Site-specific Simulation of Maize Growth and Yield Using the CERES-Maize Model

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INTRODUCTION

- Site-specific information of crops allows precision management of resources in crop production.
- Crop models can predict growth, development, and yield as a function of cultivar, soil, weather and agronomic management.
- Such models can be useful to simulate site-specific crop growth and to evaluate the causes of spatial yield variation.

Objectives

- Assess the CERES-Maize model as a tool to study the spatio-temporal variation in maize response to nitrogen (N) fertilizer.
- Simulate site-specific maize growth and yield using the CERES-Maize model in a spatially variable field.

MATERIALS AND METHODS

Study site

- A 7-ha field of continuous maize since 2015 in southwestern Minnesota (Fig. 1)
- Normania series soil type: very deep, well-drained
- Hot summer humid continental climate

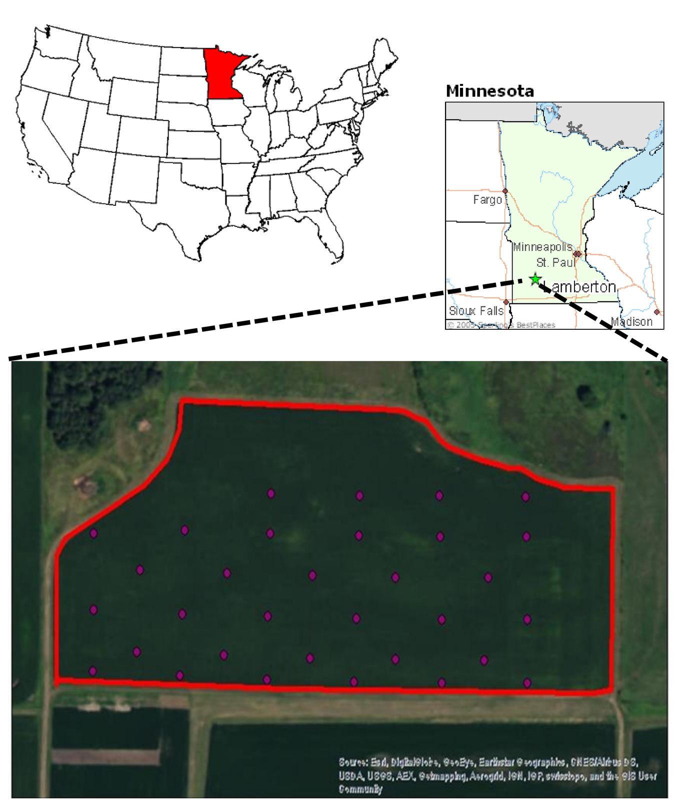

Fig. 1 - Study site located at the University of Minnesota Southwest Research and Outreach Center at Lamberton, MN.

Treatments

- Control: No N
- Fertilized: 118 kg N ha^{-1} side-dressed at 6 leaf-collar stage in strips

Soil samples

- Before planting, at 20 geo-referenced points from 0 to 90 cm depth at 30 cm interval for total N, P, K, organic carbon, CEC, pH and soil texture
- Soil texture determined at study site: clay loam (CL), sandy clay loam (SCL) and sandy clay (SC)

Data collected

- Phenology, aboveground biomass at 8 leaf-collar (V8) and tasseling (VT) stages at 20 georeferenced points across the field
- Grain yield using a field-scale combine equipped with a yield monitoring device

Crop model

- CERES-Maize in DSSAT v 4.6.5
- Model was run for each soil type (CL, SCL and SC).

Crop model performance statistics

- Normalized root mean square error (*nRMSE*)
- Correlation of determination (R^2)

RESULTS

- Low yielding spots (lesser than 4000 kg ha^{-1}), indicated as dark red areas in yield map of Fig. 2, were unfertilized and had greater sand percentage ranging from 47 to 55%.
- High yielding spots (more than 12,550 kg ha^{-1}), indicated as dark green areas in the yield map of Fig. 2 were fertilized and were CL and SCL soils.

