Predicting Risk of Edge-of-Field Nitrate Losses in Farmers' Fields

While crop systems modeling is frequently used for prediction in controlled small-plot research experiments, this project focused on predicting tile drainage nitrate losses for different management scenarios in farmers' fields.

The initial funding for this project was through the State Soil Conservation Committee of the Iowa Department of Agriculture and Land Stewardship (IDALS). The project involved water sampling for a minimum of two years at six farmers' tile drained fields.

The project objectives were to:

1. Develop a protocol to calibrate the Agricultural Production Systems Simulator (APSIM) crop systems model using farmer data
2. Model soil and crop dynamics over time
3. Evaluate the effect of field management and weather on nitrate leaching at individual sites
4. Predict nitrate loss and soil nitrogen dynamic over time.

This report will show examples of cover crop-corn-soybean and manure management case studies from southeast Iowa. The farmer uses no-till winter rye and swine manure applications. The drainage area is 35 acres.

The Iowa Soybean Association (ISA) Analytics and Environmental Programs and Services (EPS) teams, jointly with Iowa State University (ISU) Agronomy Department researchers, calibrated the APSIM model. The data included soil temperatures and moisture amounts at different depths, crop yield, cover crop and crop biomass during the season, soil mineral nitrogen (N), tile nitrate and water flow. The site had control plots without cover crop each year.

An example of the APSIM model's calibration is shown in Figure 1.

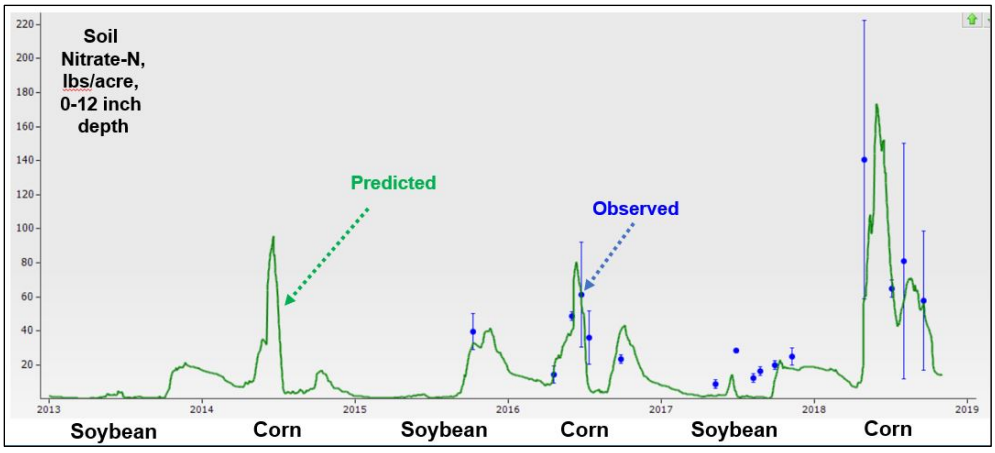

Figure 1. Calibration of APSIM model using the observed soil nitrate-N data sampled during 2016, 2017 and 2018 growing seasons with cover crop. The vertical bars are variation for each sampling date. The spikes in the predicted soil nitrate values result from manure, commercial N fertilizer applications and mineralization of soil organic matter over several growing seasons.

After the APSIM model was calibrated, four prediction farmer-practice scenarios were developed:

1. Corn-rye-soybean: Nov. 15 manure application
2. Corn-rye-soybean: Hypothetical Oct. 15 manure application
3. Corn-rye-soybean: Hypothetical Sept. 15 manure application
4. No cover crop: Nov. 15 manure application

The cover crop was planted on Oct. 1 and terminated on April 15 in all scenarios.

Simulations for a period from 2014 until the end of 2018 show the Nov. 15 manure applications without cover crop had larger soil nitrate accumulations in “2016-under corn” and “2017-under soybean” (Figure 2). The amount of soil nitrate from the Sept. 15 manure application scenario was slightly larger in the fall of 2015 and 2017, and during the summer of 2018. In general, hypothetical Oct. 15 manure applications with cover crop did not increase soil nitrate compared with the November application scenario.

