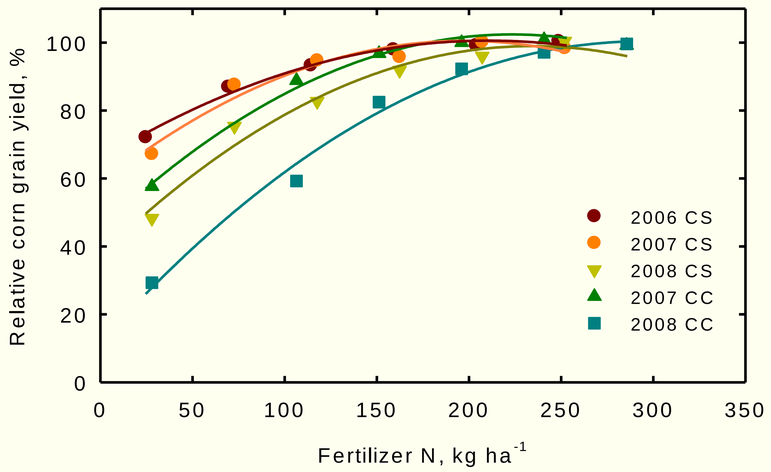
Can We Improve in-Season Corn Nitrogen Fertilizer Recommendations with a Nitrogen Transformation and Loss Model?

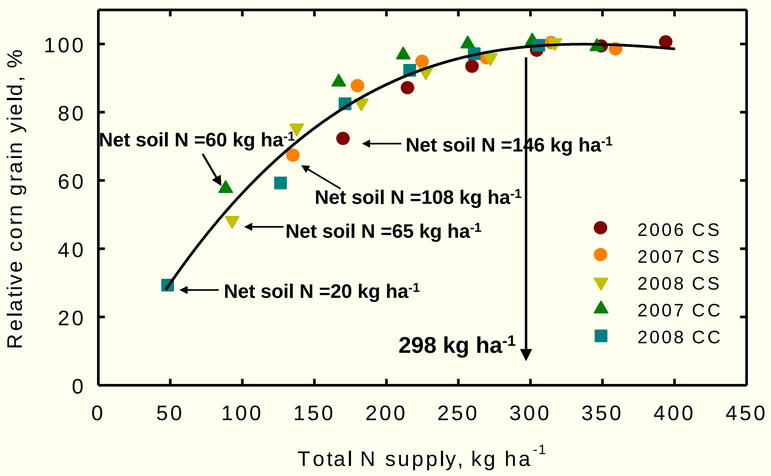
C. Zhao, B.C. Joern, J.J. Camberato and P.J. Hess
Department of Agronomy, Purdue University, West Lafayette, IN

Introduction

The year to year variability in optimum fertilizer nitrogen (N) rate for corn grown on the same field clearly indicates that weather drives soil and fertilizer N transformations and crop N availability. To better predict in-season optimum N rates in the field, we developed a weather driven N model that couples soil temperature and moisture content with soil surface and subsurface N mineralization algorithms as well as soil and fertilizer N transformation and loss processes.



The amount of fertilizer N needed to maximize grain yield varies from year to year even at the same location.



While total N supply needed to maximize grain yield is a constant, fertilizer N needed depends, in part, on net soil available N which varies from year to year.

Model Description

Hydrological Submodel

Soil moisture content is estimated from our irrigation scheduling software (www.purdue.edu/agsoftware/irrigation), which is based on FAO paper 56: Irrigation and water management.