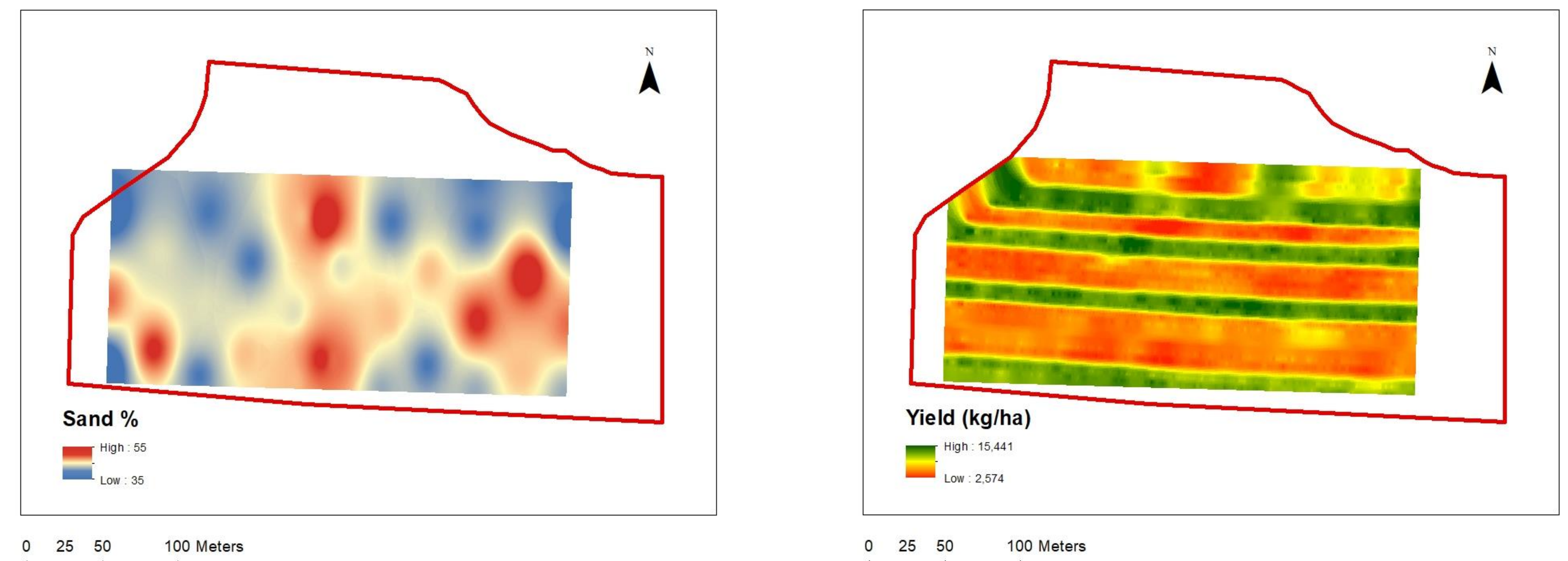

Fig. 2 - Spatial variation in sand percentage in the top 30cm soil profile (left) and maize yield (right) in the study site.

Model calibration

- Soil and crop data from three CL sites within the fertilized treatment were used for calibration as those sites gave the highest yields and therefore, were assumed to be stress-free treatments .
- Generalized Likelihood Uncertainty Estimation (GLUE), a coefficient estimator within DSSAT v 4.6.5 was used for initial calibration. Parameters were further optimized manually using the trial and error method (Table 1).
- *nRMSE* 2.5% for anthesis date, 3% aboveground biomass at VT stage and 6% for final grain yield.

Table 1: Calibrated cultivar coefficients for CERES-Maize used in this study

Maize cultivar coefficient	Calibrated values
Thermal time from seedling emergence to the end of the juvenile (P1)	195
Extent to which development is delayed for each hour that daylength is above 12.5 hours (P2)	0.99
Thermal time for silking to physiological maturity (P5)	870
Phyllochron interval between successive leaf tip appearances (PHINT)	49
Maximum possible number of kernels per plant (G2)	800
Kernel growth rate during linear grain filling stage under optimum conditions (G3)	8

Model application

- Simulated biomass at V8 did not capture the effects of soil type (Fig. 3), *nRMSE*= 31%.
- Simulated biomass at VT was slightly improved as compared to V8 biomass, *nRMSE*= 25%, R^2 = 0.44, p<0.01 (Fig. 3).
- Simulated yield was underestimated in sandy clay soil, overall *nRMSE*=15%, R^2 = 0.80, p<0.01 (Fig. 3).

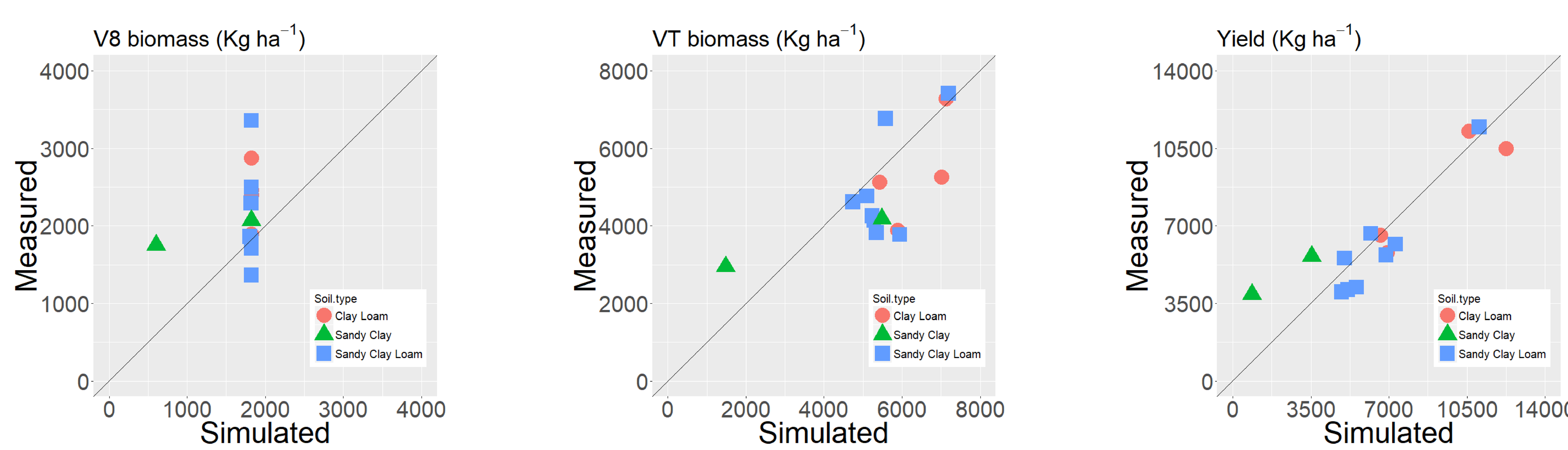

Fig. 3 - Correlation between measured and simulated biomass at 8 leaf-collar (V8) and tasseling stage (VT) and grain yield at harvest at different soil types.

CONCLUSIONS

Preliminary results show the CERES-Maize as a promising tool to simulate site-specific maize biomass and yield. This is valuable to understanding spatio-temporal variation in maize response to N fertilizer at a field level and to develop precision N management strategies in maize production.

ACKNOWLEDGMENTS

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