OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER

Effect of Flue Gas Desulfurization Gypsum and Farming Methods on Phosphorus Loss from Two Agricultural Soils

Yumei Mao[1,2], Warren Dick[2], Xiaogang Tong[2], Xiaoping Li[1], Liming Chen[2] and Leandro Michalovicz[3]

[1]East China Normal University (Shanghai, China), [2]The Ohio State University (Wooster, Ohio) and the [3]State University of Maringa (Maringa, Brazil)

Introduction

Excessive application of phosphorus (P) fertilizer to cropland increases the risk of P export to lakes and rivers(Figure 1a), leading to toxic algal bloom in Lake Erie and the contamination of water supplies in various cities (e.g. Toledo). Minimizing the water quality threat by reducing P loss from soils is necessary. One way is to reduce P solubility by precipitation with other elements such as calcium. Flue gas desulfurization gypsum (FGDG) is material produced when sulfur is scrubbed from the flue gases of electricity-generating utilities (Figure 1b) and is an excellent source of calcium.

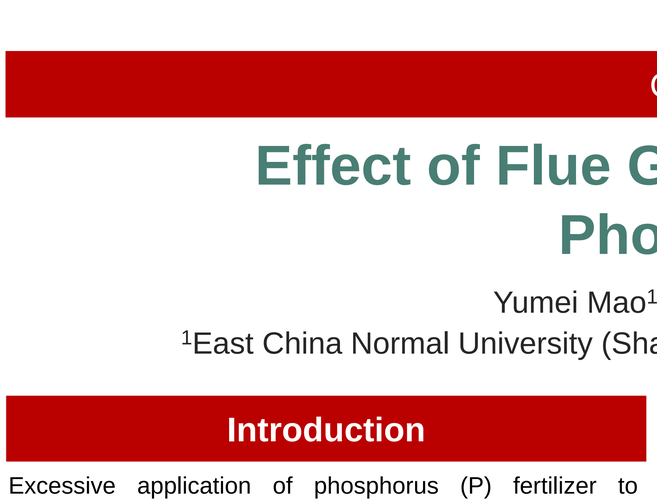

Figure 1. The phosphate cycle (a) and a schematic showing how flue gas desulfurization gypsum (FGDG) is formed in a electricity producing power plants.

(a) http://www.elmhurst.edu/~chm/vchembook/308phosphorus.html
(b) http://ohioline.osu.edu/anr-fact/0020.html.

Objectives

To evaluate the impacts of FGDG and farming methods on P loss from contrasting soils in Ohio and to provide management practices that reduce P export from agricultural watersheds into lakes and rivers.

Materials and Methods

A completely randomized design experiment was conducted in the greenhouse. Two Ohio soils collected were a Wooster silt loam and a Hoytville clay loam. Each soil was treated with fertilizer P (255 g kg^{-1}) that was either surface applied or mixed into soil. The soils were then treated with three rates of FGDG (0, 336 or 3360 kg/ha) that was either surface-applied (S) or mixed (M) with soil to simulate no-tillage and tillage (Table 1). Soils were planted with annual ryegrass *(Lolium perenne*). After three weeks to establish ryegrass growth, rainfall (0.2 mm/min for 90 min) was applied and runoff and leachate water were collected. The rainfall events were repeated every two weeks for 12 weeks. Soluble P in filtered water samples was measured.

Table 1. Experimental treatments[a].

Farming methods	M			S			
FGDG treatments	0	G	GG	0	G	GG	G/P

[a]0, G, and GG represent 0, 336 and 3360 kg/ha FGDG application rate treatments, respectively. The G/P treatment represents application of FGDG and phosphorus fertilizer together instead of sequentially.

Results

Surface application of fertilizer P (i.e. the GG/P-S treatment) leads to rapid loss of P in runoff water (Figure 2, top). Soluble P in leachate water was decreased when FGDG was applied (Figure 2, bottom) and this effect was greatest at the highest FGDG application rate. The lowest amount of soluble P loss in leachate occurred when both P fertilizer and the highest FGDG rate were applied together on the surface. This is an important finding because the majority of water lost from fields in northwest Ohio occurs via leachate (i.e. tile drainage) and not by surface runoff (Smith, D.R., 2014). Soluble P in leachate water was significantly ($P<0.05$) affected by farming methods, i.e. mixing (M) or surface (S) application of FGDG, in Wooster but not in Hoytville soil.