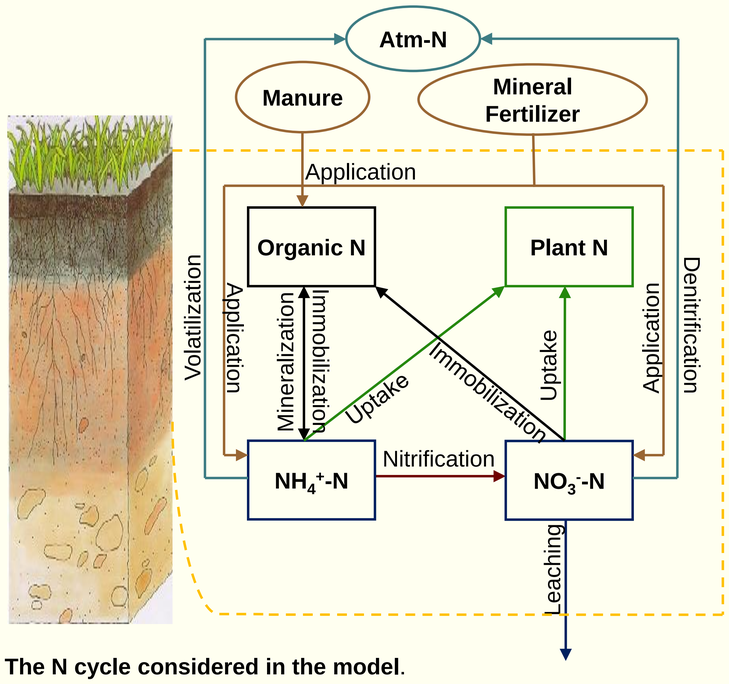
Soil Temperature Submodel

Soil temperature is estimated from the 7 day running average air temperature (time lags and damping with depth are not yet accounted for).

Crop Growth Submodel

Crop growth and transpiration are based on four growth stages (initial, development, mid-season, and late-season) and crop N uptake utilizes four or more crop specific N uptake rates based on crop development and the length of the growing season.

Model Description (Continued)



The N cycle considered in the model.

This daily time step model currently calculates crop N uptake and N transformations and losses as follows:

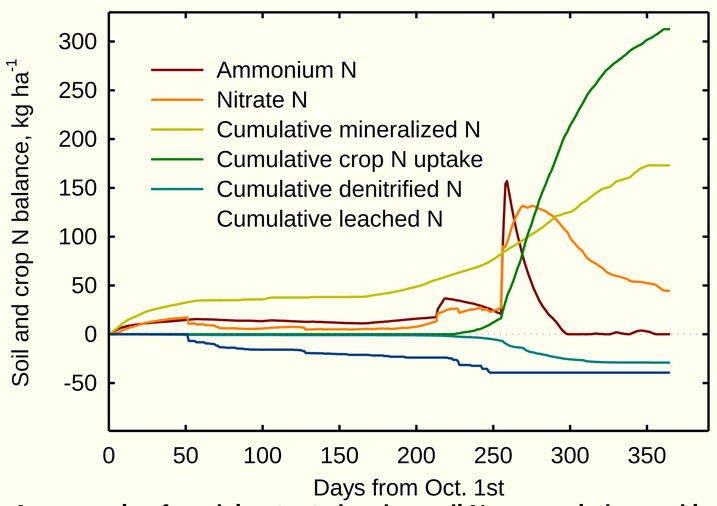
1. Determine amount of organic N that will mineralize;
2. Determine applied fertilizer ammonium and nitrate N;
3. Determine amount of ammonium N converted to nitrate N;
4. Determine amount of N taken up by crop;
5. Determine amount of nitrate N lost due to denitrification;
6. Determine amount of nitrate N lost through leaching.

Model Application

Input Data

- Soil texture with depth (NRCS Soil Data Mart)
- Soil pH and organic matter (soil test for surface or NRCS Soil Data Mart)
- Daily high and low air temperature, and precipitation/irrigation
- Fertilizer N source, placement and timing, and crop planting/emergence date
- Humidity and wind speed (optional)

Model Outputs



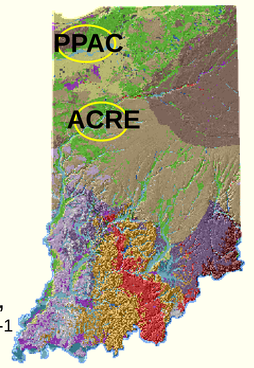
An example of model output showing soil N accumulation and loss and crop N uptake resulting from an application of 224 kg ha^{-1} fertilizer N (as UAN) in 2008 at ACRE.

