PROGRESS ON THE WISCONSIN P INDEX [1/]

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Phosphorus (P) based nutrient management is a central concept in national nutrient management policy (NRCS, 1999), and several options for developing nutrient management plans using a P strategy are included in the 2002 Wisconsin nutrient management standard (590) (NRCS, 2002). A phosphorus (P) index approach is one of the options (along with soil test P categories) for implementing a P-based nutrient management strategy. The P index considers site-specific P source and transport factors to predict the risk of P loss in runoff from individual fields. Ideally, it can be used to rank or prioritize fields based on their risk of P loss and to identify management options for reducing P loss. Initially, a draft P index was developed for Wisconsin (Murphy, 2000; Bundy, 2001) following the general concepts proposed by Lemunyon and Gilbert (1993) and modified by Gburek et al. (2000). This method assigned index values to specific site characteristics and management practices to arrive at an overall P index value for a production unit. While conceptually sound, this approach lacked the flexibility to include all of the parameters known to influence P losses in runoff. A modeling approach, similar to that used in the Iowa P index (NRCS, 2001; Mallarino et al., 2001) was adopted as a more comprehensive and quantitative method for assessing the risk of P losses in runoff. The current version of the Wisconsin P index, developed largely through the efforts of Dr. Wesley Jarrell, can be viewed at the following web site (http://wpindex.soils.wisc.edu).

Components of the P Index

The P index is a risk assessment tool that allows farmers, agency staff, and nutrient management planners to assign a numerical rating of the risk of P runoff loss from individual fields. The index estimates the total amount of P lost from a field or farm by summing the amounts of P lost through each of the major P loss processes. Currently the P index has three components: particulate P (PP), soluble P (SP), and leached P (LP). Another component related to P loss from plant residues may be added as more information on this potential source becomes available. Therefore, the total risk index for phosphorus (PI) is calculated according to the following equation: PI = PP + SP + LP. These terms are defined below.

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PP = Particulate P. This characteristic depends on erosion, amount of eroded particles delivered to a stream or lake, and the total P concentration in the soil.
SP = Soluble phosphorus includes P dissolved in solution, usually in runoff water passing over the soil surface.
LP = Leached P. This refers to dissolved P movement or leaching through the soil profile with water and subsurface transport of this P to surface waters.

Each of these components depends on the following conditions:
Particulate P: Soil erosion per field, transport of particles from field to water body, benefits of buffers in removing particulate P, and P concentrations in the eroded and transported soil particles.
Soluble P: Dissolved P from the soil; dissolved P in nutrients applied to the soil surface, such as manures and fertilizers; and dissolved P from nutrients applied to frozen soils.
Leached P: Soil P in the surface soil; volume of leaching water; soil texture; and depth to tile/groundwater. This component has not been activated in the current model, but will be as situations arise where it may be important (sandy or organic soils in particular).

To calculate a P index value, the user enters data into the spreadsheet available at (http://wpindex.soils.wisc.edu). Calculations and terms used to arrive at the PI value are described in detail on the web site. Depending on the total PI value obtained, the user is directed to a series of management practices (Fig. 1) that should lower the risk from that field. If the user runs the "improved" scenario, the PI value should go down. The management options for lowering PI values should allow the user to explore various options and select the most practical or economically feasible approach for lowering the risk of P losses in runoff.

Interpretation of the P Index Values

Based on preliminary results, it appears that fields with PI values less than 2 ("PI<2") represent a minimal threat to the water body. The following scale can be applied to identify and prioritize appropriate nutrient management activities on the farm, for a single field:

0 – 2: Minimal risk, A nitrogen (N)-based nutrient management strategy can be followed. In general, this allows manure to be applied to meet the N needs of the following crop.