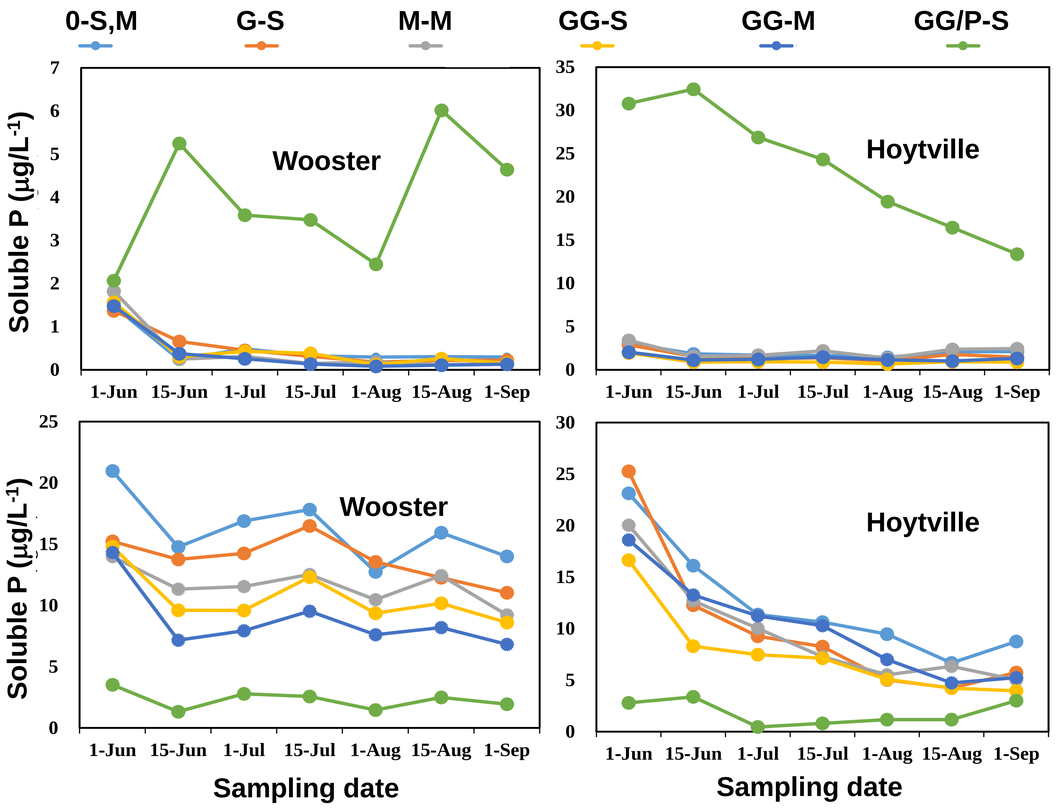

Figure 2. Soluble P in runoff (top) and leachate (bottom) water from two Ohio soils.

Results

Table 2. Soluble P in leachate water was affected by farming methods, i.e. mixing (M) or surface (S) application of FGDG[a].

	G		GG	
	M	S	M	S
Wooster	11.3a	13.6b	7.87a	9.94b
Hoytville	7.80	7.46	8.62	6.02

[a]Means with the same letter or no letter in the same row for G and for the same row for GG are not significantly different at $P< 0.05$.

Conclusions

- Phosphorus fertilizer should be mixed into soil to most effectively reduce P losses from soil via surface runoff.
- FGDG is a promising soil amendment to reduce P in leachate water, especially when FGDG is added to soil at rates such as 3360 kg/ha.
- Applying FGDG on the soil surface, as occurs for a no-tillage system, can significantly decrease P in leachate water compared to when the FGDG is mixed into the soil. This was more evident for the Wooster than the Hoytville soil.
- The decrease in soluble P in leachate due to FGDG treatment can contribute to less P moving to lakes and rivers, because most water leaving fields in northwest Ohio occurs via tile drainage (i.e. leachate).

References

Morgan, M. Steffen, B. Shafer B., and Watson, S.B. 2014. Status, causes and controls of cyanobacterial blooms in Lake Erie. *J. Great Lakes Res.* 40:466-467.

Favaretto, N., Norton, L.D., and Johnston, C.T. 2012. Nitrogen and phosphorus leaching as affected by gypsum amendment and exchangeable calcium and magnesium. *Soil Sci. Soc. Am. J.*, 76:575-585.

Smith, D.R., King, K.W., Johnson, L., Francesconi, W., Richards, P., Baker, D., and Sharpley, A.N. 2014. Surface runoff and tile drainage transport of phosphorus in the Midwestern United States. *J. Environ. Qual.* doi: 10.2134/jeq2014.04.0176.

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

East China Normal University
Shanghai, China