Nitrogen management systems in tile-drained fields:

Optimizing yields while minimizing losses

Mark David, Emerson Nafziger, and Lowell Gentry

2015 Annual Report to NREC

The overall goal of this study is to more fully understand current and new nitrogen management systems on corn yields and nitrate losses from tile-drained fields in Illinois. This report summarizes results from the first complete year of the project.

Objectives

- Evaluate timing of N application, as well as split applications, and cover crops on tile nitrate losses.
- Determine when and why tile nitrate losses occur in these management systems, during both corn and soybean rotations.

Methods

- 6 treatments (treatments listed below) with 3 replicates
- Both phases of the corn and soybean rotation every year
- 36 tile lines (18 in corn and 18 in soybean)
- Plots are 100 feet wide (50 ft on each side of 5 inch lateral) and 4.5 A in area
- Randomized complete block design (6 blocks/6 treatments)
- Treatments began in the spring (no fall N or cover crops in 2014)

Treatments

1. Full rate of NH_3 (160 lb N/acre) with nitrapyrin in the fall
2. 80 lb N applied as NH_3 with nitrapyrin in the fall

   40 lb N/acre as UAN at planting

   40 lb side-dressed as UAN
3. Full rate applied as NH_3 (no nitrapyrin) in early spring

4. Reduced rate (120 lb N/acre) as NH_3 (no nitrapyrin) in early spring.

5. 80 lb N applied as NH_3 early spring

   80 lb N as UAN side-dressed.

6. N split as in treatment #5 with cover crops

(oats-radish mixture seeded into standing soybean) and (cereal rye after corn).

