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Productive performance, chemical composition and morphogenesis of *Megathyrsus maximus* cv. Tamani under rest periods

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Abstract. The effects of pasture rest period (14, 21, 28, 35 and 42 days) on green dry matter (GDM) yield, chemical composition and morphogenetic and structural characteristics of *Megathyrsus maximus* cv. Tamani were evaluated under natural field conditions at the Roraima´s savannas. The decrease of rest period resulted in higher GDM yields, however implied significant decreases in the levels of nitrogen, phosphorus, calcium, magnesium and potassium. The leaf appearance rate and tiller populational density are inversely proportional to rest period, occurring the inverse for leaf senescence rate. Maximum GDM yields, number of live leaves tiller^{-1}, average leaf length, leaf expansion rate and leaf area index were obtained with rest periods of 38.4; 30.4; 33.8; 15.2 and 36.2 days, respectively. These data suggest that pasture grass grazing at 35 days of rest period were optimal for obtain maximum yields and regrowth of rich forage.

Keywords: chemical composition, dry matter, leaves, tillering, senescence

Desempenho produtivo, composição química e morfogênese de Megathyrsus maximus *cv. Tamani sob períodos de descanso*

Resumo. O efeito do período de descanso da pastagem (14, 21, 28, 35 e 42 dias) sobre o rendimento e composição química da forragem e características morfogênicas e estruturais de *Megathyrsus maximus* cv. Tamani foi avaliado em condições de campo nos cerrados de Roraima. O aumento no período de descanso da pastagem resultou em maiores rendimentos de matéria seca verde (MSV), contudo, implicou em decréscimos significativos dos teores de nitrogênio, fósforo, cálcio, magnésio e potássio. As taxas de aparecimento e a densidade populacional de perfilhos são inversamente proporcionais aos períodos de descanso, ocorrendo o inverso quanto a taxa de senescência foliar. Os maiores rendimentos de MSV, número de folhas vivas perfilho^{-1}, comprimento médio de folhas, taxa de expansão foliar e índice de área foliar foram obtidos com períodos de descanso de 38,4; 30,4; 33,8; 15,2 e 36,2 dias, respectivamente. O período de descanso mais adequado para pastagens de *M. maximus* cv. Tamani, visando a conciliar produção, vigor de rebrota e qualidade da forragem, situa-se em torno de 35 dias.

Palavras-chave: Composição química, folhas, matéria seca, perfilhamento, senescência

Desempeño productivo, composición química y morfogénesis de Megathyrsus maximus *cv. Tamani bajo defoliación intermitente*

Resumen. El efecto de períodos de descanso de la pastura (14, 21, 28, 35 y 42 días) en la acumulación, composición química del forraje y las características morfogenéticas y estructurales de *Megathyrsus maximus* cv. Tamani se evaluó en condiciones de campo en las sabanas de Roraima. Aumentar el período de descanso resultó en mayores rendimientos de materia seca verde (MSV), sin embargo, resultó en reducciones significativas de los contenidos de nitrógeno, fósforo, calcio, magnesio y potasio. Las tasas de aparición de las hojas y la densidad poblacional de macollas son inversamente proporcional a los períodos de descanso, mientras que lo contrario ocurrió para la tasa de senescencia de las hojas. Los mayores rendimientos de MSV, número de hojas por macollas, longitud media de las hojas, tasa de expansión de hojas e índice de área foliar se obtuvieron a 38,4; 30,4; 33,8; 15,2 y 36,2 dias de descanso, respectivamente. El período de descanso más adecuado para el pastoreo de pasturas de *M. maximus* cv. Tamani, destinada a conciliar la producción, el vigor de rebrote y la calidad del forraje, está alrededor de 35 días de descanso.
Palabras clave: composición química, hojas, macollaje, materia seca, senescencia

Introduction

In Roraima, cattle ranching is one of the most relevant economic activities and cultivated pastures are the main forage resource for the feeding of beef and milk cattle. The use of continuous grazing or with minimum rest periods associated with high defoliation intensities contribute to low availability and quality of forage, with negative effects on the animal performance indexes of the animals. Pasture productivity is strongly influenced by environmental conditions (temperature, light, water and soil fertility) and management practices, while its longevity, among other factors, results from the ability to reconstitute and maintain the leaf area after defoliation, which affects the structure of the canopy, determining its growth speed, forage accumulation, chemical composition and persistence (Almeida, 2015; Nabinger & Pontes, 2002; Souza, 2018).

