Impact of 4R Management on Crop Production and Nitrate-Nitrogen Loss in Tile Drainage

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Introduction

Corn belt corn and soybean producers are increasingly challenged to maximize crop production while addressing the contributions farm practices make to the Gulf of Mexico hypoxia. Based on the need for nitrate-nitrogen (N) reductions to meet water quality goals, new management practices are needed to reduce nitrate-N losses at minimal cost and maximum economic benefits. This ongoing field research and demonstration project is evaluating various promising N management methods and technologies by documenting the nitrate-N export and crop yield from various systems. This is a summary of four years of crop yield data.

Materials and Methods

Funds provided by the Iowa State University Department of Agronomy Endowment helped to instrument the site for replicated studies of drainage water quality in 2013. In 2014, the site was uniformly cropped with treatments implemented for the 2015 growing season.

The site has 32 individual subsurface drained plots for drainage water quality evaluation. Drainage lines from individual plots are directed to separate sumps within culverts where drainage is diverted for sampling. Each treatment is replicated four times. Treatments consist of corn-soybean rotation with each phase of the rotation present each year. The four treatments are:

1. Fall (anhydrous ammonia with nitrapyrin), 135 lb N/acre
2. Spring (anhydrous ammonia), 135 lb N/acre
3. Split N, with 40 lb/acre of urea 2 x 2 starter at planting plus remainder in-season Agrotain treated urea, 135 lb N/acre total
4. No nitrogen applied

Tile flow water samples are quantified for nitrate-N concentration. Additionally, the project documents crop yield for each treatment. Grain samples are evaluated to determine N export and assess N use efficiency.

Results and Discussion

Except for the early fall 2014 freezing conditions, which prevented fall anhydrous ammonia application (completed early spring 2015), agronomic operations were completed in a timely manner each year (Table 1). The 2015 year was characterized by greater than normal precipitation in late summer and fall, as well as a greater yearly precipitation than the 30-yr average (Cherokee, IA weather station about 10 miles south of the project site) (Table 2). The 2016 crop year also had more than the 30-yr average precipitation, with noticeably greater precipitation in April and September. The April precipitation delayed planting in 2016. The 2017 crop year had near normal precipitation in April and May, but much less than normal precipitation the rest of the year. Precipitation in 2018 was above normal in May, June, and September with the total being 5 in. above normal for the year.

In 2015, there was a 40 bushels/acre corn yield increase with N application in Treatments 1–3 as compared with Treatment 4 where no N was applied (Table 3). In 2016, the corn yield increase with N application was greater than 50 bushels/acre. During both 2015 and 2016, no statistically significant corn yield differences were observed between the treatments where N was applied. In 2017, corn yield increase with Treatments 1 and 2 compared with no N application was more than 75 bushels/acre. Also, in 2017, there was a lower corn yield with the split N application compared with fall and spring ammonia timing. This was likely due to the limited precipitation after the sidedress N application and dry summer conditions (dry surface soil), which limited N movement into the soil and active corn root zone. In 2018, split N application was timely with over an inch of precipitation a day after application. There was no statistically significant difference between the N application treatments in 2018, but all were significantly different compared with no N applied. There were no statistical differences among the soybean yields in 2015, which would be expected based on the uniform previous site history, no treatments applied to soybean, and no prior-year N applications to corn. Soybean yields in 2016 were greater than 70 bushels/acre for all treatments and greater than 60 bushels/acre in 2017. In 2018, soybean yield had very little variability in treatments and were 70–72 bushels/acre.

We are continuing to summarize the crop canopy sensing, stalk nitrate, grain N, and soil nitrate-N data collected up to 2018 along with 2018 drainage water quality.

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Table 1. Dates of field operations for corn.

	2015	2016	2017	2018
Fall NH_3-N application	4/18/15	11/10/15	11/16/16	11/6/17
Spring NH_3-N application	4/18/15	4/12	4/12	4/29
Planting date	5/18	5/19	5/6	5/9
Urea starter banded at planting	5/18	5/19	5/6	5/9
Agrotain treated urea sidedress	7/18	7/14	7/6	7/3
Harvest	10/18	10/29	10/24	10/4
Sulfur application		11/3		
Planting population (seeds/acre)	34,000	34,000	35,077	35,077
Corn hybrid	Pioneer P0453	AgriGold 6267VT2RIB	Pioneer P0157AMX	Legend 9701

Table 2. Monthly precipitation from 2015 to 2018.

	Precipitation (in.)				30-yr avg. precip. at
Month	**2015**	**2016**	**2017**	**2018**	**Cherokee, IA (in.)**
Jan	0.1	0.2	1.0	0.7	0.6
Feb	0	0.4	0.8	0.8	0.6
Mar	0.6	2.1	1.4	2.0	1.9
Apr	3.1	5.2	3.2	1.5	3.1
May	3.5	3.5	3.0	4.4	3.9
Jun	2.6	1.8	1.9	6.3	5
Jul	6.8	3.9	1.3	3.1	3.9
Aug	6.1	3.2	4.3	4.2	3.7
Sep	2.8	7.5	2.3	8.2	3.5
Oct	1.9	3.5	3.3	2.1	2.1
Nov	4.9	1.8	0.2	1.2	1.5
Dec	1.8	1	0.2	1.5	0.9
Total	34.1	34	22.94	36	30.7

Table 3. Crop yields for 2015, 2016, 2017, and 2018 (bu/ac).

	Corn				Soybean			
Nitrogen Management for Corn	**2015[1]**	**2016**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**
Fall NH_3 (with inhibitor)	221a[2]	198a	203a	200a	62a	74a	62a	70a
Spring NH_3 (no inhibitor)	223a	200a	203a	195a	64a	75a	67a	71a
Split N	224a	196a	181b	205a	64a	72a	66a	70a
None	183b	141b	125c	107b	61a	74a	64a	72a

[1]Early fall 2014 freezing conditions, which prevented fall anhydrous ammonia application (completed early spring 2015).
[2]Means with the same letter in the same column are not significantly different, P = 0.05.
Yields reported at 15.5% moisture for corn and 13% for soybean.