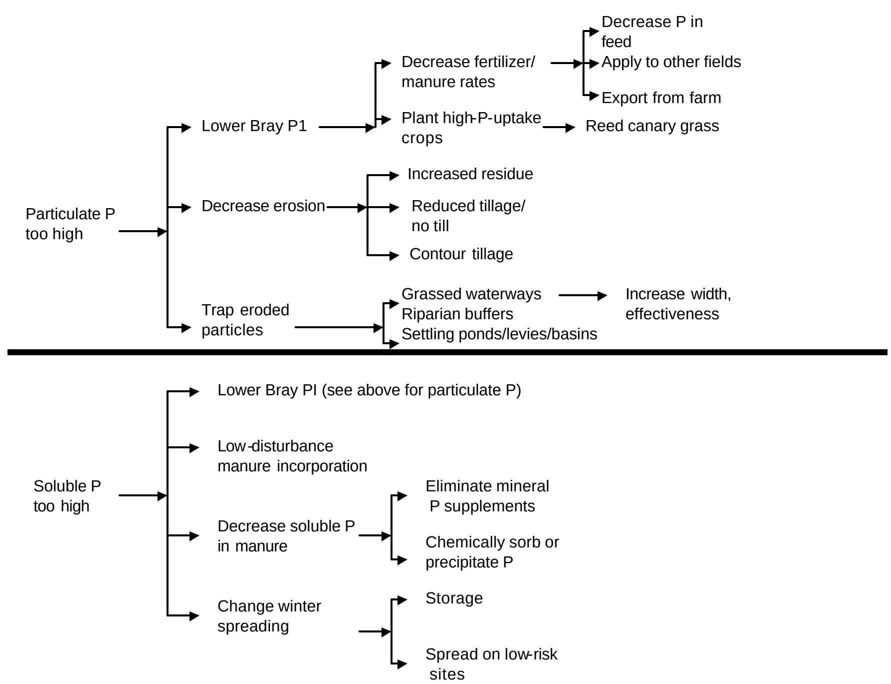
2 – 6: P index value should not increase over 4 years or length of average rotation. This requires that P inputs do not exceed crop P removal over a 4-year period or that management practices producing a higher P index value be avoided.

6 – 10: Implement nutrient management plans to decrease the PI to <6 over two rotations or a maximum of 5 years. Determine the relative contributions of particulate P and soluble P to the high risk index value,

and implement appropriate improved management strategies to lower the P index (see Fig. 1). In general, this may require P inputs to be lower than crop P removals, or that management practices that will reduce P losses be implemented.

>10: Implement nutrient management plans to decrease the PI to <6 over three rotations or a maximum of 8 years. (see Fig. 1). P index values greater than 10 indicate a very high risk of losing P in runoff and require a longer term management shift.

Fig. 1. Improved management practices to decrease PI if values are too high



Potential Refinements to the P Index

The current version of the Wisconsin P index is a work in progress and changes in the index are likely as more information becomes available. One source of information that could potentially improve the accuracy of the P index is from research in progress on the effects of various management alternatives on the risk of P losses from cropland. For example, results from simulated rainfall studies with various soils and management systems can be used to evaluate and potentially improve the Wisconsin P index. Phosphorus losses in runoff were measured following simulated rainfall (2.95 in/hour) on three typical Wisconsin soils with a range of soil test P and manure and tillage treatments. Most of this data is summarized in several recent or emerging publications (Bundy et al, 2001; Andraski and Bundy, 2003; Andraski et al., 2003). The Wisconsin P index was calculated for the conditions used in each set of treatments subjected to simulated rainfall, and these values were compared with observed P loads in the runoff.

For soluble P, initial P index values were not closely related to observed soluble P loads in runoff. Simulated rainfall data showed substantial differences among sites in the percentage of incoming precipitation that was lost as runoff and in the amount of interaction time between soil and runoff water. These observations appeared to be related to major water infiltration rate differences among the soils evaluated. When the P index was adjusted for these two factors, relationships between soluble P index values and observed soluble P loads in runoff were substantially improved (r^2 = 0.84 to 0.98). Experimental results showed that soluble P in runoff increased much more rapidly with increasing soil test P on the slowly permeable Eastern red soils (Kewaunee and Manawa), presumably due to greater interaction time between soil P and runoff water. When the Rusle 2 soil erosion program is implemented, it may automatically provide some of this information.

The current P index provides reasonable predictions of observed particulate P loads in runoff for well-drained medium-textured soils, and this relationship is relatively insensitive for the slowly permeable red soils in Eastern Wisconsin. When soluble and particulate P components are combined, the P index (with the soluble P modification described above) was well correlated (r^2 = 0.58 to 0.77) with observed total P loads in runoff at all sites.

These results indicate that information from simulated rainfall experiments can be used to improve the predictive value of the Wisconsin P index by identifying parameters needing adjustment to more accurately reflect site or treatment influences. Several of these areas thus far identified include: 1) Fraction of precipitation contributing to runoff (Rusle 2); 2) Soil permeability effects on interaction time between soil and runoff water (extraction efficiency); 3) Soil-specific differences in the effects of soil P level, tillage, and manure additions on P in runoff; 4) Timing (spring, fall, or winter) of tillage and manure application effects on P losses; 5) Soil test P – total P relationships in soils; 6) Buffer effectiveness factors; 7) Animal diet effects on soluble P in manures; and 8) Linking the P index with the SNAP and Rusle 2 programs to generate a tool for preparing comprehensive nutrient management plans. Work is in progress to identify appropriate adjustments to the Wisconsin P index for these parameters and to incorporate these changes into the index.

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