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

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Introduction

The primary objective of this project is to determine the impact of appropriate rates of swine manure applications to corn and soybeans based on nitrogen requirements of crops, and the potential of nitrate leaching to groundwater. Another purpose of this long-term experimental study is to develop and recommend appropriate manure and nutrient management practices to producers to minimize the water contamination potential and enhance the use of swine manure as an organic fertilizer. A third component of this study is to determine the potential effects of rye as a cover crop to reduce nitrate loss to shallow ground water.

Materials and Methods

Table 1 identifies the treatments established in 2007 on 36, one-acre plots. Comparisons begin in 2008 to eliminate previous treatment effects. Five treatments compare the effect of timing and source of N on subsurface drain water quality and crop yields in a corn-soybean rotation, and two treatments compare the effect of manure use on water quality under continuous corn rotation with and without stover removal. The spring-applied urea-ammonium nitrate (UAN) with cover crop and fall-applied manure are the only treatments using no-till. The rest of the treatments use fall chisel plow as method of tillage.

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, and 2011 and 2012 were 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 NO_3-N concentrations in subsurface drain (tile) water are summarized in Table 3. Eight-year average NO_3-N concentrations in tile water from plots receiving swine manure were the highest in comparison with other treatments/systems. The cover crop system with UAN application had the lowest average concentrations. The fall applied manure to soybean rotation in Treatment 3 had consistently higher NO_3-N concentrations in tile water when compared with all other soybean rotations. Two systems (Systems 1 and 5) receiving UAN resulted in the lowest NO_3-N concentrations in tile water. Comparing the results for Systems 1 and 5, we see a statistically significant decrease in NO_3-N concentrations with System 5. System 5 had cover crop rye and System 1 did not. Combining across the corn and soybean phase, we see a decrease of about 30 percent. Reviewing the direct tillage impact between Systems 2 and 6, we see no statistically significant difference in NO_3-N concentrations. Table 4 shows tile flow drainage water for the treatments.

The effects of source and timing of nitrogen application on corn and soybean yields for 2008 through 2015 are shown in Table 5. The spring UAN application at 150 lb N/acre resulted in the highest average corn yield of 197.8 bushels/acre compared with other systems. Treatments 2 and 3 had the next higher corn yields. Treatments 5 and 6 had the lower corn yields for the rotation treatments. Although receiving higher nitrogen rates, the continuous corn treatments showed slightly lower corn yields than the rotation treatments. Soybean yields from the no-till plots had the highest yield at 66 bushels/ac, and Systems 3 and 2 receiving swine manure resulted in average soybean yield of 65.1 and 64.5 bushels/acre, respectively.

Reviewing the corn yield in corn-soybean rotation, all systems with tillage (Systems 1–3) had statistically higher corn yield than the no-till systems (Systems 5 and 6). There was no statistically significant difference within the tillage (Systems 1–3) or no-till systems (Systems 5 and 6). For soybeans, we see systems where manure was applied had statistically greater soybean yields than the UAN systems. Unlike corn, when comparing the direct tillage systems (Systems 2 vs. 6), we see no difference in yield indicating the no-till soybeans yielded equivalent to soybeans with tillage. When comparing the cover crop system (System 5) to its closest comparison system (System 1), we see a statistically significant soybean yield decrease with the cover crop treatment. Although other studies in Iowa have seen a corn yield risk from cover crops, it has been unusual to see any yield risk in soybeans. The potential yield drag at this site is an aspect that warrants future investigations.

Table 1. Experimental treatments for water quality study at the ISU Northeast Research Farm, Nashua, IA.

System	Timings and source of N	Crop	Tillage	Application method	Rate, lb/ac N-based	Rate, lb/ac P-based
1	Spring	Corn	Chisel plow	Spoke inject	150	If needed
	(UAN)	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	Fall (manure)	Cont. corn	Chisel plow	Inject	200	-
4	Fall (manure)	Cont. corn Stover removal	Chisel plow	Inject	200	-
5	Spring	Corn/rye cover	NT	Spoke inject	150	-
	(UAN)	Soybean/rye cover	NT	-	-	If needed
	-					
6	Fall (manure)	Corn	NT	Inject	150	-
		Soybean	NT	-	-	If needed

Table 2. Precipitation for the growing season.

