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Simulating Nitrogen Losses from Discovery Farms Minnesota with Adapt-N

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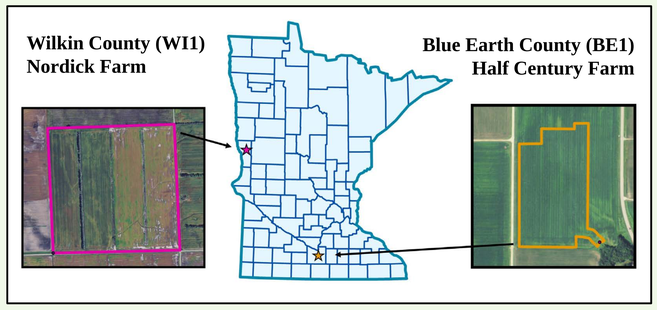
Abstract

Nitrogen fertilizer applications represent both a major environmental and economic impact within agricultural systems. These applications are done at a high financial cost to producers and excessive N is subject to aqueous and gaseous losses which can negatively impact air and water resources. Maximizing N application efficiency is ideal, but often difficult for crop producers to achieve. Recently developed user-friendly, adaptive models provide producers with an additional tool to manage N within their fields. One such model, Adapt-N, combines modeling of site-specific soil and crop biogeochemical processes with high-resolution climate data to provide adaptive and real-time information to producers. Models like Adapt-N also serve as a valuable resource to researchers interested in understanding, predicting and mitigating future N losses. The goal of this study was to determine the predictive accuracy of this model at select Minnesota farm sites. The modeled results were compared to measured yields of total N, from surface and tile drainage, from 2011, 2013, and 2014 at the selected study sites from the Discovery Farms Minnesota project. Out of the four modeled scenarios examined, we found that Adapt-N was reasonably accurate in its predictions, with the notable exception of deviations for fields that utilized either a manure N source or N-stabilizers.

Introduction

- N-fertilization rates directly influence the environmental impacts and economic outcomes of an agronomic systems
- Losses of N via leaching or denitrification represent major financial cost to producers and a significant, negative impact on the environment
- Precision agriculture technologies such as user-friendly, adaptive models are an additional tool producers can use to manage N within their fields
- The goal of this study was to determine the accuracy of the Adapt-N model in predicting N-leaching losses compared to edge-of-field water quality monitoring data from Minnesota Discovery Farm
- **Hypothesis:** Adapt-N will provide reasonably accurate N-leaching loss data to serve the needs of agronomic producers



Above: Location of studied Discovery Farms MN fields

Adapt-N

Model Inputs:
- Soils (Slope, Texture, Artificial Drainage, SOM)
- Management (Fertilizer Type/Quantity, Irrigation, Tillage)
- Crop (Previous Crop, Yield Target, Maturity Class, etc.)
- Climate (Precipitation and Temperature data from 25km^2 grid)

Model Outputs:
- N-Losses (Gaseous and Leaching)
- N-Availability (Mineralization, Inorganic-N and Nitrate)
- Crop Processes (Growth Stage and Uptake)

Pros:	***Cons:***
Simple End-User Interface	No Data Export
Multiple Field Zones	Limited Input Options
Model Historical or Hypothetical Conditions	No Control on Background Assumptions

Discovery Farms MN

Half Century Farm (BE1):
- Swine finishing and grain enterprise (corn-soybean)
- Corn yield of 290 q/ha in 2011 and 270 q/ha in 2013
- Silty-clay loam (poorly drained)
- Slope = 1.4%; SOM = 6.5%
- Surface runoff (32 ha) and subsurface tile drainage (27 ha)
- Fall chisel, and spring field cultivator tillage
- Fall Manure: 245 kg N/ha in 2011
- Fall Urea w/ Nitrification Inhibitor: 170 kg N/ha in 2013

