VALIDATION OF CANEGRO-DSSAT V3.5 FOR CONTRASTING SUGARCANE VARIETIES IN MAURITIUS

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Abstract

The Canegro module available in the DSSAT V3.5 suite of models has been developed with genetic coefficients of varieties NCo376 and N12. Since the morphology and phenology of varieties grown in Mauritius are different, the use of coefficients available in the original version of the model for variety R 570 resulted in gross overestimation of the leaf area indices (LAI), aboveground biomass, and stalk and sucrose yields. The coefficients were therefore amended to suit variety R 570 and two other contrasting varieties, namely, M 13/56 (an efficient sucrose partitioning but low yielding variety) and M 555/60 (a drought resistant, medium yielding variety). Coefficients were computed from available growth analysis data. Regression of simulated versus observed stalk dry mass of variety R 570 under different water regimes (rainfed to fully irrigated) gave R^2 and RMSE of 0.613 and 6.25 t/ha respectively, for dry mass yields ranging from 0 to 55 t/ha. For the same parameter, the R^2 and RMSE were 0.589 and 7.34 t/ha respectively, for variety M 13/56, and 0.618 and 7.84 t/ha respectively for variety M 555/60. These values are comparable with those published in recent literature, confirming that model performance is satisfactory.

Keywords: sugarcane, modelling, variety coefficient, Canegro

Introduction

Model development is an expensive venture and the adoption of models developed elsewhere offers a cost effective alternative, since extrapolation to other conditions is feasible where crop responses to management, soil properties and weather parameters are constant. However, crop varieties are specific to local industries and it is important that these are adequately represented for sensible simulation outputs and reliable applications.

Of the range of sugarcane varieties that are commercially adopted in the Mauritian context, coefficients for variety R 570 only were available in the Canegro-DSSAT V3.5 model. Preliminary testing of the model for this variety resulted in gross overestimation of the leaf area indices (LAI), the above-ground biomass, and stalk and sucrose yields (Cheeroo-Nayamuth and Nayamuth, 2000). Since yield estimation by the model is heavily dependent on LAI estimation, coefficients and equations describing the contributing characters of leaf emergence, leaf size, green leaves per stalk and stalk population, were amended for variety R 570 and derived for M 13/56 (an efficient sucrose partitioning but low yielding variety) and M 555/60 (a drought resistant, medium yielding variety).

Materials and Methods

The canopy coefficients were computed from growth analysis data pertaining to the first ratoon crop grown under fully irrigated conditions at Belle Vue. Leaf emergence was specified in thermal time using a base temperature of 10°C (phyllochron intervals, PI1 and PI2). The maximum number of green leaves per stalk was set to 10. Leaf length and leaf width were given as a function of leaf rank. The evolution of stalk population was described as a polynomial function of thermal time using a base temperature of 16°C. After calibration, the Canegro-DSSAT model was validated with additional datasets collected at Belle Vue (20°05'S 57°35'E) and Mon Desert Alma (20°13'S 57°31'E). Model validation for variety R 570 was also done under water regimes ranging from rainfed to fully irrigated conditions at Tamarin (20°19'S 57°23'E). The simulation runs for model calibration and validation were made with on-site weather data, recorded agronomic practices and Penman-Monteith evapotranspiration estimates.

Results and Discussion

Canopy coefficients computed from the available data (Table 1) showed clearly that varieties were contrasting in terms of leaf emergence, leaf sizes and tillering patterns. Thus, the rate of leaf emergence in variety M 13/56 remained constant at 130°d/leaf throughout the crop cycle, while for varieties M 555/60 and R 570 leaf emergence rate was reduced to 169°d/leaf after the fourteenth leaf. The leaf areas of M 13/56 were lowest (maximum area of 484 cm^2) while those of R 570 were highest (maximum area of 714 cm^2) and those of M 555/60 were intermediate (maximum area of 600 cm^2).

Table 1. Canopy coefficients of sugarcane varieties M 13/56, M 555/60 and R 570 derived from a ratoon crop grown under fully irrigated conditions.

