Suitability of Simulation Models for Crop Growth and Development in West African Sudan Savannah

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SPONSORED BY THE Federal Ministry of Education and Research

Introduction

Increased food security and livelihoods in West African Sudan Savannah (WASS) can be gained through sustainable cropping systems modeling. Since existing cropping system models needs to be parameterized and validated before a systematic use can be envisaged in West Africa, it was examined how and to what extent CERES and CROPGRO models of DSSAT 4.6 package can capture growth and development in *Zea mays* L., *Sorghum bicolor* L., *Vigna anguiculata* L., and *Gossypium hirsutum* L. based production systems in the Sudan Savannah agro-ecological zone of Benin.

Materials and methods

Field experiments were carried out at Ouri Yori in North-West Benin.

The data collection was guided by the calibration, validation, and application of the models.

Goodness of fit of predictions were assessed using the lowest root mean square error (RMSE), normalized RMSE (nRMSE), modeling efficiency (EF) ≥ 0 , and index of agreement (d) $\geq$ 0.75.

Figure 1. Partial view of collaborative research involving farmers as partners through farmer managed and joint researcher and farmer managed field trials

Results and discussion

Calibration of models components

Table 1. Observed and simulated anthesis (days after planting, DAP), physiological maturity (DAP), harvest index, final yields (k gha^{-1}) for *Z. mays* and *S. bicolor* in 2014

Variables	*Z. mays (var. EVDT-97 STR)*				*S. bicolor (var. Local)*			
	Obs.	Sim.	RMSE	nRMSE	Obs.	Sim.	RMSE	nRMSE
Anthesis	52	52	0	0%	78	76	2	3%
Maturity	80	80	0	0%	103	103	0	0%
Yield	2887	2840	47	2%	1778	1822	44	2%
HI	0.32	0.34	0.02	5%	0.22	0.22	0.00	0%
Biomass	9110	8489	621	7%	8265	8250	15	0.2%

Table 2. Observed and simulated anthesis (DAP), physiological maturity (DAP), harvest index, final yields (k gha^{-1}) for *V. anguiculata and G. hirsutum* in 2014

Variables	*V. anguiculata* (var. Local)				*G. hirsutum (Var. H-279-1)*			
	Obs.	Sim.	RMSE	nRMSE	Obs.	Sim.	RMSE	nRMSE
Anthesis	55	55	0	0%	50	50	0	0%
Maturity	83	83	0	0%	121	121	0	0%
Yield	885	860	25	3%	1431	1685	254	18%
HI	0.27	0.26	0	1%	0.42	0.43	0.01	2%
Biomass	3249	3218	31	1%	3395	3267	128	4%

