First Soybean Multi-model Sensitivity Analysis to CO 2 , Temperature, Water, and Nitrogen

Kritika Kothari, Montserrat Salmeron, Rafael Battisti, Kenneth Boote, Sotirios Archontoulis, Adriana Confalone, Julie Constantin, Vianna Cuadra Sanatiago, Philippe Debaeke, Babacar Faye, et al.

First Soybean Multi-model Sensitivity Analysis to CO_2, Temperature, Water, and Nitrogen

Kothari Kritika[1] (kritikakothari@uky.edu), Salmeron Montserrat[1], Battisti Rafael[2], Boote Kenneth J[3], Archontoulis Sotirios[4], Confalone Adriana[5], Constantin Julie[6], Cuadra Sanatiago Vianna[7], Debaeke Philippe[6], Faye Babacar[8], Grant Brian[9], Hoogenboom Gerrit[3], Jing Qi[9], Laan Michael van der[10], Macena Fernando[7], Marin Fabio[11], Nehbandani Alireza[12], Nendel Class[13], Purcell Larry[14], Qian Budong[9], Ruane Alex[15], Silva Evandro da[11], Smith Ward[9], Soltani Afshin[12], Srivastava Amit[8], Vieira Nilson Aparecido[11]

[1] *Plant and Soil Sciences, University of Kentucky, Lexington, KY, United States*; [2] *Escola de Agronomia, Universidade Federal de Goiás, Goiânia, Brazil*; [3] *Agricultural and Biological Engineering, University of Florida, Gainesville, FL, United States*; [4] *Department of Agronomy, Iowa State University, Ames, IA, United States*; [5] *Facultad de Agronomía, Universidad Nacional del Centro, Buenos Aires, Argentina*; [6] *Agrosystèmes et Agricultures, National Institute for Agricultural Res., Tolosan, France*; [7] *Empresa Brasileira de Pesquisa Agropecuá, São Paulo, Brazil*; [8] *Crop Science and Resource Conservation, University of Bonn, Bonn, Germany*; [9] *Agriculture and Agri-Food Canada, Ottawa Research and Development Centre, Ottawa, Canada*; [10] *University of Pretoria, Pretoria, South Africa*; [11] *Biosystems Engineering Department, University of São Paulo, São Paulo, Brazil*; [12] *Agronomy Group, Gorgan University of Agricultural Scienc, Gorgan, Iran*; [13] *Ecosystem Modelling, Leibniz Centre for Agricultural Landscap, Müncheberg, Germany*; [14] *Crop, Soil, and Environmental Sciences, University of Arkansas, Fayetteville, AR, United States*; [15] *NASA Goddard Institute for Space Studies, New York, NY, United States*

Introduction

Crop model responses to changes in climatic and management factors could be highly variable due to variation in model coding and prior calibration with limited observed data, thus introducing high uncertainty in food projections. Coordinated multi-model comparison studies play a crucial role in evaluating model uncertainty and improving existing models. The present study is the first model intercomparison effort on a legume, soybean (*Glycine max* L. (Merr.)), with special emphasis on the crop N processes. Previous multi-model studies in cereal grain crops identified the value of model ensembles to reduce uncertainties in yield projections (Bassu *et al.*, 2014; Martre *et al.*, 2015). Interestingly, model responses to changes in temperature and atmospheric carbon dioxide concentration [CO_2] were not affected by the level of observed data available for calibration (Bassu *et al.*, 2014). We propose to test: 1) whether soybean multi-model ensembles are better estimators of yield, crop growth and grain nitrogen concentration (grain N%) than individual models; and 2) whether the level of observed data available during calibration influences model responses to variation in climatic and N fertilization factors ([CO_2], Temperature, Water, and Nitrogen; CTWN sensitivity analysis).

