What's Cropping Up?

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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

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?

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

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).

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

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).

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.

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

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

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

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.

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?

- o Use the equation that was developed for the extraction method and lab that supplied your soil test data only.
- o Request Mehlich-III Al be determined too.
- o 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.
- o 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).

Crop Management

Corn Emergence in 2002

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The 2002 growing season has been another challenging year for New York corn growers. Temperatures averaged about 3.5°F below normal and precipitation averaged about 2.0 inches above normal in May. New York corn growers planted less than 50% of their crop by the end of May. Unfortunately, some of the corn that was planted in late April and early to mid-May had less than satisfactory emergence. We were able to plant our corn silage hybrid trials in central/western New York in late April and early May, and will share with you our observations on corn emergence from these trials.

We planted 35 corn hybrids at the Aurora Research Farm on April 24th. Temperatures averaged only 52.5 (high) and 35°F (night) during the immediate 9 days following planting (Table 1). Despite such cool conditions, all hybrids emerged by May 13, 19 days after planting. Surprisingly, only 90 growing degree days (GDD) accumulated from planting until emergence, instead of the usual 110 GDD required for corn emergence. Apparently, the continuously wet soil conditions (~4.75 inches of precipitation from planting until emergence) reduced the GDD requirement for corn emergence. The 35 hybrids at Aurora averaged 85% emergence with most hybrids ranging from 80 to 90% (Table 2). Overall, emergence at the Aurora site was very satisfactory given the early planting date and ensuing cool wet conditions.

We planted the same 35 hybrids at the Southview Farm near Groveland Station on May 8th. Despite the later planting date, the corn hybrids did not emerge until May 28, 20 days after planting (Table 1). In fact, the corn hybrids required about 125 GDD to emerge, instead of the typical 110 GDD or the 90 GDD that was observed at Aurora. Apparently, the heavy rains (3.00 inches in the immediate 9 days after planting) followed by dry conditions created a significant crust at this site, which delayed emergence. Furthermore, the crust also reduced emergence as indicated by only 78% emergence at the Southview Farm compared with 85% at Aurora (Table 2).

Conclusions:

1) Early planting dates (late April) and cool, wet conditions (-4.25°F and + 3.00 inches of precipitation at Aurora from April 24 until May 14) are usually not the reasons for unsatisfactory crop emergence.

2) Hybrid selection is usually not the reason for unsatisfactory emergence as indicated by the similar emergence for 22 of the 35 hybrids in this study (LSD = 5, Table 2) and the 77 to 86% range in emergence for 33 of the 35 hybrids.

3) Unsatisfactory emergence is usually associated with other factors such as soil conditions (crusting, drainage, eroded knolls, etc.), planter operation (calibration, depth, mechanical problems, etc.), pest problems (birds, seed corn maggot, wireworm, etc.), land preparation (excess residue, cloddy conditions, etc.), and other miscellaneous problems (fertilizer injury, allelopathy, etc.).

Table 1. Percent emergence of 35 hybrids planted at the Aurora Research Farm on April 24 and at the Southview Farm in Groveland Station on May 8.

	Percent Emergence		
Hybrid	Aurora	Southview	Mean
DKC59-08	88	84	86
DKC65-00	89	82	86
34M94	88	83	86
DKC61-25	91	80	86
33D31	90	80	85
N58-D1	87	83	85
24X	85	84	85
DKC51-43	88	81	84
DKC53-34	89	80	84
X5117CL	89	80	84
DKC48-15	84	84	84
TMF108	85	82	84
HT4602Bt	87	80	84
36N71	88	79	84
H8906	82	84	83
EX18195	84	82	83
36N70	88	79	83
HLS058	89	78	83
6630RR	89	76	83
AG5095	88	76	82
DKC56-71	86	79	82
34B23	86	78	82
H7706	83	79	81
35P12	89	73	81
477SL	83	77	80
HLS041	78	80	79
AG5121	86	72	79
8715	86	72	79
8640IT	84	74	79
HLSX2097	82	74	78
AG5215	81	74	78
677SL	80	74	77
HLS067	79	74	77
HLSX2096	80	69	74
N48-K2	65	71	68
Avg.	85	78	
LSD 0.05	2		5

Table 2. Temperature and precipitation at the Aurora Research Farm and at Dansville from corn planting until corn emergence.

