THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

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Best Management Practices for Mitigating Phosphorus Loss from Agricultural Soils

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Monitoring of watersheds that discharge into Lake Erie has revealed that dissolved reactive phosphorus (DRP) levels have increased over the last decade (Baker, 2007). Many of these watersheds have a large agricultural base, suggesting that a portion of the increased DRP is likely attributable to agricultural activities. The objective of this fact sheet is to discuss management practices that can be implemented by producers to minimize the risk of phosphorus loss. Implementation of these practices not only has environmental benefits but economic benefits as well. Producers today are facing higher input costs (including fertilizer), and the more efficiently inputs are managed, the greater the economic return. Any nutrient transported off-farm represents a loss on an investment.

Soil Testing

The most cost effective and environmentally sound practice a producer can implement is the use of soil analysis. Soil testing allows one to assess a soil's current nutrient status and decide on appropriate fertilizer rates to maximize crop production. The Ohio State University recommends that a single composite soil sample (consisting of a minimum of 15 individual cores at an 8-inch depth) represent no more than 20 contiguous, uniform acres. Once soil samples have been collected, they should be thoroughly mixed and submitted to a reputable lab for analysis. After analysis has been completed, one will receive a soil test report that should reveal the soil's current phosphorus level.

The first step in making a phosphorus fertilizer decision is determining whether additional phosphorus is necessary. Ohio State has established critical levels for phosphorus based upon a Bray-Kurtz P1 extraction (Table 1). If a Mehlich III extractant is used for phosphorus determination, refer to the fact sheet titled "Understanding Soil Tests for *Plant-Available* Phosphorus" (search **http://ohioline.osu.edu**) to make the conversion from Mehlich III to Bray-Kurtz P1. Soil test levels near or below the established critical levels indicate a risk of phosphorus deficiency, and warrant an application of phosphorus to ensure that it is not limiting crop productivity. Phosphorus fertilizer rates have also been calibrated to soil test levels (Table 2). Utilization of Ohio State phosphorus fertilizer recommendations should minimize the risk of phosphorus deficiency and ensure that soil test levels are maintained at or reasonably above the established critical level.

Notice that for soil test levels above the established critical level, Ohio State recommendations are designed to reduce soil test phosphorus levels (Table 2). A producer can grow crops with little risk of phosphorus deficiency for many years on these soils. Remember, the soil is well buffered against changes in soil test phosphorus. This means that phosphorus added or removed from the soil should not dramatically change soil test levels. An illustration of this concept can be made with fluid dynamics. Figure 1 shows two reservoirs of varying width. The left side (narrow reservoir) represents what we measure with soil testing, and the right side (wide reservoir) represents the soil's capacity to buffer against change in the soil test level (from phosphorus that is adsorbed to soil particles or precipitated from solution). If we desire to increase the level in the narrow reservoir by 1 unit, can we just add 1 unit to the right side? No, we have to add considerably more to the right side due to the width of the reservoir. Similarly, to lower the level in the narrow reservoir, we have to remove considerably more from the wide reservoir to observe a change. This relationship is how phosphorus behaves in soils, where the extent of buffering is a function of soil texture, phosphorus saturation, and soil pH. As a rule of thumb, for every 15–20 lbs of phosphorus in fertilizer (P_2O_5) added or removed, the available phosphorus level will change by 1 ppm. (Some soils may be more buffered/some less). Thus, soils that test high in available phosphorus are unlikely to receive any agronomic benefit from additional phosphorus fertilizer (at least in the short term).

