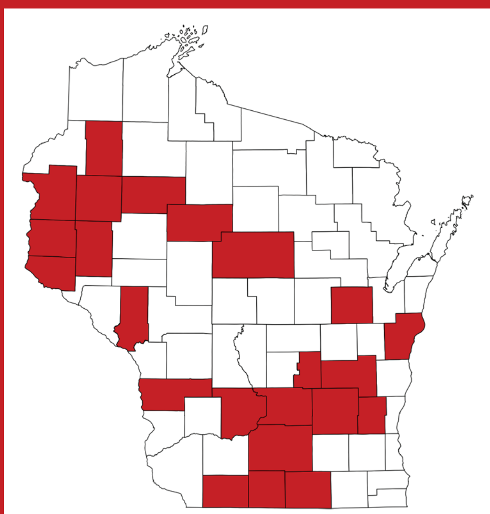
SOIL TEST PHOSPHORUS SURVEY 2023

Map: 2023 Statewide Soil Test Phosphorus Project - 23 counties, 58 farms, 156 fields



Extension
UNIVERSITY OF WISCONSIN–MADISON

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Assessing Water Quality Risk
through soil sampling

Mission and Methods

Extension's Agriculture Water Quality Program sought on-farm data to improve understanding on how soil health practices impact surface soil phosphorus levels. A trade-off of reduced tillage systems are surface applications of fertility. The goal of this soil and management survey data is to explore how high surface concentrations are in order to assess risk, and to find if there are systems that are mitigating high surface concentrations even when phosphorus is routinely surface applied.

Interested farmers chose up to 3 fields to be sampled in the fall before fertility applications. Fields of interest included those utilizing soil health practices for varied lengths of time. Soil samples were taken from 5 acre portions of fields at 0-6 inch depth, cores were split into 0-2" and 2-6" segments and composited into two samples submitted for routine analysis.

Phosphorus Build Up and Soil Test Phosphorus (STP)

The long history of animal agriculture and manure application in Wisconsin has led to an excess of phosphorus in soils. More phosphorus has been added through manure or fertilizer than removed by crops which makes the excess susceptible to being lost through soil erosion and runoff. Phosphorus, essential for crops, also contributes to aquatic degradation and is a finite resource, making it crucial agriculturally, environmentally, and economically.

Figure 1. Soil sampling to measure STP in Northern Wisconsin

Soils contain 200-6,000 lbs/ac of phosphorus, but about 90% is unavailable to plants, being tied up in organic matter or bound to soil particles. Only phosphorus in soil solution is accessible to plants. (Sturgul et al., 2004) Phosphorus becomes available through mineralization and chemical reactions, influenced by temperature, moisture, and soil binding properties. Additions of manure, fertilizer, and crop residue can increase phosphorus levels, raising the risk of phosphorus loss to water if binding sites are saturated.

Stratification: Yield and Water Quality Impacts

Stratification of nutrients occurs naturally in both agricultural and natural systems. For instance, due to the concentration of plant roots, residue and weather, soils tend to have higher organic matter content closer to the soil surface. However surface level fertility can be exacerbated by management practices like no-till or surface-applying fertility that concentrate nutrients at the soil surface. There is currently no research evidence to show nutrient stratification within the top 6 inches has any impact on yield in high fertility settings. Common annual crops like soybeans and corn have shallow roots that can readily access these nutrients. Increased yields in long term no-till systems after surface mixing (tillage) are likely a result of fixing compaction, or increased organic matter decomposition, rather than phosphorus or potassium relocation.

Phosphorus concentrated at the soil surface indicates a higher risk for water quality, as it impacts both phosphorus loss pathways, particulate phosphorus loss (soil erosion) and dissolved phosphorus loss (runoff). Soil at the surface with high fertility is moved during soil erosion events and interacts the most with runoff water that carries dissolved phosphorus even if no soil is moved.

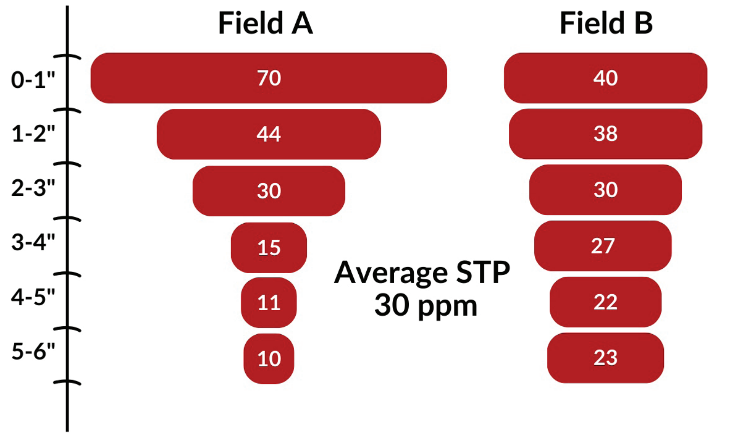


Figure 2. Soil Test Phosphorus (STP) levels (ppm) varies with depth. Soil samples are typically taken to a 6-inch depth for agronomic nutrient management. However, this can mask nutrient variations with depth, potentially affecting water quality risk assessments.

