Simulating Nitrogen and Water Dynamics in a Rotational Production System

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INTRODUCTION

Motivation
- Section 502(14) of the US Clean Water Act defines nitrate nitrogen (NO$_3$-N) as a nonpoint source pollutant.
- NO$_3$-N leaching is more pronounced in porous sandy soils on a karst topography as of Suwannee River Basin (SRB).
- Intensive agriculture practices intensifies NO$_3$-N contamination.
- More than 93 % (14 out of 15) of the springs in SRB have NO$_3$-N concentrations greater than the threshold of 0.35 mg/L (FDEP, 2020).

What is being done?
- Florida Department Environment Protection (FDEP) adopts Basin Management Action Plan (BMAP) to meet Total Maximum Daily Load (TMDL).
- Florida Department of Agriculture and Consumer Services (FDACS) gets involved in developing and adopting Agriculture Best Management Practices (BMPs) via
  - Nutrient Management
  - Irrigation management
  - Buffers, setbacks and swales
- Additionally, FDACS administers
  - Water quality policy and planning
  - BMP research and demonstration
  - Mobile Irrigation lab
  - Technical assistance

How Rotational Production qualify as BMP?
- Use of soil moisture sensors to manage irrigation
- 4R principles of nutrient management
- Demonstration to growers about farm-scale BMP
- Rotation of agronomic crops with legumes, Bahia grass and cattle grazing

OBJECTIVES

- Assess the performance of DSSAT to simulate nitrogen and water dynamics on a peanut-maize rotational production system.
- Simulate water dynamics using HYDRUS 1D during corn growing season.

MATERIALS and METHODS

Experimental Site and Design
- Study Domain: Suwannee River Basin
- Site: Suwannee Valley Agricultural Extension Center, Live Oak, FL
- Study years: 2019-2022
- Soil type: Fine sand
- Climate: Sub-tropical Humid

Data Collection
- Water samples
- Soil samples
- Plant tissue
- Crop management data
- Yield and yield Components

Simulation Models
- Facilitates long-term study after successful model calibration, validation and Evaluation.
- Allows to test the effectiveness of BMPs without having to deal with rigorous and long-term field trials on different soil and climatic conditions.

DISAT

- Simulation models for 42 different crops.
- CERES-Maize and CROPGRO models for maize and peanut, respectively.
- Ritchie water balance (tipping bucket) for hydrological process.
- Water flow: Richard’s equation

RESULTS and DISCUSSION

Soil NO$_3$-N
- Volumetric water content in soil profile
- Actual root water uptake (cm)

Table 1: SWAT runoff and soil loss

<table>
<thead>
<tr>
<th>Date</th>
<th>SWAT Runoff</th>
<th>Soil Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/01/2019</td>
<td>15 cm</td>
<td>0.2 g</td>
</tr>
<tr>
<td>06/01/2019</td>
<td>10 cm</td>
<td>0.1 g</td>
</tr>
<tr>
<td>07/01/2019</td>
<td>5 cm</td>
<td>0.05 g</td>
</tr>
</tbody>
</table>

Fig 4: Observed vs Simulated (DSSAT) soil NO$_3$-N (μg [g] N/g [Soil]) on a peanut-maize rotational production during 2019-2021 growing season.

Nitrogen Dynamics

<table>
<thead>
<tr>
<th>Crop</th>
<th>Year</th>
<th>Obs N leached</th>
<th>Sim N leached</th>
<th>Sim-N mineralized</th>
<th>Sim-N uptake</th>
<th>Sim-N fixation</th>
<th>N Fertilizer Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut</td>
<td>2019</td>
<td>82</td>
<td>80</td>
<td>111</td>
<td>30</td>
<td>349</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>73</td>
<td>108</td>
<td>130</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maize</td>
<td>2020</td>
<td>175</td>
<td>182</td>
<td>49</td>
<td>305</td>
<td>0</td>
<td>138</td>
</tr>
<tr>
<td>Maize</td>
<td>2020/21</td>
<td>87</td>
<td>55</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Conclusion and Future work

- Leaching event was triggered by fertilization as well as precipitation and irrigation.
- DSSAT simulated soil nitrate nitrogen with greater precision as compared to nitrate leaching.
- DSSAT and HYDRUS 1D produced similar results on soil water dynamics.

This is an ongoing study and future work will include simulating nitrogen and water dynamics using DSSAT, HYDRUS-1D, SWAT as well as machine learning models.

Acknowledgement
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