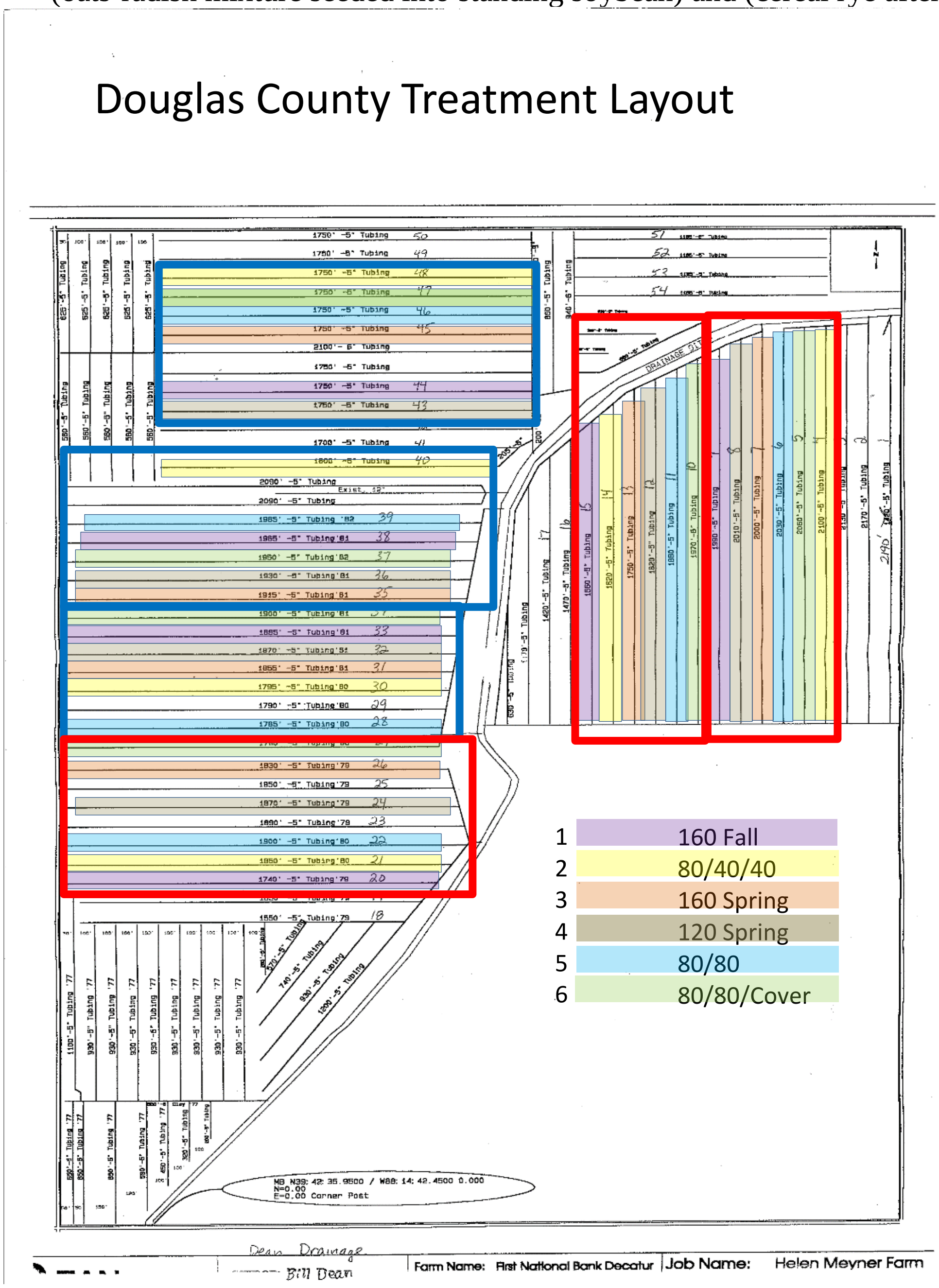


Figure 1. Tile map and experimental design.

Note: corn was planted across the entire research area in 2014; therefore, N rates were adjusted up to 200 lbs of N/A for corn in 2015. In addition, no fall N was applied in 2104, and Treatments 1 and 2 were changed to Treatment 3. Therefore, for corn yield data, 9 plots were averaged together for Treatment 3, 3 plots were averaged together for Treatment 4, and because there were no cover crops planted in 2014, treatments 5 and 6 were averaged together.

Corn system: The spring anhydrous ammonia application occurred on April 22, 2015 (Treatments 1, 2, and 3 received 180 lbs of N/A; Treatment 4 received 130 lbs of N/A; and Treatments 5 and 6 received 90 lbs of N/A). Corn (Dekalb DKC60-67RIB) was planted on May 20, 2015 at 34,000 plants/A with 20 lbs of N/A of starter on all plots. On June 11, corn was side-dresses with 28% at 90 lbs of N/A for treatments 5 and 6. Corn yield rows (center 8 rows) were harvested on October 8 and 9 and the remainder of the field was harvested on October 16.

Soybean System: Soybean was planted at 150,000 plants/A on May 21, 2015. Soybean was harvested on September 25.