Nordik Farm (WI1):
- Grain enterprise (corn-soybean)
- Corn yield of 200 q/ha in 2013 and 2014
- Very fine sandy loam (poorly drained)
- Slope of 1.1%; SOM = 5.4%
- Subsurface tile drainage (180 ha) via edge-of-field sump pump
- Fall chisel, and spring field cultivator tillage
- Pre-Plant Ammonium Sulfate: 150 kg N/ha in 2013 and 2014
- Starter UAN: 6 kg N/ha in 2013 and 2014
- Sidedress UAN: 6 kg N/ha in 2013 and 30 kg N/ha in 2014

Above: Water quality and climate monitoring station for BE1 (***left***) and WI1 (***right***)

Methods

Discovery Farms Data Collection:
- Real-time weather data and soil conditions via edge-of-field monitoring
- Automatic flow sampling and flow volume measurement from flume and tile drainage
- Analytical measurement of total Kieldahl nitrogen (TKN) and nitrate plus nitrite (NO_2+NO_3) at off-site laboratory
- Yields for Total Nitrogen (TN) were calculated from the sum of measured concentrations of TKN and NO_2+NO_3, each multiplied by the volume of flow sampled

Adapt-N Modeling:
- Each field from Discovery Farms MN was modeled by Adapt-N using the closest available choice provided by the model to reflect the specific field management practices and environmental conditions documented
- Daily model output values for N-leaching loss (lbs/acre), average temperature (^{o}F), precipitation (in), soil nitrate top 12" (ppm), and root zone inorganic-N (lbs/acre) recorded from each model run
- Measured losses of TN were compared to predicted N-leaching loss values for each day, month, and for the water year
- Nash-Sutcliffe modeling efficiency (NSE), root mean square error (RMSE), and Index of Agreement (d) were calculated on a daily-time step for an annual basis (*Table 1*) using methods from Nangia et al., 2010

Discussion

***BE1 2011 – Difference of* -38 kg N/ha** (*Figure 1a*)
- Modeling manure application and collecting accurate data on manure nutrient content can be challenging
- Significant gaseous N-loss predicted (135 kg N/ha)

***BE1 2013 – Difference of* 21 kg N/ha** (*Figure 1b*)
- Adapt-N lacks the ability to account for the use of an N-Stabilizer

***WI1 2013 – Difference of* -5 kg N/ha** (*Figure 1c*)
- High levels of Inorganic-N (53 kg N/ha) predicted to remain in the root zone at the end of the year

***WI1 2014 – Difference of* -10 kg N/ha** (*Figure. 1d*)
- Low predicted levels of Nitrate (<1 ppm) before fertilizer application (on May 18th) may explain to underestimation