Sampling at a shallower depth is recommended for long-term no-till fields to address decreasing pH from nitrogen fertilizers. This helps identify and manage the riskiest fields. The "zone of interaction," where water, soil, and organic materials interact, especially during freeze-thaw cycles, is linked to surface phosphorus loss. Managing surface fertility levels reduces phosphorus loss and retains vital nutrients and organic matter on crop fields.

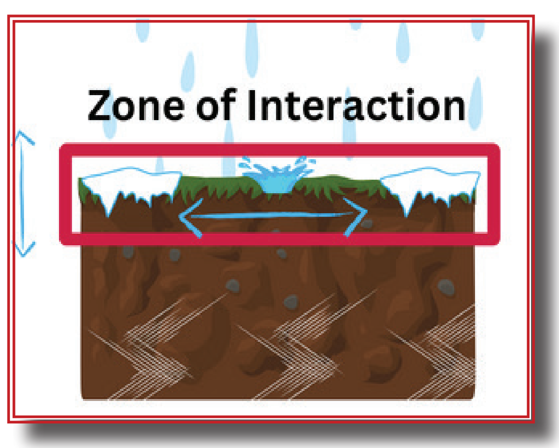
Soil test phosphorus is an agronomic measurement to estimate plant available phosphorus for the growing season. It is typically only 10% of the soils' total phosphorus and is impacted by microbial activity, moisture and temperature.

STP has been correlated with crop response in fields across the state for years. Fields with excessively high STP values have <2% chance of a yield response to additional P. (Laboski et al., 2012)

Managing Water Quality

Phosphorus concentrated at the soil surface impacts water quality due to its interaction with runoff. To reduce this risk, assess STP values in the **"zone of interaction."** This depth varies with precipitation, soil type, and other factors, but 0-2 inches is a good starting point and easy to sample. **Sampling from 0-6 inches may miss fields that qualify as a water quality risk. If 0-2 inch samples exceed 80 ppm, prioritize drawing down STP as these fields are at increased risk of losing dissolved phosphorus to water.** (Zopp et al., 2019)

Figure 3. The "zone of interaction," where water, soil, and organic materials interact during freeze-thaw cycles, is linked to winter phosphorus loss when STP levels are high.



Your Results

Your Soil Test Values

Field 1 = no-till & no covers		
	0-2 in	**0-6 in**
Phosphorus (P)	56 ppm	32.5 ppm
Potassium (K)	188 ppm	135.5 ppm
pH	5	5.6
Organic Matter (OM)	2.9%	2.3 %
Field 2 = no-till & multi-species cover crop		
Phosphorus (P)	74 ppm	44.2 ppm
Potassium (K)	243 ppm	173.5 ppm
pH	5.1	5.6
Organic Matter (OM)	2.5 %	2.0 %
Field 3 = no-till & cereal rye cover		
Phosphorus (P)	76 ppm	47.7 ppm
Potassium (K)	238 ppm	185.4 ppm
pH	5.2	5.6
Organic Matter (OM)	2.7 %	2.1 %

Table 1. Your STP measurements from soil samples taken in fall of 2023

UW Recommendations

Soil Test Category					
	Very low (VL)	**Low (L)**	**Optimum (O)**	**High (H)**	**Excessively High (EH)**
Soil Group	---------------------------Soil Test P ppm-----------------------------				
Demand level 1: corn grain, soybean, clover, small grains (but no wheat), grasses, oilseed crops, pasture					
Loamy	<10	10-15	16-20	21-30	>30
Sandy, Organic	<12	12-22	23-32	33-42	>42
Demand level 2: alfalfa, corn silage, wheat, beans, sweet corn, peas, fruits					
Loamy	<12	12-17	18-25	26-35	>35
Sandy, Organic	<18	18-25	26-37	38-55	>55

Table 2. Soil Test P interpretation categories based on soil samples 0-6". Laboski et al., Nutrient Application Guidelines for field, vegetable, and fruit crops in Wisconsin pg. 53

Your Results

Your Soil Test Values

Field 4 = conventional till & cereal rye cover		
	0-2 in	**0-6 in**
Phosphorus (P)	50 ppm	33.8 ppm
Potassium (K)	224 ppm	143.9 ppm
pH	5	5.4
Organic Matter (OM)	2.4 %	2.2 %
Field 5 = coventional till & no covers		
Phosphorus (P)	55 ppm	33.5 ppm
Potassium (K)	222 ppm	147.1 ppm
pH	5.3	5.7
Organic Matter (OM)	2.5 %	2.2 %
Phosphorus (P)		
Potassium (K)		
pH		
Organic Matter (OM)		

