Northern New York
Agricultural Development Program

FACT SHEET

How Manure Application Timing, Crop, and Soil Type Affect Phosphorus Leaching

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Why Study the Factors Affecting Phosphorus Leaching?

Certain soils, crops and crop production practices may cause higher losses of phosphorus.

A three-year research project conducted at the Cornell Baker Research Farm in Willsboro in Essex County, NY, offers farmers insight into production practices that promote a well-balanced production-stewardship operation.

Introduction

Northern New York farmers, like farmers across the state, are working to balance high-yield, high quality crop production with conscientious environmental stewardship. Certain soils, crops and crop production practices may cause higher leaching losses of phosphorus (P) into soil, tile lines and then on to streams and lakes. A three-year (October 1997-October 2000) research project conducted at the Cornell Baker Research Farm in Willsboro in Essex County, New York, evaluated how manure application timing, crop choice and soil type affect P leaching into surface waters via tile lines. The conclusions drawn from this project offers farmers insight into production management practices that can help promote a well-balanced production-stewardship operation.

Objective:

The objective of this project was to measure the transport of manure-derived phosphorus into shallow ground water and tile lines as affected by two crop choices: corn and orchard-grass, by two soil types: clay loam and loamy sand, and by the timing of applications by seasons.

Methods:

The researchers working on this study began their work with the following earlier research conclusions in mind:

- P losses are primarily a function of soil P availability and the processes of runoff and erosion (Lemunyon and Gilbert, 1993)
- application of P fertilizer or manure at agronomically acceptable rates generally poses little concern for excessive P leaching (Sims et al., 1998)

- soils with a history of high P applications may easily exceed critical soil P levels and cause excessive P leaching (Hesketh and Brookes, 2000)
- artificially drained fine-textured soils that may not be P saturated may lose P through rapid movement through preferential flow paths to subsurface drains and on to surface waters (e.g., Gaynor and Findlay, 1995)
- management practices also affect nutrient leaching loss, e.g., P applications on perennial forage crops often show higher losses than annually cropped land (Culley et al., 1983; Sims et al., 1998)
- application timing may also affect nutrient loss (Sims et al., 1998; Goehring et al., 2001).

This study measured phosphorus (P) leaching losses from liquid manure applied to a clay loam and to a loamy fine sand soil from September 1997 to September 2000. Manure was applied to corn and orchardgrass on both soils over 16 plots. Soil test results prior to manure application for this project showed generally low-to-medium P levels.

Manure Application on Corn

Liquid manure obtained from storage on a nearby dairy farm was agitated before transport to the test plots at the Cornell Baker Research Farm. Manure was applied to the corn plots at an annual rate of 10,000 gallons per acre in one application for both fall and early spring applications and in two equal amounts of 5,000 gallons per acre for the spring split applications. The rates were selected to supply the corn nitrogen requirements from spring manure applications.

A Nuhn Industries manure applicator with 15 drop hoses set 23 cm apart was used to spread the manure that was disc-incorporated twice within three hours of application with the exception of the spring sidedressing that used a four-unit drop hose system with S-tine cultivators between crop rows for immediate incorporation. The corn was harvested as silage.

Manure Application on Orchardgrass

Manure was surface-applied by drop hose to orchardgrass plots in two equal applications of 5,000 gallons per acre. Three plots received manure in early spring (target date: April 15) and after the first cut in late spring (target date: June 15). Three plots received manure after the first cut and after the third cut in early fall (target date: October 1). Two plots received no manure, but were topdressed three times each year with ammonium nitrate. Cornell pest control and nutrient guidelines were followed. The grass was harvested three times based on forage quality in all three study years.

For more information about phosphorus studies at NNY research stations and farms, go online to www.nnyagdev.org and click on Agricultural Environmental or contact the Cornell Cooperative Extension office for your county:

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Water Sampling
Water flow out of tile pines in each plot was sampled at least weekly and more often during high flow events. Over the three-year period more than 1,000 water samples were analyzed for total P content.

Precipitation
Precipitation levels included a 426 mm/16.77 in high (winter 1997-98) and a 123 mm/4.84 in low (one-third the normal rainfall) during the very dry 1999 growing season. The 2000 growing season received higher-than-normal precipitation of 396 mm/15.59 in.

Results and Conclusions

Total P losses were consistently higher (39-fold on average) for the clay loam than the loamy sandy soil. Before manure application, average total P losses for the clay loam soil were negligible. After application, losses from the clay loam soil increased beyond U.S. Environmental Protection Agency's guidelines (0.1 mg/L) for surface water quality, while average concentrations for the loamy sand site were well below the guideline levels.

Although nitrate leaching is generally of greater concern with coarse than fine-textured soils (Sogbedji et al., 2000; van Es et al., 2002), the opposite appears to be the case when considering P losses in artificially-drained soils, and the discrepancies are much higher. It appears that P leaching from manure application on artificially-drained clay loam soils inevitably poses environmental concerns, and risks appear to be augmented by early fall manure applications, especially under untilled grass. For loamy sand soils, concerns about P leaching do not exist as long as soil P concentrations remain well below the saturation point.

Phosphorus losses varied seasonally with the highest losses from early-fall application to corn on the clay loam soil. P losses appear to be more related to precipitation conditions, particularly the timing of rainfall relative to manure application.

Table 1. Flow-weighted mean (FWM) total P losses for drain flow periods at the clay loam and loamy sand sites.

Treatment	3-yr. Mean: Corn	Treatment	3-yr. Mean: Grass
	CLAY LOAM mg L^{-1}		
Early fall	0.609b	Early fall+late spring	1.444ba
Late fall	0.266c	Early+late spring	0.194c
Early spring	0.284c	Mean	0.646
Early+late spring	0.289c	Site mean	0.504
Mean	0.362		
	LOAMY SAND mg L^{-1}		
Early fall	0.004a	Early fall+late spring	0.005a
Late fall	0.044a	Early+late spring	0.029a
Early spring	0.009a	Mean	0.011
Early+late spring	0.002a	Site mean	0.013
Mean	0.362		

Note: The FWM concentrations were significantly higher for the clay loam than those for the loamy sand for each season, as well as the 3-yr mean.

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The Northern New York Agricultural Development Program selects and prioritizes research the results of which can be practically applied to farms in the six-county region of Northern NY: Jefferson, Lewis, St. Lawrence, Franklin, Clinton and Essex counties.

To learn more about the Northern New York Agricultural Development Program, contact: Co-Chairs Jon Greenwood, 315-386-3231, or Joe Giroux, 518-563-7523; or R. David Smith, Cornell University, 607-255-7286; or visit www.nnyagdev.org. ◆

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