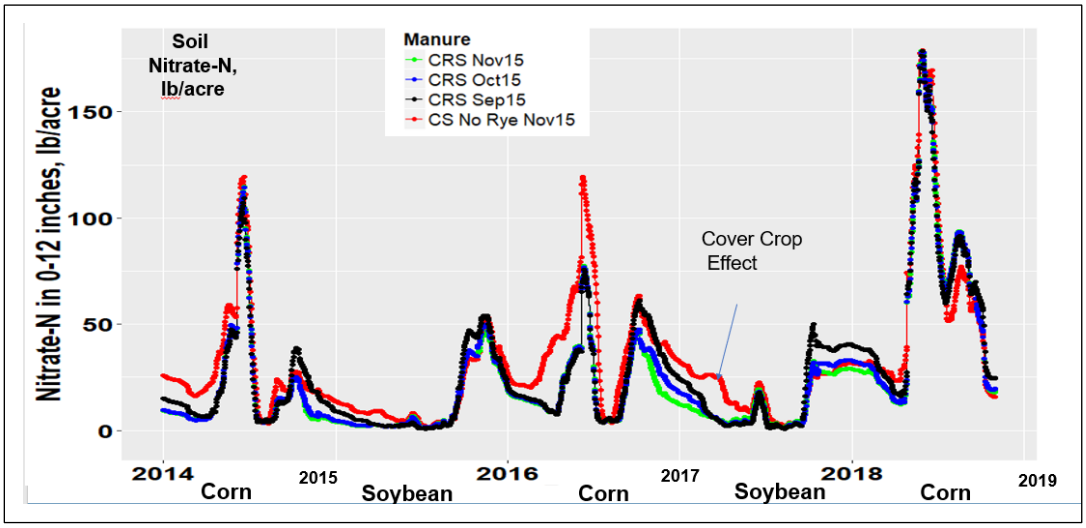

Figure 2. Soil nitrate dynamics for four simulation scenarios with different timing of fall swine manure applications with or without cover crop.