Excessive amount of NO_3^--N was observed at the end of the growing season which may be lost through leaching in the coming year.

Model Evaluation

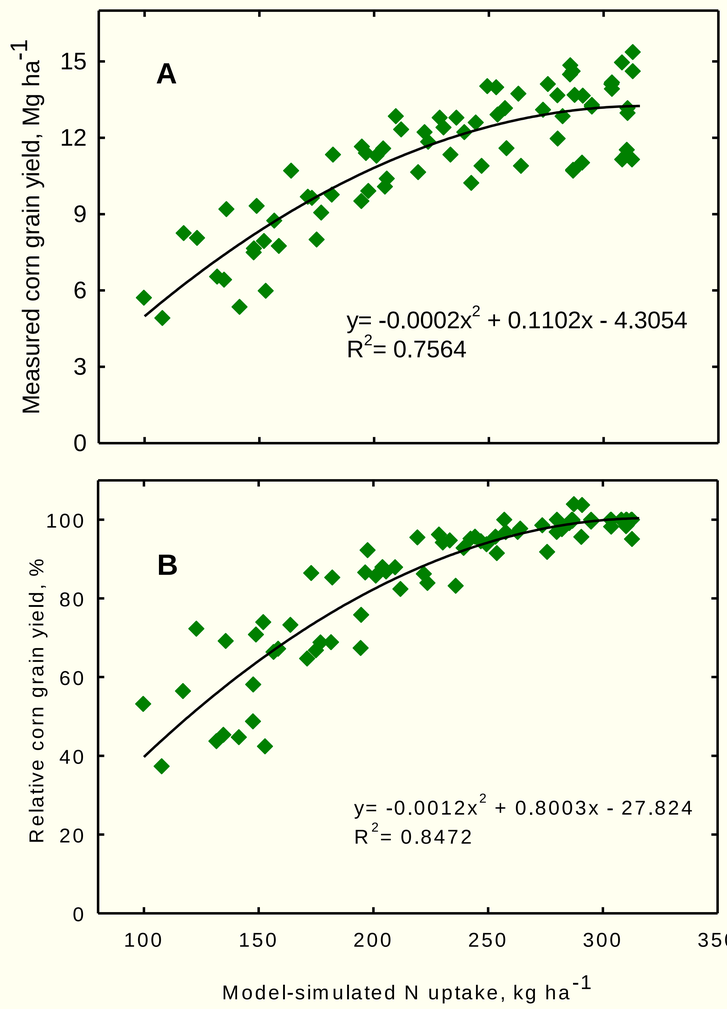
Field Sites

- Soil series:
  ACRE: Chalmers silty clay loam
  PPAC: Sebewa loam
- Cropping system:
  Corn-soybean rotation
- Fertilizer management:
  Nitrogen fertilizer was side dressed early (V6) or late (V10 to V12) at a rate of 0, 45, 90, 134, 179, or 224 kg ha^{-1} plus 28 kg ha^{-1} of starter fertilizer (as UAN).



Map of Indiana.

Results



Relationship between model-simulated corn N uptake and measured corn grain yield (A) and relative corn grain yield (B) for various fertilizer rates from 2006 to 2011.

The relationship between modeled corn N uptake and measured corn grain yield was strong ($R^2 > 0.75$) across 16 site years at two locations. $R^2 > 0.97$ for any individual site year.

Future Work

Further programming is underway to i) incorporate ammonia volatilization and manure N mineralization into the model, ii) calculate net precipitation based on variations in topography and soils, iii) test the model across different soil and climatic conditions and iv) add more crops (corn following soybean and winter wheat are the only crops currently programmed).