Results

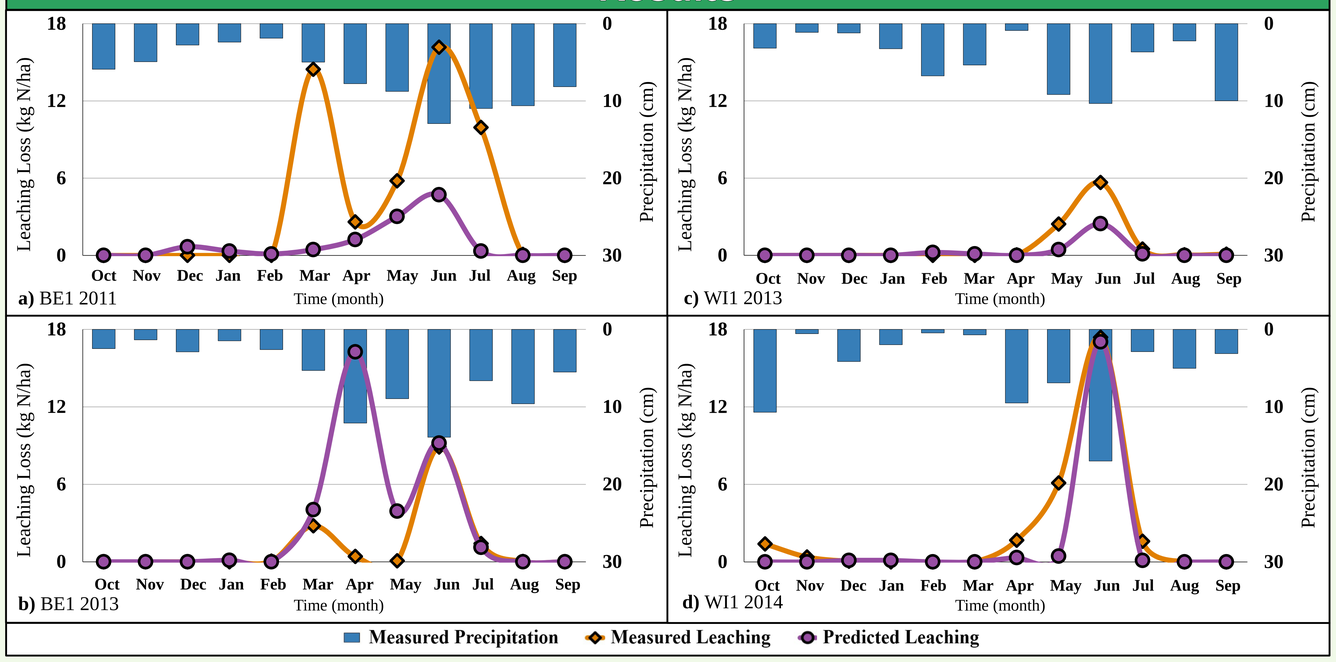


Figure 1. Comparison of monthly N-leaching losses for (a) BE1 2011, (b) BE1 2013, (c) WI1 2013, (d) WI1 2014

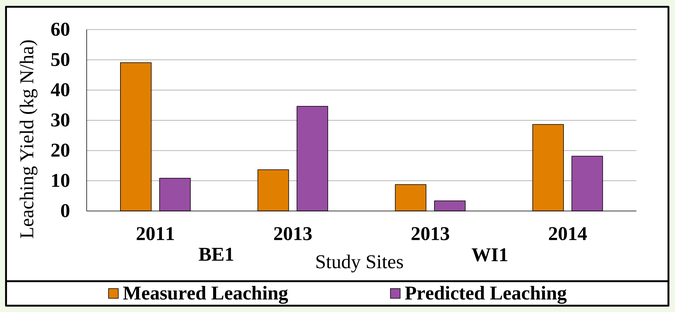


Figure 2. Comparison of annual N-Leaching losses for all fields

	NSE	RMSE	d
BE1 2011	0.101	0.363	0.288
BE1 2013	-2.907	0.335	0.350
WI1 2013	0.301	0.056	0.656
WI1 2014	0.430	0.163	0.862

Table 1. Statistical analysis of measured and predicted values

Conclusions

Based on NSE, the accuracy of Adapt-N at was…
- Unsatisfactory (NSE ≤ 0.36) at BE1 2011, BE1 2013,F and WI1 2013
- Satisfactory (0.36 ≤ NSE ≤ 0.75) at WI1 2014

Based on RMSE and d, the accuracy of Adapt-N at was…
- Unsatisfactory at BE1 2011 and BE1 2013
- Satisfactory at WI1 2013 and WI1 2014

Overall, Adapt-N was reasonably accurate in predicting N-leaching losses for agronomic purposes given consideration for:
- The relative size of N-Leaching losses compared to total N-flux within the modeled fields
- Limited model input parameters
- Potential errors within field management data

Future potential applications of Adapt-N include:
- Quantifying N-leaching on a site-specific basis
- Providing accurate N-application recommendations under changing climatic conditions
- Evaluating the costs and benefits of potential BMPs with regard for economic and environmental impacts

References

- Nangia, V., et. Al. 2010. Modeling Impacts of Tile Drain Spacing and Depth on Nitrate-Nitrogen Losses. Vadose Zone J. 9:61-72

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