Forage productivity and morphogenesis of *Mesosetum chaseae* under defoliation frequency

Produtividade de forragem e morfogênese de *Mesosetum chaseae* sob frequências de desfolhação

Productividad de forraje y morfogénesis de *Mesosetum chaseae* bajo frecuencias de defoliación

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Abstract
The effect of defoliation frequency (14, 21, 28, 35, 42, 49 and 56 days) on forage production and morphogenic and structural characteristics of *Mesosetum chaseae* (Luces) was evaluated under natural field conditions during the dry season, in the savannas of Roraima. The reduction in pasture defoliation frequency resulted in higher green dry matter (GDM) yields, number of tillers plant^{-1}, number of leaves tiller^{-1}, tiller leaf area, leaf senescence rate and average leaf size. The relationship between defoliation frequency and GDM production was quadratic, with the maximum value estimated at 53.8 days of regrowth. Absolute rates of growth and leaf appearance and expansion were inversely proportional to defoliation frequencies. The highest rate of leaf expansion was obtained at 49.7 days of regrowth. Aiming to reconcile forage productivity with the optimization of the morphogenic and structural characteristics of the grass, the most appropriate period of use of its pastures is between 42 and 49 days of regrowth.
Keywords: Leaves; Dry matter; Tiller; Senescence.

Resumo
O efeito da frequência de desfolhação (14, 21, 28, 35, 42, 49 e 56 dias) sobre a produção de forragem e características morfogênicas e estruturais de *Mesosetum chaseae* (Luces) foi avaliado em condições naturais de campo, durante o período seco, nos cerrados de Roraima. A redução na frequência de desfolhação da pastagem resultou em maiores rendimentos de matéria seca verde (MSV), número de perfilhos planta^{-1}, número de folhas perfilho^{-1}, área e taxa de senescência foliar e tamanho médio de folhas. A relação entre frequência de desfolhação e a produção de MSV foi quadrática, sendo o máximo valor estimado aos 53,8 dias de rebrota. As taxas absolutas de crescimento e de aparecimento e expansão foliar foram inversamente proporcionais às frequências de desfolhação. A maior taxa de expansão foliar foi obtida aos 49,7 dias de rebrota. Visando conciliar produtividade de forragem com a otimização das características morfogênicas e estruturais da gramínea, o período de utilização mais adequado de suas pastagens situa-se entre 42 e 49 dias de rebrota.
Palavras-chave: Folhas; Matéria seca; Perfilhamento; Senescência.

Resumen
Se evaluó el efecto de la frecuencia de defoliación (14, 21, 28, 35, 42, 49 y 56 días) sobre la producción de forraje y las características morfogénicas y estructurales de *Mesosetum chaseae* (Luces) en condiciones naturales de campo durante la época poco lluviosa, en las sabanas de Roraima. La reducción en la frecuencia de defoliación de los pastos resultó en mayores rendimientos de materia seca verde (MSV), número de macollas planta^{-1}, número de hojas macollas^{-1}, área foliar de macolla, tasa de senescencia de hojas y tamaño promedio de hoja. La relación entre la frecuencia de defoliación y la producción de MSV fue cuadrática, con el valor máximo estimado en 53,8 días de rebrote. Las tasas absolutas de crecimiento y aparición y expansión de hojas fueron inversamente proporcionales a las

frecuencias de defoliación. La mayor tasa de expansión foliar se obtuvo a los 49,7 días de rebrote. Con el objetivo de conciliar la productividad forrajera con la optimización de las características morfogénicas y estructurales de la gramínea, el período más adecuado de uso de sus pastos se encuentra entre los 42 y 49 días de rebrote.
Palabras clave: Hojas; Materia seca; Macolla; Senescencia.

1. Introduction

In the Roraima´s savannas, the native pastures represent the most economical source for feeding the herds. Forage production during the year presents seasonal fluctuations, due to climatic fluctuations, that is, abundance in the rainy season (May to September) and deficit in the dry season (October to April), which negatively affects animal productivity indices (Braga, 1998; Gianluppi et al., 2001; Costa et al., 2016). The use of appropriate management practices is one of the alternatives to reduce the effects of seasonality in forage production. The growth stage at which the plants are harvest directly affects yield, regrowth capacity and persistence. In general, less frequent grazing provides higher forage yields, however, concomitantly, there are sharp decreases in its chemical composition, increase in fiber contents, reductions in the leaf/stem ratio and, consequently, lower consumption by animals (Pereira et al., 2018; Cruz et al., 2021).

