Estimation of dry matter production in *Brachiaria hybrid* cv. Cayman during the dry season

RESEARCH ARTICLE

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ABSTRACT. Introduction: In the production of forage species, it is imperative to determine the dynamics of biomass accumulation at different times of the year. Objectives: This study was aimed at modeling the dynamics of dry matter production in ***Brachiaria hybrid*** cv. Cayman grass during the dry season. **Methods:** The data correspond to total biomass obtained from an investigation of pasture management with different cutting intervals, using a completely randomized block design. Two non-linear models were used (Gompertz and logistic). **Results:** The Gompertz model showed the best fit for estimating accumulated dry matter production (kg DM ha−1) in ***Brachiaria hybrid*** cv. Cayman at different cutting intervals. Accumulated dry matter production in ***Brachiaria hybrid*** cv. Cayman remained uniform for a longer time period for a 42- to 49-day cutting interval. **Conclusions:** Application of the Gompertz model is suggested for drought conditions. The sustainability of dry matter production is determined by cutting interval, intrinsic growth rate of ***Brachiaria hybrid*** cv. Cayman, and other factors affecting the development of this species.

Keywords: cutting intervals; growth patterns; grasses

Estimación de la producción de materia seca de *Brachiaria híbrido* cv. Cayman en época de sequía

RESUMEN. Introducción: la dinámica de acumulación de biomasa en las diferentes épocas del año es de vital importancia en la producción de una especie forrajera. **Objetivos:** modelar la dinámica de producción de materia seca del pasto ***Brachiaria híbrido*** cv. Cayman en el periodo de sequía. **Metodos:** Los datos corresponden a la biomasa total obtenida de un ensayo realizado para estudiar el manejo de pastos con diferentes intervalos entre corte, bajo el esquema de un diseño de bloques completamente aleatorizados. Se consideraron dos modelos no lineales (gompertz y logístico). **Resultados:** El modelo de Gompertz mostró el mejor ajuste para estimar la producción acumulada de materia seca (Kg MS ha-1) en ***Brachiaria hybrid***o cv. Cayman a diferentes intervalos entre corte. Para un intervalo entre cortes de 42 a 49 días, la producción de materia seca acumulada de ***Brachiaria híbrido*** cv. Cayman se mantuvo de manera sostenida por un período más largo. **Conclusiones:** Se sugiere el uso del modelo de gompertz en condiciones de sequía. El intervalo entre cortes, la tasa intrínseca de crecimiento de ***Brachiaria híbrido*** cv. Cayman, así como otros factores que afectan el desarrollo de esta especie, determinan la sostenibilidad de la producción de materia seca.

Palabras clave: intervalos entre corte, modelos de crecimiento, pastos

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Introduction

Knowledge about the dynamics of biomass accumulation in forage species at different times of the year is useful for best crop planning and use to achieve highest yields and plant material of good nutritional quality (Montes ***et al.***, 2016). Several species and varieties with creeping or erect growth habits have been used for forage production, including Brachiaria brizantha. Therefore, determining its growth dynamics under different edaphoclimatic conditions is vital for establishing methods to improve its use and management. Obtaining non-linear models can be extremely helpful in explaining and predicting grass and forage behavior regarding certain factors like age, as available studies are limited to certain geographical areas (Verdecia ***et al.***, 2012). The Gompertz (Laird, 1965), Logistic (Nelder, 1961), Richards (Richards, 1959), Von Bertalanffy (Bertalanffy, 1957), and Brody (Brody, 1945) models are the most frequently used growth functions for describing the growth of plants, animals, and organisms. Considering this, knowledge and control of crop growth and development are useful parameters for researchers as their characterization enables their efficient management. It also enables designing of management programs according to the growth characteristics of each species. By applying non-linear models, this study mainly aimed at modeling dry matter production dynamics in ***Brachiaria hybrid*** cv. Cayman grass during the dry season.

Materials and Methods

The data were obtained from an assay performed for studying the management of grasses with different cutting intervals in the Palma Sola farm, located in Papelón Municipality, Palma Sola sector, between 450 570.307 West longitude 985 346.992 North Latitude, with an average annual rainfall of 1847.3 mm. The plant material used was pelleted commercial certified seed of ***Brachiaria hybrid*** cv. Cayman. The treatments comprised different grass cutting ages (21, 28, 35, 42, and 49 days), using a completely randomized block design. Total aerial biomass was the response variable considered for constructing the model. The indicator for describing this variable was kilograms of dry matter per hectare (kg DM * ha−1). The regressor variable in the t model was cutting days. Two non-linear models (Gompertz [Laird, 1965] and Logistic [Nelder, 1961]) were applied for determining the relationship between cutting interval and yield. Statistical analyses were performed using the R software package.

