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Impact of Swine Manure Applications on Nitrate and Phosphorus in Subsurface Drainage Water

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Abstract

Nonpoint source nutrient pollution related to land application of manures is recognized as an important environmental and social issue for several reasons. First, manure from swine production facilities can have serious impacts on the quality of ground water resources. Second, several states are in the process of creating laws and/or regulations to reduce nitrogen (N) and phosphorus (P) loadings from manure to soil and water resources. Third, pollution of water resources from nutrients supplied by manure to croplands will help set parameters for developing public policies on the management of manure.

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Agronomy, Agricultural and Biosystems Engineering

Disciplines

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Introduction

Nonpoint source nutrient pollution related to land application of manures is recognized as an important environmental and social issue for several reasons. First, manure from swine production facilities can have serious impacts on the quality of ground water resources. Second, several states are in the process of creating laws and/or regulations to reduce nitrogen (N) and phosphorus (P) loadings from manure to soil and water resources. Third, pollution of water resources from nutrients supplied by manure to croplands will help set parameters for developing public policies on the management of manure.

Objectives

- To determine the impacts of recommended swine manure application rates based on N and P needs of crops, on water quality.
- To study the long-term effects of over-application of swine manure on N and P losses with subsurface drainage.
- To study the long-term effects of spring and fall injection of swine manure on crop yields, and N and P concentrations in shallow groundwater.
- To develop and recommend appropriate manure and nutrient management practices to reduce the water contamination potential from manure and fertilizer N (UAN) applications and enhance the use of swine manure as an alternative to the use of inorganic fertilizers for Iowa's sustainable agriculture.

A field study was conducted for four years (2000–03) to address public concerns about water quality from the use of swine manure as a source of nutrients (N and P). This site has 36, one-acre plots that are instrumented with devices to monitor subsurface drainage flows for continuous water quality assessment. The field experiments were initiated in the fall of 1999. The 2000 crop year data are included, but 2000 is a transition year because prior study treatment effects could have continued to influence results. When based on manure-N or fertilizer-N for corn, intended rates were 150 lb total-N/acre. When based on manure-P for corn, intended rates were for expected corn grain removal, 60 lb P/acre. When manure was applied before soybeans, the intended rate was 200 lb total-N/acre. Manure was always injected. The liquid manure source was finishing swine, from under-building storage.

Results and Discussion

In this ongoing six-year study, we are evaluating the effects of six different nutrient management treatments on subsurface water quality. Table 1 lists the experimental treatments, application rate basis for each treatment, and the average manure N and P applied.

Tables 2 and 3 summarize experimental results for the years 2000 through 2003. Table 2 gives yearly average NO_3-N concentrations and yearly NO_3-N losses with tile water. Treatment 4, with swine manure application each year (to both corn and soybeans), resulted in the highest single-year average NO_3-N concentration in tile water (38.5 mg/l in 2000), and had an average of 31.4 mg/l for 2000–2003. One reason for this initial high NO_3-N concentration in tile water would be the fact that these plots were under continuous corn from 1993–1998 and received continuous applications of swine manure during those six years. The continued trend of high NO_3-N concentrations is due to the repeated application of manure each year on both crop rotations of treatment 4. The prior continuous corn treatment also seems to be influencing yield in treatment 4 because the soybean yields were considerably higher in that treatment in 2000–2003. There were no large differences in NO_3-N concentrations, losses, or crop yields between treatments, except for treatment 4 where manure applied each year resulted in higher average NO_3-N concentrations, losses, and soybean yield. Treatment 6, with spring application of manure, resulted in the lowest average NO_3-N concentration (13.8 mg/l) in the tile water for the four years. This shows that leaching of NO_3-N with manure application can be managed with the right application method and timing. However, NO_3-N loss in the corn year of treatment 6 was similar to all treatments with manure application. Nitrate-N tile losses were the lowest in fertilizer-N application treatments and in treatment 3 where manure-N (P-based rate) was supplemented with fertilizer-N. The N loss results are more affected by the tile flow volume than the N concentration results.

