

**Farmer/Farm Advisor
Water Quality Sampling Network**

Final Report R/LUP-1-BOR

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Greg LaBarge
Ohio State University Extension
Professor
Field Specialist, Agronomic Systems



THE OHIO STATE UNIVERSITY

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AND ENVIRONMENTAL SCIENCES

Final Report

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Summary

Sampling of water leaving field sites, either at the end of tile or with a drainage water management structure with Dissolved Gradient Thinfilm (DGT) samplers were done by volunteer farmers during the September to December 2015, 2016 and March to July 2016, 2017. For the project 209 farmer participated monitoring 329 fields. The DGT samplers were bench tested and calibrated to continuously monitored field sites in the WLEB. The sampler results when compared to continuously monitored sites either over or under estimated P concentration depending upon the weather conditions in the monitored periods. The data provides an overall trend but does not provide a reliable calculated estimated concentration. Soil samples were taken and compared to sites that were monitored throughout the 4 sampling periods. The only variable that explained P concentration was soil test P level. The trendline indicates a general relationship of higher soil values leading to higher concentrations of P estimated in the tile outflow but much variation was seen. This is a similar observation to other studies making a comparison of soil test and measured water concentrations of P (Duncan, 2017). Soil test provides a measure of risk but other site factors such as soil type, distance from water, and tillage will contribute to the overall field risk of P losses.

Project Objectives

- Initiate a farmer/farm advisor water quality sampling network in Western Lake Erie Basin (WLEB) to collect field specific water samples, soil samples and management data.
- Data from this project will be collected with a criterion that compliments data resulting from the highly instrumented edge of field collection sites in the Western Lake Erie Basin (WLEB) Watershed.
- Data generated will be made available to a variety of projects.
- Data generated will also be used to inform the agricultural community and other interested citizens on the quantification of risk factors leading to non-point source nutrient loss focused on phosphorus.

Results

Farmer Participation in a Farmer Sampling Network

A project website was established at <https://agcrops.osu.edu/FarmerPhosphorusWaterQualityMonitoringProject>. Recruiting of farmers for the project occurred through mass media, Ohio State University Extension Newsletters and other media. Farmers or landowners wishing to participate voluntarily provided contact information and field descriptions. Samplers were distributed to participants prior to the sampling period. The participants placed the samplers in tile or water management structures for 30 day periods. Participants were instructed to change the samplers on a monthly basis and stored new or previously deployed samplers in the refrigerator when not in the field.

Participating farmers were from Williams, Fulton, Lucas, Auglaize, VanWert, Henry, Seneca, Putnam, Huron, Ottawa, Defiance, Wood, Sandusky, Hancock and Mercer. Number of farmer, fields monitored and acres monitored for each sampling period are summarized in Table 1.

Table 1. Farmer Participation by Sample Period.

	Fall 2015	Spring 2016	Fall 2016	Spring 2017
Farmers	40	61	60	48
Fields	51	101	95	82
Acres Monitored	2003	3437	3205	2787

Diffuse Gradient Thinfilm (DGT) Passive Samplers

Precision plastic DGT devices accumulate dissolved substances in a controlled way when deployed in water or soil. Devices can be used for measuring trace metals, phosphate, sulphide and radionuclides. In freshwaters and seawaters deployment, they measure average concentration over a time period. In soil and sediment they can measure both fluxes and concentration.

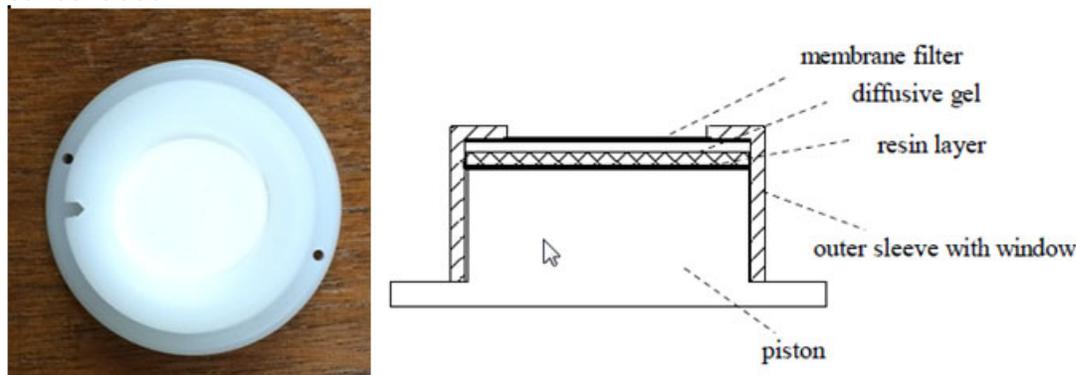


Figure 1. Actual device showing plastic body with filter size of 2.5 cm or 1 inch (Left). Drawing showing device components (Right).

DGT was invented in Lancaster by Bill Davison and Hao Zhang. The patent filed by Lancaster University in 1993 is granted throughout the World. The device base is loaded with a resin gel, diffusive gel and filter. The device being used in the Farmer Phosphorus Water Quality Monitoring Project is using a Fe-oxide gel for monitoring dissolved phosphorus. The devices were deployed in tile outlets or Drainage Water Management structures. The monitors are stored in plastic sleeves prior to deployment and once collect returned to plastic bags to prevent drying out. When not in the field the devices were stored in a refrigerator.

The sampling procedure for the Farmer Phosphorus Water Quality Monitoring Project uses a three month spring and three month fall deployment schedule during what are generally the highest rainfall periods. The spring sampling period is March through June in 2016 and 2017. The fall sampling period is September to December in 2015 and 2016. Edge of field monitoring indicates that 90% of the phosphorus leaving through tile is in the soluble form thus monitors that measure this form of P should be a general indicator of losses.