Logistic Model. The logistic model is shown below:

$$N(t) = \frac{A}{1 + Be^{-Kt}}$$

Where: ***B*** = any positive real number that depends on initial condition N (0)

A = value for maximum population growth

K = intrinsic growth rate

Gompertz Model. The Gompertz model is shown below:

$$N(t) = Ae^{-Be^{-Kt}}$$

Where: ***B*** = a positive real number that shifts the model to the left or right

e = irrational number (natural logarithm base)

A = value for maximum growth

t = time

k = establishes the intrinsic growth rate

This equation is known as the Gompertz equation.

Results and Discussion

Tables 1 and 2, and Figure 1 show the fitting of the two non-linear models to the accumulated dry matter data (kg DM ha−1) of ***Brachiaria hybrid*** cv. Cayman at different cutting ages during the dry season. Both models display an excellent fit to the accumulated dry matter dataset with an R2 close to 1.0 for the logistic and Gompertz models. Nevertheless, the AIC value for the Gompertz model (99.712) was lower than that for the logistic model (180.958) (Table 1). The above results suggest that the Gompertz model has the best fit for estimating accumulated dry matter production (kg DM ha−1) in ***Brachiaria hybrid*** cv. Cayman at different cutting ages during the dry season (Table 2).

These results are consistent with those reported by Rodríguez ***et al.*** (2011) who determined the growth dynamics of ***Pennisetum purpureum*** cv. Cuba CT-169. They reported that the classic growth models, Gompertz for the rainy season and logistic for the low rainfall season, were the best fit for the variables accumulation of dry matter and plant height. Furthermore, Martínez ***et al.*** (2010), Rodríguez ***et al.*** (2011), and Rodríguez ***et al.*** (2013) concluded that the Gompertz and logistic models provided the best fit for modeling accumulated dry matter yield of King Grass and its clones. These investigations considered functions that allow the estimation of biomass production as a function of time. Likewise, these results are consistent with the findings of Villegas ***et al.*** (2019) who estimated dry matter production in ***Brachiaria brizantha*** grasses at different cutting ages using nitrogen fertilization.

Table 1. Logistic model fitting for estimation of accumulated dry matter production (kg DM ha−1) in ***Brachiaria hybrid*** cv. Cayman at different cutting ages (days) during the dry season.

Cutting age (days)	Age at inflection point (*t*) (days)	Autocorrelation		Model fit		Estimated model parameters and their significance					
		dw	*P value*	R^2	*AIC*	*A*	*P value*	*B*	*P value*	*K*	*P value*
21	61	1.662	0.0002	99.30	246.72	5456	0.0000	6.449	0.0000	0.0308	0.0000
28	64	2.696	0.0008	99.49	205.14	7273	0.0000	7.696	0.0000	0.03173	0.0000
35	69	3.591	0.0088	99.78	149.83	9386	0.0000	8.699	0.0000	0.03142	0.0000
42	80	2.472	0.0007	99.88	151.05	13260	0.0000	8.446	0.0000	0.0266	0.0000
49	84	2.338	0.0006	99.84	152.05	13260	0.0000	8.446	0.0000	0.0266	0.0000
Average		2.5518	0.00222	99.658	180.958	9727	0	7.9472	0	0.02943	0

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Table 2. Gompertz model fitting for estimation of accumulated dry matter production (kg DM ha−1) in ***Brachiaria hybrid*** cv. Cayman at different cutting ages (days) during the dry season.