Materials and Methods

Field experimental data from five environments (Azul, Argentina; Auzeville, France; Brasilia, Brazil; Ames, IA, and Fayetteville, AR, United States) were used to calibrate models under baseline conditions. Each experiment included different years, planting dates (early and late) and/or water levels (irrigated and rainfed). We evaluated two types of calibrations: (1) with phenology data only (blind calibration), and (2) with high intensity observed data including seasonal plant growth and N composition (full calibration). After each calibration, a CTWN sensitivity analysis was conducted, consisting of 30-yr simulations (1980–2009) for 124 combinations of [CO_2] (360 ppm to 720 ppm), temperature (−3 to +9 oC), water (−30% to +30% rainfall, and irrigated), and nitrogen (0 and 400 kg N/ha). By the time of this submission, a total of nine soybean models had been calibrated against phenology data (blind calibration).

Results and Discussion

Preliminary results after the blind calibration indicate a median root mean square error (RMSE) in simulating grain yield, biomass, and grain N% of 29, 25, and 17%, respectively, when individual model outputs were compared with the measured data. However, when individual model outputs were averaged and compared with the measured data (model ensemble), estimation of grain yield and biomass improved with RMSEs of 24 and 24%, respectively. In contrast, the estimation of grain N% worsened (RMSE 27%) compared to the median from individual models. The CTWN sensitivity analysis after the blind calibration showed negative effects on yield of increasing temperature, and positive effects of increasing [CO_2] on yield. Increasing water level typically increased crop production. The yield response to nitrogen levels was more variable across models.

Conclusions

Our preliminary data suggests that the ensemble of models was a better predictor of grain yield, but not of grain N%. On a next step we will evaluate CTWN responses after a full calibration with high intensity observed data. The uncertainty in soybean model projections across different CTWN levels after a full and blind calibration will be presented.

.../...

Acknowledgements
USDA-NIFA.

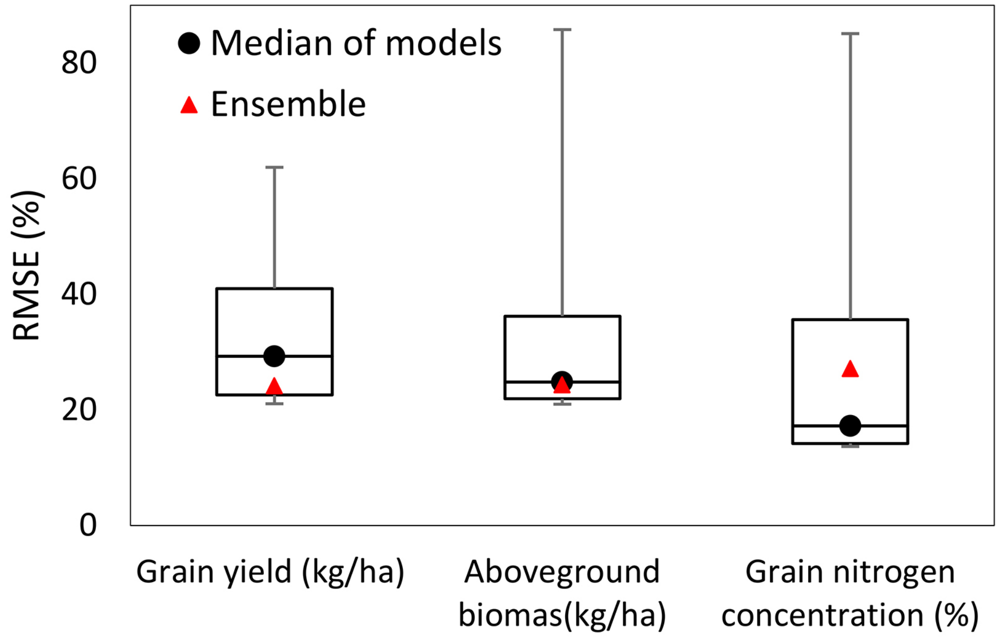

Figure 1. Boxplot of normalized root mean square error (RMSE, %) for grain yield, aboveground biomass, and grain nitrogen concentration simulated by nine soybean models after a blind calibration. The RMSE obtained using the ensemble of models as a predictor is shown by red triangles.

Keywords: AgMIP-Soybean, Blind Calibration, Full Calibration, CTWN response.

References:

1. Bassu et al., Global Change Biology 20, 2301-2320. https://doi.org/10.1111/gcb.12520
2. Martre et al., Global Change Biology 21, 911-925. https://doi.org/10.1111/gcb.12768