Calibration Studies DGT

Bench Calibration

A lab bench study against known solution concentration was completed to evaluate the samplers, extraction methods and calculations. Table 2 shows bench results where the DGT samplers were exposed to known solution concentrations of 0.5 and 1.0 PPM soluble P. The solution of 0.5 PPM P was comparable to the calculated value of 0.49 PPM. The 1.0 PPM P was comparable to the recovered value of 0.88 PPM.

Table 2. Bench calibration results. (Source: Dayton & Whitacre, 2017)

Solution Concentration P PPM	Digest Concentration mg/L	Mass conversion Mg P	Calculated P Concentration PPM
0.5	0.0338	0.000177	0.49
1.0	0.0605	0.000311	0.88

Field Calibration

To provide a field calibration, the DGT samplers were used at sites where tile were being monitored using ISCO samplers monitored tile flow on a continuous basis and determinations of nutrient concentration are made using laboratory analysis of water collected during flow events. Phosphorus recoveries during matching deployed time intervals for the DGT samplers and measured values from the same time period of the continuous sampling were compared. Two periods were sampled. The fall 2015 period is shown in Figure 2 and the Spring 2017 is shown in Figure 3.

General observations from the comparison period are:

Fall 2015 the samplers underestimated the P concentration when compared to the continuous monitoring. The samplers when dried out likely changed the adsorption characteristics. Note the general precipitation conditions that were dry until mid-December (Table 8).

Spring 2017 the samplers overestimated the P concentration (Figure 3). This period was generally the wettest of all periods sampled (Table 8). Many of the collected samplers had the presence of sediment on the filter which may have been an influence on the extracted P mass. Likewise the farmer deployed samplers were in a similar condition at collection.

No adjustments have been made to the estimated P concentration values contained in this report. The results are being presented as measured. The user should keep in mind the variations in results between the DGT sampler and continuous monitoring with laboratory determination of P.

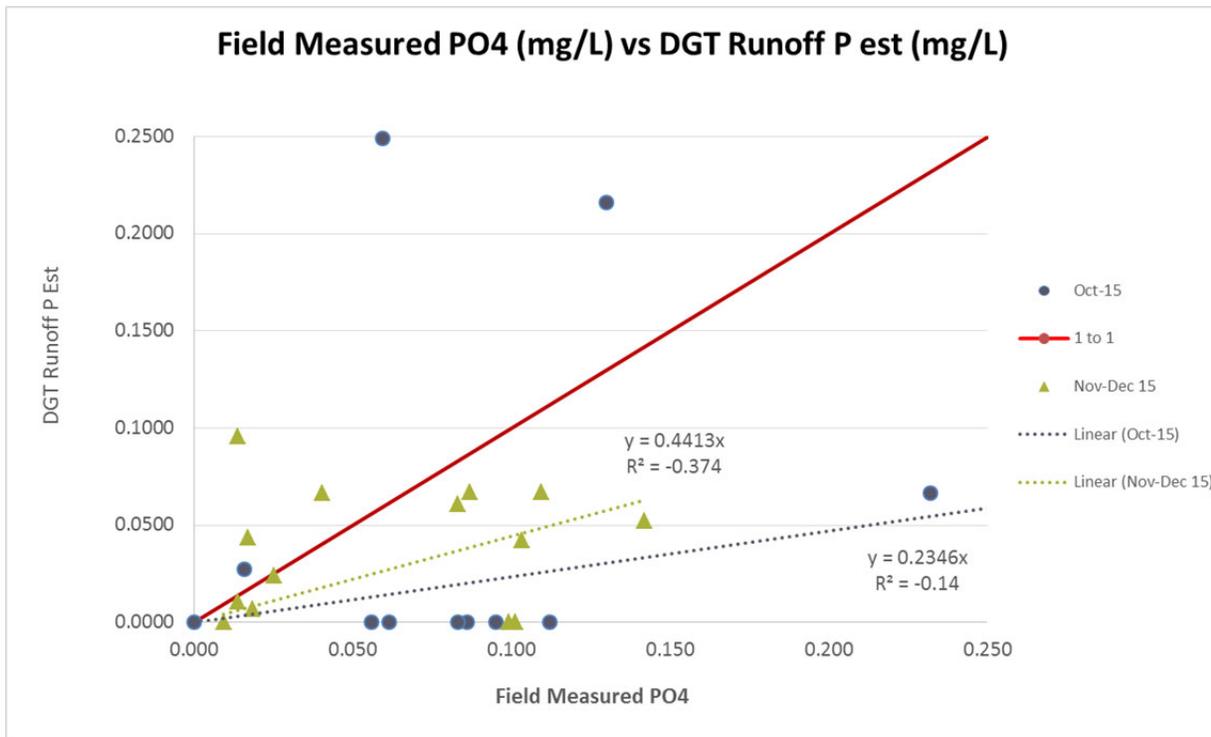


Figure 2. Comparison of concentration data derive for analysis of ISCO sampler collected samples and DGT devices for 28 site periods, Fall 2015. (Source: King, 2017)