	AURORA			DANSVILLE		
Date	Temperature		Precipitation	Temperature		Precipitation
	High	Low		High	Low	
	°F		in.	°F		in.
4/25	49	35	0.49			
4/26	49	35	0.00			
4/27	53	37	0.20			
4/28	58	34	0.35			
4/29	40	33	0.04			
4/30	56	36	0.20			
5/1	58	39	0.18			
5/2	62	36	0.05			
5/3	48	32	0.00			
5/4	64	42	0.00			
5/5	70	53	0.00			
5/6	79	55	0.40			
5/7	73	41	0.10			
5/8	58	42	0.35			
5/9	59	48	0.25	61	47	0.35
5/10	64	36	0.00	67	41	0.45
5/11	59	45	0.00	63	38	0.05
5/12	58	45	0.85	61	38	0.65
5/13	51	41	1.30	62	45	0.70
5/14				45	42	0.10
5/15				49	35	0.00
5/16				63	41	0.35
5/17				74	45	0.35
5/18				54	37	0.00
5/19				54	37	0.05
5/20				49	34	0.00
5/21				46	31	0.00
5/22				56	31	0.00
5/23				67	38	0.00
5/24				80	50	0.00
5/25				69	34	0.20
5/26				69	44	0.35
5/27				67	43	0.00
5/28				80	57	0.00

Soil Management

Tillage and Rotation Effects on Earthworm Activities

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Tillage and crop rotation are two management inputs that affect soil characteristics. Proponents of no-till systems and/or diverse cropping systems promote these management practices because of their beneficial impact on soil quality. Few studies, however, have evaluated the combined effects of tillage and crop rotation on soil biological activities and soil physical characteristics. The objective of this research was to evaluate biological (earthworm densities) and soil physical characteristics (field infiltration rates) in corn in the 6th and final year of a tillage x crop rotation study. Tillage systems included moldboard plow, chisel, and ridge tillage. Crop rotations included soybean-corn, soybean-wheat/clover-corn and continuous corn.

Sampling for earthworms was done in mid-May, shortly after corn emergence. A cylindrical soil sampler, 15 cm in diameter and height, was used to collect four soil samples each from the row and interrow positions. The soil samples were spread on a table and earthworms were counted by hand in the field. Field infiltration rates were determined in the row and nontracked interrows at the sixth leaf stage (V6) and early grain-filling (R3) of corn growth. Steel rings, 0.152 m inside diameter, were placed into the soil centered at a depth of 0.076 m. A portable custom-made rainfall simulator was placed on top of the rings and used to pre-wet the soil under near-natural conditions at a rate of 76 mm/h for 1800 s or until ponding, depending on which occurred first. A Marriott-type permeameter, which established a 0.10 m hydraulic head, was then placed on the rings. Water loss in the permeameter was recorded for a period of 660 to 840 s after establishment of a constant head.

When averaged across tillage systems and row positions, the soybean-wheat/clover-corn rotation had the greatest earthworm densities among the three rotations (Table 1). In the previous year, red clover was interseeded into standing wheat in March as a green manure crop. After wheat harvest, red clover produced significant dry matter during the late summer, fall and early spring before it was plowed under a couple of days before corn planting. The red clover residue probably had a low C:N ratio, resulting in a more favorable food source and more earthworms in the soybean-wheat/clover-corn rotation.

A tillage x row position interaction existed for earthworm densities (Table 1). Row position did not affect earthworm densities under chisel and moldboard tillage. In contrast, earthworm densities averaged 191 m^{-2} in the row compared with 515 m^{-2} in the interrow in ridge tillage. Sweeps were mounted on the planter to remove residue from the seed zone in ridge tillage because residue reduces soil temperature and corn emergence in New York. The use of sweeps, however, reduced residue in the row to 30 to 40% and increased residue in the interrow to 60 to 80%, depending upon the cropping system. The redistribution of residue from the row to the interrow during the planting operation in late April probably contributed to the difference in earthworm densities between row and interrow positions in ridge tillage in mid-May.

Field infiltration rates averaged more in chisel and moldboard plow tillage compared with ridge tillage at the V6 stage (Table 2). Spring soil loosening in chisel and moldboard plow tillage probably contributed to the two to threefold difference in infiltration rates among tillage systems at the V6 stage. Moldboard plow continued to have greater infiltration rates when compared to ridge tillage at the R3 stage (Table 2).

Field infiltration rates at the V6 stage averaged the most in the soybean-wheat/clover-corn rotation, which also had the greatest earthworm densities. Earthworm densities and field infiltration at the V6 stage, however, did not have a significant correlation. Crop rotation did not affect field infiltration rates at the R3 stage.

