Trends in Soil Test Phosphorus and Sorption Capacity following Long-term Application of Poultry Litter and Commercial Fertilizers

Interim Report
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Project Purpose and Objectives: The purpose of this project is to understand the behavior of phosphorus in soils receiving long-term applications of manure or inorganic P fertilizers. This will allow us to better predict the overall risk of P loss due to legacy soil P and better predict how soil P chemistry changes over time as we build soil test P. The specific objectives of this proposal were to 1) maintain long-term P build-up plots located at Georgetown, DE and Chestertown, MD through the 2016 season, and 2) begin to understand P behavior in soils with a history of P application. Overall, we believe that use of a soil test other than Mehlich 3 P may be necessary to better predict potential soil P drawdown and the associated risk of legacy P losses from sites with a long history of poultry litter and/or fertilizer P application.

Results and Discussion

Maintenance of University of Delaware Long-term P Buildup Sites

Long-term (17 year) field sites at Georgetown, DE and Chestertown, MD were maintained through 2016. Crop rotation at the site was continuous corn from 2000-2005 and corn/soybean rotation from 2005-2013. In 2014, we moved to a corn/corn/soybean rotation and increased manure application rates to better simulate historical P buildup at the site. The full management history of the field sites (lime applications, N and K fertilization, total P applied, etc.) is available upon request. Historically, manure and fertilizer treatments were applied (to corn only) in 15 ft × 40 ft plots at each site based on the following treatments (six replications per treatment arranged in a randomized complete block design):

1. No P applied (control).
2. Poultry litter applied annually at 3 tons/A in 2000-2002. No litter applied in 2003-2016.
3. Poultry litter applied annually at 3 tons/A in 2000-2002; poultry litter applied at 1 ton/A in 2005, 2007, 2009, 2011, and 2013; 2 ton/A poultry litter in 2014 and 2016.
4. Poultry litter applied annually at 3 tons/A in 2000-2002; poultry litter applied at 2 tons/A in 2005, 2007, 2009, 2011, and 2013; 4 ton/A poultry litter in 2014 and 2016.
5. Poultry litter applied annually at 3 tons/A in 2000-2002; poultry litter applied at 3 tons/A in 2005, 2007, 2009, 2011, and 2013; 6 tons/A poultry litter in 2014 and 2016.
6. Poultry litter applied annually at 3 tons/A in 2000-2002; poultry litter applied at 4 tons/A in 2005, 2007, 2009, 2011, and 2013; 8 tons/A poultry litter in 2014 and 2016.

7. Fertilizer P (0-46-0) applied at 20 lb P_2O_5/A in 2000-2002; fertilizer P (0-44-0) applied at 20 lb P_2O_5/A in 2005, 2007, 2009, 2011, 2013, 2014, and 2016.
8. Fertilizer P (0-46-0) applied at 40 lb P_2O_5/A in 2000-2002; fertilizer P (0-44-0) applied at 40 lb P_2O_5/A in 2005, 2007, 2009, 2011, 2013, 2014, and 2016.
9. Fertilizer P (0-46-0) applied at 60 lb P_2O_5/A in 2000-2002; fertilizer P (0-44-0) applied at 60 lb P_2O_5/A in 2005, 2007, 2009, 2011, 2013, 2014, and 2016.
10. Fertilizer P (0-46-0) applied at 155 lb P_2O_5/A in 2000-2002; fertilizer P (0-44-0) applied at 120 lb P_2O_5/A in 2005, 2007, 2009, 2011, 2013, 2014, and 2016.

In 2016, the sites were planted in corn and manure or fertilizer P was applied according to the revised treatments to begin P buildup (Table 1). Application rates in 2016 were more indicative of historical manure applications rates, which resulted in wide-spread build-up of soil test P within the region.

Table 1. Total P application rate applied in poultry litter prior to planting corn in 2016 at the University of Delaware long-term P buildup sites in Georgetown and Chesapeake Farms.

Manure Application Rate (tons/A)	**Total Phosphorus Applied (lb/A)**	
	Georgetown	**Chesapeake Farms**
2	44	46
4	88	92
6	132	138
8	176	184

Soybean yields in 2015 were reported last year, however, routine soil analysis following harvest was still pending at the time of the last report. Despite increased manure application rates in 2014, there was no significant increase in soil test P concentrations at either site between 2013 and 2014 (data not shown). This lack of significant increase in soils remains somewhat surprising since the highest manure rate added nearly 200 lb/A of total P in 2014. However, no additional manure was applied in 2015, so a further increase in soil test P in 2015 was not expected. Because of variability associated with soil testing and the potential that some of the total P applied was not plant available, we continue to recommend longer-term monitoring to examine soil test response to high application rates. Manure application is planned for 2017. In addition, we recommend collected samples from deeper depths at the site (up to 24 inches) to investigate the potential that P is leaching downward through the soil profile.