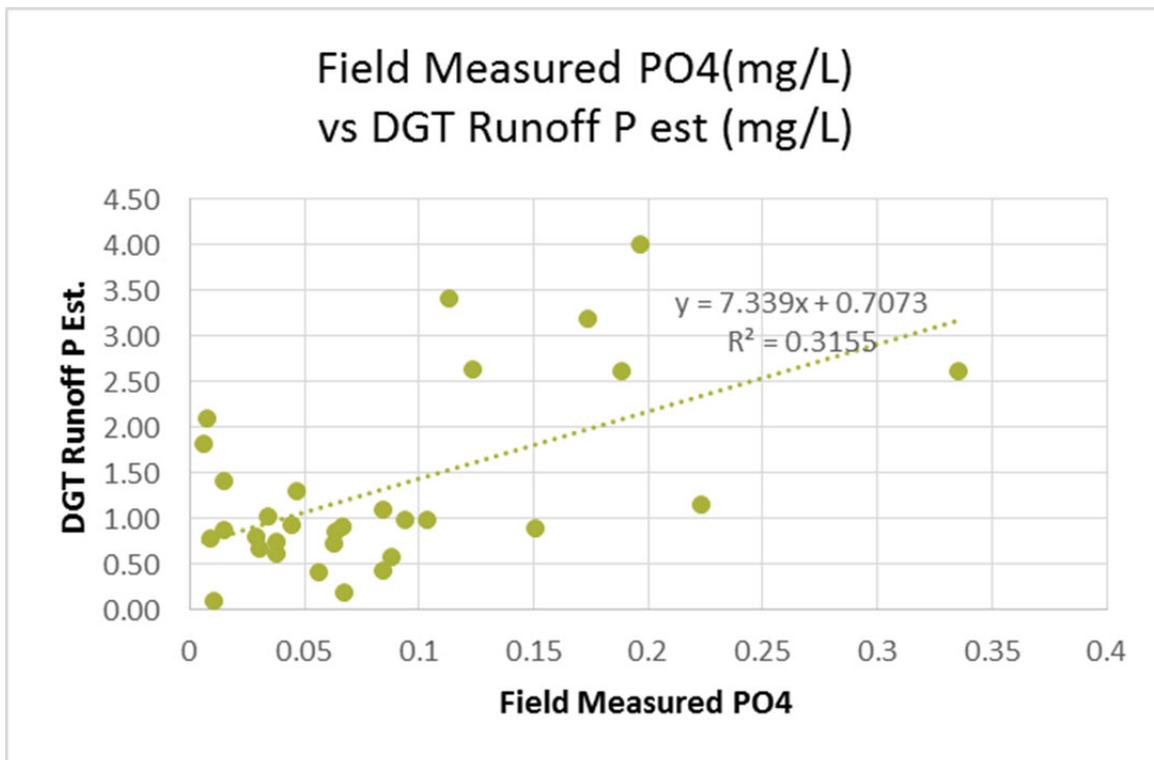


Figure 3. Comparison of concentration data derived from analysis of ISCO collected samples with laboratory analysis and DGT devices for 31 site periods, Spring 2017. (Source: King, 2017)

Field Estimated Concentrations of P

The DGT Estimated Tile concentrations of P for the sample periods are provided in Tables 3 to 5 with a frequency distribution of estimated concentrations provided in Figure 4 to 6 for the Fall 2015, Spring 2016 and Spring 2017.

The Fall 2015 period averaged 0.06 PPM Est P Concentration for the entire sampling period. Table 3 highlights the individual sampling period results. Fall 2015 rainfall was very scattered and with dry weather proceeding the sampling period. September and October rains general would have restored soil water and the December rains produced the most consistent tile flows. The OARDC Northwest Ag Research Station weather site was used as a representative site for rainfall in the region (Table 8).

The Spring 2016 averaged 0.12 PPM Est P Concentration for the entire sampling period (Table 4). The period weather was wet early then rainfall events through the most of the sampling period (Table 8). The majority of the samplers had estimated concentration values of less than 0.5 PPM (Figure 5).

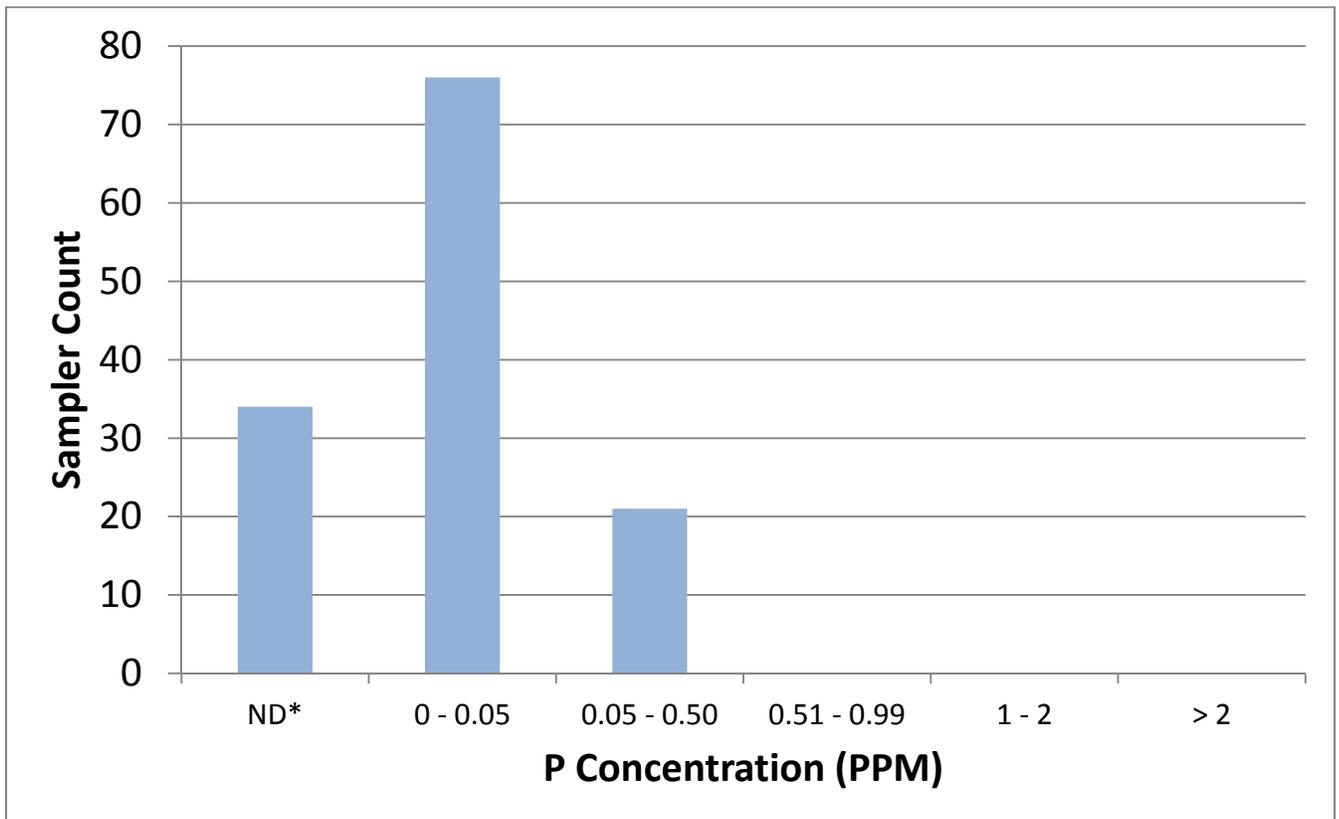
The Spring 2017 averaged 0.87 PPM Est P Concentration for the entire sampling period (Table 5). The period weather was dry early then higher rainfall during May-July that hampered spring field activities. The field calibration of the samplers showed an over estimate of P concentration.