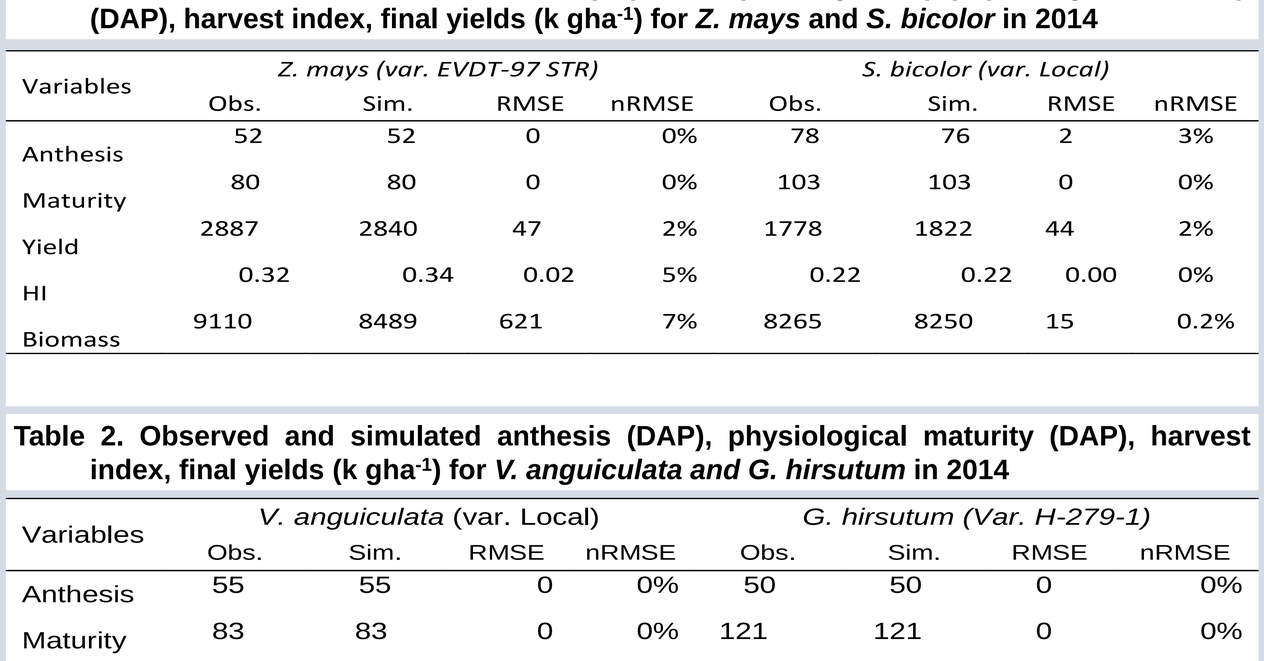


Figure 2. Observed and simulated above ground biomass of *Z. mays*, *S. bicolor*, *V. anguiculata* and *G. hirsutum* in 2014 under researcher managed trials

Models validation, application, and goodness of fit

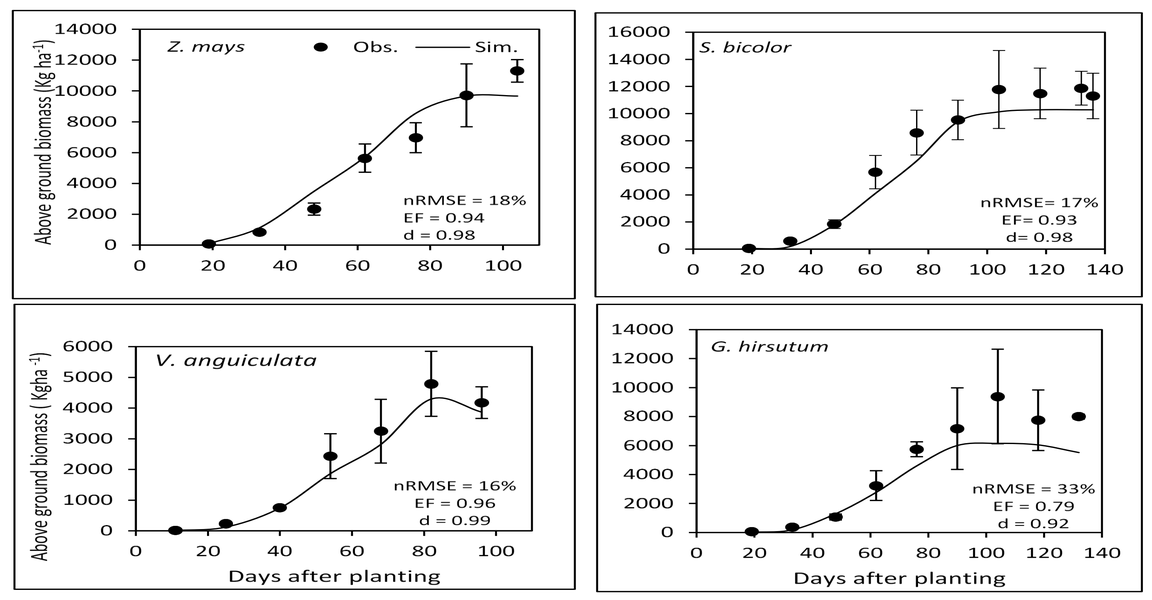


Figure 3. Observed and simulated above ground biomass of *Z. mays*, *S. bicolor*, *V. anguiculata* and *G. hirsutum* in 2015 under researcher managed trials

