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Soil testing and available phosphorus

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Abstract
This article is the continuation of a series of articles that provides producers with information that aids in phosphorus (P) management. We address the following: soil testing as a tool, trying to predict availability of P for crops, agronomic testing for P, environmental testing for P versus agronomic testing for P, and environmental perspective and interpretation.

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This article is the continuation of a series of articles that provides producers with information that aids in phosphorus (P) management. We address the following: soil testing as a tool, trying to predict availability of P for crops, agronomic testing for P, environmental testing for P versus agronomic testing for P, and environmental perspective and interpretation.

Soil testing as a tool

Soil tests are designed to help Iowa producers predict their soil's available nutrient status. Once existing nutrient levels are established, producers can use the data to best manage what nutrients are applied, decide the application rate, and make decisions concerning the profitability of their operations while managing for impacts such as erosion, nutrient runoff, and water quality.

Routine soil tests for P do not analyze for the total P content because the amount of soil P in plant-available forms is always much less than the total P. Routine soil tests also do not measure the P soluble in water because it is usually very low and does not represent appropriately the P plants can potentially absorb during a growing season. A routine soil test for P recommendations is designed to predict only the plant available P fraction.

Steps in a Soil Testing Program

1. Field collection of soil samples.
2. Laboratory extraction and analysis of the soil samples.
3. Interpreting the laboratory analytical results.
4. Making the nutrient recommendations.

Trying to predict availability of P for crops

A good test should account for all factors that influence plant availability and uptake, including soil characteristics such as type of minerals, soil pH, and conditions for root growth. Estimating all these factors appropriately is not an easy task. Thus, several soil P tests are recommended in Iowa to better adapt to varying soil conditions. Furthermore, managing P for crop availability requires understanding and implementing practices such as soil sampling depth, fertilizer placement (for example, banding fertilizers rather than broadcasting), and time of application.

Phosphorus availability is commonly lower in strongly acidic and alkaline soils because of increased P reactivity with soil and formation of insoluble compounds with aluminum and iron in acid soils and with calcium in alkaline soils. The pH associated with the maximum P availability in soils usually is between roughly pH 6.0 to 7.0.

Because most of the P applied to soils remains within 1 or 2 inches from the application point, incorporation and injection or banding fertilizer P or manure into the seedbed can reduce much of the potential P runoff, and make more P available to the crop. This is not always the case, however, and economic considerations (such as application costs) are important.

Soil P testing for crop production

Agronomic (or routine) soil tests attempt to measure an amount of soil P that is proportional to what is available to crops during a growing season. The soil test value is merely an index of this supply. One of the most useful soil test values is the critical concentration of P, the value above which there is a low probability of response (most frequently no response) to fertilization, and below which the crops likely will respond to fertilization. The most common routine soil tests recommended for use in Iowa (Bray-1, Mehlich-3, and Olsen) were developed to provide indices of P availability to plants under a variety of soil conditions (Table 1).

The Bray-1 test, one of the first developed and most widely used P tests in the Corn Belt, is better adapted to soil pH less than 7.4. It often (although not always) underestimates available P in high pH (greater than 7.3) calcareous soils, which are common in north central and western Iowa. The Olsen test is the preferred test for calcareous soils, although it also can be used for soils as acid as those with a pH near 5.0. The Mehlich-3 test is newer, is similar (as good and gives the same values) to the Bray-1 in acidic or neutral soils, and is better than the Bray-1 in many Iowa calcareous soils. Ongoing research in Iowa continues to study this test, which can also be used for other nutrients (such as potassium).

Soil P tests interpretation and fertilization requirements

Soil test values need to be interpreted with two main objectives. One is to decide whether fertilization is needed. This is particularly important for P because many Iowa farmers have applied P in excess of crops needs. If fertilization is needed, then a soil test value should provide information about the rate of fertilizer application. Thus, all soil tests must be calibrated against crop responses to nutrient applications. Each soil test must be calibrated because the amount of P extracted changes between methods. Also, soil tests have to be continuously recalibrated as new crops, new hybrids or varieties, and new management practices are introduced because the meaning of a soil test value may change. The soil test is not the only information needed to make a P fertilizer recommendation. Reliable data about P removal in harvested products, the overall needs of a crop rotation, the most efficient application method, fertilizer costs, and crop prices also are required.

