Impact of Liquid Swine Manure Application and Cover Crops on Dissolved Phosphorus in Subsurface Drainage Water

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Introduction

The objective of this study was to evaluate the impacts of various cropping and nutrient management systems on crop production and nutrient loss via subsurface tile drainage. Comparisons include the impact of fall swine manure on corn only vs. manure on both corn and soybean in a corn-soybean rotation. The impact of corn stover removal on water quality also was evaluated. A third component of this study was to determine the potential effects of cereal rye as a cover crop to reduce nutrient losses to shallow ground water. This information will be used to develop appropriate manure and nutrient management practices for producers to minimize the water contamination potential and enhance the use of swine manure as an organic fertilizer. Previous progress reports have summarized crop yield, nitrate loss with drainage, and partial results for phosphorus (P) loss with drainage. This report summarizes P loss with drainage for the entire evaluation period.

Materials and Methods

Table 1 identifies the treatments established in 2007 on 36, one-acre plots. Comparisons began in 2008 to eliminate previous treatment effects. Five treatments compare the effect of timing, source, and use of a winter cereal rye cover crop on dissolved P (PO_4-P) loss with subsurface drainage in a corn-soybean rotation, and two treatments compare the effect of manure use under continuous corn with and without stover removal. Fall-applied manure and spring-applied urea-ammonium nitrate (UAN) with cover crop treatments are managed with no-till while the remainder are fall chisel plowed.

Results and Discussion

Table 2 shows the precipitation amounts in the growing season for each year. Rainfall in 2008 and 2013 was more than 10 percent above the 8-yr average. Rainfall in 2011 and 2012 was more than 10 percent below the 8-yr average. Overall, this 8-yr period had a range of precipitation conditions.

The effects of nutrient management treatments on PO_4-P concentrations in subsurface drain (tile) water are summarized in Table 3. Eight-year average flow weighted concentrations ranged from 4.1 to 18.6 µg/L for the six systems. Eight-year average PO_4-P concentrations in plots receiving fall swine manure were higher with conventional tillage (System 2) compared with no-till (System 6) in the corn phase of the corn-soybean rotation. No statistically significant difference was found between any of the systems in the soybean phase of the corn-soybean rotation systems. The rye cover crop had no significant effect on PO_4-P concentrations. Stover removal had no significant impact on concentrations of PO_4-P in the continuous corn systems. Flow-weighted concentrations of PO_4-P tended to be higher in 2008 and 2013 when precipitation and subsurface flows were greater.

Cumulative average PO_4-P losses ranged from <0.01 to 0.03 lb/acre per year for all systems. Leaching of PO_4-P from the continuous corn plots was slightly greater, on average, than from corn-soybean rotation plots. High subsurface flow events in the spring of 2008 and 2013 accounted for a majority of the PO_4-P leaching. Overall, dissolved P losses and flow weighted concentrations observed were lower than what has been reported in similar studies.

Table 1. Experimental treatments for Nashua water quality study.

System	Timings and source of N	Crop	Tillage	Application method	Rate, lb/ac N-based	Rate, lb/ac P-based
1	Spring (UAN) -	Corn	Chisel plow	Spoke inject	150	If needed
		Soybean	Field cultivate	-	-	If needed
2	Fall (manure) -	Corn	Chisel plow	Inject	150	-
		Soybean	Field cultivate	-	-	If needed
3	Fall (manure)	Corn	Chisel plow	Inject	150	-
	Fall (manure)	Soybean	Field cultivate	Inject	100	-
4.1	Fall (manure)	Cont. corn	Chisel plow	Inject	200	-
4.2	Fall (manure)	Cont. corn stover removal	Chisel plow	Inject	200	-
5	Spring (UAN) -	Corn/rye cover	No-till	Spoke inject	150	-
		Soybean/rye cover	No-till	-	-	If needed
6	Fall (manure)	Corn	No-till	Inject	150	-
		Soybean	No-till	-	-	If needed

Table 2. Precipitation in inches for 2008–2015 growing seasons (in.).

	2008	2009	2010	2011	2012	2013	2014	2015	8-yr avg.
Apr	8.9	5.3	3.9	3.9	3.7	6.4	7.2	4.3	**5.4**
May	4.3	5.2	3.1	3.8	5.0	9.9	2.9	3.5	**4.7**
Jun	9.4	3.6	8.6	4.8	1.7	8.2	10.4	5.8	**6.6**
Jul	6.0	3.7	7.1	3.5	1.8	2.7	1.4	4.0	**3.8**
Aug	1.4	3.8	3.0	4.6	3.2	3.3	3.8	4.6	**3.5**
Sep	2.5	2.1	1.7	2.3	1.7	1.1	2.8	2.6	**2.1**
Oct	2.6	6.4	0.4	1.5	4.1	1.5	2.5	1.6	**2.6**
Nov	1.8	0.6	2.2	1.7	1.2	2.0	0.8	2.8	**1.6**
Total	**36.9**	**30.6**	**29.9**	**26.0**	**22.3**	**35.0**	**31.8**	**29.2**	**30.2**

Table 3. Effects of experimental treatments on flow weighted PO_4-P concentrations in drainage water (µg/L).

	2008		2009		2010		2011		2012		2013		2014		2015		2008-2015	
System	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S
1. Spring UAN 150 lb N/ac	4.8	10.7	3.8	3.2	4.7	4.7	2.4	16.8	0.3	0.3	21.9	9.5	-	-	3.7	3.8	5.2b	6.1a
2. Fall manure 150 lb N/ac	12.6	43.0	8.8	4.3	5.3	5.0	1.6	3.5	0.2	1.3	73.8	27.9	-	-	14.0	7.2	14.5a	11.5a
3. Fall manure 150 lb N/ac corn & 100 lb N/ac soybean	8.3	15.9	4.5	3.3	5.1	4.7	0.2	13.9	0.4	8.2	9.9	4.8	-	-	4.4	6.7	4.1b	7.2a
5. Spring UAN 150 lb N/ac + Rye removal	13.7	32.0	7.5	5.2	3.1	8.9	-	4.6	1.0	0.1	25.7	31.6	-	-	3.4	7.9	6.8ab	11.3a
6. Fall manure 150 lb N/ac	8.2	18.1	8.8	5.1	5.0	3.5	0.5	4.9	1.4	6.3	13.9	21.0	-	-	4.8	7.8	5.3b	8.3a
Continuous corn																		
4.1 Fall manure 200 lb N/ac	65.8		6.3		5.3		-		0.9		25.5		1.2		6.2		13.9a	
4.2. Fall manure 200 lb N/ac + Stover removal	108.4		4.3		4.9		0.2		0.5		23.8		5.5		1.5		18.6a	

C (corn) or S (soybeans) is for crop that year.
Means with the same letter are not significantly different.
- Losses in 2014 averaged <0.1 µg/L for all corn-soybean rotation plots.