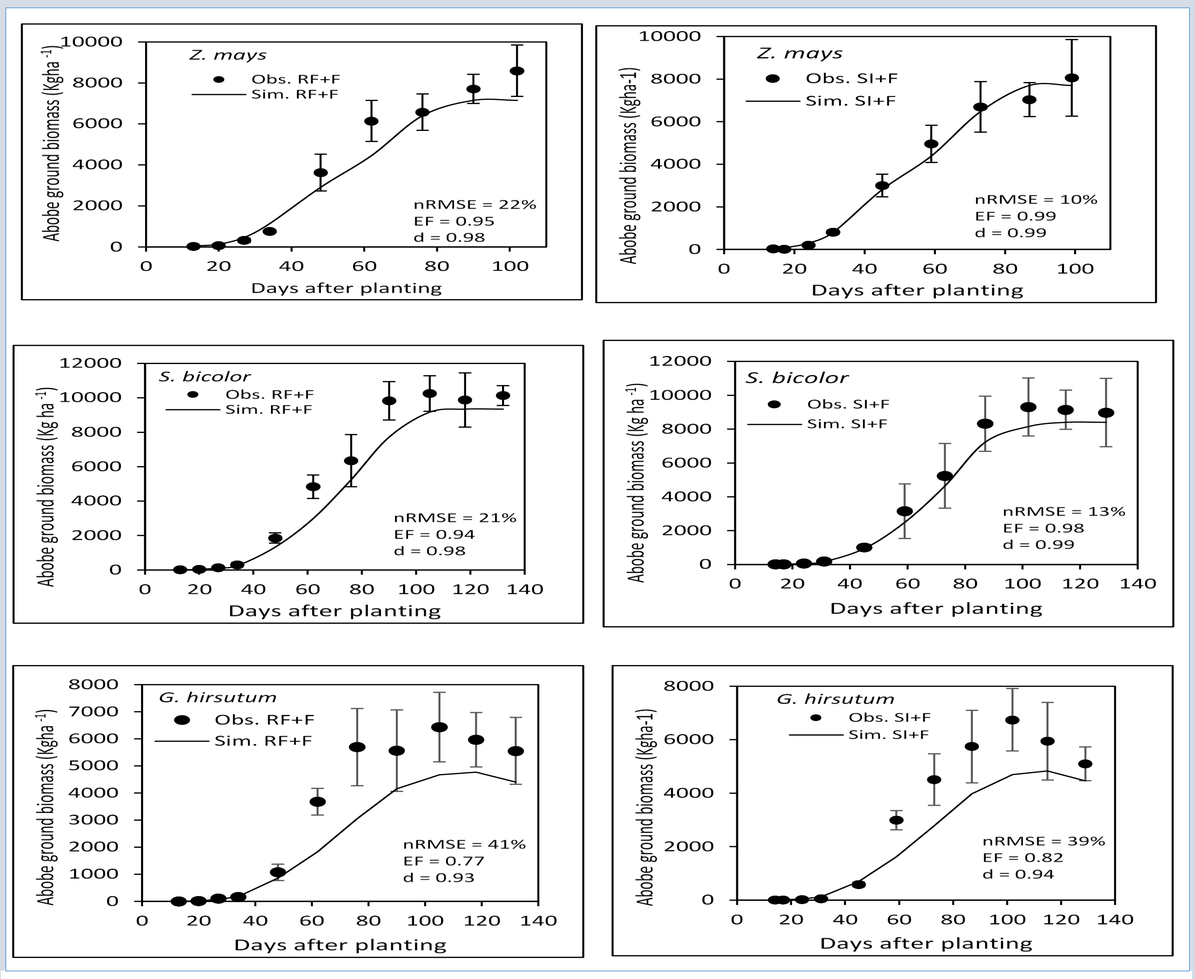
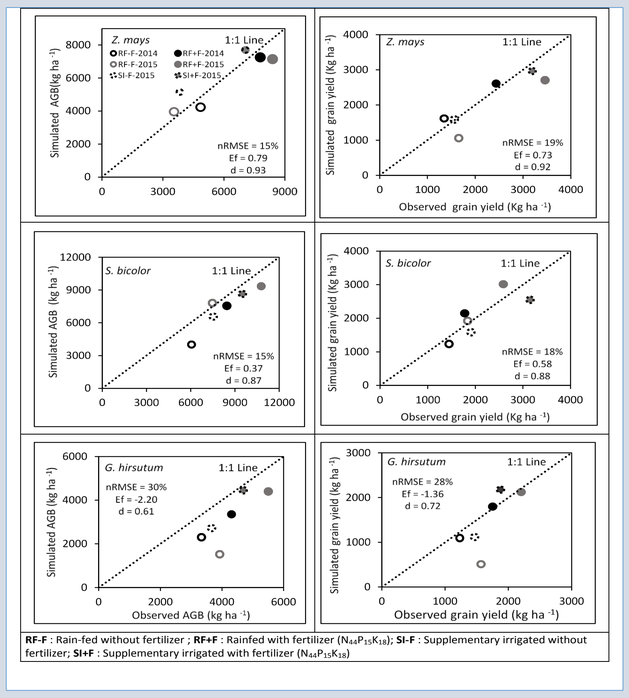