	2008	2009	2010	2011	2012	2013	2014	2015	8-yr average
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 average NO_3-N concentrations in drainage water (in mg/l).[1, 2]

	2008		2009		2010		2011		2012		2013		2014		2015		08-15	
Experimental Treatments	**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	15.1	8.0	12.1	9.5	12.3	8.0	17.8	13.8	14.0	19.5	14.6	23.3	17.7	11.5	14.4	7.7	14.8c	12.7b
2. Fall manure 150 lb N/ac	17.7	8.3	19.9	10.3	12.8	8.4	29.4	12.4	22.3	15.7	36.2	12.2	30.6	8.6	19.2	4.4	23.5ab	10.1bc
3. Fall manure 150 lbN corn & 100lbN soybean	20.3	14.2	20.3	11.1	16.1	14.0	27.7	18.2	32.1	20.1	38.3	34.3	39.9	17.7	23.1	7.3	27.2a	17.1a
5. Spring UAN 150 lb N/ac + Rye removal	12.3	8.6	8.9	8.3	10.4	4.4	9.2	8.9	8.4	7.4	7.7	12.4	15.3	10.1	10.0	6.1	10.3d	8.3c
6. Fall manure 150 lb N/ac	15.3	8.9	15.8	8.3	12.8	8.0	20.9	9.5	23.4	13.4	31.2	8.3	26.2	8.7	17.5	4.9	20.4b	8.8c
Continuous corn																		
4.1 Fall manure 200 lb N/ac	23.1		20.1		15.1		22.3		21.9		36.6		23.9		21.1		23.1a	
4.2. Fall manure 200 lb N/ac + Stover removal	23.0		17.6		16.0		24.2		19.4		40.2		25.9		22.6		23.6a	

[1]C or S is for the crop that year.
[2]Means with the same letter are not significantly different (Continuous corn and C-Sb rotations analyzed separately).

Table 4. Effects of experimental treatments on tile flow drainage water (in.).[1]

	2008		2009		2010		2011		2012		2013		2014		2015		08-15	
Experimental Treatments	**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	8.1	5.3	2.4	4.6	3.8	3.9	1.9	2.4	1.3	1.1	5.6	10.6	4.7	4.4	2.8	3.3	3.8	4.4
2. Fall manure 150 lb N/ac	12.8	7.6	2.5	9.3	8.7	5.2	2.4	7.0	4.0	1.5	6.8	10.4	6.4	4.6	3.1	6.5	5.8	6.5
3. Fall manure 150 lbN corn & 100lbN soybean	8.7	9.5	3.3	6.2	4.4	4.8	2.3	3.0	1.4	1.4	9.6	8.4	4.4	6.1	3.3	2.7	4.7	5.2
5. Spring UAN 150 lb N/ac + Rye removal	7.4	7.7	3.9	7.2	7.6	5.0	3.5	5.7	2.6	1.8	7.6	10.4	5.9	5.0	4.1	5.4	5.3	6.0
6. Fall manure 150 lb N/ac	9.4	11.1	5.4	8.5	9.1	8.1	7.1	8.0	3.5	3.8	10.7	11.5	6.6	7.8	6.1	7.2	7.2	8.2
	CC		**CC**		**CC**		**CC**		**CC**		**CC**		**CC**		**CC**		**CC**	
4.1 Fall manure 200 lb N/ac	10.0		4.6		6.2		2.8		1.9		9.8		5.5		4.2		5.6	
4.2. Fall manure 200 lb N/ac + Stover removal	7.0		3.9		4.1		3.0		1.1		6.4		4.6		5.7		4.5	

[1]C or S is for the crop that year.

Table 5. Corn and soybean crop yields for years 2008-2015.[1, 2]

	2008		2009		2010		2011		2012		2013		2014		2015		08-15	
Experimental Treatments	**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	187.5	60.0	223.5	55.1	193.4	63.8	217.3	63.9	157.3	52.2	218.2	62.2	171.5	51.6	213.9	64.2	197.8a	59.1b
2. Fall manure 150 lb N/ac	141.0	63.0	205.5	63.9	188.9	66.7	210.2	68.2	175.4	55.1	173.6	58.0	171.8	71.2	239.4	70.0	188.2a	64.5a
3. Fall manure 150 lbN corn & 100lbN soybean	141.5	62.5	213.2	64.6	195.5	67.9	218.4	69.7	152.8	57.9	180.4	62.1	185.2	71.5	235.5	64.7	190.3a	65.1a
5. Spring UAN 150 lb N/ac + Rye removal	169.8	50.9	190.7	52.5	156.1	54.4	181.9	61.4	131.3	49.7	190.7	60.0	153.2	49.7	199.6	59.3	171.7b	54.7c
6. Fall manure 150 lb N/ac	123.9	60.6	186.2	61.6	153.0	66.0	199.8	67.7	173.2	62.7	159.1	67.9	158.4	72.4	234.3	69.4	173.5b	66.0a
Continuous corn																		
4.1 Fall manure 200 lb N/ac	103.4		174.7		160.8		186.2		172.8		152.6		151.8		229.2		166.4a	
4.2. Fall manure 200 lb N/ac + Stover removal	94.7		195.8		177.7		197.4		167.5		177.1		137.1		232.0		172.4a	

[1]C or S is for the crop that year.
[2]Means with the same letter are not significantly different (Continuous corn and C-Sb rotations analyzed separately).