Phosphorus Soil Testing Methods

Cornell University annually publishes the "Cornell Guide for Integrated Field Crops Management". This document includes phosphorus (P) fertilizer guidelines for a large number of field crops grown in New York. The guidelines are based on field research in New York that shows that the Morgan soil test, the agronomic soil test used at Cornell University, can be used to predict likeliness of a yield response to additional P for crops grown under New York growing conditions.

What is an agronomic soil test?

The agronomic P soil test is an index of P availability which means that we can use the soil test to determine likeliness of a response to additional P. An agronomic soil test extracts only a small portion of the total amount of P in the soil as not all of that P is available for crop growth. Agronomic soil test results are classified as low, medium, high or very high based on crop response to additional P; crops grown on soils that are already high or very high in P are not likely to respond with a yield increase if additional P fertilizer is added. On the other hand, soils that are low or medium in P will likely show higher yields if extra P is added. For more information on P fertilizer use for corn, see Agronomy Fact Sheet 8: Starter Phosphorus Fertilizer for Corn.

(Modified) Morgan soil test method

To determine the Cornell Morgan soil test P of a soil, the soil is shaken (extracted) with a chemical solution (sodium acetate buffered at pH 4.8) in a particular soil to extraction solution ratio (1:5) and for a certain amount of time (15 minutes). The extract is filtered (Figure 1) and the P concentration in the filtered extract is measured in the laboratory (colorimetrically). Cornell University is not the only university that uses the Morgan soil test. This same test is the basis for fertility guidelines of the University of Massachusetts and a similar chemical extraction solution (ammonium acetate instead of sodium acetate called the Modified Morgan extraction) is used for fertility guidelines at the Universities of Maine, Vermont, Connecticut, and Rhode Island. The Morgan and Modified Morgan soil tests give similar results as long as the soil to solution ratio, scoop sizes, shaking time, filter paper, and instrumentation used to determine P concentration in the extracts, are identical and samples are corrected for weight and moisture content.

Figure 1: In the laboratory, soils are extracted with a chemical extraction solution, the mixture is filtered and P concentrations in the solution are measured.

Other soil testing methods

Several other tests were developed for the same purpose: to predict if additional P is needed for optimum economic yields. The most commonly used tests are the Mehlich-3 soil test, the Bray-1 and the Olson P tests. These three tests use a very different chemical extraction solution. The Mehlich-3 extraction solution is an unbuffered solution of acetate, ammonium nitrate, ammonium fluoride, nitric acid, and ethylenediaminetetraacetic acid (EDTA). The Bray-1 solution is an unbuffered dilute HCl and ammonium fluoride solution. The procedures for the Mehlich-3 and Bray-1 extractions call for a 1:10 soil to solution ratio and 5 minutes of shaking time. The Olsen procedure contains sodium bicarbonate and was specifically developed for calcareous soils.

How do soil test results compare?

Different tests will give different results as some of the chemical solutions are much more

aggressive in extracting P from the soil than others. The Mehlich-3 solution is the most aggressive and that results in the highest soil test values. The Bray-1 solution usually results in slightly lower values that the Mehlich-3 analyses (usually between 70-85% of the value of the Mehlich-3 test). The Olsen and (Modified) Morgan tests are weaker with the Morgan test extracting the smallest amounts of P. The test results from one method are not always directly comparable to those of another method. Figure 2 shows that depending on the soil, the Mehlich-3 test can extract anywhere between 3 and 30 times as much P as the Morgan test!