Figure 4. Simulation of above ground biomass of *Z. mays*, *S. bicolor*, and *G. hirsutum* under joint researcher and farmer managed trials in 2015



RF-F : Rain-fed without fertilizer ; **RF+F** : Rainfed with fertilizer ($N_{44}P_{15}K_{18}$); **SI-F** : Supplementary irrigated without fertilizer; **SI+F** : Supplementary irrigated with fertilizer ($N_{44}P_{15}K_{18}$)

Figure 5. Simulation of final yields under joint researcher and farmer managed trials in 2014 and 2015

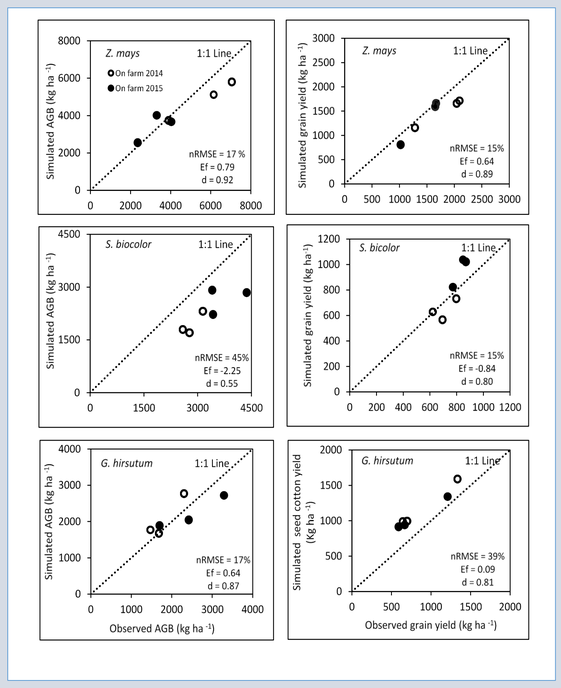


Figure 6. Simulation of final yields under farmer managed trials in 2014 and 2015

Conclusions

The CERES and CROPGRO models accurately predicted crop components within acceptable thresholds. These models are ready for simulating nutrient and water dynamics in soil-plant systems under the impact of climate change in the West African Sudan Savannah.

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