Swine Manure & Aqua-ammonia Nitrogen Application Timing on Subsurface Drainage Water

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Abstract

In Iowa and many other Midwestern states, excess water is removed artificially through subsurface drainage (/pages/27488/preferential-flow-of-manure-in-tile-drainage) systems. While these drainage systems are vital for crop production, nitrogen (N) added as manure or commercial fertilizer, or derived from soil organic matter, can be carried as nitrate-nitrogen (NO_3-N) to downstream water bodies. A five-year, five-replication, field study was conducted in north-central Iowa with the objective to determine the influence of seasonal N application as ammonia or liquid swine manure on flow-weighted NO_3-N concentrations and losses in subsurface drainage water and crop yields in a corn-soybean rotation. Four aqua-ammonia N treatments (150 or 225 lb-N/acre applied for corn in late fall or as an early season side-dress) and three manure treatments (200 lb-N/acre for corn in late fall or spring or 150 lb-N/acre in the fall for both corn and soybean) were imposed on subsurface drained, continuous-flow-monitored plots. Four-year average flow-weighted NO_3-N concentrations measured in drainage water were ranked: spring aqua-ammonia 225 (23 ppm) = fall manure 150 every year (23 ppm) > fall aqua-ammonia 225 (19ppm) = spring manure 200 (18 ppm) = fall manure 200 (17 ppm) > spring aqua-ammonia 150 (15 ppm) = fall aqua-ammonia 150 (14 ppm). Corn yields were significantly greater ($p=0.05$) for the spring and fall manure-200 rates than for non-manure treatments. Soybean yields were significantly greater ($p=0.05$) for the treatments with a spring nitrogen application to the previous corn crop.

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Why Study Sub-Surface Drainage and Manure Application?

Subsurface agricultural drainage has allowed for enhanced crop production in many areas of the world including the upper Midwest, United States. However, the presence of nitrate-nitrogen (nitrate-N) in subsurface tile drainage water is a topic of intense scrutiny due to several water quality issues. With the growing concern for the health of the Gulf of Mexico and local water quality concerns, there is a need to understand how recommended nitrogen management

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Tile Drainage Field Day (/pages/67686/tile-drainage-field-day-to-promote-manure-management) practices, such as through nitrogen rate and timing, impact nitrate-N concentrations from subsurface drainage systems. The objective of this presentation is to summarize results of studies from Iowa that have documented the impact of nitrogen application rate and timing on tile drainage nitrate loss.

What Did We Do?

The field experimental site was located near Gilmore City in Pocahontas County, IA. In the fall of 1999, seven treatments were initiated on 35 plots at the site to determine the effect of N source, rate, and application timing on crop yield and subsurface drainage water quality in a corn and soybean (CS) rotation. Two fertilizer N rates (168 or 252 kg ha^{-1}) applied in the spring or fall and liquid swine manure (LSM) applied in spring or fall (218 kg ha^{-1}) for corn production, and fall applied LSM for both crops in a CS rotation (168 kg ha^{-1}) were randomly distributed in five blocks. Flow-weighted drainage samples were collected and volume measurements recorded for each plot through sampling/monitoring systems during drainage seasons in 2001-2004.

What Have We Learned?

This multi-year experiment demonstrated that rate and to a lesser extent timing affect concentration and losses and even at constant rates, these can be highly variable depending on precipitation patterns, N mineralization/denitrification processes and crop utilization in a given season. As expected, as nitrogen application rate to corn increases, the nitrate-N concentrations in subsurface tile drainage water increase. This highlights the need for appropriate nitrogen application to corn and to avoid over application. However, it is important to note that even when recommended nitrogen application rates are used, nitrate-N concentrations in subsurface drainage are still elevated and may exceed the EPA drinking water standard for nitrate-N of 10 mg L^{-1}. Relative to timing of nitrogen application, i.e. moving from fall to spring application, our studies showed little to moderate potential to decrease nitrate-N concentrations. Likely the largest factor when looking at the effect from fertilizer application timing is when precipitation and associated nitrate-N loss occurs. Although timing of nitrogen application is important, perhaps the most important factor is to apply the correct amount of N. Manure treatments out yielded commercial N in all years. No significant differences in corn yield for any year were noted between application timing. Soybean yields were affected by N timing and less so by application rate.

(http://www.extension.org/sites/default/files/helmers1.jpg)

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Table 1. Flow-weighted nitrate-N concentrations, nitrate-N losses, and crop yield for a corn-soybean rotation from 2001-2004 at Gilmore City, IA. Means within years and on average with the same letter are not significantly different at p = 0.05.

Treatment	2001	2002	2003	2004	Average (2001-04)
	Nitrate-N concentration (mg L^{-1})				
Fall 168	14.8d	11.7c	14.7b	15.7c	14.2c
Spring 168	18.0bcd	10.9c	15.0b	15.8c	14.9c
Fall 252	19.5bcd	17.4ab	19.7ab	19.9ab	19.0b
Spring 252	28.7a	19.3ab	23.0a	21.9a	23.2a
Fall Manure 218	17.0cd	15.6bc	18.6ab	16.0bc	16.8bc
Spring Manure 218	24.6abc	18.7ab	15.0b	15.1c	18.4b
Fall Manure 168 every year	26.3ab	22.5a	20.2a	23.0a	23.0a
	Nitrate-N loss (kg-N ha^{-1})				
Fall 168	32c	27a	44a	41a	36b
Spring 168	37bc	25a	49a	58a	42b
Fall 252	53bc	33a	64a	49a	49ab
Spring 252	86a	47a	74a	49a	64a
Fall Manure 218	38bc	33a	46a	45a	50ab
Spring Manure 218	70ab	37a	46a	45a	50ab
Fall Manure 168 every year	58abc	36a	50a	56a	50ab
	Corn yield (kg ha^{-1})				
Fall 168	8199c	8707b	8293ab	10182c	8845cd
Spring 168	8871bc	8364b	7477b	10273bc	8740d
Fall 252	8277c	7973b	7945b	10283bc	8619d
Spring 252	8967bc	8474b	8450ab	11147ab	9302c
Fall Manure 218	10338a	10906a	9232a	11949a	10607a
Spring Manure 218	10060a	10609a	9227a	11813a	10427a
Fall Manure 168 every year	9562ab	10359a	7864b	11570a	9854b
	Soybean yield (kg ha^{-1})				
Fall 168	2895c	2829bc	2020ab	2913c	2683d
Spring 168	3530ab	3459ab	2222ab	3082abc	3073b
Fall 252	3006c	2580c	1874b	2890c	2625d
Spring 252	3670ab	3362ab	2287ab	3254abc	3143ab
Fall Manure 218	3175bc	2916bc	1881b	3025bc	2765cd
Spring Manure 218	3804a	3620a	2506a	3688a	3393a
Fall Manure 168 every year	3193bc	3216abc	2012ab	3563ab	2996bc

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Future Plans

Other management practices need to be explored for their potentials in reducing nitrate loads from tile drained systems. Promising practices include drainage management, alternative cropping systems and edge-of-field practices.

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Additional Information

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Impacts of Swine Manure & Aqua-Ammonia Nitrogen Application Timing on Subsurface

Drainage Water Quality (http://www.slideshare.net/LPELC/waste-to-worth-helmers) from **LPE Learning Center (http://www.slideshare.net/LPELC)**