There was, however, a clear effect of increased P application rate on soil test P concentrations in the silt loam soil at Chesapeake Farms and the loamy sand soils at Georgetown (Figure 1). While the 2014 soil data showed less clear trends for increasing Mehlich 3 P concentrations at the Georgetown soils (data not shown). In 2015, the trend for Georgetown soil test P was much more consistent with what we see at the Chesapeake Farms site, probably due to equilibration of added P among different soil P pools.

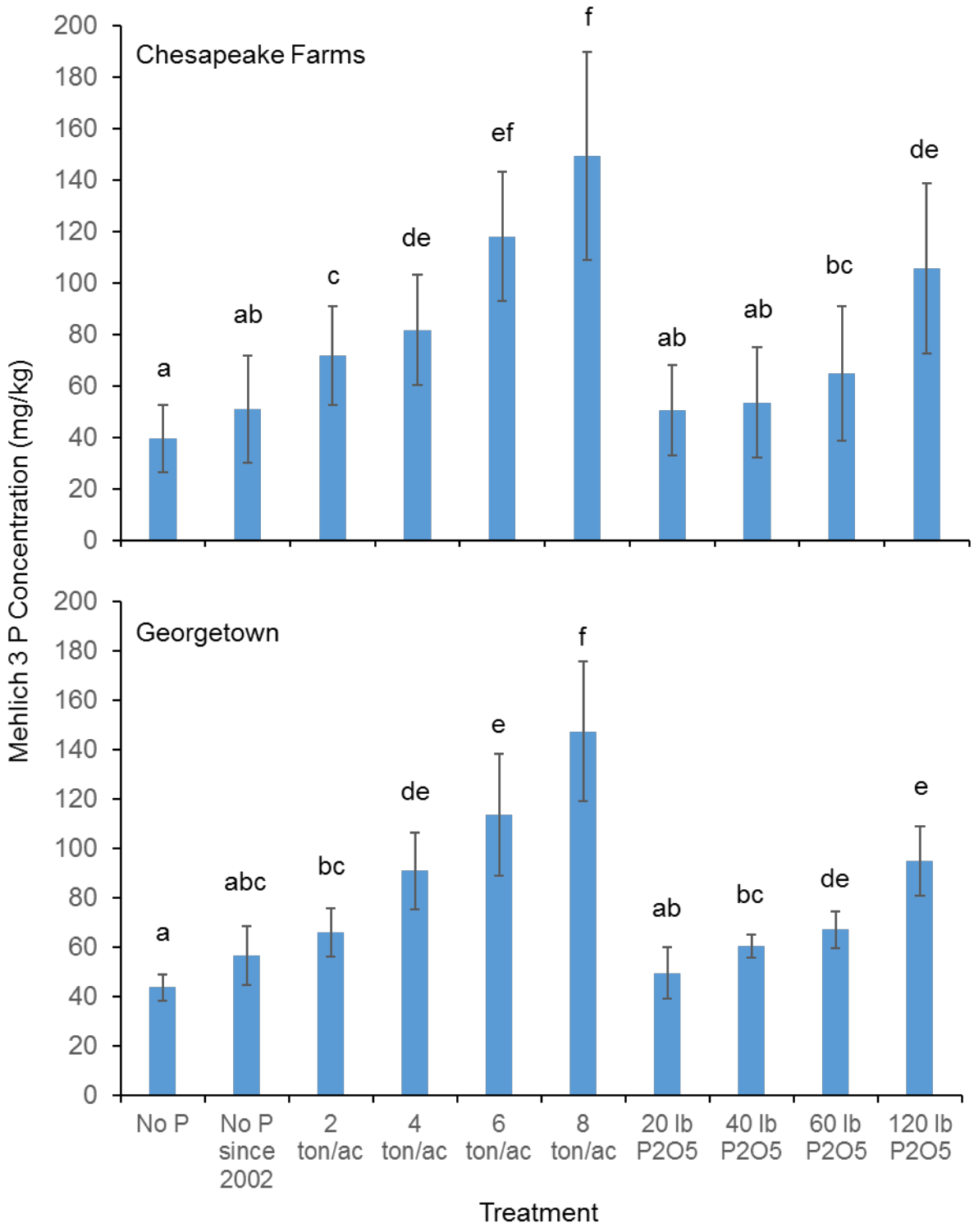

Figure 1. Effect of manure and fertilizer treatments on 2015 post-harvest soil test P at the Chesapeake Farms and Georgetown long-term P application sites. Bars with the same letter at the same site were not significantly different using Tukey's honestly significant difference test at $P<0.05$.

Corn grain samples were collected prior to harvest and routine soil samples were collected immediately following harvest in 2016. All samples were dried and ground and submitted to the University of Delaware Soil Testing Laboratory; results are pending.