Table 3 shows that treatment 2 with fall manure application to corn resulted in the highest corn yield, with an average of 176 bushels/acre, whereas treatment 4 with fall manure application to soybeans had the highest average soybean yield (54 bushels/acre). However, that yield advantage was not observed in 2003.

Table 1. Experimental treatments for the Nashua site.

Application timings and source of N	Crop	Application rate, lb/ac	
		N based rate	P based rate
1. Spring UAN 150 lb N/ac	Corn	150	60
	Soybean	-	44
2. Fall manure 150 lb N/ac	Corn	150	-
	Soybean	-	-
3. Fall P based manure + UAN 150 lb N/ac	Corn	150	60
	Soybean	-	44
4. Fall manure 150 lb N/ac	Corn	150	-
(Plots receive manure both years)	Soybean	200	-
5. UAN w/LCD 150 lb N/ac (Sidedress)	Corn	150	60
	Soybean	-	44
6. Spring manure 150 lb N/ac (No-till)	Corn	150	-
	Soybean	-	-

Table 3. Crop yields for the various treatments.

Corn yield, bushels/acre						
Trt.	1	2	3	4	5	6
2000	164	171	166	153	161	159
2001	163	177	173*	181	159	169
2002	192	194	191	194	189	192
2003	156	163	164	167	149	157
Avg.	168	176	173	174	164	169
Soybean yield, bushels/acre						
Trt.	1	2	3	4	5	6
2000	55	58	58	71	58	54
2001	46	51	43	56	46	44
2002	54	56	57	59	54	53
2003	31	29	29	28	30	28
Avg.	46	48	47	54	47	45

*Excludes Plot 6 due to cutworm damage

Table 2. Effects of experimental treatments on average NO_3-N concentrations and losses with surface tile drain water.

NO_3-N Conc. in tile water, mg/l	2000		2001		2002		2003		Avg	
Experimental Treatments	CS	SC	CS	SC	CS	SC	CS	SC	CS	SC
1. Spring UAN 150 lb N/ac	21.5	18.8	14.2	18.8	11.4	18.8	21.7	18.2	17.2	18.6
2. Fall manure 150 lb N/ac	21.8	16.0	24.9	15.8	16.9	19.3	26.8	16.1	22.6	16.8
3. Fall P based manure/150 lb N/ac	17.0	17.5	16.9	12.7	8.8	16.1	21.6	16.3	16.1	15.6
4. Fall manure 150 lb N/ac	38.5	26.6	25.9	31.5	31.8	20.7	29.4	44.6	31.4	30.8
5. UAN w/LCD 150 lb N/ac	13.6	16.4	12.6	18.4	12.4	20.3	19.4	20.5	14.5	18.9
6. Spring manure 150 lb N/ac	15.2	13.2	12.4	8.3	9.6	9.3	18.1	11.1	13.8	10.5
NO_3-N Loss in tile water lb/acre	2000		2001		2002		2003		Avg	
Experimental Treatments	CS	SC	CS	SC	CS	SC	CS	SC	CS	SC
1. Spring UAN 150 lb N/ac	10.2	6.0	11.5	19.3	0.4	2.0	12.5	13.4	8.6	10.2
2. Fall manure 150 lb N/ac	13.3	6.0	21.7	31.7	7.2	2.2	17.1	23.9	14.9	16.0
3. Fall P based manure/150 lb N/ac	2.4	7.7	17.2	12.5	0.1	1.1	16.6	7.2	9.1	7.2
4. Fall manure 150 lb N/ac	16.4	8.3	24.3	46.6	4.1	2.0	20.6	45.2	16.4	25.5
5. UAN w/LCD 150 lb N/ac	6.6	6.8	15.2	31.1	3.4	3.9	13.3	22.5	9.6	16.1
6. Spring manure 150 lb N/ac	12.8	12.7	23.3	19.3	5.2	6.9	23.9	17.6	16.2	14.1