The Fall 2016 period is not included due to a dispute between the laboratory providing analysis and The Ohio State University. There is an ongoing attempt to resolve this dispute and attain the period sample results.

Table 3. Fall 2015, Summary of Sample Period Water Results.

Sample Period Fall 2015					
Period Number (General Month)	Average Number of Days in Field	Range Number of Days in Field	Average Est. P Concentratio n (PPM)	Standard Deviation (PPM)	Highest Detectable Est. P Concentration (PPM)
1 (October)	36	7-103	0.05	0.08	0.38
2 (November)	28	20-35	0.03	0.04	0.16
3 (December)	25	14-39	0.04	0.06	0.26
Total (Oct-Dec)	73	25-151	0.04	0.06	0.38

Figure 4. Fall 2015, Distribution of Sampler Concentration Values (Total Samplers=131).

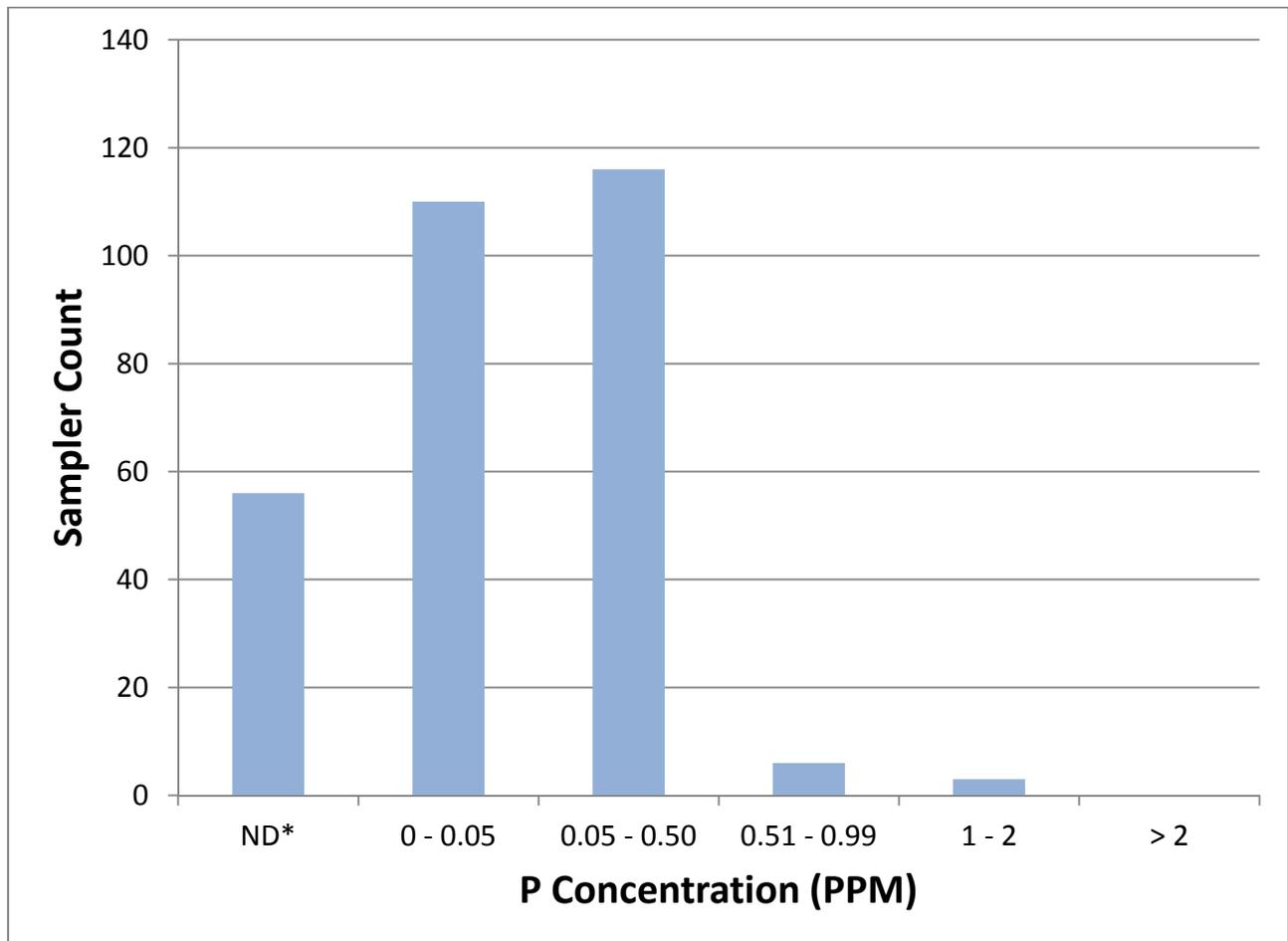


*ND=Non-Detectable/Non-Determined-Due to the condition of the sampler at time of analysis a concentration could not be determined

Table 4. Spring 2016, Summary of Sample Period Water Results.

