Assessment and comparison of leaf area modeling approaches for Maize

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Introduction

Crop models are being increasingly relied on to provide assessments of climate change impacts on future yields, primarily through temperature and water stress effects. It is therefore important to accurately estimate leaf area expansion and senescence, and their linkage to leaf ontogeny and phenology particularly when average temperatures are above the optimum. The purpose of this study is to compare different approaches to modeling leaf area in maize to assess their strengths and weaknesses, and identify areas where knowledge gaps exist

Materials and Methods

Here we investigated several maize models including, AgMaize (Dzotsi et al., 2015), Hybrid Maize (Haishun Yang, 2004), and MAIZSIM (Kim et al., 2012) to assess leaf growth response to temperature and carbon. The model simulation results were compared to observed leaf area data from three locations, two having a range of plant densities. In addition, the models' responses to temperature and water were compared using 30 years of daily weather data generated by CLIM-Gen with average temperatures adjusted upwards by +3 and +6 C and precipitation adjusted downward by 20 %. The three models use similar approaches to model leaf addition rate and leaf expansion. However the methods of quantifying temperature are different.

In AgMaize and MAIZSIM, a non-linear beta function is used to quantify the temperature responses of single leaf addition and expansion rates. Hybrid Maize uses growing degree days and simulates LAI as a function of temperature.

Results and Discussion

Generally there were not large differences in LAI among the models. Leaf area simulations for Hybrid Maize were higher than for the other two models. The individual leaf area calculations in AgMaize and Maizsim resulted in leaf areas closer to the measured values. Hybrid Maize, however was not calibrated for this data set.

AgMaize and MAIZSIM responded similarly to temperature where the LAI of both models decreased with increasing temperature (Table 1). This was partially due the shorter period of leaf growth resulting from shortened lifecycle (more rapid senescence) at increasing temperatures. Leaf addition and elongation rates were also slower at high temperatures in AgMaize and MAIZSIM. Hybrid Maize uses a GDD approach that does not decrease leaf addition and expansion processes at super-optimal temperatures. Hence for the Hybrid Maize simulations maximum LAIs were not decreased at temperatures above the normal records.

Table 1. ***Leaf area index simulated at normal and temperatures 3 and 6 °C higher than normal.***

Treatment	LAI		
	Model		
	AgMaize	HybridMaize	MaizSim
Normal	3.9	5.1	3.9
Normal Avg +3	3.8	5.0	3.7
Normal Avg +6	3.4	5.0	3.4

Conclusions

Some calibration/fitting may be necessary to obtain optimal parameters for leaf area expansion for a particular variety. Size of largest leaf and location on the stem is one of the most critical variables. Non-linear temperature dependencies for leaf processes appear useful to simulate the effects of elevated temperatures on leaf addition and expansion. Suggestions for improvement of the models including potential dependency of leaf expansion on hydraulic processes in the leaf will be discussed.

Reference

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