AGRONOMIC AND ENVIRONMENTAL MANAGEMENT OF PHOSPHORUS

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Everyone associated with agriculture is aware of the concerns that revolve around the relationships between nutrient management and environmental quality. In the late 1980s and early 1990s, attention was focused on the environmental impacts of nitrogen applied in fertilizers and manures. More recently, attention has shifted to the effect of phosphorus management on the quality of water in lakes and rivers.

There is ample evidence to show that algal growth in surface waters is directly related to concentrations of nitrogen and phosphorus. Therefore, the amount of phosphorus that enters surface waters has received special attention.

Various research efforts throughout the United States have focused on the development of management practices that can be used to control the loss of phosphorus from the agricultural landscape. This publication will describe those management practices and their effect on phosphorus losses.

In general, phosphorus losses are affected by:

1) crop grown, **2)** tillage systems, **3)** rate, time, and method of application of inorganic and organic sources of phosphorus, and **4)** soil test level for phosphorus.

Crop Selection

The crop grown on the landscape can have a substantial effect on phosphorus loss. Examples of measured losses from various cropped landscapes are listed in **Table 1**. When measuring losses, both the water and sediment are analyzed for phosphorus. The phosphorus found in the water is described as soluble. The amount attached to the soil particles is referred to as sediment phosphorus. Both components are added together to calculate the total amount of phosphorus lost from the landscape.

Table 1. Phosphorus losses from various landscapes.

Land Use	Phosphorus Loss		
	Soluble	Sediment	Total
	lb. P/acre		
grass	0.45	6.60	7.05
no-till corn	0.98	1.90	2.94
conventional corn	0.27	13.48	13.75
wheat/summer fallow	0.18	1.25	1.43

The losses listed in **Table 1** are taken from summaries of a variety of research projects. Losses can be rather small (wheat/summer fallow cropping system) or substantial (conventional corn cropping system). In evaluating these reported losses, it's obvious that most of the phosphorus lost is attached to soil particles. Therefore, any cropping system that reduces soil erosion will reduce the loss of phosphorus from the landscape.

Tillage Systems

Several research projects have focused on the effect of tillage system on the loss of phosphorus from the landscape. Because of different procedures used in the research projects, actual measured losses vary with each study. The results summarized in **Table 2** are typical of those found in many studies.

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Table 2. The effect of tillage system with and without the broadcast application of phosphate fertilizer on phosphorus loss.

Tillage System	Phosphate Use	Phosphorus Loss Soluble	Sediment	Total
		------- lb. P/acre -------		
ridge-till	yes	.061	4.09	4.15
	no	.005	2.96	2.97
conventional	yes	.003	10.01	10.01
	no	.001	6.69	6.69

P_2O_5 Rate = 115 lb./acre. Source: Romkins et al., Purdue

It's obvious that the use of a conservation tillage production system (ridge-till) is important in reducing total phosphorus loss. Since conservation tillage production systems reduce soil loss, major reductions in phosphorus losses are those losses associated with the sediment.

In Minnesota, the ridge-till planting system is an excellent choice for controlling soil erosion. Yields of corn and soybeans grown in this planting system have been comparable to yields of these crops grown in the more conventional moldboard plow system **(Table 3)**.

Table 3. The effect of tillage system on corn and soybean yields in Minnesota.

Location	Crop	Tillage System Moldboard Plow	Ridge-till
		------- bu./acre -------	
Morris	corn	137.0	138.0
	soybeans	43.7	44.2
Lamberton	corn	133.0	134.0
	soybeans	40.7	41.0
Waseca	soybeans	42.4	41.0

Source: Randall et al. (FO-6676-C), University of Minnesota Extension Service

The need for planting systems that control soil erosion changes with the varied landscapes of Minnesota. When erosion control is needed, the ridge-till planting system is well-suited for the soils and climate of Minnesota.

Placement of Phosphorus Sources

If the majority of phosphorus lost from the landscape is attached to soil particles, it's reasonable to expect that placement of phosphate fertilizers and manures can have a substantial impact on phosphorus loss. Research projects have clearly demonstrated that phosphorus loss is strongly affected by the placement of phosphorus sources. Results from a study conducted in Virginia are typical of summaries from several other research projects **(Table 4)**.

Table 4. The effect of placement of phosphate fertilizer in two tillage systems on phosphorus loss.

Tillage System	Phosphate* Placement	Total P Loss
		lb. P/acre
no-till	none applied	0.10
	subsurface injection	0.24
	surface broadcast	0.53
conventional	none applied	1.91
	subsurface injection	2.58
	surface broadcast	4.71

* P_2O_5 Rate = 94 lb./acre. Source: Mostaghimi et al., Virginia

In Minnesota planting systems, the use of a deep band applied in the fall before planting, or a starter fertilizer applied at planting, are appropriate practices for the subsurface application of phosphate. When phosphate fertilizers are broadcast on the soil surface and incorporated, some phosphorus is left either at or close to the soil surface. This phosphorus is subject to loss from erosion. The potential for loss is much lower when phosphate fertilizers are applied in a band below the soil surface. The same reasoning applies to manure applications.

The banded application of phosphate fertilizer has not reduced corn yields in Minnesota. Results of several research projects have shown that rates of phosphate needed for optimum production can be reduced if the fertilizer is applied in a band rather than broadcast and incorporated before planting. The results from a study conducted at Lamberton are similar to results from other studies **(Table 5)**.

Table 5. The effect of rate and placement of phosphate fertilizer on corn yield. Lamberton.