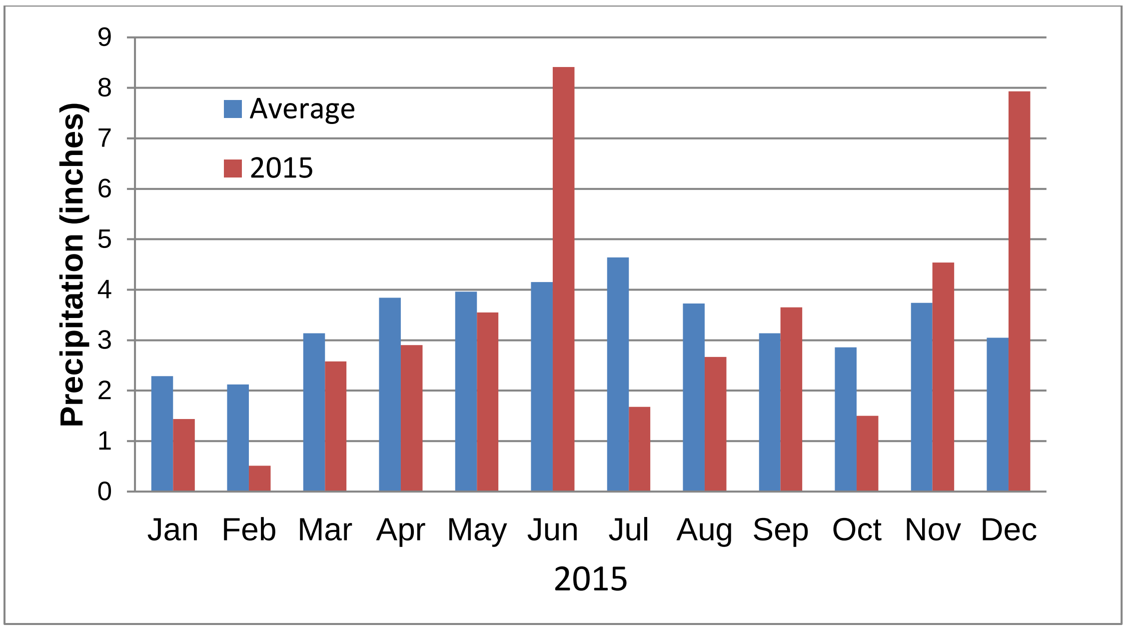


Figure 2. Precipitation measured on site during 2015 compared to local 30 year average.

Precipitation was below the 30 year average for this site throughout the winter and spring months; however, more than 8 inches of precipitation occurred in June which flooded low areas of the field. The months of July and August had below average precipitation. These conditions were not conducive for maximum productivity of either row crop.

The combination of an extremely wet June and a dry July stressed the corn crop. However, this relatively short statured crop produced 175 bu/A regardless of the timing of application. The reduced N rate produced lower corn yields of 155 bu/A. Soybean yield averaged 53 bu/A, and was also a short statured crop.

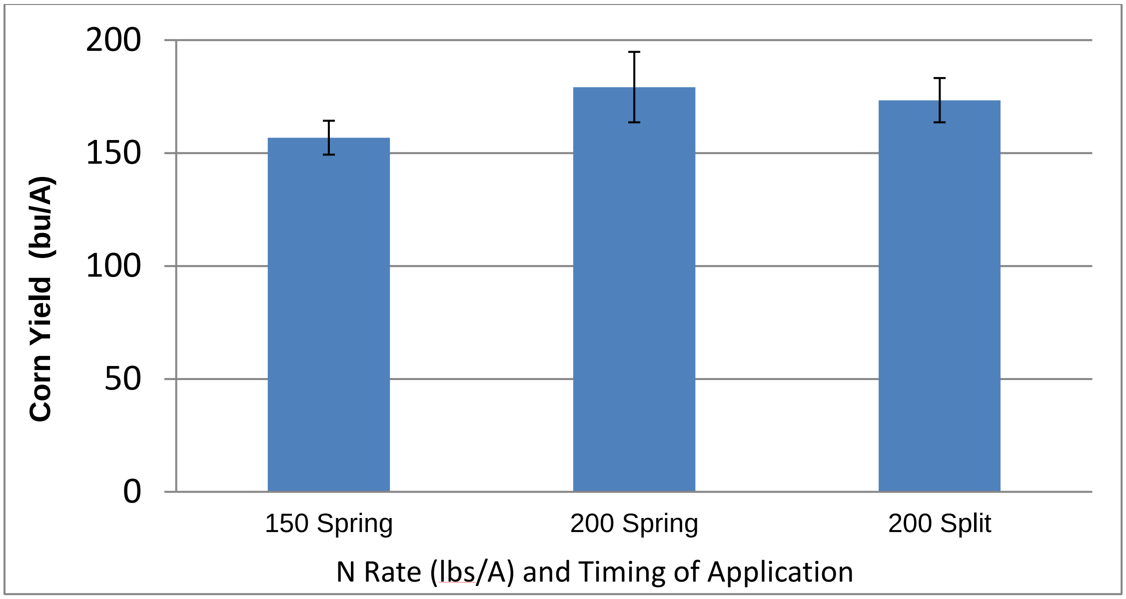


Figure 3. Corn grain yield in the reduced N rate compared to the full N rate in the spring or split application (spring and side-dress).

