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Phosphorus Soil Testing and Nutrient Management Planning in New York

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Introduction

In 1999, USDA-NRCS and US-EPA published a document entitled "Unified National Strategy for AFO's" (http://www.epa.gov/npdes/pubs/finafost.htm). The document expresses a desire that US AFO's of all sizes (Box 1) *will be* implementing a Comprehensive Nutrient Management Plan (CNMP) by 2009. In New York, all CAFO's are *required* to obtain a SPDES Permit from NYS DEC and develop and implement a CNMP by January 2005. A CNMP must meet USDA-NRCS standards and specifications at the farmstead and in the field. The main requirements are described in NRCS Waste Management System Standard 312 (http://www.ny.nrcs.usda.gov/standards/ny312.pdf). Nutrient management at the field level is guided by NRCS Nutrient Management Standard NY590 (http://www.ny.nrcs.usda.gov/standards/ny590.pdf).

Box 1: An Animal Feeding Operation (AFO) includes most commercial dairy or livestock farms that house or feed animals for more than 45 days per year in a concentrated area such as a barn or barnyard. A large Concentrated Animal Feeding Operation (CAFO) exceeds 1000 animal units. Additionally, in New York State a medium CAFO may be 300-999 units if it has the potential to discharge polluted stormwater into public streams or waterbodies through a man-made ditch or pipe (http://www.dec.state.ny.us/website/dow/cafohome.html).

NY590 requires that nutrients such as nitrogen (N) and phosphorus (P) must be managed within a reasonable tolerance of Land Grant University (Cornell) guidelines. NY590 also requires the use of the New York Phosphorus Index (NY PI) to estimate the potential for runoff on all fields. Cornell fertilizer and manure guidelines and the NY PI are based on the Morgan soil test offered by Cornell's Nutrient Analysis Laboratory (CNAL). However, many private laboratories utilized by New York producers, consultants and agri-service analyze soil samples using the Mehlich-III extraction. Phosphorus soil chemistry is more complex than for most other nutrients. The Morgan test and the Mehlich-III test measure different fractions of the total amount of phosphorus in the soil. Mehlich-III P soil tests always measure more of the total soil P than the Morgan P soil tests. However, depending upon the circumstances, Mehlich-III can remove anywhere from 3 to 30 times more P than Morgan. Since the relationship is not straightforward, more information was needed to compare the two soil test methods.

Given the need to comply with NRCS standards, New York basically had two options: 1) implement the use of a conversion equation that would allow producers to accurately derive Morgan P equivalents from Mehlich-III soil test values and then use Cornell's field research database to derive fertilizer recommendations; or 2) require Morgan soil tests for all New York farms. The first option was easier said than done because, at that stage, it was not known if such a conversion equation could be derived. However, it was obvious that we had to investigate the feasibility of this option first.

Action

Cornell University researchers in collaboration with agri-service staff and private consultants and funding from USDA-NRCS, New York State Department of Agriculture and Markets and NYS Department of Environmental Conservation, initiated a study to evaluate if it was possible to derive Morgan equivalents from Mehlich-III soil tests. Several hundred high-volume soil samples were collected and analyzed by three major private agricultural testing laboratories. Results showed that if soil pH and Mehlich-III extractable P, Ca, and Al were known, we could somewhat reliably convert Mehlich-III soil test results to a Morgan P equivalent (Box 2).

Box 2: What do you need to derive a Morgan equivalent from Mehlich-III tests done by a laboratory that participated in the Cornell conversion study?

- Soil pH
- Mehlich-III P
- Mehlich-III Ca
- Mehlich-III Al

Why do we need Al to convert from Mehlich-III to Morgan P?

It was stated earlier that a straight comparison between Morgan and Mehlich-III P soil tests showed that the Mehlich-III test extracted anywhere between 3 and 30 times as much as the Morgan test. Our study showed that we could improve the accuracy of our Morgan prediction from Mehlich-III data considerably if we knew the Mehlich-III Al concentration in the soil (Box 3).

Agronomic soils in New York include both acid till soils dominated by Al chemistry and high lime soils dominated by free Ca (and less active Al). Fluoride present in the Mehlich-III solution reacts with Al and Fe oxides and hydroxides in the soil releasing P associated with these more tightly held bonds while free carbonates in the high lime soils can neutralize the solution and hence reduce its ability to extract P. Thus, it is no surprise that we see a greater Mehlich-III to Morgan P ratio for the acid till, high Al soils than for the high lime soils. Of the three commercial laboratories that participated in this study, Brookside Laboratories Inc. offers Mehlich-III Al in its standard package. The two others will measure Al in the Mehlich-III extract *if requested* by clients.