The restoration of productivity of forage grasses after defoliation results from their continuous capacity to produce new leaves and tillers, an important process for the restoration of the leaf area after cutting or grazing and which ensures its perpetuity (Townsend, 2008). The processes of leaf formation and development are fundamental for plant growth, given the importance of leaves in the photosynthesis process, the starting point for the formation of new tissues and, consequently, forage accumulation (Barbero et al., 2015; Costa et al., 2017).

During the vegetative growth stages, the morphogenesis of a grass can be explained by three physiological mechanisms: the appearance rate, the elongation rate and the longevity of the leaves, which are generally genetically determined, however they can be strongly affected by the environmental factors and pasture management practices adopted (Nabinger & Carvalho, 2009; Cruz et al., 2021). The knowledge of the morphogenetic and structural characteristics can allow the proposition of specific management practices for each forage grass (Heringer & Jacques, 2012; Costa et al., 2018) as it provides a visualization of the seasonal forage production curve and an estimate of its quality.

In this work, were evaluated the effects of defoliation frequency on the forage production and morphogenic and structural characteristics of *Mesosetum chaseae* (Luces), a native grass of the Roraima´s savannas.

2. Methodology

The research was performed under field natural conditions using the quantitative method. As there are still gaps about the effect of the potassium fertilization on the productive performance of native tropical forage pastures, the hypothetical-deductive method was chosen to be used (Pereira et al., 2018).

The experiment was carried out on a native *Mesosetum chaseae* pasture, located in Boa Vista, Roraima, which was submitted to burning in the mid-dry period (November). The experimental period was from January to March 2016, which corresponds to the dry season, with an accumulated rainfall of 48 mm. The soil in the experimental area is a Yellow Latosol, with the following chemical characteristics, at a depth of 0-20 cm: pH = 4.2; P = 1.5 mg kg^{-1}; Ca + Mg = 0.83 cmol$_c$.dm^{-3}; K = 0.012 cmol$_c$.dm^{-3} and Al = 0.65 cmol$_c$dm^{-3}. The experimental design was completely randomized with three replications, and the treatments consisted of seven defoliation frequencies (14, 21, 28, 35, 42, 49 and 56 days after pasture burning). The plots measured 2.0 x 2.0 m, with a useful area of 1.0 m^2.

The parameters evaluated were green dry matter (GDM) yield, absolute growth rate (AGR), number of tillers plant^{-1} (NTP), number of leaves tiller^{-1} (NLP), leaf appearance rate (LAR), leaf expansion rate (LER), leaf senescence rate (LSR), average leaf size (ALS) and tiller leaf area (TLA). The productivity of GDM was determined through mechanical cuts

performed at 10 cm above the ground. The AGR was obtained by dividing the GDM yield, at each defoliation frequency, by the respective regrowth period. LAR, LER and TLA were determined only in live tillers. LAR and LER were calculated by dividing the accumulated leaf length and the total number of leaves in the tiller, respectively, by the regrowth period.

To obtain an estimate of the leaf area of each tiller, samples of fully expanded green leaves were collected, seeking to obtain an area between 200 and 300 cm^2. The samples were digitized and the leaf area was estimated using an electronic optical planimeter (Li-Cor 3100C). Subsequently, the sample was taken to a greenhouse subjected to forced air at 65ºC until reaching constant weight, obtaining the leaf GDM. The specific leaf area (SLA) was estimated through the relationship between the green leaf area and its GDM (m^2/g of leaf GDM). The TLA was determined from the product of total green leaf GDM (g GDM/m^2) by SLA (m^2/g of leaf GDM). The LSR was obtained by dividing the length of the leaf that was yellowish or necrotic by age of regrowth.

The data were subject to analysis of variance and regression considering the significance level of 5% probability. In order to estimate the response of the parameters evaluated to the defoliation frequency, the choice of regression models was reason on the significance of the linear and quadratic coefficients, using the Student's "t" test at the level of 5% probability.

3. Results and Discussion

The GDM yields were significantly (P<0.05) increased with the reduction of defoliation frequency. The highest values were obtained with cuts at 56 (624 kg ha^{-1}) and 48 days (591 kg ha^{-1}), while the highest AGR were verified in the period of 14 and 21 days (Table 1). The relationship between defoliation frequencies and GDM yield was quadratic and defined by the equation $Y = 15.2143 + 21.1276 X - 0.19896 X^2$ ($R^2 = 0.91$), with the maximum estimated value at 53.8 days of regrowth. The AGR was inversely proportional to the defoliation frequencies. The relationship was linear and described by the equation: $Y = 21.4793 - 0.21393 X$ ($r^2 = 0.99$).