Most of our heavy rainfall and tile flow occurred after side-dressing N in corn and we found no corn yield difference between spring or split application of fertilizer N.

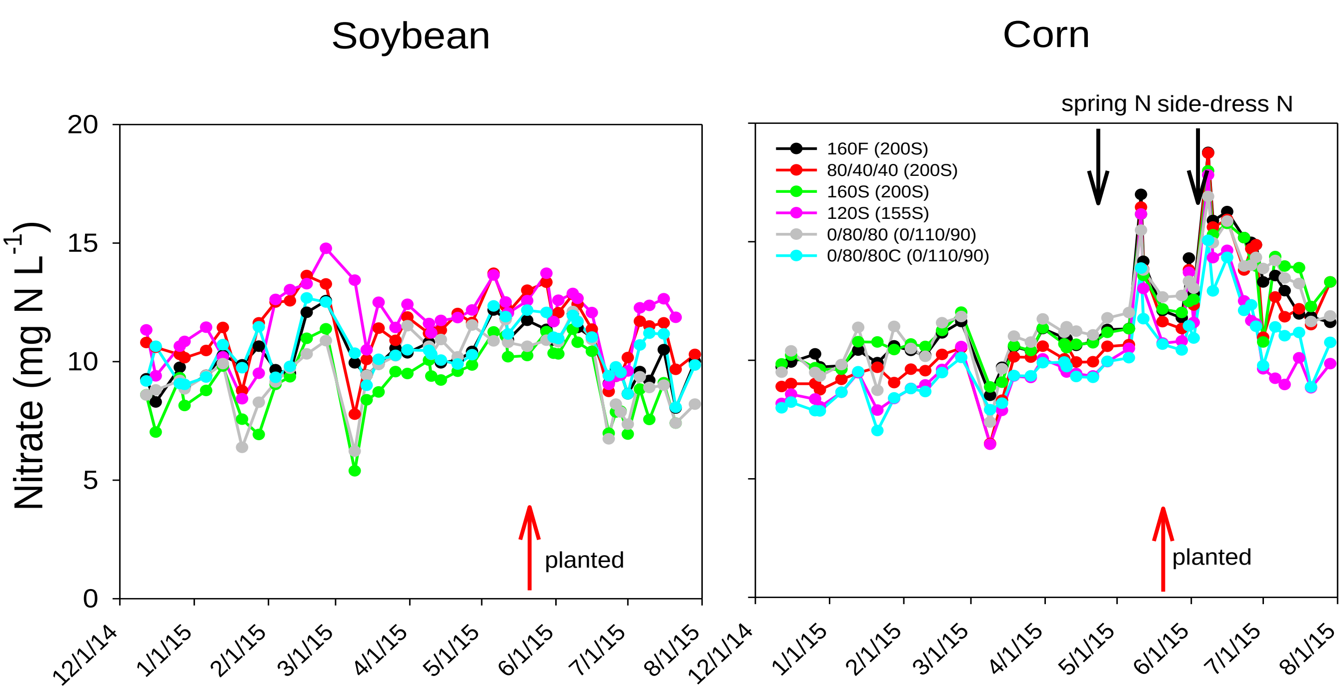


Figure 4. Tile nitrate concentrations averaged across treatments for corn and soybean. **Note:** All plots were in corn in 2014. Corn N rate is greater (max of 200 lbs/A) in this first year (2015 N rates in parenthesis). More than 1400 water samples were collected and analyzed.

Tile nitrate concentrations from soybean production, as well as corn production until spring N was applied, can be viewed as baseline conditions and demonstrates the natural variability across the individual plots (or individual tile laterals). During this baseline period, the inherent variability of tile nitrate concentration can be assessed. There was one lateral from soybean production that contains atypically high nitrate concentrations and that replicate increased the average (pink dots in soybean). This tile nitrate concentration is becoming more in line with the other two replicates over time and may have been due to overlapping passes during fertilization in the previous year.

For corn production, tile nitrate concentration responded during flow events that followed fertilizer N application. This is apparent when comparing and contrasting the pattern of tile nitrate concentrations between the two crop phases where no fertilizer N was applied to soybean.

