Prediction of Herbage Accumulation of *Cynodon* Grasses by an Empirical Model Based on Temperature and Daylength

H. R. de Medeiros
Universidade de São Paulo, Brazil

Carlos G. S. Pedreira
Universidade de São Paulo, Brazil

N. A. Villa Nova
Universidade de São Paulo, Brazil

L. G. Barioni
Universidade de São Paulo, Brazil

A. C. C. Mello
Universidade de São Paulo, Brazil

ID # 06 – 07

PREDICTION OF HERBAGE ACCUMULATION OF *CYNODON* GRASSES BY AN EMPIRICAL MODEL BASED ON TEMPERATURE AND DAYLENGTH

H.R. de Medeiros[1], C.G.S. Pedreira[1], N.A. Villa Nova[2] , L.G. Barioni[1*]and A.C.C. Mello[1]

[1]Univresidadede SãoPaulo-ESALQ, Dept.ProduçãoAnimal, Piracicaba, SP, Brasil, 13418-900

[2]Universidade de SãoPaulo – ESALQ, Dept. de Ciências Exatas.

Abstract

The objective of this work was to estimate dry matter production of *Cynodon* grasses as a function of photothermal units (PU). Total PU values were calculated for the period from February 1 to April 24, 1996, from a location in southeastern Brazil. Regression analysis was run between *PU* and herbage production from a published data set on five *Cynodon* cultivars, with an r^2 of 0.9983. Differences between measured and estimated values were under 5%. Model testing using an independent data set on herbage dry matter production from grazed *Cynodon* pastures showed an overestimation, probably due to water deficit during the experimental period. In addition, grazing intensity may have been a reason for the less than optimal fit. The model was adequate in predicting the variation in production potential throughout the periods studied although modifications to include the effect of water balance, nitrogen fertilization and defoliation intensity may allow for better predictions under sub-optimal environmental conditions and varying management strategies.

Keywords: Photothermal unit, seasonality, photoperiod, forage production

Introduction

Potential pasture accumulation may be seen as a response of the forage plant to environmental factors, including climate, soil fertility and water availability, and to the defoliation imposed by animals or mechanical harvest. The main factors determining seasonality of production in tropical and temperate pastures are temperature and solar radiation (both highly correlated) and water balance (Rolim, 1980; Scott et al., 1985). The seasonal variation in pasture production makes feed planning complex, requiring, ideally, prediction of pasture production and feed budgeting (Parker, 1993). Consequently, the development of mathematical models that allow for the estimation of pasture production throughout the year as a response to climate variations will facilitate decision making in livestock production in pastoral systems.

Villa Nova et al. (1999) have established an empirical mathematical model that estimates dry matter accumulation in elephantgrass (*Pennisetum purpureum* Schum.). The model predicts pasture dry matter accumulation as a function of a variable named Photothermal Unit (*PU*), which adjusts degree-days to the variation of photoperiod calculated for the respective latitude. The PU model improves the production estimated by degree-days in spring and autumn. Production estimates by the model are accurate, however, only when there are no limitations such as soil fertility, soil moisture, diseases or pests. Villa Nova et al. (1999) suggested that further work should be carried out in order to parameterize the model for other species. This paper has the objective of parameterizing the Phototermal Unit model to estimate the dry matter production of *Cynodon spp*.

Material and Methods

The value of the photothermal unit was calculated using equation 1 as proposed by Villa Nova et al. (1983):

$$PU = \frac{\left(\frac{nDD}{2}\right)^{\left(\frac{N_f}{N_i}-1\right)}}{\left(\frac{N_f}{N_i}-1\right)}, \tag{1}$$

where n is the number of days from last grazing or harvest, DD is the average degree-days of the period, N_i and N_f are the day lengths at the beginning and end the period for which production is to be estimated, respectively. PU was calculated using base temperature of 13°C and a correction factor for maximum temperatures above 30°C. DD was calculated using equations 2, 3 and 4:

$$DD = \left(\overline{T} - T_B\right) - C \tag{2}$$

$$DD = \frac{\left(\overline{T_X} - T_B\right)^2}{2\left(\overline{T_X} - \overline{T_M}\right)} - C \tag{3}$$

where:

DD is the average degree days (°C.day)
$\overline{T_X}$ is the average daily maximum air temperature (°C)
$\overline{T_M}$ is the average daily minimum air temperature (°C)
$\overline{T}$ is the average daily mean air temperature (°C)
T_B is the base temperature of the plant for DD calculation (°C)

and

$$C = \frac{(\overline{T_X} - 30)^2}{2(\overline{T_X} - \overline{T_M})} \tag{4}$$

where C is the correction factor for maximum temperatures above 30 °C.

Herbage production data obtained by Gomide (1996), at 21° 15' 22" S, 48° 18' 58" W, for five *Cynodon* grasses (*Cynodon ssp.* cv. 'Tifton 85', *C. dactylon* cv. 'Florakirk', and *C. nlemfuensis* cultivars 'Florico', 'Florona' and 'Tifton 68') were used for model parameterization. Non-linear regression analysis of pasture accumulation (kg DM ha^{-1}) against *PU* (independent variable) was performed using the least squares method. The model was tested using an independent dataset published by Fagundes (1999), collected from Aug. 1 to Dec. 31, 1998 on 'Florakirk', 'Tifton 85' and Coastcross (*Cynodon spp*) pastures. Those pastures were grazed by sheep on a high fertility soil. *PU* was calculated from 3-week averages of maximum, minimum and mean temperature of the period (Feb. 1 to 27 April 1996), recorded at a weather station located at 22° 42' 30" S, 47° 38' 00" W.

Results and Discussion

The least squares estimate of the modified Gompertz function studied produced equation 5,

$$P = \frac{9.87}{1 + \exp\left(1.693 - 1.282.10^{-4} UF\right)} - 1.53\,, \quad (5)$$

where *P* is the quantity of pasture accumulated (kg DM ha^{-1}) in the *n*-day period and *PU* is the total of photothermal units in the same period. The equation had a good fit ($R^2 = 0{,}9983$) and differences between pairs of estimated and actual values were all below 5%.

Model testing showed a trend for overestimation of the data. Linear regression analysis with null intercept showed that the model had a bias of +25.5%, overestimating actual production (Figure 1). This overestimation should be expected as the model completely disregards water availability effects (Figure 2). In addition, production data from the grazed pastures was averaged across four treatments, where swards were maintained at 5, 10, 15 and 20 cm constant height. Because the most severe defoliation treatments showed lower pasture accumulation rates and the model also disregards grazing intensity in the prediction of pasture production, overestimation would be expected.

The model of Villa Nova et al. (1983) was adequate in predicting the variation in production potential throughout the periods studied. Modifications in the model to include the effect of water balance, nitrogen fertilization and defoliation intensity may allow for better predictions under sub-optimal environmental conditions and varying management strategies.

The model presented itself as a promising tool for planning of livestock production on pasture, enabling the construction of feed budgets in tropical conditions in places with no previous experimental or on-farm measurements. This could enable supplementation, fertilization and marketing strategies, among others.