Box 3: When Mehlich-III Al was less than 700 ppm, Mehlich-III test results were on average 7 times greater (range: 3-12) than the Morgan tests. For soils with Al concentrations between 700 and 900 ppm, Mehlich-III extracted on average 10 times as much as the Morgan solution (range 4-15). When Mehlich-III Al was greater than 900 ppm, Mehlich-III soil tests were on average 20 times greater than the Morgan test values (range: 10-30).

How accurate are these conversion equations?

The use of any conversion equation will add uncertainty to the final recommendation. Our task was to document this risk. It is the user's decision to accept or reject this risk. The conversion equations were tested on a database of several

thousand soil samples from Agricultural Consulting Services, Inc. For 89% of the samples, the Mehlich-III conversion resulted in a P_2O_5 recommendation within ±10 pounds of the Morgan generated recommendation. For 11% of the data, greater differences in recommendations were obtained. The results of these studies were documented and discussed in What's Cropping Up? (2001) 11(3): 2-3.

Important additional findings

The original equations were derived using Mehlich-III data generated by Brookside Laboratories Inc. In the ideal world, a sample split into two and sent to two different laboratories that use the same testing procedures to analyze for pH and Mehlich-III P, Ca, and Al would give us identical or close to identical results. The original dataset showed that that was *NOT* the case. The dataset showed that values reported for Mehlich-III nutrients by one laboratory could be more than a few percent different from those reported by another laboratory. Furthermore, one laboratory was not consistently reporting higher or lower than another, but differences varied depending on which nutrient we were looking at. For example, lab 1 may have reported a Mehlich-III P value that is consistently 6% lower than the value on the report from lab 2. For the same two labs, Ca tests may be 15% lower for lab 1, while Al values may be virtually identical. These differences in reported values for the same soil sample may be caused by differences in analytical methods and/or reporting of the results to the clients. In most cases, soil test results from labs that use the same extraction solution (Mehlich-III in this case) relate to each other well, but they show consistent absolute differences. Thus, as long it is known what the differences are, we can convert Mehlich-III results from one lab to those of another without introducing much error. However, these differences between labs can result in quite large variations when we attempt to derive Morgan equivalents from Mehlich-III input data and thus increase our chances of deriving incorrect recommendations. For example, using Spectrum Analytic input data in the equation derived for Brookside Laboratories results in a Morgan soil test prediction that is on average only 65% of the value predicted with the Brookside input data. This could result in up to 30 pound difference in P recommendation! *Because of this variation between labs, we had to develop unique equations for each laboratory that participated in the study (Box 4).* These findings were also the reason for expansion of the project to include more laboratories and analyses. Currently, four Northeastern state university laboratories and four private laboratories have analyzed the original dataset and conversion equations are being developed.

Box 4: Currently available are conversion equations that derive Morgan P equivalents using input data from:

- Brookside Laboratories Inc. (Mehlich-III)
- Spectrum Analytic Inc (Mehlich-III and Morgan)
- A&L Laboratories Inc. (Mehlich-III and Modified Morgan)

What can you do to reduce risk?

As mentioned above, there is a risk of producing an incorrect nutrient recommendation even when using lab specific conversion equations to derive a Morgan equivalent. In some circumstances, the conversion equations may classify a high P soil as a low P soil. While this result is not a threat to crop yield, the recommendation is much higher than needed, a waste of money and a risk to the environment. Conversely, the conversion equations may classify a low P soil as a high P soil. This situation could result in yield reduction where fertilizer applications are the only inputs (i.e no manure is being applied). Consequently, the user must realize there is risk involved in the use of these conversion equations and be prepared to accept all risk. If you are willing to accept the risk, box 5 shows a few things you need to take into account to reduce the risk as much as possible.

Box 5: What can you do to reduce the risk if you decide you are willing to accept it?

- Use the equation that was developed for the extraction method and lab that supplied your soil test data only.
- Request Mehlich-III Al be determined too.
- Be mindful of the units in which soil test results are reported (i.e. lbs/acre or ppm). To convert from lbs/acre to ppm divide by two.
- Compare your results to previous records (soil tests, manure and fertilizer applications, etc.).

Conversion Tools and More Information

A web-based conversion module and an excel spreadsheet were developed to help users with deriving a Cornell Morgan equivalent from their Mehlich-III input data from the three commercial laboratories. Also included in the spreadsheet are conversions for Morgan test results from Spectrum Laboratories Inc. The conversion equations are also incorporated into Cornell Cropware (version 1.0.16). All tools can be found on the Nutrient Management Spear Program website: http://www.css.cornell.edu/nmsp (click on software). These tools will be updated once equations are derived for other laboratories that joined the project this year. For further questions, contact Quirine Ketterings (qmk2@cornell.edu) or Karl Czymmek (kjc12@cornell.edu).