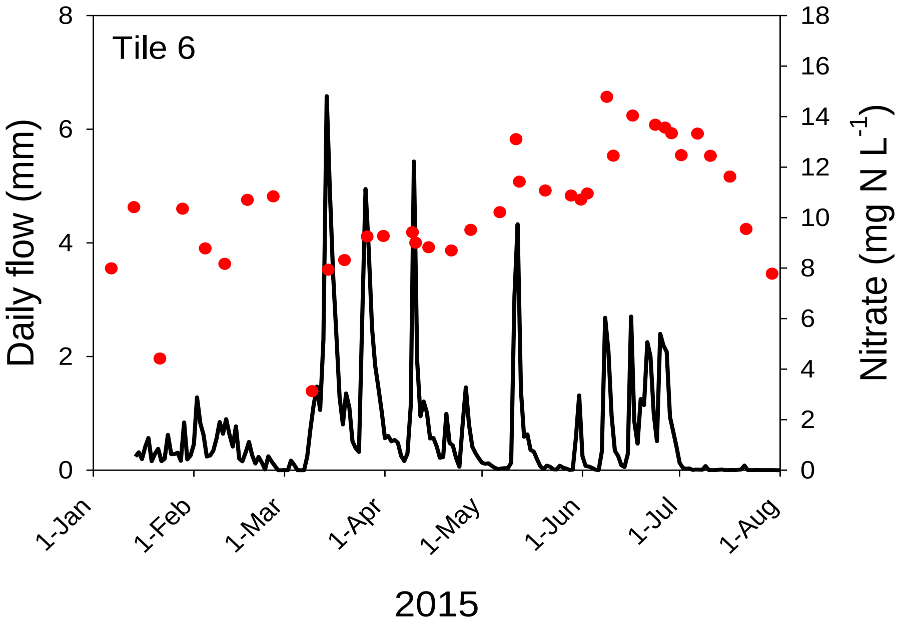
We found that there was no significant difference in N loss between any of the treatments. This is not surprising with the subset of treatments imparted in 2015 as well as the lack of flow events between spring N application and side-dress.

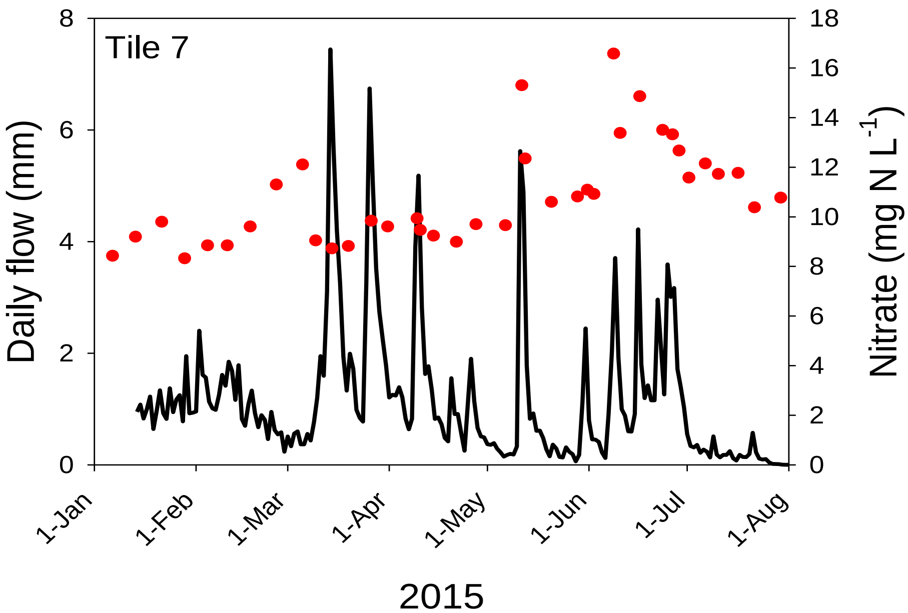
Table 1. Tile N loads and flow weighted mean nitrate concentrations for the entire drainage season or only after May 1.