Environmental versus agronomic testing for P

Producers also should be aware of concerns about P losses from agricultural operations. Over the years, many producers have built up soil P to levels that are about optimum for crop production. But some producers have built up soil P to much higher levels. The potential for P losses and environmental risks to surface waters increases at high soil P levels, and this has the potential to change the way producers manage P in their soil.

Because commonly used soil P tests were developed to estimate P availability for crops, researchers are looking at alternative soil P tests that could be better predictors of the loss of dissolved P to water systems. Ongoing research in Iowa is studying, for example, tests based on water extraction and on paper or plastic membranes coated either with ion exchange resins or iron-oxide, which have the capability of retaining P. Preliminary research suggests that these new tests are as useful as the commonly used routine soil tests to predict P losses. Although the amount of P extracted from soil samples varies greatly between tests, all tests show that increasing soil P to very high levels increases the risk of P loss.

Environmental perspective and interpretation

The soil test level is only one of many factors that influence P loss to water supplies. Other factors that can affect P runoff or P loss to drainage tiles from cropland include soil texture and pH, erosion, timing and rate of P application, tillage, and crop residue on the soil surface. For example, injection and banding fertilizer P into the soil, avoiding excessively high P application rates, and residue management practices that reduce sediment losses and increase water infiltration into the soils reduce much of the potential P runoff. These aspects, and a P risk assessment tool (or P index) currently being developed by a multidisciplinary team will be discussed in detail in a future article.

Summary

Soil tests are a guide for developing a total soil fertility program. Other important considerations include estimating P removal in harvested crops, using effective soil sampling, using effective fertilizer (or manure) placement, considering alternative application strategies for the particular crop rotation (frequency and rates), and environmental aspects.

Getting a Good Soil Test

Soil test laboratories can only analyze and interpret what is provided to them, so the soil test data that producers receive are only as good as the methodology used in gathering a representative sample. Here are some tips for getting accurate soil samples.

What to do: Take soil samples after harvest and before winter (or at least at the same time every year). Divide the field into sampling areas on the basis of soil survey maps, or soil color, texture, major differences in observed crop yields, and uniform histories of cropping, fertilization, and liming. Intensive grid sampling is another alternative currently under study. Use the soil probe and obtain an adequate number of cores (at least 15 cores, although 10 to 12 cores may be more cost-effective with intensive grid sampling) so the sample correctly represents each area. Make sure that your samples contain soil from the depth soil tests are calibrated (6 to 7 inches).

What to avoid: Don't bias samples by including cores from areas influenced by gravel roads; farm lanes; field borders; and small, severely eroded spots.

What to include on the information sheet: Crop advisers and soil test laboratories can give you the most accurate recommendations for your soil if you provide cropping history and intended crops for the upcoming seasons, realistic yields, fertilization practices, past (especially recent) lime applications, and history of manure applications.

Table 1. Agronomic interpretation of soil test values for P determined by Bray P1, Mehlich-3, or Olsen extractant for surface soil samples (6- to 7-inch-deep cores).

	Bray P1 or Mehlich-3 P			Olsen P		
	Wheat, alfalfa	All crops except wheat, alfalfa		Wheat, alfalfa	All crops except wheat, alfalfa	
		Subsoil P			Subsoil P	
Relative Level		Low	High		Low	High
	ppm					
Very low	0-15	0-8	0-5	0-10	0-5	0-3
Low	16-20	9-15	6-10	11-14	6-10	4-7
Optimum	21-25	16-20	11-15	15-17	11-14	8-11
High	26-30	21-30	16-20	18-20	15-20	12-15
Very high	31+	31+	21+	21+	21+	16+

Adapted from Iowa State University Extension publication PM 1688, General Guide for Crop Nutrient Recommendations in Iowa [1].

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