INTERNATIONAL CONSORTIUM FOR SUGARCANE MODELLING

RESEARCH PROJECT ON
"MODELLING WORLD-WIDE GXE INTERACTION"

REPORT ON EXPERIMENTAL DATA ANALYSIS AND PRELIMINARY MODEL ASSESSMENT

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EXECUTIVE SUMMARY

The goal of this project is to gain a better understanding of the physiological mechanisms underlying the genetic (G) variation in crop response to environmental (E) factors by monitoring and modelling key plant processes contributing to cane and sucrose yield in a common set of diverse cultivars grown in diverse environments from around the world.

Eight experiments were conducted between 2014 and 2017, consisting of plant and ratoon crops at four sites: Pongola, South Africa; La Mare, Reunion Island; Belle Glade, Florida USA; and Chiredzi, Zimbabwe. Three cultivars (N41, R570 and CP88-1762) were common to all sites, while HoCP96-540, Q183, ZN7 and NCo376 were grown at some of the sites. The eight experiments cover a range of temperature (4000-5500 °Cd), radiation (6000-8500 MJ/m^2) and water availability (minimal to significant water stress) environments.

Experimental observations have been processed and analysed, and used to derive key model parameters. A preliminary evaluation of two sugarcane models have been conducted as well.

Genotypic differences in crop growth and development within experiments were typically subtle and not always statistically significant. Statistically-significant GxE interactions were however present in final aerial dry mass and stalk dry mass, warranting further exploration. Aerial dry mass at final harvest ranged between 29 t/ha (R570 at Belle Glade, ratoon crop) and 75 t/ha (R570, plant crop at La Mare). Final SDM yield ranged from 21 t/ha (R570 ratoon crop at Belle Glade and HoCP96-540 ratoon crop at Pongola) to 52 t/ha for the CP88-1762 plant crop at Belle Glade.

Main findings to date include:

- Determining the actual time of primary shoot emergence accurately was very challenging and yet also very important, as many crop phenology parameters are defined with this event as a reference.
- The start of stalk growth is a key parameter for determining yield, and is better predicted using a thermal time than an aerial biomass threshold. Although no

genotype differences were detected, there was a strong negative correlation between average solar radiation intensity and the thermal time requirement.
- It was not always possible to reliably estimate interception of radiation by the canopy due to sparse observations. This hampered the calculation of maximum radiation use efficiency, a key parameter defined as dry biomass produced per unit of intercepted radiation under ideal conditions. Nevertheless results suggest that this parameter represents a key genotype specific trait.
- The data analysis and model parameter derivation has revealed gaps in our understanding of certain processes previously understood to be driven primarily by thermal time accumulation under fully-irrigated and well-fertilised conditions. These include tillering / canopy development, and the timing of the start of stalk growth. Discrepancies in thermal time-related parameters were at least partly explained by solar radiation differences between experiments.
- The simulation of the experiments for a single cultivar produced reasonably accurate results for DSSAT-Canegro for plant and ratoon crops, and for Mosicas with ratoon crops only. The default parameter values for plant crops in Mosicas appear problematic. Calibration of the models is necessary to demonstrate their full potential. Additionally, the models ought to be assessed at a process level, for example by forcing state variable values from observations and then assessing the accuracy of 'downstream' process output variables.

Modelling work is set to continue. APSIM-Sugar will also be evaluated and model parameters for all three models for the different cultivars will be estimated from the experimental data. This will guide further model development to improve capabilities for simulating genetic control of sugarcane crop response to environmental factors.