EVALUATION OF MOSICAS SUGARCANE GROWTH MODEL IN BRAZIL

By

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KEYWORDS: Sugarcane, Simulation Model, Growth, Yield, Irrigation.

Abstract

SUGARCANE computer growth simulation models developed in Brazil were rarely used and their programming became outdated. MOSICAS is a simulation model developed by Centre de Coopération Internationale en Recherche Agronomique pour le Dévelopment (CIRAD) with successful application by sugarcane farmers and their associated mills and available for research cooperation. The model consists of a carbon balance, with partitioning to roots, leaves and stalk (fibre and sucrose) according to the interception of solar radiation by a given leaf area. This is linked to the water balance by the canopy transpiration. A field trial to test this model was conduced at Piracicaba, one of the main regions for sugarcane growing in Brazil. The model was tested for two local varieties, RB72454 and SP83-2847, in reference to R570 and to NCo376. The simulations for total above ground biomass, millable stalk dry matter, yield, leaf area index, plant height, root density, maximum root depth and soil water balance presented a significant correlation with observed data. These results are promising and MOSICAS has potential for use in research for understanding sugarcane growth and yield under Brazilian conditions.

Introduction

There are sugarcane growth simulation models developed in Brazil (Delgado-Rojas and Barbieri, 1999; Pereira and Machado, 1986), but their application was not usual in research, plantations and industry. As a consequence, their computer code did not follow the software evolution and became outdated.

Countries like South Africa and Australia developed models with successful application in research and by sugarcane farmers and their associated mills (Bezuidenhout *et al*., 2003; Keating, *et al*., 1999). The aim of this study was to evaluate MOSICAS. The MOSICAS model is a new model developed by Centre de Coopération Internationale en Recherche Agronomique pour le Dévelopment (CIRAD).

The results, comparing simulation and observed data, in different climates in Reunion Island were very good (Martiné, 2003). The model consists of a carbon balance, with partitioning to roots, leaves and stalk (fibre and sucrose) according to the interception of solar radiation by a given leaf area. This is linked to the water balance, similar to the CERES model (Jones *et al*., 2003), by the canopy transpiration. The calculations are done in a daily time step, with the simulation platform SIMULEX (Martiné, 2003).

Material and methods

A sugarcane field planted on October 29th, 2004 with 15 buds per metre and inter-row spacing of 1.4 m at Sugarcane Technology Center (CTC) in Piracicaba, Brazil (22°42' S, 47°33' W, altitude 566 m) under Cwa climate in transition to Cfa using Köppen system, i.e., decreasing the winter drought,was studied under sprinkler irrigation and rainfed conditions. During the experimental period, daily weather data were collected, using an automatic meteorological station. The soil is a Typic Hapludox (Anon, 1999) of low natural fertility, well drained, loamy to very loamy. The weekly water application was calculated to replenish the soil to its field capacity and compared to readings of soil tensiometers.

Previous and independent field data were collected to calibrate the leaf emission rate of the varieties in the model. The above-ground biomass, divided in millable stalks, dry and green leaves and tops, were collected from eight tillers from different stools in the plot every sampling date. Non-destructive leaf area index measurements were done on eight tillers with a LI300A device (Licor®). Harvest was on September 26th. Plant height was measured from soil level to the insertion of +1 leaf. Alive root dry matter, their maximum depth, density in the soil (mg/cm^3) and the root growth velocity in the soil (g/m^2) were studied in four layers and at three distances from the planting row.

At least 0.06% of the total area and 0.63 m^3 of soil per hectare were collected, which is representative to characterise total root biomass and maximum root depth, according to the evaluation of Chopart and Marion (1994). Sampling occurred at 34, 49, 125, 179 and 241 days after planting, in three replicates. The model was tested for two local varieties, RB72454 and SP83-2847, in reference to R570, the variety originally used to parameterise and calibrate MOSICAS in La Reunion, , and to NCo376, the variety widely modelled by DSSAT (Jones *et al*., 2003). Measured and simulated data were compared by correlation and regression.

Results and discussion

The coefficient of determination (r^2) of the linear regression between measured and simulated total above ground biomass, millable stalk dry matter, yield, leaf area index and plant height were all higher than 0.95. The coefficient of the linear regression was higher between data from the irrigated plots then from the rainfed plots for plant height and, for other parameters, the r^2 was about 0.9. The yields of RB72454 were 145 t/ha and 154 t/ha, in the irrigated and rainfed plots, and NCo376 yielded 138 t/ha and 158 t/ha..The R570 and SP83-2847 had similar yields in the irrigated and rainfed plots, of 110 t/ha and 140 t/ha, respectively. The root growth velocity in the soil was 0.72 cm/day in the irrigated and 0.80 cm/day in the rainfed plots, similar to the findings of Chopart and Marion (1994) and matching those simulated by the model. Smith *et al*. (2005) mentioned higher root velocity in rainfed compared to irrigated fields.