P_2O_5 Applied	Placement	Grain Yield
lb./acre		bu./acre
0	-	126.1
40	starter	143.6
200	broadcast	143.8

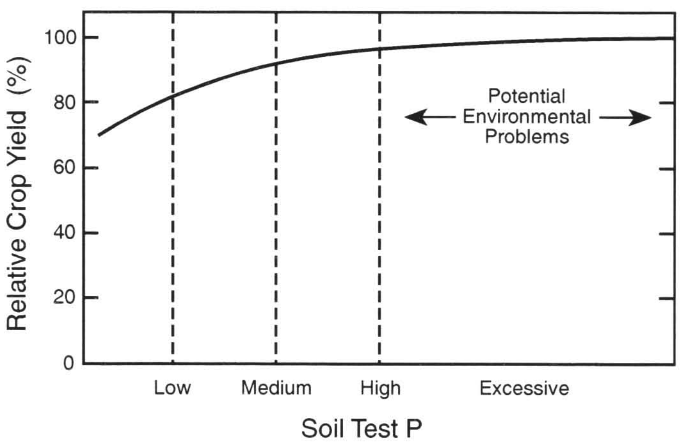
Soil Test P = 6 ppm (low)

In general, recommended rates of phosphate can be reduced by one-half if applied in a band rather than broadcast and incorporated before planting. The benefits of banded applications of phosphate fertilizer have positive economical as well as environmental benefits.

Phosphorus Soil Test Levels

Testing for phosphorus in soils is a management practice that is usually used to predict the amount of phosphate needed in a fertilizer or manure program for optimum yield. Crop yields decrease as the soil test level for phosphorus drops into the medium range and below **(Figure 1).** The potential for environmental problems increases as soil test levels move into the high range. An increase in soil test levels for phosphorus indicates a larger amount of phosphorus in the root zone. With higher amounts present in the soil, there is an increased potential for loss.

Figure 1. Relationship of soil test levels for phosphorus to relative crop yield and the potential for environmental problems.



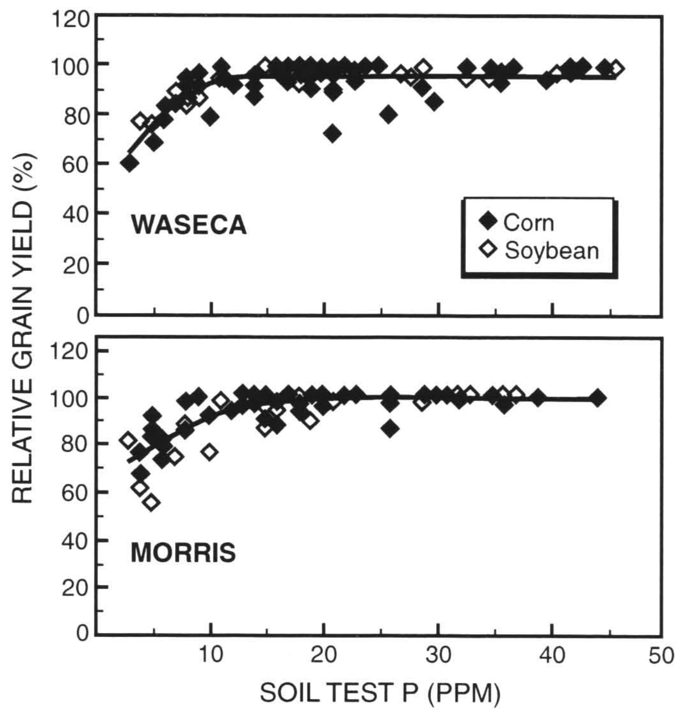
In Minnesota, soil test levels are measured in a laboratory by either the Bray or Olsen procedure. The Bray procedure is usually used when soil pH is less than 7.4. The Olsen procedure is used when soil pH is 7.4 or higher. The soil test values for phosphorus corresponding to the relative levels are listed in **Table 6**.

Table 6. Definition of soil test values for phosphorus as measured by the Bray and Olsen procedures.

Relative	Procedure	
Level	Bray	Olsen
	-------- ppm -------	
very low	0-5	0-3
low	6-10	4-7
medium	11-15	8-11
high	16-20	12-15
very high	21+	16+

In general, phosphorus supplied either in fertilizer or manure will not increase crop yields if soil test levels for phosphorus are in the high range and above. A research project conducted at the Morris and Waseca Experiment Stations for several years showed that yields did not increase when the Bray soil test for phosphorus exceeded about 13 ppm at Waseca and 19 ppm at Morris.

Figure 2. Relative grain yields of corn and soy beans in relationship to soil test levels for phosphorus.



This information, gathered over several years, shows that there is no economic justification for building soil test phosphorus levels above 20 ppm as measured by the Bray procedure. When amounts of phosphorus added to the soil as either fertilizer or manure are higher than amounts removed by crops, soil test levels will increase. Therefore, soil testing for phosphorus should be a routine management practice when manure use is a consistent component of the farm enterprise.

Likewise, application of phosphate fertilizer for crop production, when the soil test for phosphorus is 20 ppm or higher, does not increase yield. These additions simply increase the potential for loss of phosphorus from the landscape. There is no economic or environmental justification for adding phosphorus to the soil system when the phosphorus soil test is 20 ppm and higher (Bray test) or 16 ppm and higher (Olsen test).

Summary

Management of phosphorus inputs for crop production systems is a very important task, but does not have to be complicated. In general, management practices that reduce the potential for environmental contamination also provide for optimum economic production. Those important management practices are:

- Use conservation tillage systems to reduce the amount of soil lost by erosion
- Band or inject phosphate fertilizers and manure below the soil surface
- Monitor soil test levels for phosphorus. There is no economic or environmental justification for building these levels above 20 ppm (Bray test) or 16 ppm (Olsen test).

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