P.

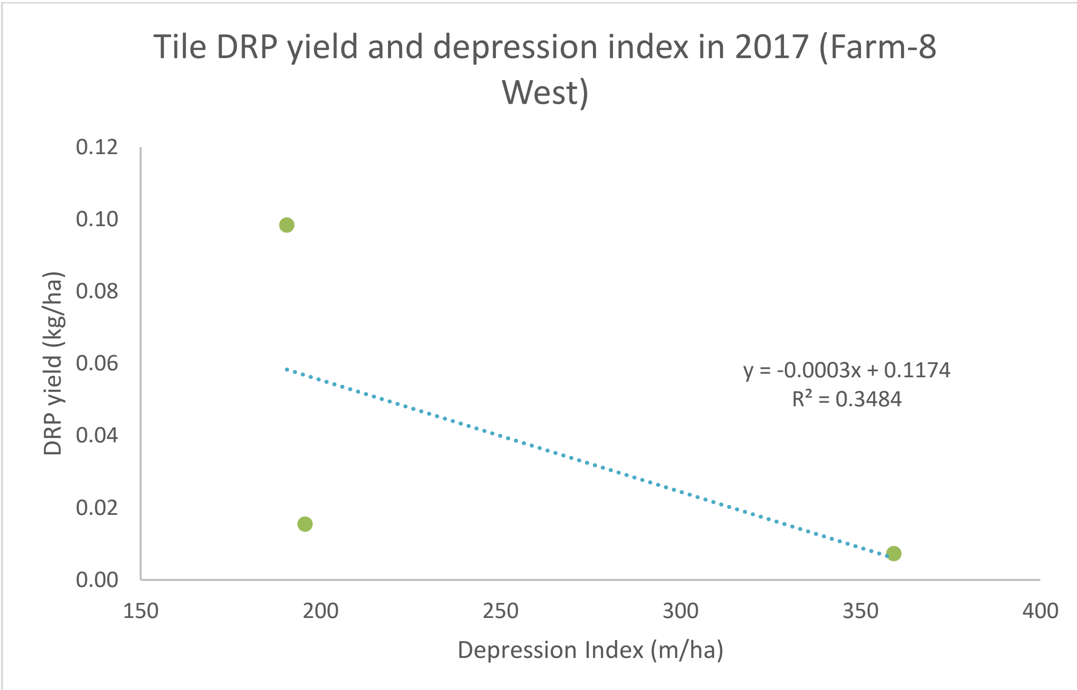

Figure 7. Regression of depression index values and tile DRP load in 2017 from Farm 8 west.