	All Year		After May 1	
	lbs/A	ppm	lbs/A	ppm
Corn	18.6	11.3*	9.0*	13.7*
Soybean	16.6	10.2	7.4	10.3

When averaged across all treatments for a given crop, we found no signifcant difference in tile N loads between corn or soybean for the entire drainage season. However, after fertilizer N application, we found significant differences ($p<0.05$) for both tile nitrate load and flow weighted mean nitrate concentration (May 1 through tile cessation in August).

In addition to inherent variability in tile nitrate concentration across the laterals, there is also variability in tile flow for a given lateral. Together this variability will challenge our ability to test for significant differences among treatments, however, over time treatment differences will likely become more pornounced, especially now that we have the full complement of treatments in place.





Figures 5A and 5B. Tile flow and nitrate concentration in two adjacent tiles.

Tiles 6 and 7 are examples of two adjacent tiles that produce different flow volumes, but the flow patterns are very similar. It is interesting to note that Tile 7 consistently has greater flow than Tile 6 and they are only 100 feet apart. If flow relationships among tiles are consistent year after year, then it may be possible to standardize flow across all laterals for greater precision in load estimates. Therefore, our load estimates from this first year should be considered provisional at this point.

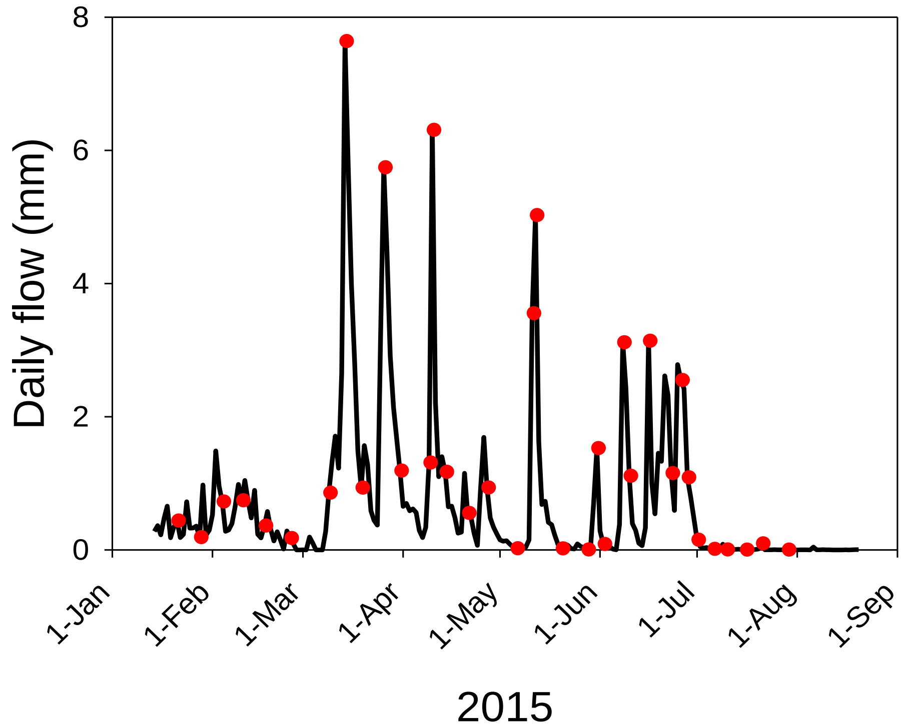


Figure 6. An example of daily tile flow with sampling times indicated.

This first year of tile nutrient data was conducted via grab samples and this figure shows that we sampled on almost every high flow day. We now have 36 automatic water samplers purchased and they will be deployed in March. This will increase our sampling ability and may improve our nutrient load estimates. Automatic water samples will be set to sample every 4 hours and this will be particularly useful when we investigate tile P concentrations and loads for our newly funded NREC project (Understanding mechanisms and processes of dissolved reactive phosphate loss in Illinois tile-drained fields).