Sample Period		Spring 2016			
Period Number (General Month)	Average Number of Days in Field	Range Number of Days in Field	Average Est. P Concentrati on (PPM)	Standard Deviation (PPM)	Highest Detectable Est. P Concentration (PPM)
1 (April)	32	5-78	0.12	0.16	1.09
2 (May)	32	19-65	0.11	0.16	1.07
3 (June)	30	7-64	1.07	0.20	1.22
Total (Apr-Jun)	86	30-116	0.12	0.12	0.55

Figure 5. Spring 2016, Distribution of Sampler Concentration Values (Total Samplers =291)

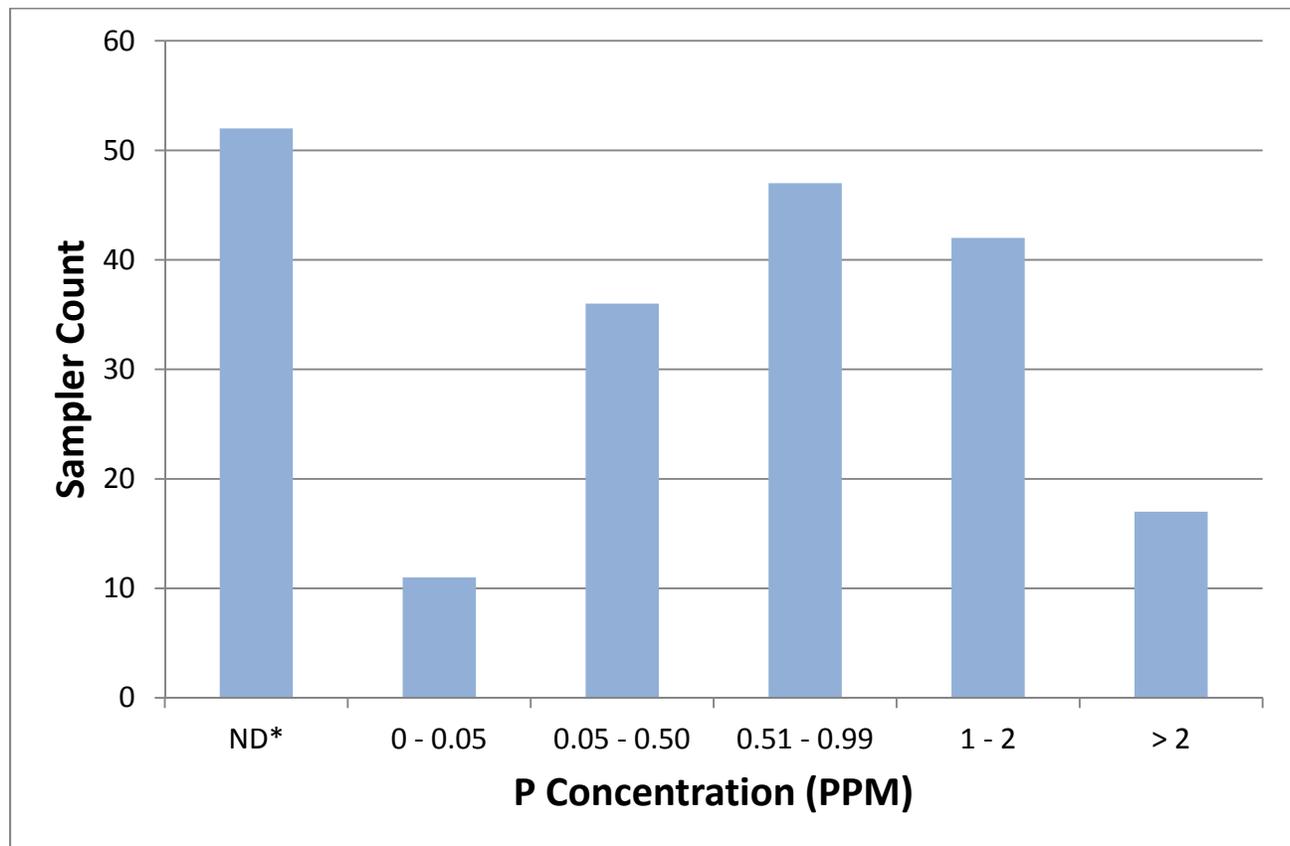


*ND=Non-Detectable/Non-Determined-Due to the condition of the sampler at time of analysis a concentration could not be determined

Table 5. Spring 2017, Summary of Sample Period Water Results.

Sample Period Spring 2017					
Period Number (General Month)	Average Number of Days in Field	Range Number of Days in Field	Average Est. P Concentration (PPM)	Standard Deviation (PPM)	Highest Detectable Est. P Concentration (PPM)
1 (May)	25	11-43	1.24	1.27	7.71
2 (June)	32	1-58	0.94	0.68	3.11
3 (July)	29	15-36	0.83	0.68	2.68
Total (May-Jul)	74	1-95	0.87	0.72	4.19

Figure 6. Spring 2017, Distribution of Sampler Concentration Values (Total Samplers= 205).



*ND=Non-Detectable/Non-Determined-Due to the condition of the sampler at time of analysis a concentration could not be determined

Soil test

Soil samples were collect at 68 sites in May/June 2017. The sites for which soil samples were collect participated in 3 to 4 of the sampling periods. The soils were analyzed for parameters commonly used in soil nutrient recommendation development plus Permanganate-oxidizable C and two common soil pathogens of soybean.

Collection methods for soil test analysis and permanganate-oxidizable C were a total of 10-1 inch cores from each site. The cores were mixed and two subsamples prepared. One subsample was sent for chemical analysis using standard soil testing procedures by Brookside Labs, New Bremen OH. The second sample was sent to Dr Steve Culman, The Ohio State University for permanganate-oxidizable C determination. For soybean pathogen analysis a two pound sample of soil was taken with a shovel 5 inches deep with a 1 inch slice at 5 locations in the field bulked and a 5 pound sample transported to the labs of Dr Anne Dorrance, The Ohio State University.

Chemical soil test

Soil test provide the foundation for nutrient management and can be used as an indicator test for environmental losses that are source based. The ultimate contribution of a site is source factors represented by the soil test combined with transport factors such as rainfall, connectivity to water, intensity of drainage and natural site factors.

