Resilient Food Systems for a Changing World:

Proceedings of the

5th World Congress of Conservation Agriculture

INCORPORATING

3rd Farming Systems Design Conference

Brisbane Convention & Exhibition Centre

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Co-location of the 5th World Congress on Conservation Agriculture (WCCA) and the 3rd Farming Systems Design (FSD) Conference, with substantial input from Landcare, provides a great opportunity to explore the application of conservation agriculture practices and principles in a broad systems context.

Our common objective is the design of more productive, economic, and sustainable farming systems to meet the challenges of expanding population, global change, and environmental degradation.

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5th World Congress on Conservation Agriculture

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3rd Farming Systems Design Conference

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Using agro-climatic models to estimate the Guineagrass potential production in Brazilian tropical Savanna

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Introduction

Currently, Brazil has the world's largest commercial herd of cattle, much of which is raised in extensive grazing farms. The area occupied by pastures in Brazil is approximately 172 million hectares, i.e. 69% of the total area dedicated to agricultural production. *Panicum maximum* grasses are particularly important in intensive production systems, i.e. irrigated and fertilized, because of their high annual productivity in Brazil's tropical climate. Managing these intensive systems will require designing robust farming systems and better allocations of limited and increasingly more expensive inputs, in highly variable climates and markets. The development of simulation models that consider the influence of the climate on forage production can facilitate the planning and administration of forage production on the farm. Moreover, simulation models are commonly used to estimate expected changes in climate on the productivity of agricultural systems. Agro-climatic models are, in general, simple to use, require wide available inputs, and can be useful tools for these purposes. When applied in such a specific environment, they can often give more accurate simulations than more complicated and data intensive mechanistic models. In addition, agro-climatic models are often much easier to develop and calibrate than mechanistic models (Teh, 2006). In this paper we parameterized and tested three alternative agro-climatic models, (i) a degree-day model (*DDi*), (ii) a photo-thermal-units model (*PUi*), and (iii) a growth climate index model (*GCI*), to estimate the dry matter production of *Panicum maximum* cv. Mombaça in São Paulo State, Brazil.

Materials and Methods

Experimental results from a *Panicum maximum* cv. Mombaça (Guineagrass) experiment run at Embrapa Southeast Cattle (São Carlos, Brazil, lat 21° 57' 42" S, long 47° 50' 28" W and altitude 860 m) were used to develop the required data sets for model calibration and validation. Guineagrass pastures were sown in 18/11/2009, fertilized and irrigated in order to develop data sets under potential production conditions. The plots, 36 m^2, were arranged in completely randomized blocks with four repetitions. Samples were taken above 0.3 m at time intervals determined by cumulative thermal times during each growth cycles (i.e. 250, 500, 750 and 1000 °C, base temperature = 0°C). After the last sampling time (1000° C), all the plots were uniformly cut 0.3 m above the soil to begin a new cycle of regrowth and sampling. There were 8 growth cycles over a period of 13 months (2010-2011). At each sampling we recorded total above ground biomass, i.e. green leaves + stems. A weather station recorded daily air temperature (maximum, minimum and average), rain, and incoming solar radiation. Non-linear and linear regressions were used to estimate the model parameters using SAS.

Model development:
The DDi was developed using equation 1:

$$DDi = \sum\left[(\max t_i + \min t_i)/2\right] - bt \quad \text{when} \quad mint_i > bt \qquad \text{(eq. 1.1)},$$

$$DDi = \sum(\max t_i - bt)^2 / 2.(\max t_i - \min t_i) \quad \text{when} \quad bt > mint_i \qquad \text{(eq. 1.2)}$$

Where, $maxt_i$, $mint_i$ and bt are, the daily minimum and maximum air temperature and the minimum base temperature (bt=15.7ºC), respectively. The *PUi* model was calculated as in Villa Nova et al., (1983) (eq. 2):

$$PUi = \sum \frac{\left[\left(\frac{n}{2}\cdot DD\right)^{Ne/Ns+1}\right]}{Ne/Ns+1} \qquad \text{(eq. 2)}$$

where n = days number of growth period, DD = total of degree-days of the period (as in eq. 1), Ne and Ns = length photoperiod at the end and at the start of the period. We used the *GCI* by Fitzpatrick and Nix (1973) where the growth rate is calculated based on the mean temperature, solar radiation and water availability (eq. 3):

$$GCI = LI \cdot TI \cdot MI \qquad \text{(eq. 3)}$$

where, LI = light index; TI = thermal index, and MI = moisture stress index (equal to 1.0 because the pasture was irrigated). The LI value is calculated from the incident solar radiation (IL = 1.0-exp[-3.5(Rs*23.92)/750)], where Rs is the daily total solar radiation (MJ m^{-2}); and the TI value is calculated from average daily air temperature values. The model was validated with an independent dataset from 15 growth cycles of the same species recorded between 2005 and 2006 in São Carlos, SP Brazil, (Bertolone, 2009). The pasture was used for beef cattle grazing. After grazing, the pasture was fertilized with 50 (May-October) and 100 (November-April) kg N/ha. Model performance was tested by calculating the determination coefficient (R^2) and the index "d" (Willmott et al, 1985).