On September 14, 2015, a cover crop mixture of radish and oats was planted with a Hagie high clearance machine into standing soybean for Treatment 6. The radish and oat mixture only accumulated 0.25 tons of biomass/A before severe frost in November. It is unlikely that this amount of biomass will have any measurable impact on tile nitrate concentrations or load.

On September 16, 2015, cereal rye was aerially broadcast into standing corn for Treatment 6. We will determine the biomass in the spring prior to cover crop termination with glyphosate.

Fall N application of anhydrous ammonia with N-serve occurred on November 15, 2015 for both Treatments 1 and 2. Soil temperatures on site climbed above 50° F at the 4 inch depth from December 12 through 14 and again on December 23.

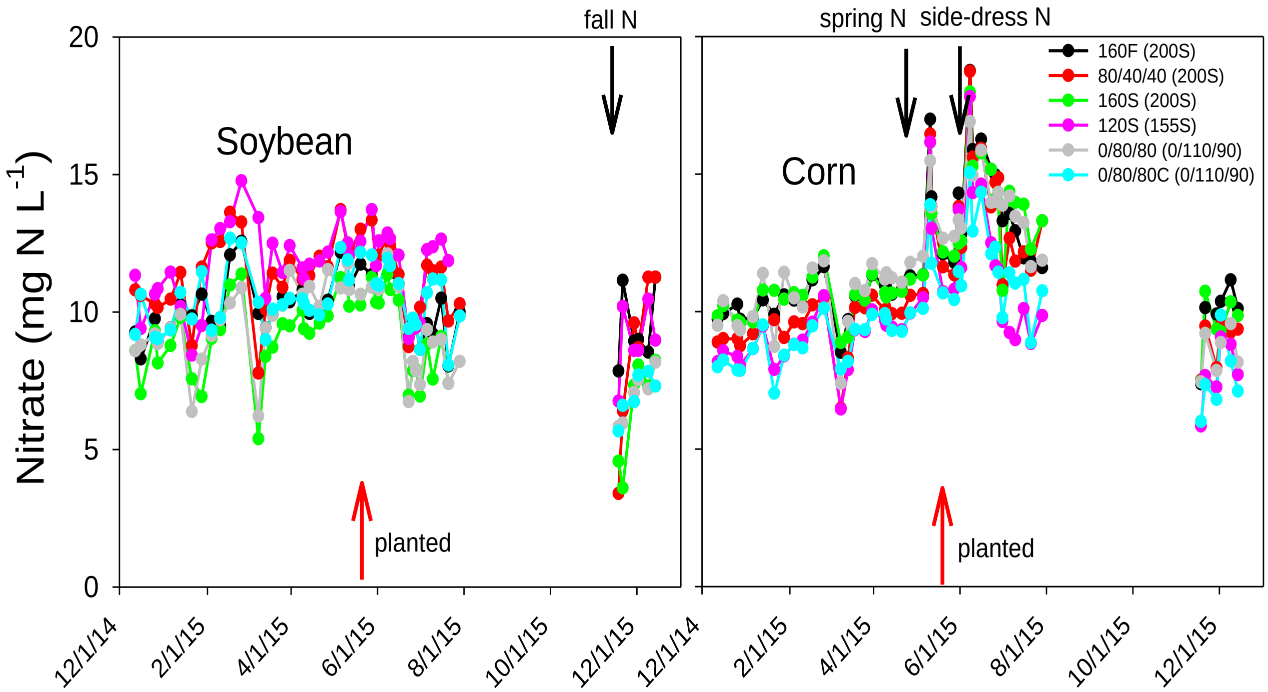


Figure 7. Tile nitrate concentrations averaged across treatments for corn and soybean through December 2015.

These warm temperatures followed by nearly 6 inches of rain from December 24-26 may have caused some of the fall N to nitrify and leach into tile lines. Preliminary data show that all 6 plots with fall N have the greatest nitrate concentrations regardless of full rate or half rate of fertilizer N.

Now that the crop rotations are established, fall N is applied, and cover crops are planted, this experiment is fully underway. This experiment will show how and when nitrate leaches from these various N treatments under both corn and soybean production systems, which will help producers maximize yields and hopefully minimize nutrient losses.