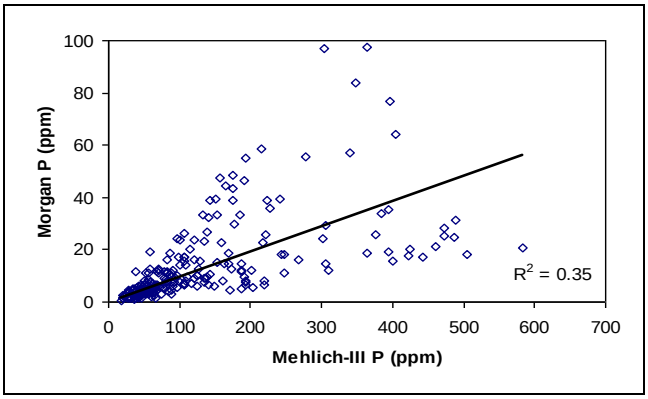

Figure 2: We cannot use a Mehlich-3 P test to determine fertility guidelines in New York as the Mehlich-3 test results are very poorly related to the Morgan soil test upon which all fertility guidelines are based in New York.

Conversion models

If the pH of the soil and the amount of Mehlich-3 extractable P, Ca and Al are known, an estimate of the Morgan soil test P value can be derived. These conversions will not be totally accurate for all soils and require sampling in the fall at a 2-3 sample per acre density for greatest accuracy (see Figure 3).

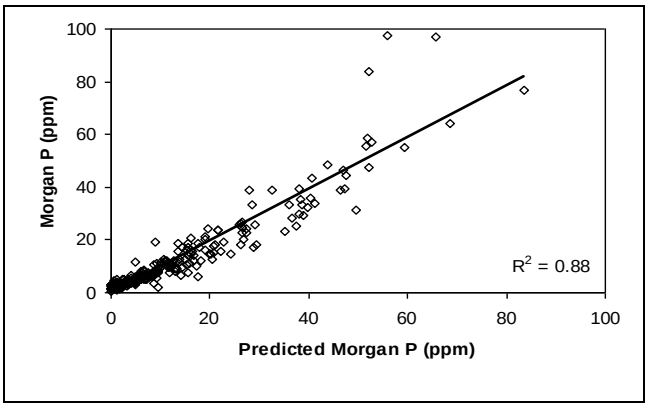

Figure 3: Morgan soil test estimates can be derived based on Mehlich-3 Ca, P, Al, and soil pH (predicted Morgan P) but the conversions are not 100% accurate for all soils.

Laboratory to laboratory differences

Slight differences in laboratory procedures (e.g. different soil to solution ratios, shaking times, filter paper, etc.) will lead to differences in the soil test results. This can be seen in Table 2 for four random soil samples. Thus, laboratory specific conversions need to be used to derive Cornell Morgan soil test estimates from Mehlich-3 data.

Table 2: Laboratories differ in the methods used to determine agronomic soil test P levels. In this example four samples were analyzed by five laboratories that all use the Mehlich-3 extraction.

	Mehlich-3 soil test P results (ppm)				
	Lab A	Lab B	Lab C	Lab D	Lab E
Sample 1	49	37	41	49	43
Sample 2	56	42	42	43	46
Sample 3	145	106	107	108	107
Sample 4	220	202	199	216	205

Soil test conversion tools

A stand-alone excel conversion tool is available from the Nutrient Management Spear Program website: http://nmsp.css.cornell.edu/software/morganequivalents.asp. When you use this conversion tool, make sure to correctly identify (1) the laboratory that generated the Mehlich-3 data, and (2) the units (ppm versus lbs/acre)! Input data needed for the conversion from Mehlihc-3 data to Morgan equivalents are: soil pH, Mehlich-3 extractable P, Ca and Al. Keep in mind that not all soils give reliable conversions; always check field histories to make sure the results make sense!

Additional resources:

- Cornell University Agronomy Fact Sheet #8 (Starter Phosphorus Fertilizer for corn), Fact Sheet #12: (Phosphorus Basics – The phosphorus Cycle): nmsp.cals.cornell.edu/publications/factsheets.asp.
- Nutrient Management Spear Program soil test conversion website: http://nmsp.cals.cornell.edu/software/morganequivalents.asp.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

Quirine M. Ketterings and Pete Barney

2010 (first released in 2006)