Summary of key chemical soil test parameters is provided in Table 6 below. The parameter fall into a range generally seen in other summaries of soil test for phosphorus with 13% less than critical (15 PPM Bray P1), 72% in the maintenance range (15-50 PPM Bray P1) and 15% above the economic fertilizer recommended value (>50 PPM Bray P1). The average cation exchange capacity of 17 meq/100 g of soil would be representative of a medium textured soil. The average pH of 6.6 falls into the range recommended for row crop production.

Table 6. Summary of Key Soil Test Parameters (n=66).

Parameter (Test)	Average	Standard Deviation	Range
Phosphorus (Bray P1)	41	43	4 - 244
Cation Exchange Capacity (meq/100 g)	17	4	9 - 27
Potassium (Mehlich 3)	176	53	96 - 381
Organic Matter (%)	3.6	0.9	2.1 - 7.3
pH	6.6	0.5	5.5 - 7.7

Permanganate-oxidizable C (POXC)

Permanganate-oxidizable C (POXC) is a measure of active carbon and may provide one measure of soil health. One study (Hurisso, et.al., 2016) found POXC reflected practices that promote organic matter accumulation or stabilization and therefore can be a useful indicator of long-term soil C sequestration. The Comprehensive Assessment of Soil Health (CASH) measure 15 physical, biological and chemical parameters of soil is provided by Cornell University. The POXC test is used in the CASH package as the measure of soil active carbon.

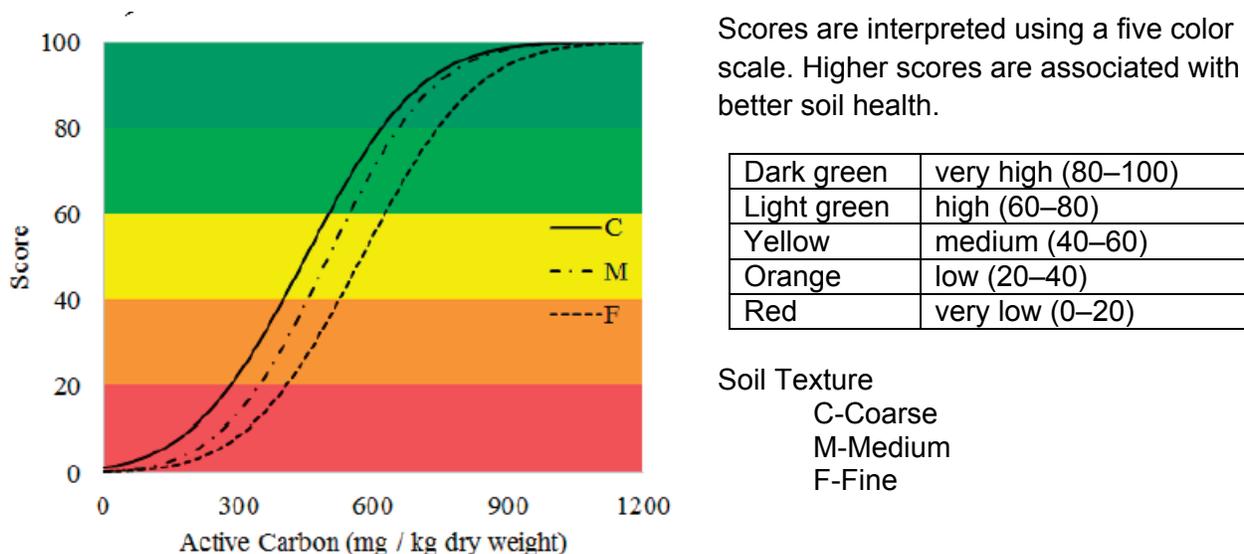
Figure 7 defines the classification of active carbon provided in that tool for soil textures of C-Coarse, M-Medium and F-Fine. (Fine, 2017)

Summary of Permanganate-oxidizable C (POXC) parameters is provided in Table 7 below. Based on a medium textured soil the average of 507 mg C/kg soil falls into the middle of medium score zone for the parameter in CASH.

Table 7. Summary of Permanganate-oxidizable C (POXC). (n=62)

Parameter	Average	Standard Deviation	Range
Permanganate-oxidizable C (POXC) (mg C/kg soil)	507	115	317-1031

Figure 7. Interpretation for Permanganate-oxidizable C (mgC/kg soil) from Comprehensive Assessment of Soil Health (Fine, 2017).



Estimated P concentration tile compared to soil test parameters

Soil test P values were compared to the estimated P concentration measured in the tile for each sampling period with results shown in Figures 8 to 10. The trendline indicates a general relationship of higher soil values leading to higher concentrations of P estimated in the tile outflow but much variation seen. This is a similar observation seen in other comparisons of soil test and measured water concentrations of P (Duncan, 2017). Soil test provides a measure of risk but other site factors such as soil type, distance from water, and tillage will contribute to the overall field risk of P losses.

Other comparisons of estimated P concentration were made with soil pH and organic matter but there was no observable trend. The estimated P concentration was also compared to the POXC results but no observed trend was seen.

Figure 8. Fall 2015 period comparison of Soil Test Phosphorus levels to estimated P concentration (PPM) in tile flow.

