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Simulation of silage maize growth and development under water stress with the PILOTE and CropSyst Models

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Title: Simulation of silage maize growth and development under water stress with the PILOTE and CropSyst Models

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Abstract:

Models that simulate the effects of water stress on crop growth and development can be a valuable tools in irrigation management. We evaluated the crop growth simulation models PILOTE and CropSyst on their ability to simulate silage maize (Zea mays L.) growth and yield reduction caused by water stress under semiarid conditions of Tadla (Morocco). The simulation of evolution of biomass, leaf area index (LAI) and soil water reserve (SWR) is also evaluated. In flood-irrigated experiment, different water treatments: T1 (100%ETc), T2 (80%ETc), T3 (60%ETc) and T4 (40%ETc) were applied during all cycle growth in 2009 and 2010. Linear regressions between simulated and measured data, root mean square error (RMSE) and Nash coefficient efficiency (CE) were evaluated to express a comparison between treatments.

The sensitive analysis of CropSyst model showed that biomass and leaf area index are particularly sensitive to the parameters “above ground biomass transpiration coefficient”, “extinction coefficient for solar radiation” and “specific leaf area”. The same outputs are low sensitive to “degree day emergence”, “base temperature”, “ET crop coefficient at full canopy” and “initial green leaf area index”. Concerning PILOTE model, yield biomass was more sensitive to efficiency of solar radiation interception, moisture at field capacity (Hcc), moisture at permanent wilting point (HpF) and temperature sum for flowering (Tf). The soil water reserve is sensitive to a maximum root depth (Rmax) and Hcc. The leaf area index was very sensitive to Tf, [U+F067] (LAI shape coefficient) and LAImax.
As results of calibration and validation of this models, soil water reserve and biomass were simulated satisfactorily by both the models (RMSE equal to 13.4 mm and 0.95 t/ha for CropSyst and 14.5 mm and 1.16 t/ha for PILOTE respectively). The values of coefficient efficiency for these two outputs are 0.79 and 0.87 for CropSyst and 0.75 and 0.82 for PILOTE respectively. The poor accordance in soil water reserve simulation by both models can be explained by relatively low infiltration uniformity. CropSyst overestimates slightly LAI especially in the more water-stressed treatment. The RMSE and CE was 1.22 and 0.61 respectively. PILOTE model simulate very more satisfactory LAI as well in non stressed and more stressed treatment. The value of RMSE and CE are 0.41 and 0.91 respectively. The regression of the PILOTE simulated vs. measured values of LAI had intercept that were not significantly different from 0 and slope not different from 1.

These models can thus be used to calculate biomass yield reduction due to water stress and to manage water irrigation of silage maize under the arid climate of Tadla.

Key words: Irrigation, crop model, PILOTE, CropSyst, sensitivity analysis, water stress, Morocco.