Design of African rainfed cotton ideotypes using DSSAT CROPGRO-Cotton

Romain Loison, Alain Audebert, Philippe Debaeke, Edward Gérardeaux

Design of african rainfed cotton ideotypes using dssat cropgro-cotton

R. Loison [1] – A. Audebert [2] – P. Debaeke [3] – E. Gérardeaux [1]

[1] CIRAD, UR AÏDA, Av. Agropolis, 34398 Montpellier, France, romain.loison@cirad.fr
[2] CIRAD, UMR AGAP, Av. Agropolis, 34398 Montpellier, France
[3] INRA, UMR AGIR, CS 52627, 31326 Castanet-Tolosan, France

Introduction

Crop simulation models (CSM) have been successfully used to study the impacts of increasing climate variability and climate change, and assess adapted cultivars (He et al., 2015; Rötter et al., 2013; Xiao and Tao, 2014). The CSM DSSAT CROPGRO-Cotton was proved effective in predicting cotton yield in African rainfed conditions (Gerardeaux et al., 2013). In Northern Cameroon, cotton (*Gossypium hirsutum L.*) is the main cash crop grown exclusively in rainfed conditions (Sultan et al., 2010). Despite breeding efforts, seed cotton yield has been decreasing steadily since the 80s in Northern Cameroon (Naudin et al., 2010). In order to support breeders in their quest for new cultivars in an uncertain future, optimizing CSM genetic parameters for yield simulation under changing or current climate was reviewed to be efficient in the design of best yielding ideotypes (Rötter et al., 2015). To our knowledge, the use and evaluation of CSM for rainfed cotton ideotype design has never been attempted. In this study, model-based ideotyping will be applied to the conditions of low fertility soils of Far North Cameroon.

Materials and Methods

Crop phenology, morphology, leaf area index (LAI), aerial biomass, yield components and seed cotton yield were measured in 2012 and 2013 in 3 locations of N. Cameroon. In each plot, soil was sampled at planting for water and nutrients contents. Precipitation was measured daily on the fields. Temperature, solar radiation, dew point temperature, and wind speed were recorded daily with synoptic stations located within 10 km from the field. Then, calibration and validation of the CSM were done according to Gérardeaux et al., (2013). A simulated climatic series was generated from NASA dataset with WGEN (Richardson, 1985). As candidate ideotypes for the area, 42 virtual cultivars (VC) were designed by modifying within existing ranges the CSM genetic parameters which govern the main plant functions: (i) phenology: phasic duration before and after anthesis, (ii) photosynthesis: maximum assimilation rate and specific leaf area, and (iii) light interception: maximum size of a fully expanded leaf. The VC showing higher average seed cotton yield over the climatic series and for the worst climatic years (environmental indexes ≤1), and smaller standard deviation of the mean compared to the reference cultivar are possible ideotypes.

Results and Discussion

DSSAT CROPGRO-Cotton was successfully calibrated and validated in field conditions of N.Cameroon. Indeed, the RRMSE of anthesis date, boll opening date, LAI maximum, and seed cotton yield of calibration dataset were 5.3%, 4.3%, 28%, and 25.7%, respectively. For the worst climatic years (*Figure 1*, environmental indexes below 1), we found that the rejected VC always showed lower seed cotton yields whereas the VC selected as possible ideotypes showed almost always higher seed cotton yields compared to the reference cultivar L484. This ideotype has earlier anthesis date, longer reproductive duration, thicker leaves with higher potential assimilation rate, and smaller leaves as compared to cv. L484. This ideotype seems achievable since leaf thickness, potential assimilation rate and leaf area are positively correlated while no clear correlation exists between vegetative and reproductive durations.

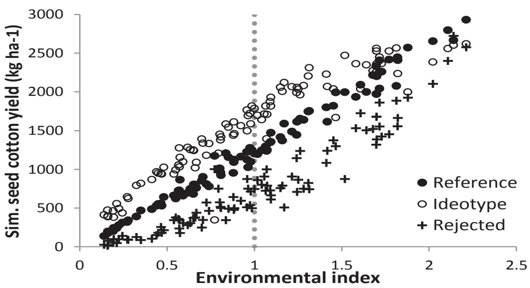

Figure 1. Simulated seed cotton yield over an environmental index (EI) for the reference cultivar L484 (●), the worst VC rejected (+) and the best VC possible ideotype (○). Average seed cotton yield of reference: 1253 kg ha^{-1}, ideotype: 1575 kg ha^{-1}, rejected: 775 kg ha^{-1}. Average seed cotton yield for EI≤1 of reference: 722 kg ha^{-1}, ideotype: 1085 kg ha^{-1}, rejected: 345 kg ha^{-1}. Standard deviation of the mean of reference: 702 kg ha^{-1}, ideotype: 644 kg ha^{-1}, and rejected: 616 kg ha^{-1}.

Conclusions

We concluded that morpho-physiological traits could be imported into breeding programs in F5 generation where high genetic diversity still exists and plant material starts to be considered as a line rather than a single plant. Consequently, we invite breeders to target cultivars with shorter "emergence to anthesis" duration and longer reproductive duration, thicker and smaller leaves and high chlorophyll content under the lowest available water conditions.

Acknowledgements

This study was funded by the agreement between Sodecoton (Société de développement du coton camerounais), IRAD (Institut de Recherche Agricole pour le Développement) and CIRAD (Centre de coopération Internationale en Recherche Agronomique pour le Développement).

References

Gérardeaux, E., Sultan, B., Palai, O., et al., (2013). Agron. Sustain. Dev. 33, 485–495.
He, L., Asseng, S., Zhao, G., et al., (2015). Agric. For. Meteorol. 200, 135–143.
Naudin, K., Goze, E., Balarabe, O. et al., (2010). Soil Tillage Res. 108, 68–76.
Richardson, C.W. (1985). Trans. ASAE 28, 1602–1606.
Rötter, R.P., Hohn, J., Trnka, M., et al., (2013). Ecol. Evol. 3, 4197–4214.
Rötter, R.P., Tao, F., Höhn, J.G. et al., T. (2015). J. Exp. Bot. erv098.
Sultan, B., Bella-Medjo, M., Berg, A., et al., (2010). Int. J. Climatol. 30, 58–71.
Xiao, D., Tao, F. (2014). Eur. J. Agron. 52, 112–122.