Assimilating leaf area index into a simple crop model to predict soybean yield and maximum root depth at field scale

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Introduction

Yield forecasting has been extensively tackled by the use of crop growth models, however its implementation at field scale still faces numerous constrains due to the lack of input data required and uncertainties in parameter value. Current accessibility of remote sensing data with global coverage and free access offers a great opportunity to enhance crop model predictions throughout retrieval biophysical parameters to link with model, such as leaf are index (LAI). Among methods available to assimilate LAI into the model, calibration has been successfully applied for wheat (Gaso, et al., 2019). Therefore, the aim of this study was to predict spatial variability of soybean grain yield and maximum root depth (RDmax) at field scale by assimilating temporal series of Sentinel-2.

Materials and Methods

Study area and field data

The study area was located in southern part of Uruguay during 2017-2018 growing season. A field was planted with soybean in early December and harvested in May. Flowering and maturity dates are required by the model as input parameters but this information is not available for the site. Therefore this information was derived from official variety trails at a nearby location (INIA-INASE Trials). Weather data was downloaded from the closest meteorological weather station. Yield was measured using standard yield monitor mounted on harvesting machines.

Crop growth model inversion

The model described by Campbell and Diaz, (1988) was implemented in Python language. This model is based on soil water budget and biomass is calculated through the link between carbon assimilation and water transpiration. A total of 20 parameters are included in the model.

Time series of LAI derived from Sentinel 2 was used to estimate the parameters driving the model through the optimization of the predicted vs observed LAI. The estimation of maximum root depth (RDmax) was optimized by the use of inversion method of LAI curves. In a following step, forward running was executed using parameter values assigned through the optimization process for the whole growing season, including grain filling.

Results and Discussion

Rainfed soybean system performance is determined by water availability and WHC plays a crucial role on water supply for rainfed crops. Through the approach of inverting model, a value for RDmax was obtained for each pixel and yield prediction was enhanced by means of adjusting RDmax. Calibrated values for RDmax have agronomic meaning and their values were between the expected range for this property, but it is not feasible to validate these values with field data. The rooting depth is a property hard to measure because, there is no sharp value for this feature, and root presence is not necessarily related to root activity in water extraction which makes validation even more complex. After the calibration procedure, yield predictions were successfully achieved (Figure 1). Although predicted yield by the model presented a wider range than observed yield, spatial distribution of the observed yield was accordingly with the distribution of estimated yield (RMSE= 507 kg ha-1).

Conclusion

Spatial variability of grain yield could be accurately predicted by means of using the methodology proposed. Valuable results were obtained from the calibration procedure of RDmax. Parameter values of RDmax provided useful information to improve field characterization and detect limitations for summer crop production.

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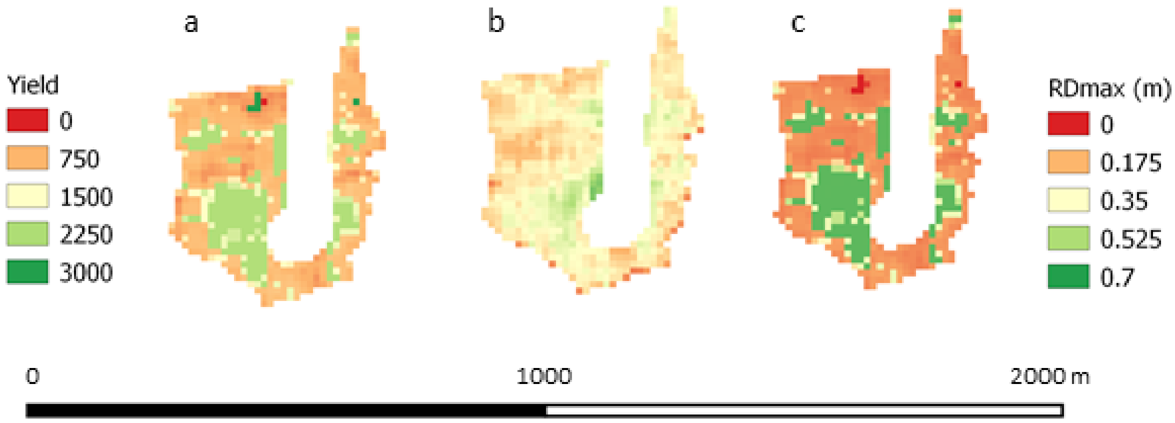

Figure 1. Spatial distribution of yield (kg ha-1) for the field study: (a) predicted yield, (b) observed yield and (c) calibrated value for RDmax (m).

References:

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