SARRA vs SARRAH: From a simple crop water balance model to a simple crop water and carbon balance model in water limited environments

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Robust simulation tools are needed to estimate the impact of climate scenarios on annual crop yields in semiarid environments such as the Sahel. The present study compares the performance of a water balance based crop model, SARRA, with that of an expanded version of the same model, SARRAH, that also simulates carbon assimilation and conversion to yield. SARRA is a simple crop water balance model for field and regional scales, used in many developing countries to asses drought risks and agricultural impact. For example, the DHC early warning system of Agrhymet for the Sahel (9 countries in SSA) uses SARRA in combination with Meteosat based estimates of precipitation. SARRA derives yield indices from daily reductions in crop evapotranspiration accumulated during a season, and converts them to grain yield using an empirical function obtained from field survey data. The expanded version, SARRAH, simulates radiation driven carbon assimilation modulated by a water balance derived stress term, and uses physiological detail to simulate variation in crop duration and harvest index. It thus predicts water-limited, attainable yields.

Model comparisons were conducted for millet on the basis of on-station field experiments in Bambey, Senegal, and on-farm yield surveys in 14 regions of the same country. Both models gave similarly good correlations between simulated and observed yield data (R^2 between 0.66 and 0.83 depending on the year and source of data) but SARRAH over-estimated on-farm yields 3-fold. This suggests that a 3-fold gap exists between attainable and actual yields, and that the relative size of this gap varies little among years and regions. Water balance related constraints, as simulated by the models, therefore explain most of the spatial and temporal variability of millet yields in Senegal, but they seem to be unrelated to the large gap observed between attainable and actual yields. The possibility to disaggregate climatic, edaphic, cultural and genetic components of yield variability using crop models is discussed.

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