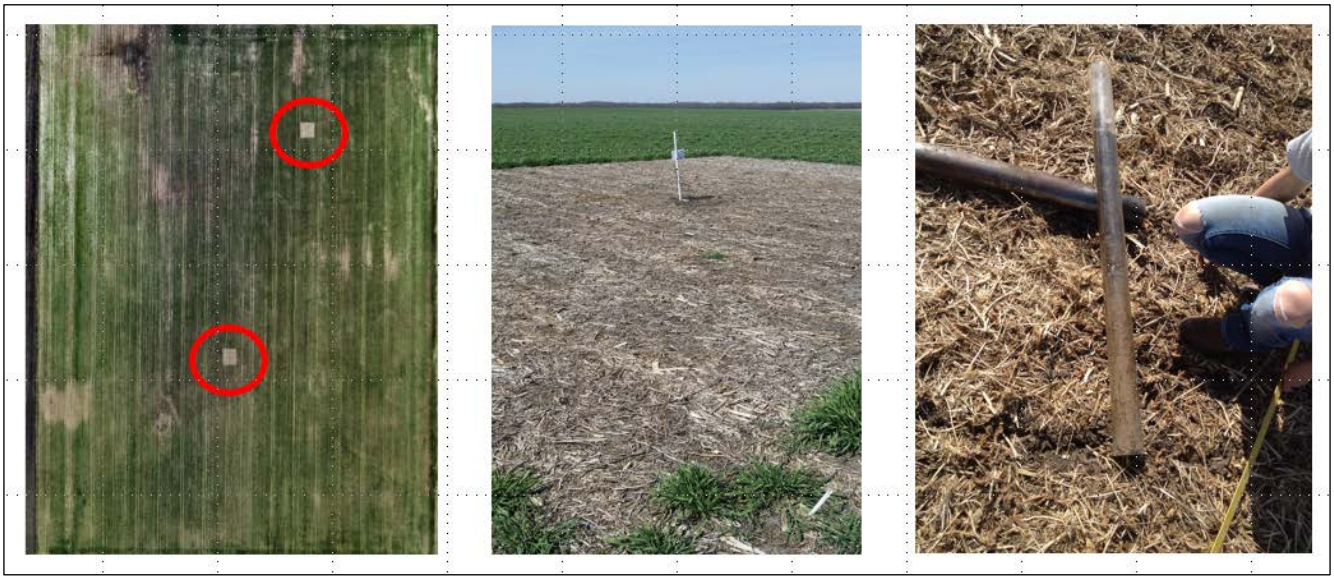

Figure 3. Left: Two control areas without cover crops in a farmer’s field with tile drainage. Center: Soil and moisture sensors at the control area. Right: Soil cores taken at 0–36 inches to develop a digital soil profile for modeling simulations.

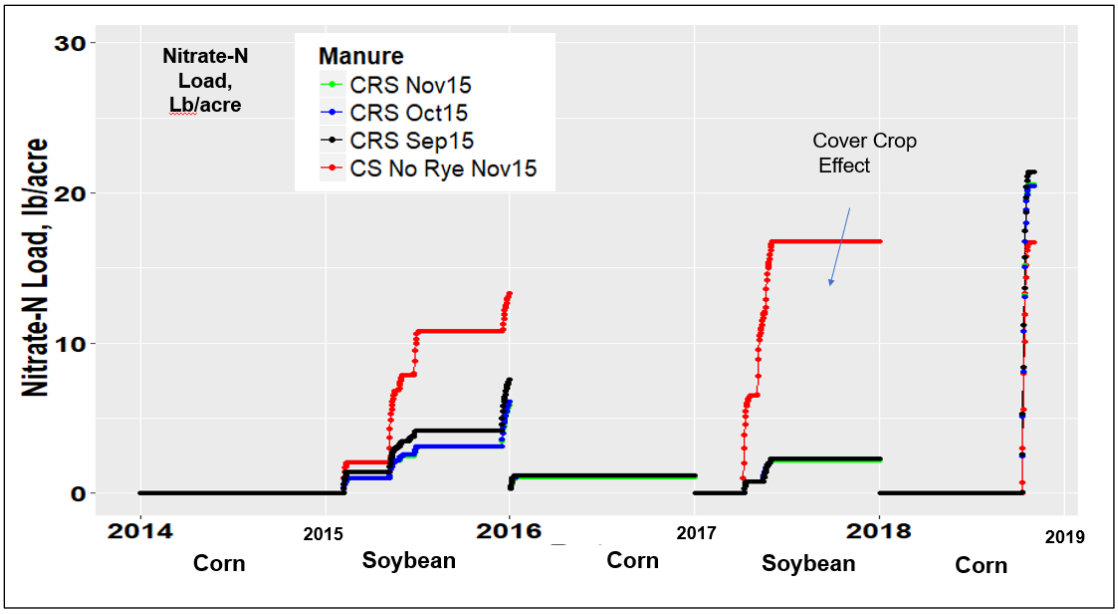

Figure 4. Nitrate loss from four simulation scenarios with different timing of fall swine manure applications with or without cover crop.

The winter rye cover crop decreased nitrate loss in two of the five years. The nitrate loss reduction from the cover crop was 5-7 lb/acre in 2015 and 12-14 lb/acre in 2018. The hypothetical Sept. 15 manure applications with cover crop had slightly larger nitrate loss in 2015. Most nitrate losses in 2018 occurred in the end of summer or early fall after crop maturity, reducing the effect of fall planted cover crop to use available soil nitrate.

This type of predictive modeling enables the quantification of nitrate reduction from different practices for farmers' fields. For example, in the case study from southeast Iowa (Figure 4), the cumulative effect of cover crop for nitrate reduction over the last five years was approximately 42 percent (19 lbs nitrate saved from 45 lbs lost without cover crop).

The tested crop systems modeling protocols during the last two years are being deployed for similar predictions in farmers' fields in the Elk Run watershed in western Iowa and in other on-farm agronomic replicated trials.

Future use of modeling can help determine how much of a reduction is expected from specific fields and can estimate the total reduction over time under variable weather conditions.