Evaluating CERES and IXIM, the Maize Simulation Models in DSSAT v4.5, under Irrigated Mediterranean Conditions

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Computer simulation is a cost-effective methodology to examine the results of alternative crop management practices on agricultural production, estimate the use efficiency of resources, and assess the sustainability of cropping systems. Confident use of simulation models depends on the continuous improvement of these tools and the adequate calibration to local conditions. The Decision Support System for Agrotechnology Transfer (DSSAT) is a simulation environment providing models for 25 crops. The newest version of DSSAT, version 4.5, gives users the opportunity to choose between two maize models, CSM-CERES, and CSM-IXIM a more mechanistic model. In this work we compare the simulations of crop growth and yield obtained with these crop models in two high yielding irrigated cropping systems of Mediterranean climate in Spain.

Methodology

CSM-CERES is the modular version of CERES-Maize (Jones and Kiniry, 1986), available in DSSAT since the first release in 1989. CSM-IXIM (Lizaso et al., 2008) was modified from CSM-CERES and includes a number of improvements and new modules. The main improvements are associated to the simulation of leaf area (Lizaso et al., 2003), plant growth and partitioning (Lizaso et al., 2005), ear growth and grain yield, and plant N.

Maize hybrid Dracma (FAO 700) was sown at 8.7 plant m^{-2} in 2008 and 2009 in Albacete, Castilla-La Mancha, in a loan well drained soil and sprinkler-irrigated maintaining growing conditions close to optimum. Three N doses were applied (0, 150, and 300 kg ha^{-1}). Measurements on the highest N dose on both years were used to calibrate genetic coefficients. Only results of the mid N dose are reported. Maize hybrids Cecilia (FAO 600) and Eleonora (FAO 700) were sown at 8.5 plant m^{-2} on three dates (March, April, and May) on each of three years, 2003, 2004, and 2005 in Lleida, Ebro Valley. The soil was loam, well drained, without salinity problems. Data from sowing dates of March and May were used to calibrate genetic coefficients and only April measurements are reported here. Coefficients for each model were calibrated independently in both sites. Crop biomass was evaluated at mid-season and at harvest, shortly after physiological maturity. Grain yield was determined in the two central rows of each experimental plot.

Results and Discussion

Genetic coefficients were calibrated first to match correctly crop phenology and later to approximate measured grain yield. To calibrate phenology, duration of juvenile phase (P1), photoperiod sensitivity (P2), and phyllochron (PHINT) were iteratively modified, until silking date and leaf number were adequately simulated. Later, the period silking-maturity (P5) was adjusted until date of physiological maturity was closely simulated.

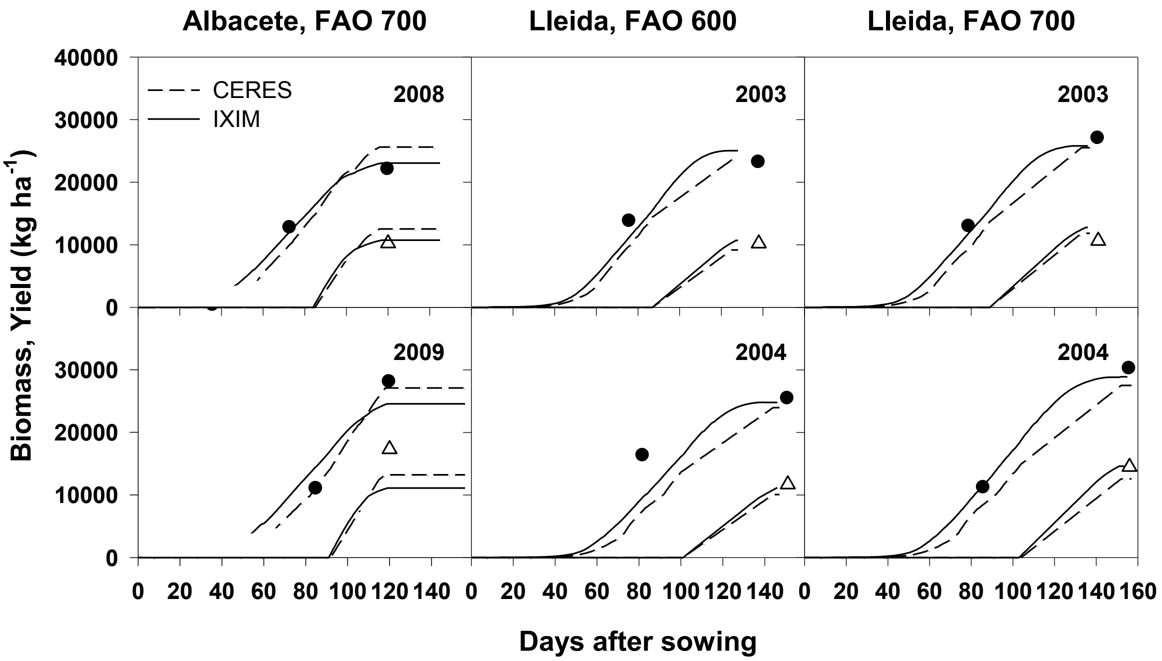

Figure 1: Shoot biomass and grain yield measured (symbols) and simulated with CSM-Ceres (dashed lines) and CSM-IXIM (continuous lines) in two irrigated cropping systems of Spain. Cultivars used were Dracma (Albacete), Cecilia (Lleida, FAO 600), and Eleonora (Lleida, FAO 700).

Data availability limited model components to be evaluated. Here only shoot biomass accumulation and grain yield were examined. Under non-limiting soil water and nitrogen supply, both models exhibited close to measured simulations. Simulation of shoot biomass and grain yield by CSM-IXIM was as good as or better than simulations with CSM-CERES, with the only exception of the 2009 season in Albacete.

CSM-CERES does not allow calibrating leaf area for cultivars with different leaf area surface as CSM-IXIM does. An inconvenient that for the cultivars here examined did not result in poor growth simulation. Also the PAR use efficiency approach in CSM-CERES may limit accuracy under stress compared to a photosynthesis and respiration simulation as in CSM-IXIM. More detailed field data might be required to evaluate additional model components such as the simulation of biomass partitioning among organs, yield components, and plant N concentrations. Also the new modules simulating P and K system dynamics in both models will require plant concentrations of P and K.

Acknowledgment

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