DEVELOPMENT AND VALIDATION OF THE WISCONSIN PHOSPHORUS INDEX

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In their national policy guidelines on nutrient management, the USDA-Natural Resources Conservation Service (NRCS, 1999), identified three strategies for managing phosphorus (P) applications to cropland on a field-by-field basis to reduce the risk of resulting surface water contamination. Two of the strategies – limiting applications to agronomic recommendations and limiting applications above specified soil test P threshold levels – rely on soil test P as the sole indicator for guiding manure management decisions. The third NRCS strategy is the use of a comprehensive P loss risk assessment, or P Index.

Development

Phosphorus indices are being developed on a state-by-state basis throughout the United States. The Wisconsin P Index assesses risk by calculating a gross estimate of the P that would be delivered annually in runoff from a field to the closest water body. Separate estimates are made for annual edge-of field loads of dissolved and particulate (sediment-bound) P, as well as for acute (single-runoff-event) P losses from unincorporated manure and fertilizer P applications. The dissolved and sediment-bound P load equations take the form:

Annual runoff/sediment amount x average runoff/sediment P concentration = P load

RUSLE2, the NRCS most current tool for estimating soil erosion, is used to estimate sediment loss and also is part of the procedure for estimating annual non-winter rainfall runoff volumes. Runoff volumes for the winter period (frozen and thawing soil) are estimated using a different procedure, as soil and management factors influence runoff volumes differently during this period. The equations estimating runoff and sediment P concentrations were developed using Wisconsin small plot and simulated rainfall runoff research, as were the single-event factors for unincorporated P applications. Based on research, the proportion of surface-applied manure P at risk of loss in runoff varies by season, with the highest risks of loss in the winter.

To arrive at a total P Index value, the three types of annual edge-of-field P loads are added together, and then multiplied by a factor that represents the proportion of the total annual P load leaving the field that is expected to be delivered to the nearest stream or lake. This delivery factor is based on the average slope and distance of the field-to-stream runoff flow path. More information on the P Index equations and the research base for each can be found at http://wpindex.soils.wisc.edu/.

The information needed to run the P Index is information that is available to producers and crop consultants. For the most part, it is information that is already used routinely in nutrient management or conservation planning:

- Routine soil test reports
- Fertilizer P rate, method, and timing of application.
- Manure type, P rate, method, and timing of application
- Soil series or mapping unit, field slope, slope length, crop and tillage method •Distance and average slope to water from the edge-of-field

A nutrient management planning software program that calculates field-by-field P Index values, SNAP-Plus, can be downloaded for free from http://www.snapplus.net.

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Validation

Currently, 18 cropped fields in Wisconsin have had at least one crop-year of continuous year-round runoff monitoring. These fields are on both private and research farms. The in-field monitoring systems are of two types: automated samplers on H flumes installed by United States Geological Survey (USGS) staff and passive samplers with flow splitters used by University of Wisconsin researchers. Both types are designed to operate during the freezing and thawing conditions of snowmelt events as well as during non-winter runoff events. Runoff volumes, sediment, and dissolved and total P concentrations were measured year-round at every site. The monitored fields vary by crop, tillage, soil test P, soil type, topography, and P applications – all of which are taken into account in the Wisconsin P Index. The monitoring has allowed us to calculate annual P loads for each monitored crop year for each site and compare them to the annual edge-of-field P Index value. The purpose of this comparison is to determine if the P Index is effectively assessing the relative effects of field characteristics and management practices on agricultural P losses.

Annual P Loads (Crop Years 2003 and 2004)

Total P loads ranged from 0.2 to 26.8 lb/acre/year, and were well correlated with P Index values, as shown in the graph below (Figure 1). Annual P loads were not at all related to field soil test P (Figure 2). This is because some of the fields with the highest soil test P had very little runoff and sediment loss and vice versa.

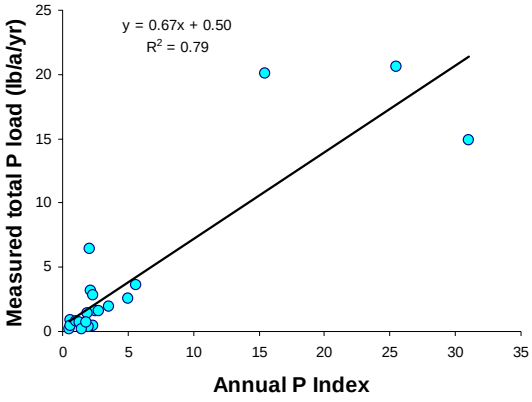

Figure 1. Measured annual total P loads compared to annual edge-of-field P Index values for 18 Wisconsin fields in 2004 and 3 fields in 2003.