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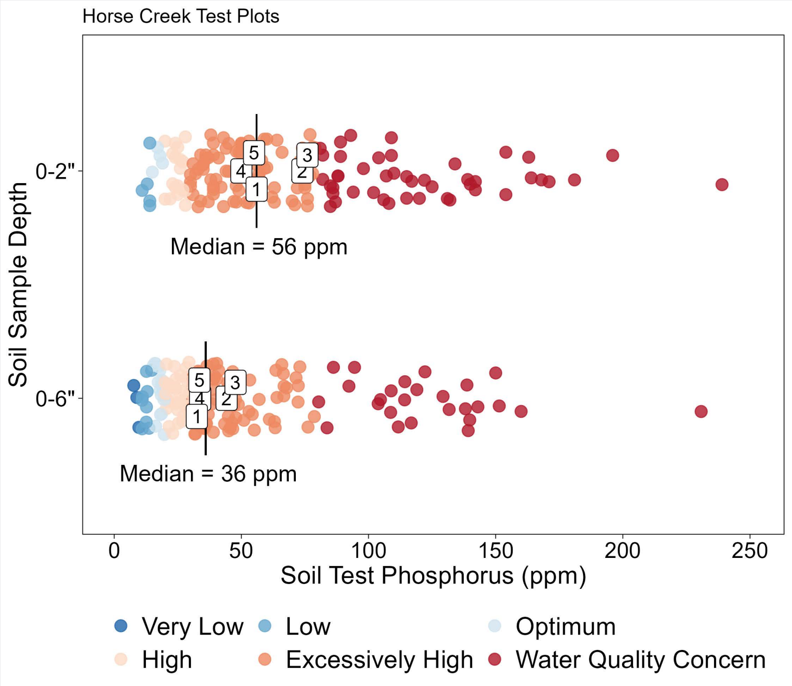

Your results summary:

We plotted all STP values for fields included in our 2023 soil sampling. Points at the top of the figure correspond to 0–2-inch soil samples, and points at the bottom are the 0–6-inch samples. The points are color-coded based on soil test categories. The red data points indicated STP greater than 80 ppm, which is a water quality concern. We have labeled the median or middle values using a vertical black line. The STP results from your fields are plotted over top of the group data using white boxes labeled with the field ID number.

Phosphorus Drawdown Strategies

Soil test phosphorus (STP) builds up from overapplication, and reducing this excess takes much longer than nitrogen or herbicides due to soil's buffering capacity. A typical corn crop removes only 3-5 ppm of soil P annually, making it a slow process to lower soil phosphorus levels (Laboski et al., 2012). During this time, phosphorus is prone to environmental loss. Soil's ability to bind phosphorus has made it a major source of phosphorus after years of overapplication. Reducing STP economically minimizes water quality risks without sacrificing yield.

Due to Wisconsin soils' strong buffering capacity, reducing STP takes years. When phosphorus is removed, more is released from soil particulate pools to maintain equilibrium. Consistent drawdown strategies are crucial for reducing STP and water quality risks. This should be done alongside erosion control practices like cover crops and grass waterways to address particulate phosphorus loss. Lowering soil phosphorus will impact dissolved phosphorus losses, which are harder to control with other conservation practices.

Drawdown strategies include:

- Reduce or eliminate phosphorus inputs on high-risk fields (STP >80 ppm), as yield response is unlikely (<2%) based on data from 0–6" soil samples.
- Increase phosphorus removal by harvesting overwintering cover crops close to planting to maintain soil erosion benefits.
- Place fertility below the surface (e.g., manure injecting or banding) while minimizing disturbance if maintenance applications are necessary.

Resources:

1. Laboski C. M. & Peters J. P., (2012). Nutrient Applications Guidelines for Field Vegetable, and Fruit Crops in WI, https://learningstore. extension.wisc.edu/products/nutrient-application-guidelines-for-field-vegetable-and-fruit-crops-in-wisconsin-p185?_pos=1&_ sid=636613ba5&_ss=r
2. Sturgul S. J. & Bundy L. G., (2004). Understanding Soil Phosphorus, https://ipcm.wisc.edu/wp-content/uploads/sites/54/2022/11/UnderstandingSoilP04.pdf
3. Zopp Z. P., Ruark M. D., Thompson A. M., Stuntebeck T. D., Cooley E., Radatz A. M., Radatz T., (2019). Effects of Manure and Tillage on Edge-of-Field Phosphorus Loss in Seasonalls Frozen Landscapes, *Journal of Environmental Quality, 48*(4), 966-977.

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