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To cite this version:

Rafael Battisti, Sampaio Sobral, Marcos Lana. Performance of CSM-DSSAT-CROPGRO model for soybean plant density in low latitude in Brazil. ICROPM2020: Second International Crop Modelling Symposium , Feb 2020, Montpellier, France. hal-02950274

Performance of CSM-DSSAT-CROPGRO model for soybean plant density in low latitude in Brazil

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Introduction

Sowing dates, maturity group and climate conditions associated with plant density can lead to different effects on soybean (Battisti et al., 2017). Light interception explains responses to plant density among different maturity groups and environments (Edwards et al., 2005). Decisions concerning sowing density need to take into account two main factors: the lowest possible sowing density to reduce seed costs, and the optimum possible interception of solar radiation. Crop models can help to evaluate the interaction between these factors, but studies about plant density are very scarce, especially for soybean. In order to better explore this knowledge gap, this study aims to evaluate the CSM-DSSAT-CROPGRO-Soybean regarding plant development and yield in response to plant density for two distinct soybean maturity groups (7.7 and 8.8) in low latitudes, Brazil.

Materials and Methods

Fields experiment were conducted in Paragominas, PA, Brazil (Lat -3.37°; Long -47.42°; 176 m a.s.l; Aw climate, Yellow Latosol, very clayey). The cultivars M7739 IPRO (MG 7.7, quasi-determinate,) and M8808 IPRO (MG 8.8, determinate) were sowed on 06 Jan (Sowing date 1(S1)), 19 Jan (S2), and 16 Feb (S3) in 2018, and 12 Jan (S4) for 2019. Sowing densities were 10 (MG 7.7 – S1, S2 and S4; MG 8.8 – all S), 20 (MG 7.7 – all S; MG 8.8 – S1, S2 and S4), 30 (MG 7.7 – all S; MG 8.8 – S1 and S4) and 40 (MG 7.7 – S1 and S4; MG 8.8 – S3 and S4) plants m-2. Field measurements included phenology, grain yield, leaf area index, and aboveground (total, leaf, stem, and pod) dry biomass. S1, S2, and S3 data were used for model calibration and S4 for model evaluation. Calibration started with default parameters from CROPGRO, following Hunt and Boote (1998) calibration steps. The relative root mean square error (RRMSE) and Willmott index (d) were used to evaluate crop model performance.

Results and Discussion

The model calibration was able to adequately simulate phenology, reducing the initial RRMSE from 25% (uncalibrated) to less than 4% after calibration. MG 7.7 grain yield had an RRMSE of 12% and 3.5%, respectively, for calibration and evaluation, with d above 0.83 (Figure 1a). MG 8.8 had similar result for calibration (RRMSE = 10%; d = 0.76). However, the crop model outputs showed yield variability associated to plant density in the evaluation, contradicting field observations of MG 8.8 S4 (Figure 1b). As consequence, the MG 8.8 yield RRMSE increased to 32%. The yield response for MG 8.8 S4 was associated with a reduction of leaf area index and biomass at the field, with the crop model overestimating these results. For the leaf area index, the calculated RMSE was 0.12, 0.46, 0.68 and 1.10 for 10, 20, 30 and 40 plants m-2, respectively. The same tendency was observed for MG 8.8 during calibration.

Conclusions

In most cases, the model was able to simulate yield, leaf area index and biomass in response to plant density. The limitation was observed for the MG 8.8 in the evaluation step. Our hypothesis is that other limitations particular to MG 8.8 features, or even environmental limitations in N fixation (due soil saturation after extreme precipitation events) or solar radiation quality are not captured by the model. While the model was able to correctly mimic the MG 7.7 cultivar, further analysis needs to be done to clarify the source of limiting yield and crop model performance for MG 8.8.

Acknowledgments

We gratefully acknowledge support from the Juparanã Agrícola.

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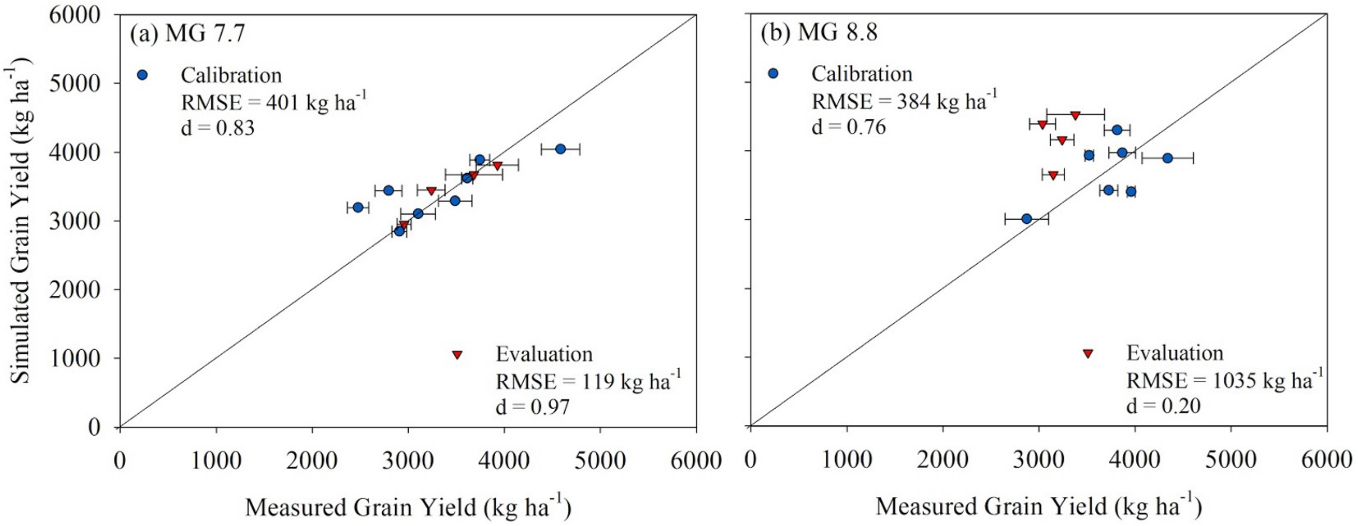

Figure 1. Relationship between measured and simulated soybean grain yield for calibration and evaluation phase for maturity group 7.7 (MG 7.7) (a) and MG 8.8 (b). RMSE is the root mean square error and d is the Willmott index.

Keywords: Crop modeling, crop management, maturity group, potential yield.

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