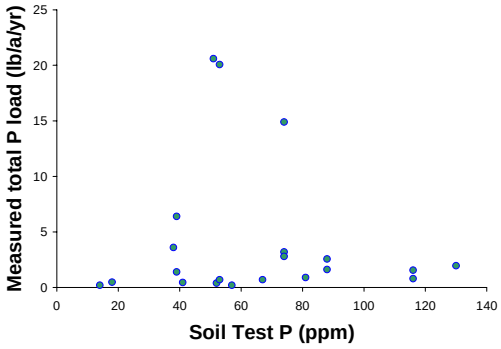

Figure 2. Measured annual total P loads compared to field soil test P values for 18 Wisconsin fields in 2004 and 3 fields in 2003.

A close examination of the monitoring data revealed that the good relationship between P Index values and monitored loads was primarily a result of the P Indexes ability to estimate management effects on sediment-bound P losses. Most of the results (18 fields) shown are from crop year 2004, which was characterized by unusually heavy spring and summer rainfall throughout most of Wisconsin. Sediment loss ranged from 0.03 to 26.8 tons/acre/year, with the highest losses from fields in consecutive years of corn silage. These silage fields also had the highest annual sediment-bound P loads, as shown in Figure 3.

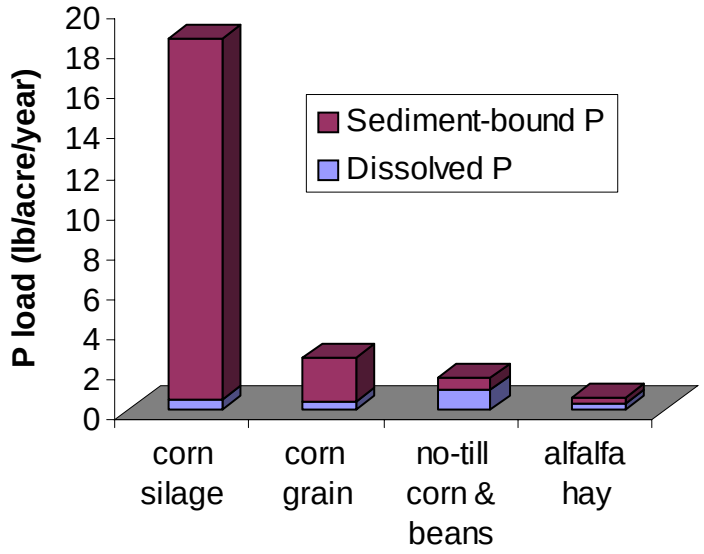

Figure 3. Annual sediment-bound and dissolved P loads by crop and tillage category for 18 Wisconsin fields in 2004 and 3 fields in 2003. Corn silage (tilled), 3 fields; corn grain (tilled) is 1st and second year, 7 fields; no-till corn or soybeans; 5 fields; established alfalfa or alfalfa/grass hay; 6 fields.

Winter Losses (Crop Year 2005)

Crop year 2005 was characterized by an unusually high number of winter-time runoff events and little-to-no spring and summer runoff state-wide. While the lack of non-winter rainfall runoff makes it impossible to use the 2005 crop year data to assess the P Index's ability to evaluate the relative effects of management practices on non-winter P loads, we can compare the winter-time (frozen and thawing soil) P loads to winter P Index values calculated from the P Index components related to runoff from frozen and thawing soil. These are:

- Winter-time runoff dissolved P
- Acute P losses from manure applications to frozen/snow-covered soil.

Adding these two components together produces a winter-time P Index value that is well-correlated with the 2005 winter-time runoff ($r^2 = 0.70$, preliminary data).

Summary

The Wisconsin P Index is a nutrient management planning tool for assessing the risk of P delivery from a given field to the nearest surface water body. On-field runoff monitoring data collected to date indicate that the P Index adequately assesses the relative effects of field conditions and management on P losses in rainfall and snowmelt runoff from crop land. Soil test

P by itself, however, is not a good predictor of field P runoff loads because it does not take into account a field's potential for runoff and erosion.

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Reference

Natural Resources Conservation Service (NRCS). 1999. General Manual, 190-GM, Issue 9, Part 402.