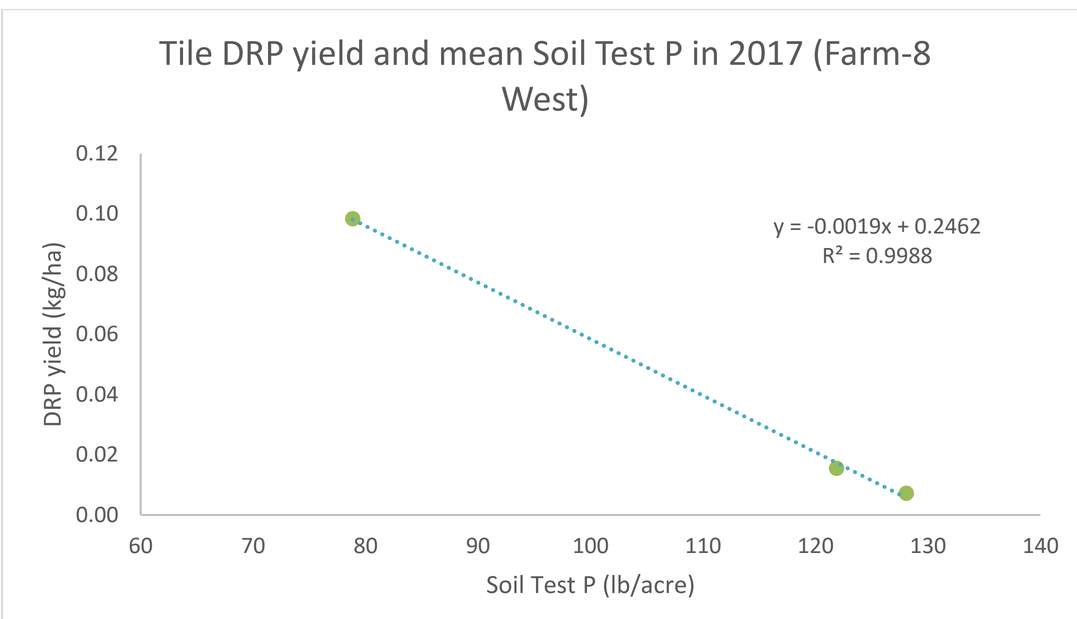

Figure 8. Regression of soil Bray P1 interpolated mean values and tile DRP load in 2017 from Farm 8 west.

While we observed correlation between tile DRP and depression index in Farm 9, we do not see any clear correlation between tile DRP and depression index in Farm 8 (Figure 7&8). The reason might be attributed to the acreage covered per tile line is much larger in Farm 8 than that in Farm 9. In Farm 8, various soil physicochemical management factors (till vs no-till) might be influencing the tile DRP loads.

Objectives 3&4: Progress in Jan 2017 –Jan 2018

We examine the saturated hydraulic conductivity at the soil test P sampling locations in Farm 9 and 8 west. The measurements of saturated hydraulic conductivity (Ksat) we completed in March 2017 for Farm 9 and in Nov 2017 for Farm 8. Ninety nine STP sampling points in Farm 9 were used for comparison with Ksat. We hypothesized the accumulation of P in the soil over time will disperse soil colloids (Rolfe, et al., 1991), resulting in low saturated hydraulic conductivity. The Ksat measurements in two fields (previously corn and soybean were grown) are shown in Figures 9 and 11.

In the field with tile #4-#27 where soybean was grown in the preivous year, average Ksat is 4.68E-03 cm/s (Figure 9). At the majority of sites, Ksat was greater than 0.002 cm/s (Figure 4).There is no correlation between STP and Ksat (Figure 10), suggesting that observed P accumulation was not affecting the drainage as the result of P induced colloidal dispersion.

On the contrary, the average Ksat of the area (tile #28-48) is significantly lower, 8.78E-04 cm/s, than that in the soybean field (Figure 11). Although the data are variable (at only few locations), Ksat at most of sites are less than 0.002cm/s. We did not observe any correlation between STP and Ksat (Figure 12).

The difference in Ksat values might be attributed to the soil structure as affected by the type of crops. In general, soil on which soybeans have been grown is generally observed more lose and friable comparing to corn (Martin,1949; Smith, 1947). It was reported that the canopy afforded by the broadleaf soybean plants after several weeks of growth was effective in preventing the compaction of soils. Decomposition of soybean nodules is known to facilitate the aggregation of soil particles. It was also noted that frequent wetting and drying conditions in the soybean roots zone induces aggregation. This is because the root system of soybean is less extensive than that of corn at the effective roots zone, but the concentration of soybean roots is greater than that of corn at the surface. Because of the dense root system of soybean and the large water requirement of soybean, soybean fields tend to undergo an extensive wet-dry cycle at the surface. These factors are known to contribute to an increase in aggregation.

After the harvest season, we completed the rest of the hydraulic conductivity measurements in Farm 8. We chose Farm 8 East because of a similar crop rotation in Farm 9. Farm 8 West was not chosen due to a different crop management to Farm 9. Having an additional evidence of crop specific Ksat will help us argue the research findings. Interestingly, we observed no crop specific trend of Ksat. The average Ksat values in the soybean and corn fields showed 0.00317±0.0008 cm/s and 0.0065±0.0007, respectively. Unlike in the no-till system in Farm 9, The conventional seemed to make the soil surface more uniform, resulting in no-crop specific Ksat.

We will repeat the Ksat measurements in Farm 9 to test the hypothesis that crop specific roots system is driving the macropore structure in soils in soybean system.

