Drainage Water Quality Impacts of Agricultural Management Practices: Effect of Manure Application Timing and Cover Crops

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Introduction

The primary objective of this study is to evaluate the impact of various cropping and nutrient management systems on drainage water quality and crop yields. Treatment comparisons evaluate the impact of liquid swine manure application timing, nitrification inhibitor with late fall swine manure application, cereal rye cover crop, and gypsum application. These comparisons will be conducted for multiple years and used to develop appropriate manure and nutrient management practices in order to minimize water contamination potential and enhance the use of swine manure as a nutrient resource.

Materials and Methods

Table 1 lists the treatments established on 36, one-acre plots in the fall of 2015 at the Northeast Research Farm drainage water quality research site. Early fall manure, early fall manure with cereal rye cover crop, and late fall manure applications prior to corn are compared in a corn-soybean rotation. The cover crop also is included in the soybean phase of the rotation. In continuous corn, late fall manure with and without a nitrification inhibitor, late fall manure with a single gypsum application to date of 1 ton/acre in the fall of 2015, and spring manure are compared. The early fall manure with and without cover crop and late fall manure treatments are no-till, while the rest of the treatments receive tillage. The cereal rye cover crop is seeded with a no-till drill in the fall after harvest and manure injection. Spring termination of the cover crop is done with glyphosate approximately 10 days prior to corn planting and approximately two days prior to soybean planting.

Results and Discussion

Table 2 gives the monthly precipitation for the 2016 and 2017 growing seasons. Growing season precipitation in 2016 was the wettest since recordkeeping began in 1976, and exceeded rainfall totals from the National Weather Service station in Charles City, Iowa, going back to 1951. June and September 2016 were unusually wet compared with the historical average. Total April through November precipitation for 2017 was very close to the 30-yr average, with July and October being wetter than normal and August and November being drier than normal.

Water quality. Table 3 shows quarterly and annual average flow-weighted nitrate-N concentrations in drainage water for 2016. The first-year results show higher concentrations in the continuous corn plots compared with the corn-soybean rotation plots. Early fall manure with a cereal rye cover crop had a statistically significant reduction in nitrate-N levels compared with early fall manure with no cover crop. There was no significant difference in nitrate-N levels between late fall and spring swine manure applications in continuous corn. Early fall manure resulted in higher nitrate-N concentration than late fall manure in corn but

not soybean. This was expected since prior to 2016 systems 2 and 6 were similar and the early fall manure was first applied prior to the 2016 corn crop. In continuous corn, the nitrification inhibitor did not reduce nitrate-N concentrations compared with no inhibitor.

Table 4 shows the quarterly and annual average flow-weighted nitrate-N concentrations in drainage water for 2017. In the corn phase of the corn-soybean rotation, the early fall manure treatment had a significantly higher annual average nitrate-N concentration than the late fall manure treatment, which was significantly higher than the early fall manure with cover crop treatment. In continuous corn plots, the spring manure treatment had a significantly lower annual average nitrate-N concentration than late fall manure, late fall manure with gypsum, and late fall manure with Instinct nitrification inhibitor. The nitrification inhibitor did not reduce nitrate-N concentrations compared to no inhibitor. In soybeans, the cover crop treatment resulted in a significantly lower annual nitrate-N concentration than was observed in any of the no cover crop treatments.

Yields. Table 5 gives the treatment effects on grain yield of corn in corn-soybean rotation for 2016 and 2017. In 2016, plots receiving late fall manure had a statistically greater corn yield than those receiving early fall manure. The highest average corn yield was achieved with spring UAN application and conventional tillage. Early fall manure plots had a significantly higher yield than early fall manure plots with a rye cover crop. It should be noted the fall of 2015 was wetter than average, as was June, so the early fall manure application may have had more of a corn yield issue in 2016 than in years with normal rainfall.

In 2017, plots receiving late fall manure had a significantly higher yield than those receiving early fall manure. The highest average corn yield was achieved with spring UAN application and conventional tillage. The yield in early fall manure plots with a cover crop was not statistically different than the no cover crop treatment.

Table 6 gives the yield results for continuous corn in 2016 and 2017. In 2016, spring manure application resulted in a statistically significant increase in corn yield compared with late fall manure application. Late fall manure plus the Instinct nitrification inhibitor had higher yield on average than with no inhibitor. However, System 3a is in transition from a corn-soybean rotation to continuous corn so there may have been a rotation effect from the 2015 soybean crop compared with continuous corn. There was no difference in corn yield with the 1 ton/acre gypsum application compared with no gypsum.

In 2017, spring manure application resulted in a significantly higher yield than late fall manure. Late fall manure with Instinct nitrification inhibitor had a 12 bushels/acre greater yield than late fall manure with no inhibitor. There was no difference in corn yield with the 1 ton/acre gypsum application compared with no gypsum.

Table 7 shows the treatment effects on soybean yield in corn-soybean rotation for 2017. Soybean yields in 2016 are not reported due to 2016 being a transition year to different nitrogen management practices. In 2017, systems 1 and 2 had statistically greater yields than systems 5 and 6, for an unknown reason. The cover crop treatment had a slightly lower yield than the comparable no cover crop treatment. Yields will continue to be monitored in 2018 to get a better estimate of treatment differences over a range of weather conditions.