A tillage x crop rotation interaction existed for corn yield in 1997 because of the relatively high yield in the soybean-wheat/clover-corn rotation in moldboard plow tillage, but relatively low yield in ridge tillage (Table 3). The relatively low yield in the soybean-wheat/clover-corn rotation in ridge tillage was associated in part with low corn densities and N availability. Despite factors other than soil management influencing corn yields, corn yields had significant linear and quadratic relationships with earthworm densities and infiltration rates at the V6 stage.

Table 1. Earthworm densities in the row and interrow positions of three tillage systems and three rotations in mid-May of 1997 at Aurora, NY.

	CHISEL		PLOW		RIDGE		
ROTATION	Row	Interrow	Row	Interrow	Row	Interrow	Avg.
	Earthworms m^{-2}						
Continuous Corn	223	350	159	127	95	286	207
Soybean-Corn	287	271	270	207	143	668	308
Soybean-Wheat/Clover-Corn	493	350	605	652	334	559	504
	334	324	345	329	191	515	
LSD 0.05			240†				146‡

† LSD is the interaction LSD that compares the means between row positions for each tillage system.
‡ LSD compares the means among rotations.

Conclusion

The soybean-wheat/clover-corn rotation had the greatest earthworm densities shortly after corn emergence and infiltration rates during vegetative growth of corn. Moldboard plow tillage had the greatest infiltration rates among tillage systems during the vegetative and reproductive corn growth. Earthworm densities explained 27% and infiltration rates during vegetative development explained 24% of the variability in corn yields. The much greater corn yield in the soybean-wheat/clover-corn rotation in moldboard plow tillage is probably associated in part with its greater earthworm densities and infiltration rates. More diverse cropping systems apparently improve soil quality, which can increase corn yields.

Table 2. Field infiltration rates in the row and interrow positions under three tillage systems and three rotations at the 6th leaf (V6) and early grain-filling (R3) stages of corn growth at Aurora, NY in 1997.

	Continuous Corn		Soybean-Corn		Soybean-Wheat/ Red Clover-Corn		AVG.		MEAN
TILLAGE	Row	Interrow	Row	Interrow	Row	Interrow	Row	Interrow	
					μm s^{-1}				
					V6				
Chisel	10	55	25	30	49	110	28	65	47
Plow	61	71	51	49	89	127	67	82	75
Ridge	2	12	15	81	21	13	13	35	24
Mean	35		42		68		36	61	
LSD 0.05			30†				21‡		23§
					R3				
Chisel	69	34	93	50	65	55	76	47	61
Plow	228	86	94	23	154	49	159	53	106
Ridge	16	12	37	23	73	24	42	20	31
Mean	74		54		70		92	40	
LSD 0.05			NS†				27‡		47§

† LSD compares means among rotations.
‡ LSD compares means between row positions.
§ LSD compares means among tillage systems.

Table 3. Corn yields under three tillage systems and three crop rotations at Aurora, NY, in 1997.

ROTATION	CHISEL	PLOW	RIDGE
		bu acre^{-1}	
Continuous Corn	106	100	104
Soybean-Corn	144	144	146
Soybean-Wheat/Clover-Corn	152	182	128
LSD 0.05		22 †	

† LSD is the interaction LSD that compares the means of each rotation across tillage systems.

Calendar of Events

August 1	Aurora Farm Field Day, Musgrave Research Farm, Aurora, NY
August 28-29	NAV CANADA Training & Conference Centre, Corwall, Ontario
October 2-4	Northeastern Division of American Phytopathological Society, Bromont, Quebec
October 22, 2002	Field Crop Dealer Meeting, Chaucers Rest. & Banquet House, Clifton Park, NY
October 23, 2002	Field Crop Dealer Meeting, Ramada Inn, New Hartford, NY
October 24, 2002	Field Crop Dealer Meeting, Batavia Party House, Batavia, NY
October 25, 2002	Field Crop Dealer Meeting, Holiday Inn, Auburn, NY
November 10-14, 2002	ASA-CSSA-SSSA Annual Meetings, Indianapolis, IN
November 19-21	Ag & Food Systems Inservice, Ithaca, NY
December 4-6	Certified Crop Advisor Training, Ramada Inn, Ithaca, NY
December 7-9	National Fusarium Head Blight Conference, Erlanger, KY

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