We collected 6 soil cores in Farm 9 (in 1 feet increment up to 6 feet) near tile lines and away from tile lines. Soil samples are currently grind and preparing for the physicochemical measurements (e.g., soil pH, soil test P, P fractionation).

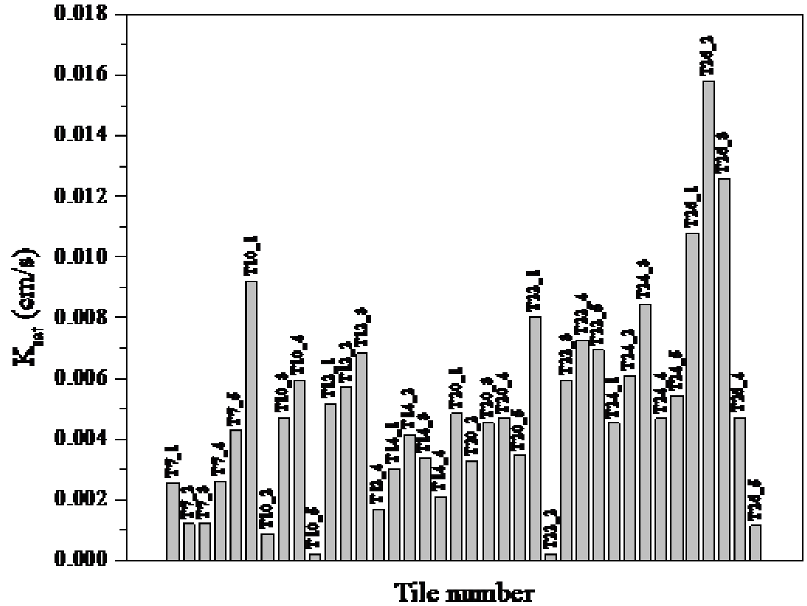

Figure 9: The results of saturated hydraulic conductivity measurement in Tile #4-27 where soybean was grown in the previous year.

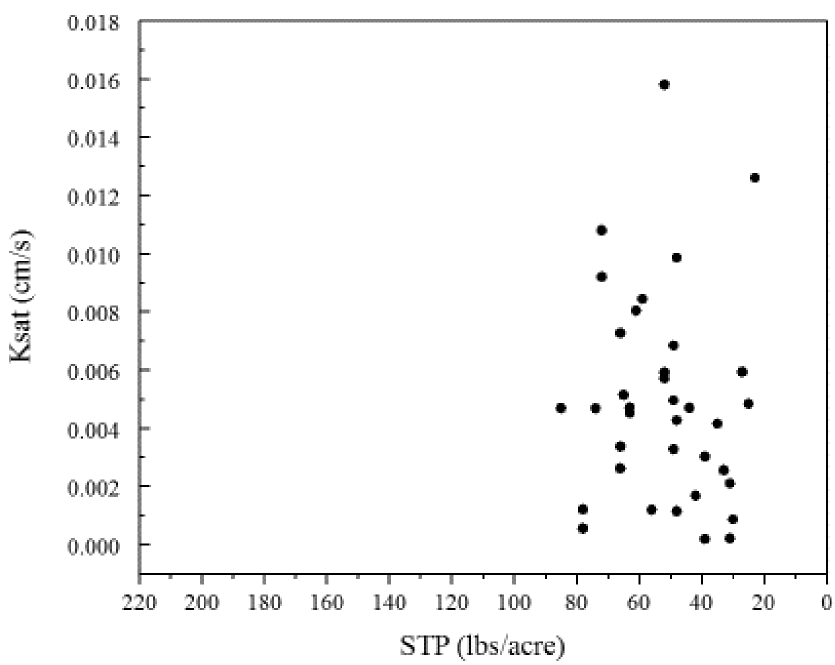

Figure 10: Correlation between STP and Ksat in Tiles #4- 27 where soybean was grown in the previous year.