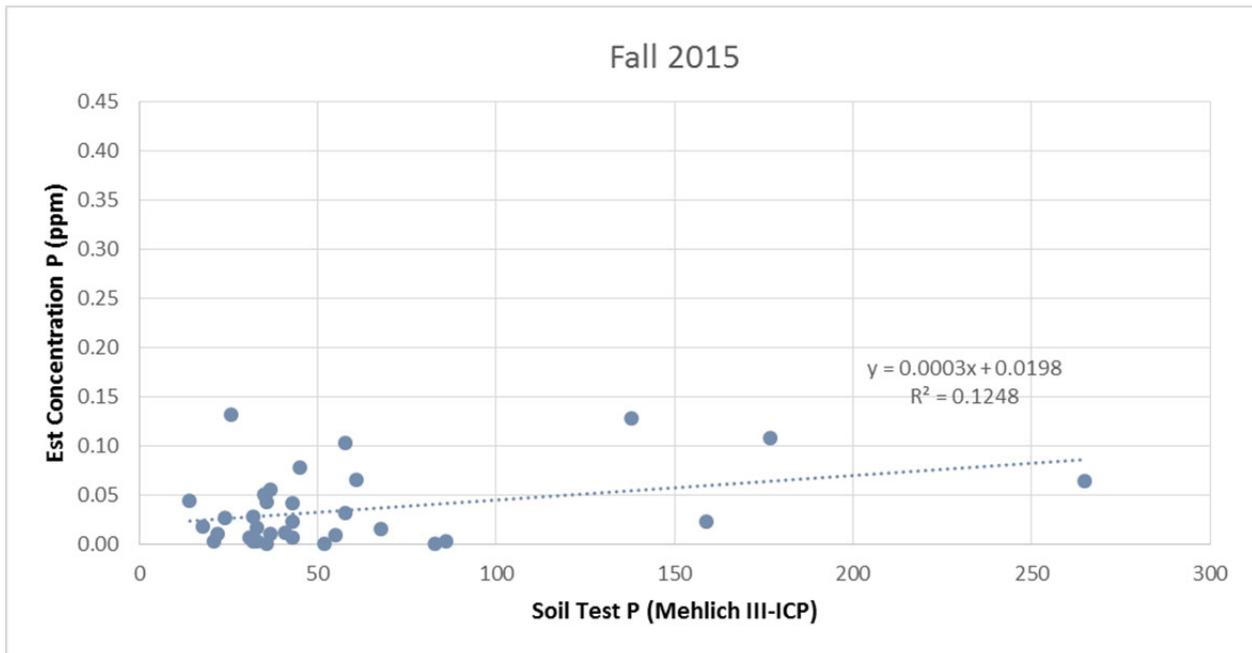


Figure 9. Spring 2016 period comparison of Soil Test Phosphorus levels to estimated P concentration (PPM) in tile flow.

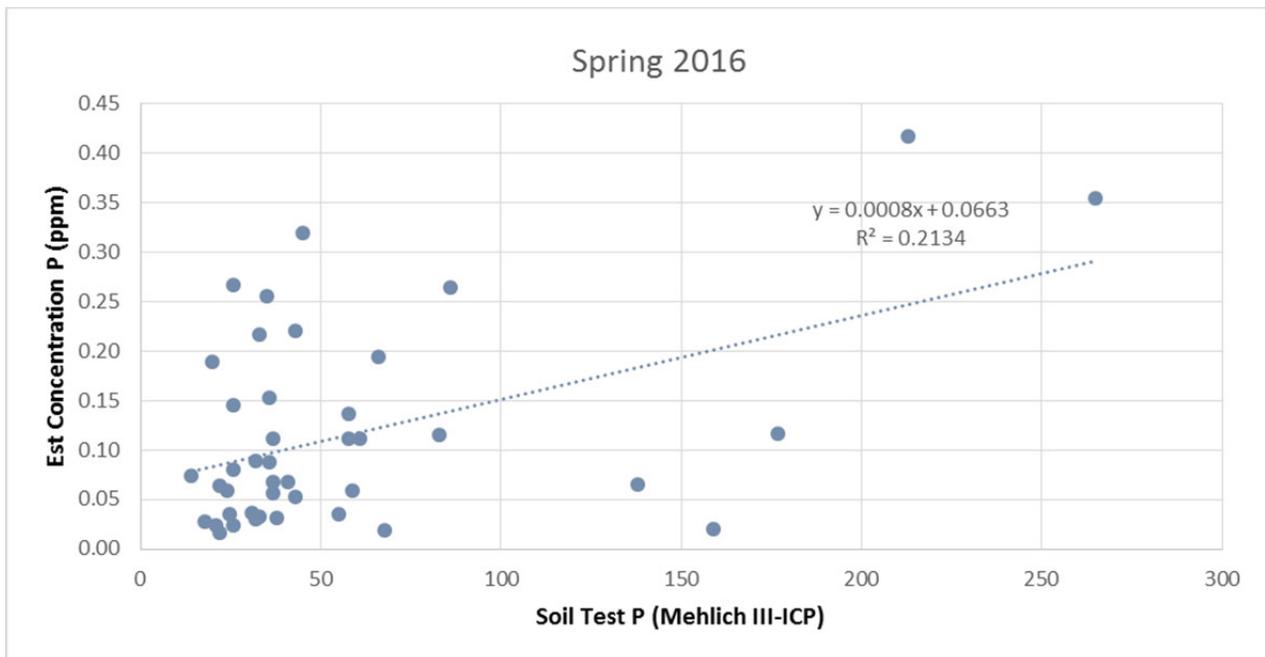


Figure 10. Spring 2017 period Soil Test Phosphorus levels compared to estimated P concentration (PPM) in tile.