Results and Discussion

Nonlinear and linear regressions were fitted to develop the relationships in eq. (1), (2) and (3) (Figure 1). The R^2 values indicate that simple relationships could be used to parameterize equations to predict the dry mass production of the Guineagrass. High correlation values, between the dry mass production and climatic parameters, were also observed by Araujo et al. (2010), working with tropical grass in Brazilian. These authors explained that the use of empirical models can be efficient to estimate the biomass production of tropical grasses under ample water and nutrients supply. During validation, the three climate models showed high accuracy. The *PUi* was the most accurate, with a slope of about 1.0 (Figure 2). This model also showed the highest precision (R^2 = 0.82) and index "d" (0.85). All models overestimated the dry mass production (Figure 2 and 3). The models' overestimation was probably caused by factors not contemplated in the models. One may have been phenology, as biomass production usually decreases during flowering. Another important point could be the pasture's age. While the experiment used to calibrate the models was in its first year of production, the experiment used to validate the models was established many years ago. We also have to consider the contrasting managements of the pastures in the calibration and validation data sets. While the experiment used to calibrate the models was carried out under mechanical cuts, the experiment used to validate the models was carried out under grazing. Probably, all these factors may have influenced the difference between the observed and estimated values by the models in this paper. The *PUi* seems to outperform the other two models. Here we conclude that simple empirical models that use air temperature and daylength to estimate potential production of Guineagrass, can offer an attractive alternative to more complicated mechanistic models.

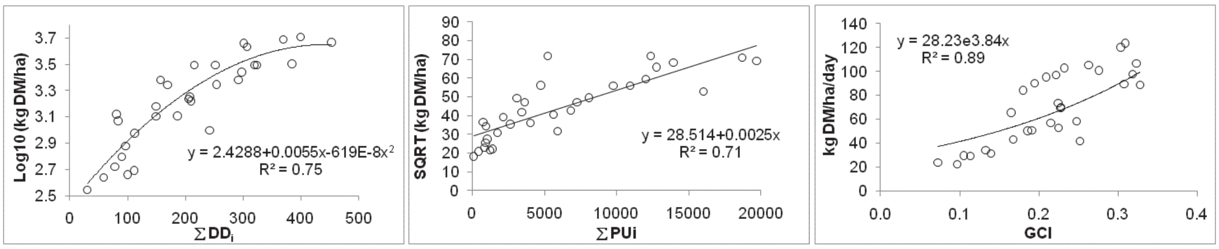

Figure 1. Calibration equations to estimate the dry mass (DM) production of the Guineagrass using a degree-day model (DDi), a photothermal-units model (PUi), and a growth climate index (GCI) model. Each point is the average of four replications**.** ($p \leq 0{,}01$).

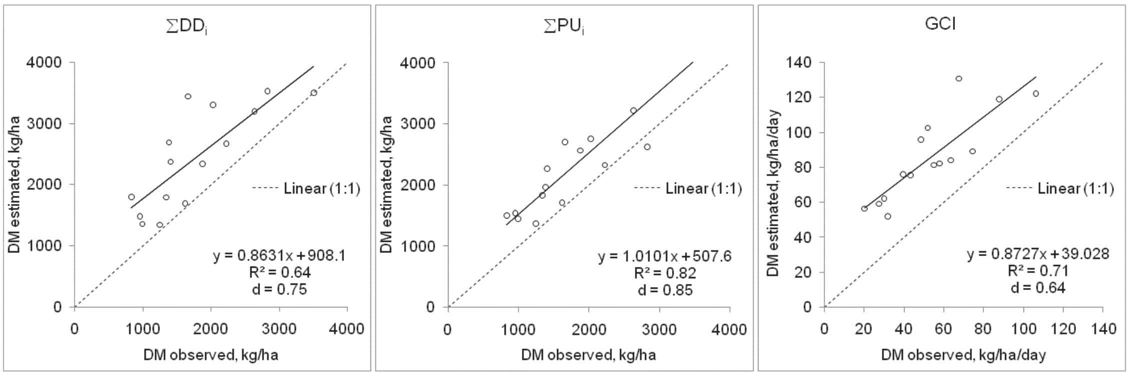

Figure 2. Observed and estimated values of the dry matter (DM) production of the Guineagrass. Degree-day model (DD_i), Photothermal-units model (PU_i) and Growth climate index (GCI). Index "d". ($p \leq 0{,}01$).

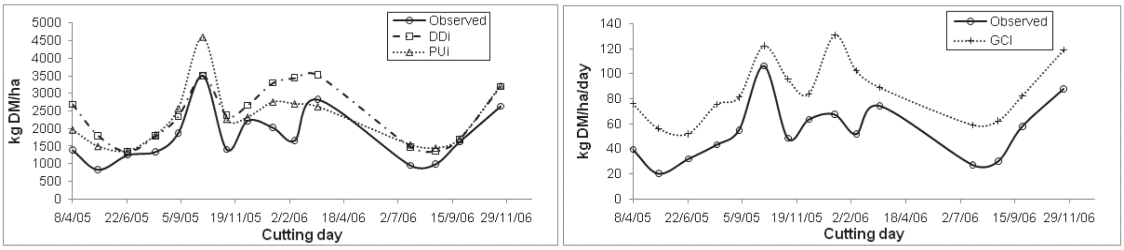

Figure 3. Time series of dry matter (DM) production of the Guineagrass simulated over two years in São Carlos, SP, Brazil. Degree-day model (DD_i), Photothermal-units model (PU_i) and Growth climate index (GCI).

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