Data analysis was completed to determine the effects of fertilization on corn yield at the Georgetown site only. Yields at the Georgetown site ranged from 170 to 215 bu/A (Figure 2), which were good yields considering that corn began to fall before harvest following heavy rainfall in the area. At Georgetown, plots receiving manure at rates of 2 tons/A or higher had significantly higher yields than plots receiving no P. However, yields in plots receiving manure or inorganic P faired equally well for the most part. This was likely due to high variability in yields among treatment replications due to weather related issues. At Chesapeake Farms, there was no yield response to any of the manure or fertilizer treatments again in 2016 (data not shown), despite clear significant differences in soil test P concentrations (Figure 1). The average corn grain yield at Chesapeake Farms in 2016 was 151 bu/A. Corn at Chesapeake Farms was harvested after the significant rainfall, which may have impacted yields when corn began to fall. We also experienced combine issues during this harvest, which could have masked actual treatment differences. However, it is likely that yield was not limited by soil P availability, but by other environmental factors, such as limited rainfall since the site is not irrigated and corn was planted late.

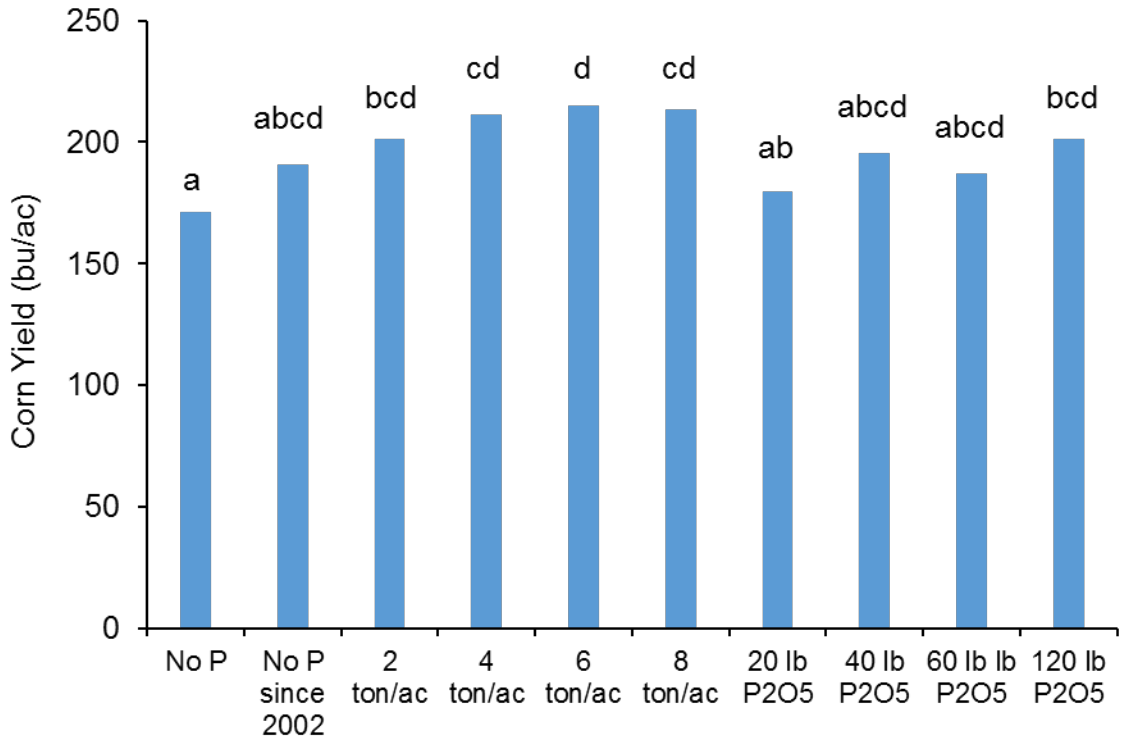

Figure 2. Effect of manure and fertilizer treatments on 2016 corn grain yield at the Georgetown long-term P application sites. Bars with the same letter at the same site were not significantly different using Tukey's honestly significant difference test at P<0.05.

Conclusions

Overall, our preliminary results showed that long-term application of manures and fertilizers affect the solubility of P in soils. There is the potential that high rates of manure P are contributing to leaching of P through the soil profile rather than buildup of P in the topsoil; therefore, we propose collecting some deeper soil samples for analyses in 2017. Maintenance activities for the UD sites are also proposed for FY 2017.

Occasions where MGPUB has received recognition

Data from this project was shared at scientific meetings including the Northeast Plant, Pest, and Soils Conference and the Mid-Atlantic Soil Test and Plant Analysis Workgroup; MGPUB received recognition for funding at all events. We will continue to recognize MGPUB as we prepare publications and present data to clientele.