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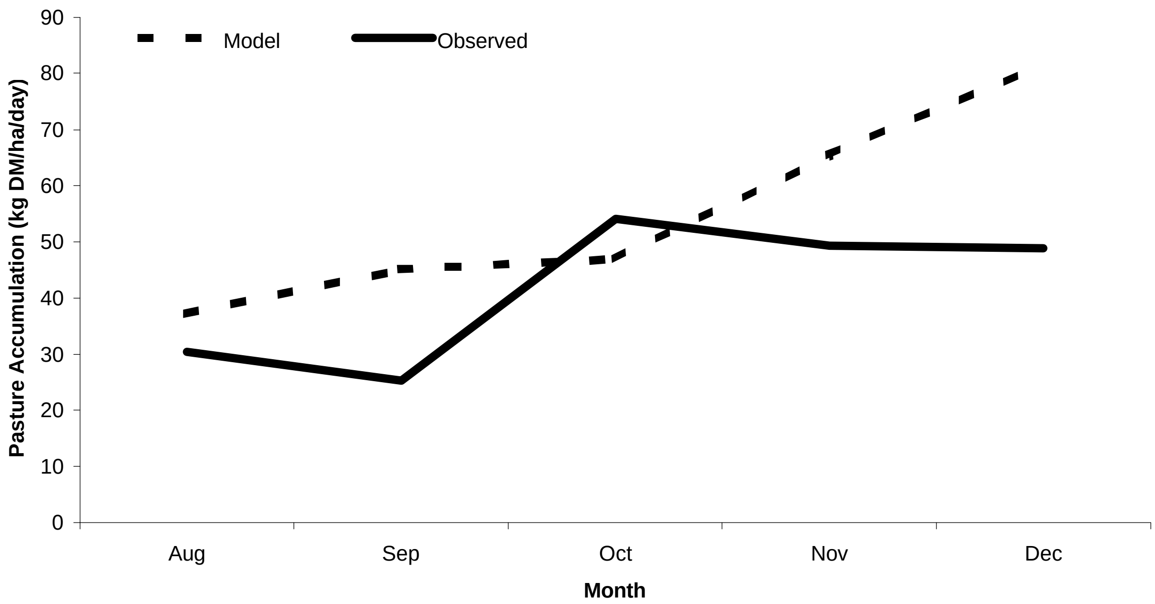

Figure 1. Herbage Accumulation (kg DM/ha/day) estimated by the Villa Nova Model and observed by Fagundes (1999)

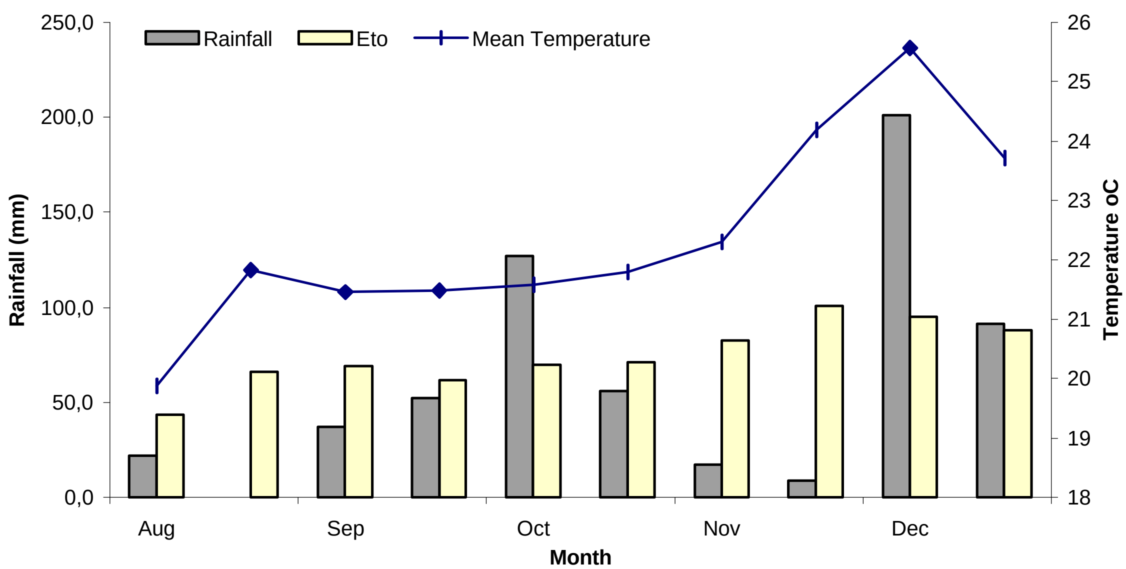

Figure 2. Rainfall, evapotranspiration, and mean temperatures reported by Fagundes (1999)