	M 13/56	M 555/60	R 570
Leaf emergence			
PI 1 (°d) PI 2 (°d)	130 130	130 169	130 169
Maximum number of green leaves per stalk			
LFMAX	10	10	10
Maximum leaf size*[1] - up to leaf 20			
Length (cm)	$-0.468*L^2 + 16.429*L$	$˜0.4152*L^2 + 17.458*L$	$˜5.5939 + 0.016234*L^3$ $1.05808*L^2 + 22.5584*L$
Width (cm)	$-0.0117*L^2 + 0.4262*L$	$˜0.0157*L^2 + 0.5861*L$	(14.7 + 2.418*L) / 10
Area (cm^2)	24.373L	41.21L	35.7L˜11.0
Maximum leaf size*[1] - leaf 21 and above			
Length (cm) Width (cm) Area (cm^2)	150 4.3 484	151 5.3 600	153 6.3 714
Stalk population (polynomial equation)			
Coefficient 1 Coefficient 2 Coefficient 3 Coefficient 4 Coefficient 5	0.25 ˜0.0001 970 ˜0.95 0.00032	0.59 ˜0.0005 918 ˜0.92 0.0003	1.85 ˜0.00201 700 ˜0.8 0.000278

*[1]L = leaf rank

Calibration of the model for the plant and first ratoon crops at Belle Vue showed that the use of computed coefficients gave a good estimation of the LAI and aerial biomass in the first ratoon crop of all three varieties (Figure 1). Overestimation of these characters in simulations of the plant cane crop was attributed to the inability of the model to simulate emergence and establishment of plant cane crops. Simulation of this process is faster than observation. Simulated stalk and sucrose dry mass were close to the observed data in the first ratoon crop of varieties M 555/60 and R 570, but were slightly underestimated in variety M 13/56. The latter underestimation was attributed to the fact that M 13/56 partitions a higher fraction of the biomass into cane and sucrose. Earlier studies showed that the fraction of biomass partitioned into cane is 0.79 for M 13/56 compared with 0.74 for M 555/60 and 0.70 for R 570 (Cheeroo-Nayamuth *et al*., 2000). However, in the simulations the partitioning factors were kept constant for all three varieties.