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Table 1. Experimental treatments for ISU Northeast Research Farm manure management and water quality study beginning fall of 2015. †

System	Application timing and nitrogen source	Crop	Tillage	N application rate (lb/acre)
1	Spring UAN	Corn	Chisel plow	150
	-	Soybean	Field cultivate	-
2	Early fall manure	Corn	No-till	150
	-	Soybean	No-till	-
3a	Late fall manure + Instinct	Continuous corn	Chisel plow	200
3b	Spring manure	Continuous corn	Chisel plow	200
4a	Late fall manure	Continuous corn	Chisel plow	200
4b	Late fall manure + 1 ton/acre gypsum	Continuous corn	Chisel plow	200
5	Early fall manure	Corn + rye cover	No-till	150
	-	Soybean + rye cover ovecover	No-till	-
6	Late fall manure	Corn	No-till	150
	-	Soybean	No-till	-

†Phosphorus fertilizer is applied as needed according to soil testing to Systems 1, 2, 5, and 6. Potassium is applied as needed according to soil testing to all systems.

Table 2. Precipitation during the 2016 and 2017 growing seasons.

	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Total
2016	2.34	3.04	11.62	6.05	7.32	14.91	2.32	1.32	48.92
2017	4.31	4.79	5.15	8.35	1.75	2.25	4.86	3.37	31.83
30-yr avg.	3.79	4.40	5.63	4.78	4.51	3.00	2.40	1.76	30.27

Table 3. Quarterly and annual flow-weighted nitrate-N concentrations in mg/L for 2016.

System	1	2	5	6	1	2	5	6	3a	3b	4a	4b
Crop	Corn	Corn	Corn	Corn	Soy	Soy	Soy	Soy	CC	CC	CC	CC
	Flow weighted NO_3-N concentration, mg/L											
Jan-Mar	10.2	22.5	17.2	14.9	11.6	13.0	10.3	13.9	21.2	18.2	17.3	19.0
Apr-Jun	15.4	31.6	18.0	23.1	15.9	14.9	9.0	15.3	31.1	28.3	30.1	34.1
Jul-Sep	10.3	16.1	7.4	12.4	8.7	8.2	4.9	10.1	16.7	18.9	17.5	14.7
Oct-Dec	8.8	10.7	6.0	8.3	7.1	7.9	3.9	7.9	11.9	13.9	12.2	8.9
Year	12.0c	20.5a	11.3c	15.7b	11.4a	10.9a	6.7b	12.0a	21.6a	22.0a	21.1a	20.7a

Table 4. Quarterly and annual flow-weighted nitrate-N concentrations in mg/L for 2017.

System	1	2	5	6	1	2	5	6	3a	3b	4a	4b
Crop	Corn	Corn	Corn	Corn	Soy	Soy	Soy	Soy	CC	CC	CC	CC
	Flow weighted NO_3-N concentration, mg/L											
Jan-Mar	10.8	22.4	10.9	13.4	12.2	10.4	6.7	9.1	15.4	13.6	14.7	14.5
Apr-Jun	14.0	32.9	14.0	22.5	14.2	9.7	4.3	8.8	20.0	14.6	19.1	21.7
Jul-Sep	12.8	17.6	8.8	21.0	10.3	7.7	4.0	7.5	17.9	16.1	16.4	16.6
Oct-Dec	14.3	12.9	5.1	18.1	8.1	9.4	5.9	7.8	18.4	-	14.2	6.4
Year	13.2c	27.2a	12.0c	20.1b	12.6a	9.5ab	4.9c	8.7b	18.3a	14.7b	17.1a	18.2a

Concentrations with the same letter are not significantly different at P = 0.05. Corn, soybean, and continuous corn were evaluated separately.

Table 5. Yield data for the 2016 and 2017 crop years for corn in corn-soybean rotation (C-S).

System	1	2	5	6
Crop	C-S	C-S	C-S	C-S
N management	Spring UAN	Early fall manure	Early fall manure + cover crop	Late fall manure
2016 yield, bu/ac	228a	168c	142d	194b
2017 yield, bu/ac	239a	158c	162c	221b

Yields with the same letter within year are not significantly different at P = 0.05.

Table 6. Yield data for the 2016 and 2017 crop years for continuous corn (C-C).

System	3a	3b	4a	4b
Crop	C-C	C-C	C-C	C-C
N management	Late fall manure + Instinct	Spring manure	Late fall manure	Late fall manure + gypsum
2016 yield, bu/ac	211*	224a	187b	179b
2017 yield, bu/ac	222b	238a	210c	209c

*Treatment 3a was planted to soybean in 2015 so it was not included in the statistical analysis due to possible rotation effects. Yields with the same letter within year are not significantly different at the P = 0.05.

Table 7. Yield data for the 2017 crop year for soybeans in corn-soybean rotation (S-C).

System	1	2	5	6
Crop	S-C	S-C	S-C	S-C
N management	-	-	-	-
Yield, bu/acre	67a	66a	64b	65b

Yields with the same letter are not significantly different at P = 0.05.