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The State of the Science Report is published periodically to provide an update on Ohio and national water quality research and emerging issues. The August edition explores soil phosphorus management strategies. An overview of the three commonly used phosphorus loss assessment approaches are provided.

Soil Phosphorus Management Strategies

Agronomic vs. Environmental Thresholds vs. Phosphorus Index

Soil Phosphorus Management

The long-term use of fertilizers and manures has increased the soil phosphorus levels of many agricultural fields up to and at times past the level required for optimum crop production. The goal of this past fertilizer management recommendation was to remove the supply of available soil phosphorus as a limitation to agricultural production. The recommendations provided to farmers to achieve this goal did not consider environmental consequences of phosphorus loss from soil to water. Farmers used soil test results, land grant university recommendations and economics (cost for fertilizer verses expected crop yield response) to determine when to stop nutrient applications. The challenge faced today is that soil phosphorus levels considered optimum for crop production may provide environmentally significant amounts of dissolved and sediment phosphorus in surface runoff, erosion and subsurface flow.

Phosphorus Loss Assessment

Phosphorus, an essential element for crop and livestock production, can lead to water quality impairments due to excessive algal growth. There have been three phosphorus loss assessment strategies used that address agricultural phosphorus:

1. The agronomic approach which limits phosphorus applications to rates recommended by soil test based fertilizer recommendations

2. The phosphorus threshold approach which identifies a soil test phosphorus level where the risk of phosphorus loss to water resources increases beyond desired levels
3. The indexing approach which ranks site vulnerability to phosphorus loss by accounting for source (soil test, fertilizer, manure) and transport factors (erosion, runoff, leaching, proximity to surface water).

Agronomic Approach vs. Environmental Threshold

Soil phosphorus tests were developed to determine the amount of plant available phosphorus in soil. Using this value, farmers determine how much additional phosphorus (from fertilizer or manure) should be added to meet realistic crop yield goals. The environmental concerns over agricultural soil phosphorus levels and its impact on water quality has led to recommendations on phosphorus applications and watershed management based on the potential for phosphorus loss due to agricultural runoff. The challenge is identifying the point when soil test phosphorus becomes high enough to result in elevated levels of phosphorus in agricultural runoff.

Many studies have documented a relationship between the soil test phosphorus content and the concentration of dissolved phosphorus in runoff. As soil test phosphorus values increase, the potential for offsite movement of dissolved phosphorus also increases. While soil test phosphorus is an important and quantifiable parameter that influences the concentration of dissolved phosphorus in runoff, it should not be the sole indicator of potential dissolved phosphorus loss. Because soil test phosphorus values are available, they have frequently been incorrectly used in environmental risk assessments. In addition to soil test phosphorus, one must also include an estimate of the runoff or erosion potential for the site in question while evaluating environmental risk.

Soil test results utilized for environmental purposes must be interpreted carefully. The categories and values given on a soil test report were established based on an expected response of a crop to phosphorus. One cannot assume a direct relationship between a soil test value that has been calibrated for crop response to phosphorus and runoff enrichment potential. In other words, one cannot accurately project that a soil phosphorus test value that is above an expected crop response level will be polluting.

Agronomic-based soil tests can play a role in the environmental management of soil phosphorus but are only the beginning of a more comprehensive approach. Several studies have found that soil test phosphorus levels are related to the release of phosphorus into the soil solution. Plots of soil test phosphorus against soil solution phosphorus have shown the existence of a two-part relationship and change point (threshold). Soils with soil test phosphorus values above the threshold release phosphorus into the soil solution at a higher rate than do soils with soil test values below the threshold. For several soils from the United States, the threshold occurred in 120-190 mg/kg Mehlich-3 P range (84-133 mg/kg Bray-1 P). These results point to a potential environmental threshold for phosphorus soil test values.

Environmental soil phosphorus thresholds are similar to agronomic limits in that they evaluate the potential for phosphorus loss in runoff based on a single parameter, soil test phosphorus. The assumption is that there is a soil test phosphorus threshold, different from the agronomic limit for crop response, where the soil test phosphorus level leads to a greater potential for phosphorus loss in runoff.

Phosphorus Index

Of the three approaches, the phosphorus index has been the most widely adopted to target phosphorus management. A phosphorus index is an assessment tool used to identify agricultural fields most vulnerable to phosphorus loss by accounting for major source and transport factors controlling phosphorus movement.

A wealth of scientific evidence is available documenting that, (in addition to soil test phosphorus, phosphorus application rate, timing, and method) erosion, runoff and drainage influence field phosphorus loss. As a result, phosphorus indices are viewed as a superior tool for identifying fields with a high potential for phosphorus loss.

It is recognized today that not all areas of the landscape contribute equally to phosphorus losses and that the majority of losses come from a small area in most watersheds and result from only a few storm events. For phosphorus losses to occur there must a source and a mechanism to transport it to surface water. Preventing phosphorus loss should concentrate on defining, targeting and remediating fields or portions of fields that combine both an elevated soil phosphorus level (source) with high overland flow and erosion potentials (transport).

Current nutrient management planning seeks to identify critical source areas of phosphorus loss. Critical areas can be single fields within a watershed or portions of a field that are disproportionately responsible for phosphorus export. The phosphorus index developed as a tool to rank the vulnerability of fields as sources of phosphorus loss in overland flow.

On-Field Ohio!

The Ohio State University, College of Food, Agricultural, and Environmental Sciences is in the final stages of development of a phosphorus index field-level evaluation tool to manage phosphorus runoff loss while maintaining agricultural production and protecting water quality. The tool called “On-Field Ohio!” will be an online, interactive program that provides long-term average estimates for erosion and phosphorus runoff. Users will be able to evaluate how voluntary changes to their management practices contribute to achieving target phosphorus runoff reduction goals.

On-Field Ohio! (OFO) is intended to provide a long-term average estimate of field-scale erosion and phosphorus runoff risk based on field properties (i.e. soil type, soil test phosphorus, slope steepness) and farmer practices (i.e. crop management, tillage and nutrient management). This allows farmers to prioritize time and resources to make effective management decisions. The output will provide information regarding the amount and source of erosion and phosphorus loss.

The user will have the ability to evaluate erosion and phosphorus loss outcomes by comparing alternative crop management scenarios. Comparing alternative outputs will illustrate how voluntary changes in practices can contribute to meeting water quality targets while maintaining agricultural production.

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