Cutting age (days)	Age at inflection point (*t*) (days)	Autocorrelation		Model fit		Estimated model parameters and their significance					
		dw	*P value*	R^2	*AIC*	*A*	*P value*	*B*	*P value*	*K*	*P value*
21	54	1.662	0.0002	99.45	241.83	6724	0.0000	2.411	0.0000	0.01635	0.0000
28	56	2.696	0.0008	99.61	200.89	8756	0.0000	2.641	0.0000	0.0172	0.0000
35	66	3.591	0.0088	99.78	205.56	12270	0.0000	2.810	0.0000	0.0156	0.0000
42	75	2.472	0.0007	99.88	151.06	16860	0.0000	2.772	0.0000	0.0136	0.0000
49	75	2.338	0.0006	99.84	151.06	16860	0.0000	2.772	0.0000	0.0136	0.0000
Average		65.23	2.5518	0.00222	99.712	190.08	12294	0	2.6812	0	0.01527

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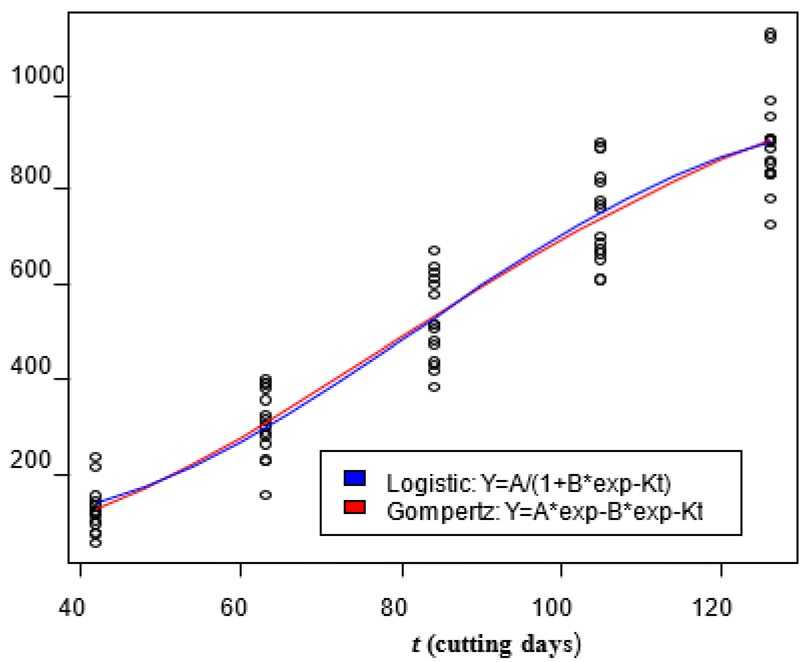

Figure 1: Fitting of the two non-linear models for estimating accumulated dry matter yield (kg DM ha−1) in ***Brachiaria hybrid*** cv. Cayman at different cutting intervals (days) during the dry season.

The highest value of ordinate t at the inflection point (75 days) was obtained for a grass cutting interval of 42 and 49 days, as shown in Table 2. This suggests that, under these experimental conditions, the accumulated dry matter production of ***Brachiaria hybrid*** cv. Cayman remains uniform for a longer time period than under the other experimental conditions analyzed in this study. Thus, determining the optimal cutting and/or harvesting times, based on the values obtained for the growth dynamics of the species in a specific place and climate, enables maximizing forage yield and obtaining greater leaf component instead of stems and dead material. Hence, forage of higher nutritional quality is obtained compared to cuts made when the forage is already dry (Castro ***et al.***, 2017).

Thus, this result suggests that the sustainability of dry matter production in ***Brachiaria hybrid*** cv. Cayman grass is determined by cutting interval, intrinsic growth rate, and other factors affecting the development of this forage species. This is consistent with the reports of Bello (2014) on a theoretical description of non-linear models, especially the Gompertz and logistic models, regarding factors affecting the X-ordinate at the inflection point. Furthermore, the growth dynamics determine the crop's phenological behavior at different times of the year, which varies depending on the environmental conditions (Montes ***et al.***, 2016). Therefore, the pasture's growth and quality can vary considerably depending on its management, with or without favorable effects, the plant species, and edaphoclimatic conditions (Del Pozo, 1998). This agrees with the findings of Cruz ***et al.*** (2017) who studied the Mulato grass exposed to different grazing frequencies and intensities, reporting that the grass accumulated more forage when harvested in 28-day periods with light grazing during the rainy season.

Conclusions

The Gompertz model had the best fit for estimating accumulated dry matter production in ***Brachiaria hybrid*** cv. Cayman at different cutting intervals during the dry season. Although both models tended to underestimate the initial dry matter production, the Gompertz model presented a higher growth speed than the logistic model. Finally, the inflection points in the logistic and Gompertz models are conditioned by intrinsic growth rate, initial dry matter production, and factors affecting grass growth.

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