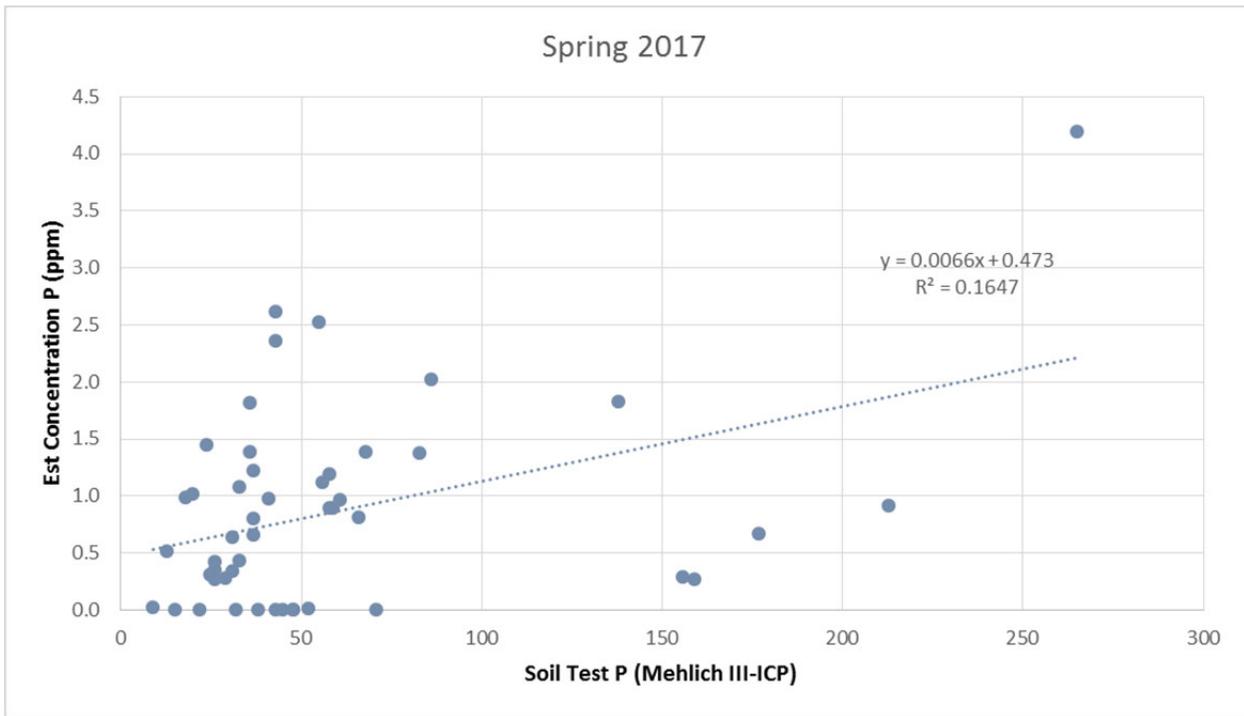
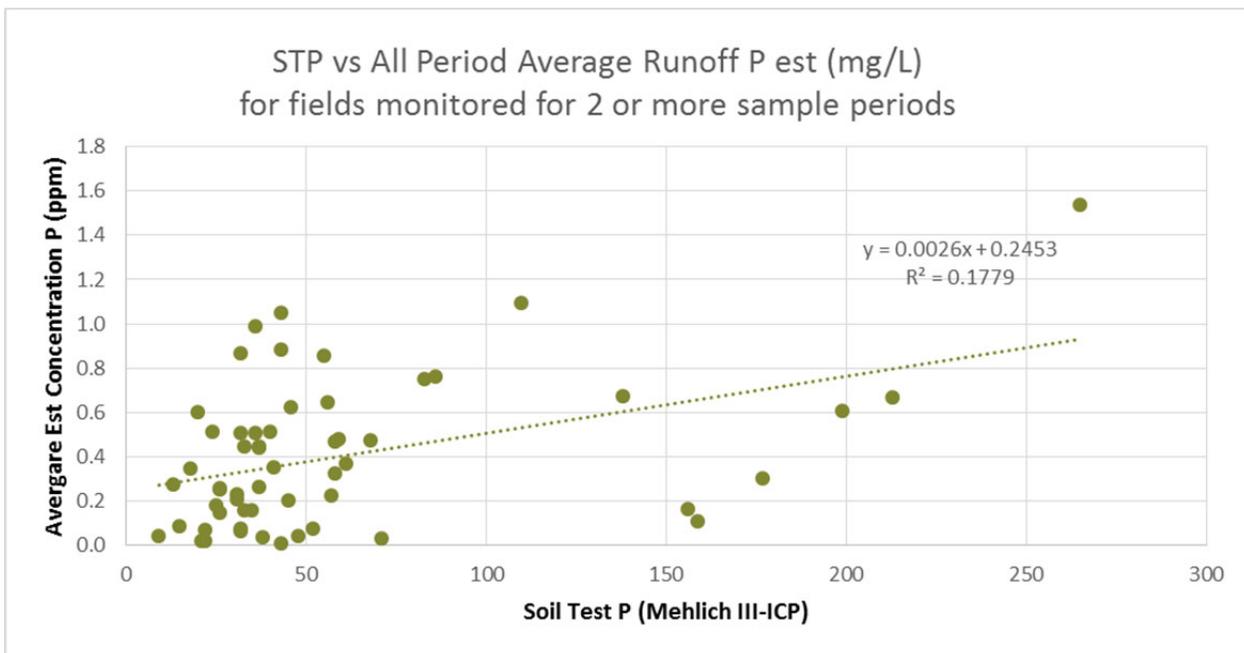


Figure 11. Comparison of Soil Test Phosphorus levels to average estimated P concentrations in tile flow for fields that were sampled for 2 or 3 project periods.



Rainfall during Sampling Periods

To provide a perspective of rainfall that occurred during the sampling periods, rainfall data was obtained for the OARDC Ag Research station located near Custar, OH. This site provides a general idea of rainfall patterns.

Table 8. Monthly Rainfall Totals (in inches) during project sampling periods. Location is OARDC Northwest Ag Station at 41.2847, -83.8444.

Month	Fall 2015	Spring 2016	Fall 2016	Spring 2017
March		3.94		1.97
April		3.33		2.79
May		2.17		5.23
June		2.94		5.12
July		1.58		5.91
September	1.44		4.04	
October	1.98		2.09	
November	1.18		1.66	
December	3.13		1.46	
Period Total	7.73	13.96	9.25	21.02

Acknowledgements

This work would not be possible without the cooperation of the participating farmers who went out monthly to change the samplers out and handled the samplers to preserve the sample integrity. The interest to commit that time to this voluntary project is commendable. Thanks to the local OSU Extension Office that served as a collection and distribution point for samplers. Also thanks to the Williams and Seneca County SWCD office for their assistance in this project.

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