Also, root density and its maximum depth were often larger in the rainfed plots. Simulated data had a significant correlation with observed data. Good agreements between measured and simulated results are probably due to the universal and well-studied eco-physiological assumptions of the MOSICAS mathematical equations. However, further studies are needed to measure the underlining physiological processes responsible for the growth and yield of sugarcane, including stressful environmental conditions. Nevertheless, these results are promising, considering the stage of the model testing.

Conclusion

MOSICAS has a good potential in research for understanding sugarcane growth and yield under Brazilian conditions.

The simulations for total above ground biomass, millable stalk dry matter, yield, leaf area index, plant height, root density, maximum root depth and soil water balance presented a significant correlation with observed data.

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EVALUATION DU MODELE DE CROISSANCE MOSICAS AU BRESIL

Par

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MOTS-CLES: Canne à Sucre, Modèle de Simulation, Croissance, Rendement, Irrigation.

Résumé

LES MODÈLES de simulation de croissance le la canne à sucre développés au Brésil ont été rarement employés et leur programmation est devenue périmée. MOSICAS est un modèle de simulation développé par le Centre International de Recherche Agronomique pour le Développement (CIRAD), disponible pour des coopérations en recherche, et dont les applications réalisées au niveau des planteurs et des industriels ont été fructueuses. Le modèle comprend un bilan carboné, avec une partition vers les racines, les feuilles et la tige (fibre et sacharose), réalisée par l'interception du rayonnement solaire au niveau des surfaces foliaires. Ce bilan carboné est lié à la transpiration foliaire incluse dans un bilan hydrique. Pour tester ce modèle, un essai a été conduit à Piracicaba, une des régions principales de culture de la canne à sucre au Brésil. Le modèle a ainsi été évalué pour deux variétés locales, RB72454 et SP83-2847, et deux variétés de référence, R570 et NCo376. Les simulations de la biomasse aérienne, de la matière sèche de tige usinable, du rendement, de l'indice foliaire, de la hauteur de la plante, de la densité de racine, de la profondeur

maximum de racine et du bilan hydrique du sol montrent une corrélation significative avec les données observées. Ces résultats sont prometteurs et MOSICAS présente un potentiel d'utilisation intéressant pour la connaissance de la croissance et de l'élaboration du rendement de la canne à sucre dans les conditions brésiliennes.

EVALUACIÓN DEL MODELO DE CRECIMIENTO DE CAÑA DE AZÚCAR *MOSICAS* EN BRASIL

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PALABRAS CLAVES: Caña de Azúcar, Modelo de Simulación, Crecimiento, Producción y Riego.

Resumen

LOS MODELOS de simulación de crecimiento computerizados de caña de azúcar desarrollados en Brasil, no han sido utilizados frecuentemente y por lo tanto, la programación no estaba debidamente actualizada. *MOSICAS* representa un modelo de simulación desarrollado por el Centro de Cooperación Internacional en Investigación Agronómica para el Desarrollo (CIRAD), habiendo tenido ya una aplicación exitosa por parte de los granjeros cañeros y sus respectivos ingenios. Se encuentra disponible para la cooperación investigadora. El modelo consiste en una mezcla de carbón, con partes de raíces, hojas y perforadores (fibra y caña) de acuerdo con la intercepción de radiación solar de una área de hojas. Esto está vinculado al equilibrio de agua por la transpiración de canopia. Se llevó a cabo un ensayo de suelo para comprobar este modelo en *Piracicaba;* una de las mayores regiones para la plantación de caña de azúcar de Brasil. El modelo fue utilizado en dos variedades locales diferentes; RB72454 y SP83-2847, en referencia a R570 y a NCo376. Las simulaciones del total de biomasa de suelo – materia seca de perforador cosechable, producción, índice del área de hoja, altura de la planta, densidad de la raíz, profundidad de raíz máxima y equilibrio de agua de suelo – presentaron una correlación significante con los datos observados. Los resultados fueron prometedores y MOSICAS posee ahora el potencial de ser utilizado para la investigación a propósito del entendimiento de crecimiento y producción de caña de azúcar en condiciones brasileñas.