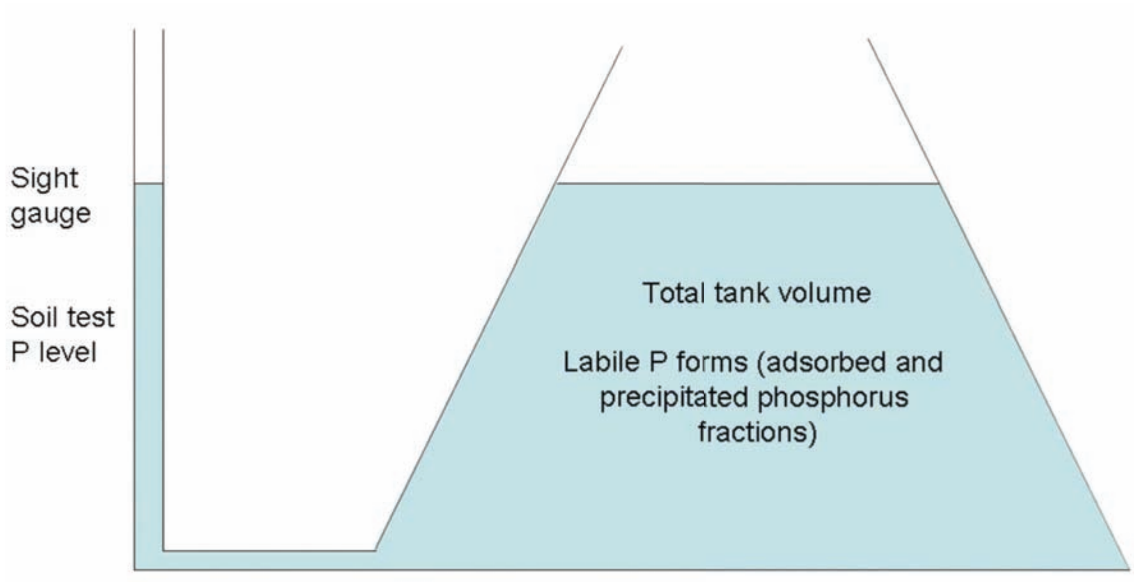
Table 1. Critical Soil Test Phosphorus Levels
(adapted from *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, & Alfalfa*)

Crop	Critical soil test phosphorus levels, ppm (lb/acre)
Corn	15 (30)
Soybeans	15 (30)
Wheat	25 (50)
Alfalfa	25 (50)

Table 2. Fertilizer Phosphorus (P_2O_5) Rate Recommendations for Corn
(adapted from *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, & Alfalfa*)

	Realistic yield goal, bu/acre				
Soil test level	100	120	140	160	180
ppm (lb/acre)	lb P_2O_5/acre				
5 (10)	85	95	100	110	115
10 (20)	60	70	75	85	90
15–30 (30–60)	35	45	50	60	65
35 (70)	20	20	25	30	35
40 (80)	0	0	0	0	0

Figure 1. Illustration of the Soil Test Phosphorus Buffer Concept



Timing and Method of Application

Once a fertilizer rate has been determined, the next considerations are when and how the application should occur. While there is no "best" time for applying phosphorus (comparing spring to fall), there *are* times when applications should be avoided for potential loss reasons. Avoid applications of phosphorus fertilizer to frozen/snow-covered ground, especially on soils that have any appreciable slope. Fertilizer applied under these conditions is subject to movement in runoff and potential loss from the field. Phosphorus fertilizers can bind to soil particles easily, but if a phosphorus prill never enters the soil as it sits on frozen or snow-covered surfaces, it may be carried off the surface by runoff. Not only does this loss have potential negative environmental implications, it also represents a significant economic loss given the price of phosphorus fertilizers.

How phosphorus is supplied also affects loss potential. Surface-applied phosphorus is at more risk for loss than fertilizer phosphorus that has been incorporated with tillage. A minimum amount of tillage following the application decreases the risk of dissolved reactive phosphorus transport and potential loss. Thus, to minimize the risk of phosphorus transport, some tillage (even if minimally invasive) is beneficial (Kleinman et al., 2002). It should be noted here that in a no-till system, while plant residue left on the soil surface can reduce runoff volume, it does not reduce the concentration of phosphorus in runoff (Nicolaisen et al., 2007).

Alternatives to Broadcast Applications

Instead of making a broadcast application of phosphorus, one may consider supplementing phosphorus in a starter blend applied with a planter. If soil test levels are near the critical level, phosphorus can be included in a starter to ensure that it is not limiting. Starter phosphorus responses have also been noted on soils with adequate phosphorus that are in a no-till production system. Phosphorus supplied as a starter is much less susceptible to loss due to the fact that it is placed below the soil surface. The unfortunate trade-off is that liquid forms of phosphorus supplied as a starter are typically much more expensive than broadcast applications on a price-per-pound of phosphorus basis.

Manure Issues

Much of the focus to this point has been on commercial fertilizer applications, but similar rules apply for manure applications. Avoid applications to frozen/snow-covered ground due to the risk of surface transport. Target applications to soils likely to benefit from phosphorus supplementation and avoid applications to soils with fertility well above established critical levels. Incorporation, with tillage or injection, is preferred to surface applications.

Remembering and utilizing these simple rules for phosphorus application will dramatically reduce the risk of phosphorus transport from agricultural soils. Considering the prices of these fertilizer materials, the economic implications for poor management are much more severe today than they have been historically. Any nutrient that remains in the soil is an economic and environmental benefit.

References

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