Evaluation of SARRAH crop model for genetic, spatial and inter-annual variability of African upland rice

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Introduction :

Robust crop models requiring limited observations for calibration and input variables for execution are needed to evaluate water limited production potential for different combinations of cultivar and environment. This study evaluated the model SARRAH, calibrated for upland rice, using experimental data from different cultivars, altitudes and years in the highlands of Madagascar and savannah of Ivory Coast.

Material and Methods :

SARRAH, is an agronomic, field-scale crop model for tropical cereals, implemented on the generic platform ECOTROP of Cirad. Originally developed for studies on agricultural impacts of climate, the model combines a 2-layer soil water balance (the 2nd layer evolving with the root front) with a photoperiod-sensitive phenology module, as well as LAI dependent transpiration module (driven by potential evapotranspiration PET and limited by the fraction of transpirable soil water FTSW) and a biomass assimilation module (driven by intercepted radiation and limited by FTSW). Leaf area is simulated with leaf biomass and specific leaf area (SLA). Biomass partitioning is simulated with allometric rules during pre-flowering stages and sink-source relationships (involving leaf senescence and reserve mobilization) during grain filling. Panicle sink potential is a function of pre-floral growth and sterility caused by heat, chilling and drought during sensitive stages.

Data from two upland rice studies were separated used to calibrate and validate the model: first, a multi-annual experiment conducted in Madagascar highland during three years (2004, 2005 and 2006) with 3 cultivars (2 japonica types and 1 japonica-intermediate type) and 2 sites (altitude 1645m and 1849m). The data of the second experiment conducted in 1998 at low altitude in Ivory Coast savannah compare 3 cultivars (1 *O. glaberrima*, 1 *O. sativa* japonica type, and 1 glaberrima x japonica hybrid) on 2 different soils (clay and sandy soils).

Results :

For each cultivar, a set of model parameters was defined empirically. About half of the parameters differing among cultivars specifically on phenological stages duration, radiation use efficiency (RUE) by radiation conversion rate (Txconv) and light extinctions coefficients (Kdf), allometric coefficients for biomass partitioning among vegetative organs, and coefficients setting the panicle sink. Globally, the model simulated faithfully the observations used for its calibration (Figure 1). The long-duration cultivars from Madagascar had lower RUE and Kdf than the West African, medium-duration cultivars.

Interannual variations were relatively well estimated for grain yield, but in one cultivar, strong inter-annual variations of shoot biomass were not well simulated (Figure 2). The model also did not simulate the observed, post-floral drought effects on the duration of maturation. Large simulation errors were also observed across sites in Madagascar, particularly for the higher altitude site. The causes are not clear but may include site-specific pest and disease problems, or model weaknesses regarding the effects of low temperatures. The SLA have also a high weight on the model and this plant caracteristicis known to be sensitive to environmental stress (drought, low temperature etc..).

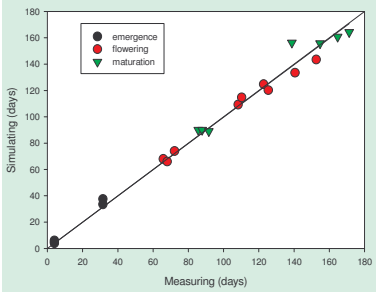

Figure 1 : Relation between measured and simulated duration development phase. Madagascar and Ivory Coast.

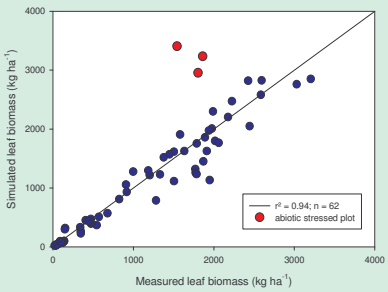

Figure 2 : Relation between measured and simulated leaf biomass. Madagascar and Ivory Coast.

Conclusion :

The forecasts of the phenology and the biomasses production by the model are acceptable as long as the culture conditions remain the same as tests used for calibrations culture conduits. Therefore, model improvement are required for good prediction performances under limiting conditions (SLA using, plant density appreciation, etc).

With regards to development cited above, SARRAH model could help breeders to simulate the performance of promising cultivars in contrasted conditions.

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