Table 1. Green dry matter (GDM - kg ha^{-1}) yield, absolute growth rate (AGR - kg ha^{-1} dia^{-1}), number of tiller plant (NTP), number of live leaf tiller^{-1} (NLT), average leaf size (ALS - cm), tiller leaf area (TLA - cm^2), leaf appearance rate (LAR - cm tiller^{-1} day^{-1}), leaf expansion rate (LER - cm tiller^{-1} day^{-1}) and leaf senescence rate (LSR - cm tiller^{-1} day^{-1}) of *Mesosetum chaseae*, as affected by defoliation frequency.

Defoliation Frequency (days)	GDM	AGR	NTP	NLT	ALS	TLA	LAR	LER	LSR
14	267 [e]	19.07 [a]	4.21 [e]	2.80 [d]	5.71 [b]	2.40 [e]	0.201 [a]	1.143 [a]	---
21	387 [d]	18.43 [a]	6.52 [d]	3.49 [cd]	5.43 [b]	2.85 [d]	0.167 [b]	0.905 [b]	---
28	462 [c]	16.51 [b]	7.40 [cd]	3.91 [bc]	6.15 [a]	3.61 [c]	0.139 [c]	0.857 [c]	0.070 [d]
35	525 [b]	15.00 [b]	8.33 [bc]	4.22 [b]	6.31 [a]	3.98 [c]	0.122 [d]	0.757 [d]	0.181 [a]
42	543 [ab]	12.92 [c]	8.74 [bc]	4.83 [ab]	6.50 [a]	4.68 [b]	0,.14 [de]	0.743 [d]	0.162 [b]
49	591 [a]	12.06 [cd]	9.29 [b]	5.28 [a]	6.38 [a]	5.07 [ab]	0.108 [e]	0.690 [e]	0.149 [c]
56	624 [a]	11.14 [d]	11.21 [a]	5.80 [a]	6.47 [a]	5.63 [a]	0.104 [e]	0.671 [e]	0.147 [c]

- Means followed by the same letter do not differ (P >0.05) by Tukey's test. Source: Reserch data

The values recorded in this study were lower than those reported by Mochiutti et al. (2005, 2006) and Rodrigues (1999), evaluating the forage availability of *M. chaseae*, in native pastures of the savannas of Amapá and Pantanal, which estimated, respectively, yields of 358 and 612 kg ha^{-1} of GDM for the mowed pastures and 343 and 417 kg ha^{-1} of GDM for burned annually pastures. Likewise, Cardoso et al. (2003) verified increases in the forage production of *M. chaseae*, as a function of the increase in the rest period of the pasture, recording yields of 825 and 1,234 kg of GDM ha^{-1}, respectively at 30

and 60 days of regrowth. In the Pantanal biome, Rodrigues (1999) obtained AGR of 14.1 and 22.4 kg of GDM ha^{-1} day^{-1}, respectively, for *M. chaseae* pastures, submitted to clearing and burning, which were higher than those recorded in this work.

The effects of defoliation frequencies on NTP and NLT were fitted to the linear regression model and described, respectively, by the equations $Y = 2.9607 + 0.142308\ X$ ($r^2 = 0.97$) and $Y = 1.9179 + 0.068911\ X$ ($r^2 = 0.99$), respectively. The correlation between NTP and GDM yield was positive and significant ($r = 0.9635$; $P<0.001$), which explained in 92.8% the increments observed in grass forage yields, as a function of defoliation frequencies. The relationship between defoliation frequencies and ALS was quadratic ($Y = 4.7543 + 0.0621\ X - 0.000617\ X^2 - R^2 = 0.96$), with the maximum value estimated at 50.3 days of regrowth (Table 1).

The values obtained in this study for the NTP, NLT and ALS were lower than those reported by Costa et al. (2019) for *Axonopus aureus*, a grass native to the savannas of Roraima, who estimated 10.75 tillers plant^{-1}; 6.95 leaves tiller^{-1} and 14.88 cm. In *A. aureus* pastures, subjected to different cutting heights, Costa et al. (2018) found 6.8, 7.5 and 8.2 tillers plant^{-1}, respectively, for plants cut at 20, 25 and 30 cm above the ground. Likewise, et al., (2001), evaluating the foliation dynamics and tillering of native grasses of the savannas of the Federal District, during the rainy season, reported significant variations for NTP and NLT, with the highest values recorded by *Trachypogon spicatus* (10.1 tillers plant^{-1} and 6.1 leaves tiller^{-1}), compared to *Axonopus marginatus* (7.9 tillers plant^{-1} and 3.4 leaves tiller^{-1}) and *Echinolaena inflexa* (4.0 tillers plant^{-1} and 6.2 leaves tiller^{-1}).