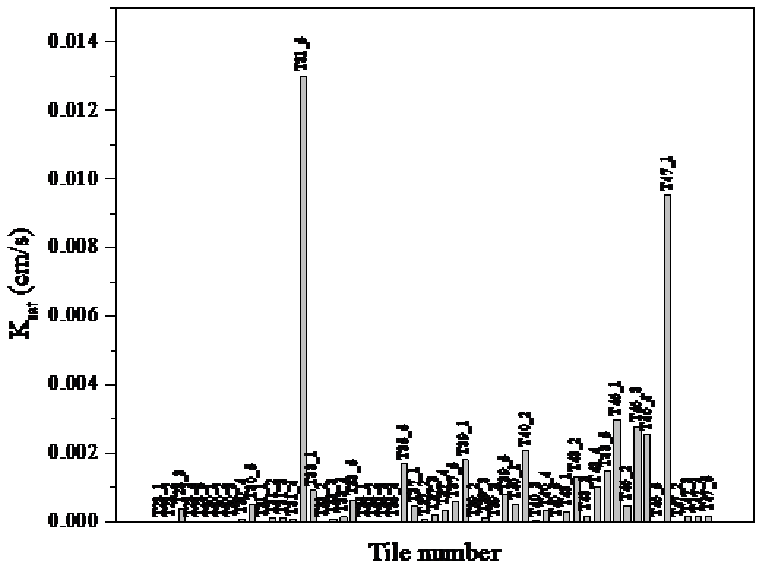

Figure 11: The results of saturated hydraulic conductivity measurement in Tile #28-Tile 48 where corn was grown in the previous year.

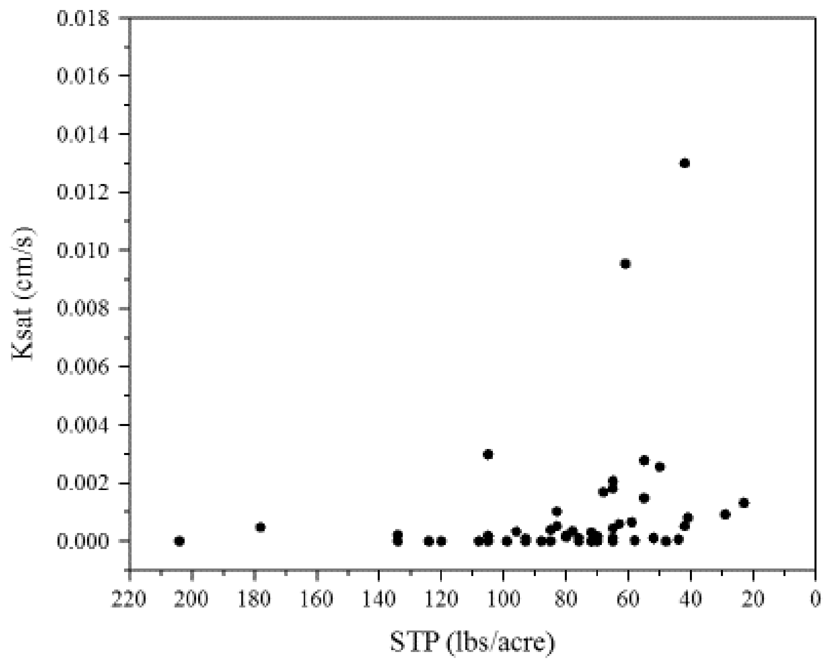

Figure 12: Correlation between STP and Ksat in Tile #4-27 where soybean was grown in the previous year.

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Highlights

- Depression depth is positively related to soil test P in the no-till system.
- There is a correlation between the tile DRP and the depression index if the structure of tile line covers the area correspond to depressions.
- Saturated hydraulic conductivity values were not positively correlated with soil test P values/depressions.
- Saturated hydraulic conductivity in no-till system might be influenced by the crop-root soil structure specific soil structure between soybean and corn in the no-till systems.

Current and future work in 2018:

Evaluation of tile DRP losses in relation to soil test P (i.e., labile P in surface soils) in selected fields will be completed. The topographic characterization of the fields and landscapes and the development of their representative metrics will be completed this summer/fall. We will be collecting the additional saturated hydraulic conductivity measurements in Farm 9 this spring. We are in the process of characterizing the physicochemical properties of soil core samples to understand the depth sequence P distribution.