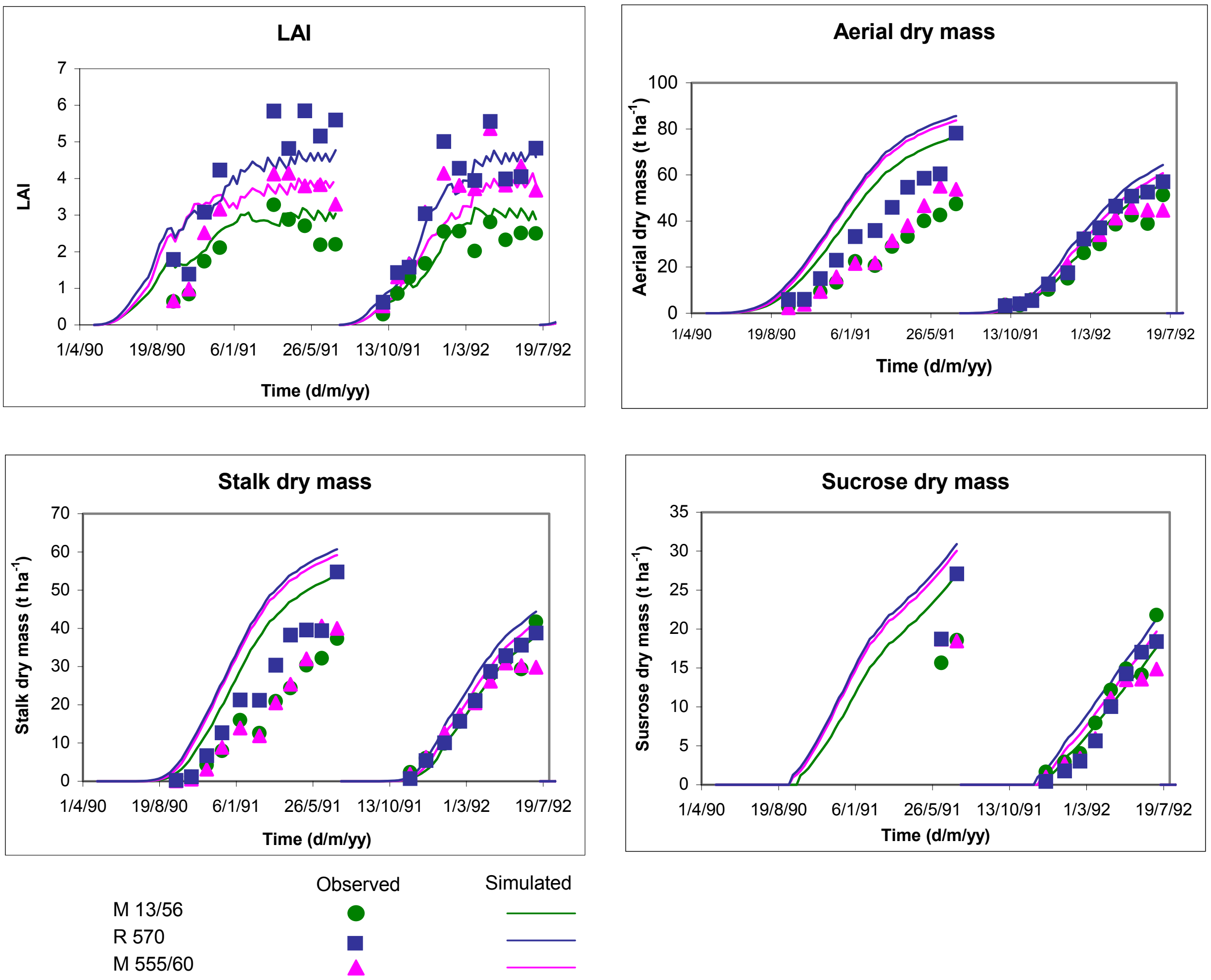

Figure 1. Trend fit of observed and simulated data for the plant and first ratoon crops of sugarcane harvested in July at Belle Vue estate in Mauritius.

In the validation step using ratoon crops from additional datasets, the regression of simulated on observed dry cane yield gave R^2 values of 0.589 for variety M 13/56, 0.618 for variety M 555/60 and 0.613 for variety R 570. Root mean square error (RMSE) was 7.34 t/ha for variety M 13/56, 7.84 t/ha for variety M 555/60 and 6.25 t/ha for variety R 570, over a dry cane yield range of 0 to 55 t/ha. These validation parameters were slightly lower than those published in recent literature.

For the same parameter in variety NCo376, Kiker *et al.* (2000) reported an R^2 value of 0.733 with an earlier version of the Canegro-DSSAT model, and Singels and Bezuidenhout (2000) reported an R^2 value of 0.74 with the Canegro-SASEX model. With the APSIM-Sugarcane model, Cheeroo-Nayamuth *et al*. (2000) reported an R^2 value of 0.73 for cane on a dry weight basis, while Keating *et al*. (1999) reported an R^2 value of 0.72 on a fresh weight basis for a range of varieties and management conditions in the Australian, South African and Mauritian sugar industries.

Conclusions

This preliminary attempt at amending the code to include contrasting varieties showed that correct specification of canopy coefficients, namely leaf size, leaf emergence rate and tillering pattern, improved the LAI and biomass simulations. Even if application studies can be envisaged in the near future, the fact that validation parameters were slightly lower than those published in recent literature indicated that further modifications would be needed to improve model performance. Aspects that are expected to have a positive impact include the possibility of modifying varietal coefficients outside the source code, the ability to model germination and crop establishment in plant cane crops, the carry-over of soil conditions from one crop season to the next and the possibility of specifying the dry matter partitioning pattern to suit varieties with different behaviour patterns.

REFERENCES

Cheeroo-Nayamuth BF and Nayamuth ARH (2000). Preliminary testing of the Canegro-DSSAT V3.5 model in Mauritius. Proceedings of the First International Workshop on the Canegro Sugarcane Model. South African Sugar Association Experiment Station, Mount Edgecombe, South Africa. pp 17-19.

Cheeroo-Nayamuth BF, Robertson MJ, Wegener MK and Nayamuth ARH (2000). Using a simulation model to assess potential and attainable sugar cane yield in Mauritius. *Field Crops Res* 66: 225-243.

Keating BA, Robertson MJ, Muchow RC and Huth NI (1999). Modelling sugarcane production systems. I: Description and validation of the APSIM sugarcane module. *Field Crops Res* 61: 253-271.

Kiker GA, Inman-Bamber NG, Hoogenboom G and McGlinchey MG (2000). Further progress in the validation of the Canegro-DSSAT model. Proceedings of the First International Workshop on the Canegro Sugarcane Model. South African Sugar Association Experiment Station, Mount Edgecombe, South Africa. pp 13-14.

Singels A and Bezuidenhout CN (2000). Testing the simulation of dry matter partitioning of the Canegro model. Proceedings of the First International Workshop on the Canegro Sugarcane Model. South African Sugar Association Experiment Station, Mount Edgecombe, South Africa. pp 20-21.