The tillering potential of a genotype, during the vegetative stage, depends on its leaf emission speed, which will produce buds potentially capable of originating new tillers, depending on the environmental conditions and management practices adopted. In native pastures of Rondônia´s savannas, Costa (2018) found that, regardless of the evaluation times (rainy and dry season), *Paspalum maritimum* (12.7 tillers plant^{-1}) presented higher tiller density, compared to *Paspalum notatum* (11.1 tillers plant^{-1}) and *Paspalum secans* FCAP-12 (8.2 tillers plant^{-1}).

The TLA was directly proportional to the ages of the plants, the opposite being true for LAR, with the relationships being linear and described, respectively, by the equations: $Y = 1.3139 + 0.077607\ X$ ($r^2 = 0.98$) and $Y = 0.2131 - 0.002214$ ($r^2 = 0.99$). The LER was adjusted to the quadratic regression model and described by the equation $Y = 1.4834 - 0.03112 + 0.000313\ X^2$ ($R^2 = 0.95$), with the maximum value recorded at 49.7 days of regrowth (Table 1). The TLA, LAR and LER obtained in this work, for most defoliation frequencies, were lower than those reported by Costa et al. (2018), under field conditions, for *A. aureus* (51.71 cm^2 tiller^{-1}; 0.154 leaves tiller^{-1} day^{-1} and 2.15 cm tiller^{-1} day^{-1}, for plants cut at 45 days of regrowth. Due to its high correlation with grass biomass production, LER has been used as one of the criteria for the selection of forage germplasm in genetic improvement studies (Pereira, 2018). In the present work, the correlations between LER, LAR and the GDM yields were negative and significant (LER: $r = -0.9905$; $P<0.01$; LAR: $r = -0.9973$; $P<0.01$), possibly as consequence of low soil moisture, which restricted the maximization of grass morphogenic and structural characteristics.

The LAR directly affects leaf size, tiller population density and number of leaves/tiller (Barbero et al., 2015). In this work, the correlation between LAR and LER was positive and significant ($r = 0.9836$; $P<0.01$), evidencing a synchronization between the time interval for the appearance and expansion of leaves, as a consequence of the low availability of water in the soil, which limited the physiological processes for the adequate growth of the grass. LER was positively correlated with the amount of green leaves remaining on the tiller after defoliation ($r = 0.7666$; $P<0.04$). The TLA synthesizes the effect of the morphogenic and structural characteristics of the grass and reflects the balance of the processes that determine the supply (photosynthesis) and demand (respiration, accumulation of reserves, synthesis and senescence of the tissues) of photoassimilates, which drive the rhythm of pasture growth (Trindade & Rocha, 2001; Nabinger & Carvalho, 2009; Pereira, 2018). For *Axonopus aureus*, a grass native to the savannas of Roraima, Costa et al. (2019) reported that the use of defoliation

frequencies greater than 63 days severely limited grass tillering, which resulted in lower forage production and delay in plant development. This resulted in poor pasture formation and caused high weed appearance and reduced pasture persistence.

The relationship between LSR and defoliation frequencies was fitted to the linear regression model and defined by the equation $Y = 0.0115 + 0.000915\ X$ ($r^2 = 0.97$). The senescence process only occurred after 28 days of age, with the highest rates observed for defoliation frequencies of 35 and 42 days (Table 1). The values recorded in this study were lower than those reported by Costa et al. (2018) for *Axonopus aureus*, who estimated a LSR of 0.224 cm tiller^{-1} day^{-1}, for cuts in plants at 45 days of regrowth. Senescence represents the last stage of forage grass growth, which begins with the complete expansion and exteriorization of the leaf (Carrèrre et al., 2007). Leaf senescence reduces the amount of good quality forage, as the green portions of the plant are the most nutritious for the animal diet, being caused by the competition for metabolites and nutrients between the old leaves and the young growing ones (Leite et al., 1998; Lemaire et al., 2011; Sarmiento et al., 2016).

4. Final Considerations

The reduction in defoliation frequency resulted in higher forage yields, absolute growth rate, number of tillers plant^{-1}, number of leaves tiller^{-1}, leaf senescence rate, leaf area and average leaf size.

Leaf appearance and expansion rates were inversely proportional to defoliation frequencies.

Aiming to reconcile forage productivity with the optimization of the morphogenic and structural characteristics of the *Mesosetum chaseae* grass, the most appropriate period of use of its pastures is between 42 and 49 days of regrowth.

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