The frequency of defoliation affects the rest period available for pasture growth and significantly influences its productivity, chemical composition, regrowth capacity and persistence. Frequent grazing provides greater forage yields, however, concomitantly, there are marked decreases in its chemical composition, with greater accumulation of fibrous material, decrease in the leaf/stem ratio and, consequently, less consumption by animals (Lemaire et al., 2011).

The adequate management of pastures consists of the mediation of the plant-animal encounter aiming at greater productivity and quality of the available forage, without affecting its persistence and ensuring the maintenance or improvement of the integrity of the physical, chemical and biological characteristics of the soil. The nutritional requirements of the animals can be ensured by achieving a balance between production and forage quality, which reflects in better animal performance (Cecato et al., 2000; Santos et al., 2012).

The morphogenesis of forage grasses can be characterized by three factors: the rate of appearance, the rate of elongation and the longevity of the leaves. The rate of appearance and the life span of the leaves determine the number of live leaves/tiller, which have a strong genetic component and can be affected by environmental factors and the pasture management practices (Nabinger and Pontes, 2002; Lemaire et al., 2011). The knowledge of the dynamics of spatial and temporal variations in the morphogenic and structural characteristics enables the planning and adoption of pasture management practices that ensure the productivity, longevity and sustainability of the pastoral ecosystem through a greater understanding of the morphophysiological mechanisms and their interactions with the environment (Nascimento, 2014; Pereira, 2013).

In this work were avaluated the effects of pasture rest periods on forage accumulation, chemical composition and morphogenic and structural characteristics of *Megathyrsus maximus* cv. Tamani in the Roraima´s savannas.

Material ans methods

The trial was conducted at the Embrapa Roraima Experimental Field, located in Boa Vista, from May to September 2015, which corresponded to an accumulated precipitation of 1,219 mm and an average monthly temperature of 24.9° C. The soil of the experimental area is a Yellow Latosol, medium texture, savanna phase, with the following chemical characteristics, at a depth of 0-20 cm: pH_{H2O} = 5.8; P = 15.5 mg/kg; Ca + Mg = 1.19 $cmol_c.dm^{-3}$; K = 0.022 $cmol_c dm^{-3}$ and Al = 0.14 $cmol_c dm^{-3}$.

The experimental design was entirely randomized with three replications. The treatments consisted of five rest periods (14, 21, 28, 35 and 42 days). The establishment fertilization consisted of the application of 90 kg of N ha^{-1}, 50 kg of P_2O5 ha^{-1} and 60 kg of K_2O ha^{-1}, in the form of urea, triple superphosphate and potassium chloride, respectively. The nitrogen fertilization was divided in three times, being 1/3 when planting, 1/3 at 21 days and 1/3 at 35 days. The plots measured 2.0 x 2.0 m, with a useful area of 1.0 m^2. During the experimental period were made 8, 6, 4, 3 and 2 cuts, respectively for defoliation frequencies of 14, 21, 28, 35 and 42 days and at a height of 30 cm above the ground.

The evaluated parameters were green dry matter yield (GDM), nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg) and potassium (K), number of live leaves $tiller^{-1}$ (NLLT), leaf appearance rate (LAR), leaf expansion rate (LER), tiller populational density (TPD), leaf senescence rate (LSR), average leaf length (ALL) and leaf area index (LAI). LER and LAR were calculated by dividing the accumulated leaf length and the total number of leaves in the tiller, respectively, by the regrowth period.

The ALL was determined by dividing the total leaf elongation of the tiller by the number of leaves. To calculate the leaf area, samples of fully expanded green leaves were collected, trying to obtain an area between 200 and 300 cm^2. The samples were digitalized and the leaf area was estimated using an electronic optical planimeter (Li-Cor 3100C). Subsequently, the samples were taken to the oven with forced air at 65° C until they reached constant weight, obtaining the leaf GDM.

The specific leaf area (SLA) was determined through the relationship between the green leaf area and its GDM (m^2/g leaf GDM). The LAI was determined from the product between the total green leaf DM (g GDM/m^2) by SLA (m^2/g leaf GDM). LSR was obtained by dividing the length of the leaf that was yellowish or necrotic in color by the age of regrowth. The N levels were analyzed according to the procedures described by Silva & Queiroz (2002); while the levels of P, Ca, Mg and K were determined according to the methodology described by Silva (2009). The levels of P and K were quantified after nitroperchloric digestion. P was determined by colorimetry; K by flame photometry and Ca and Mg concentrations by atomic absorption spectrophotometry.

The data were subjected 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 rest periods, the choice of regression models was based on the significance of the linear and quadratic coefficients, using the Student's "t" test, at the level of 5% probability.

Results and discussion

The effect of the rest period on GDM yields was adjusted to the quadratic regression model and the maximum value estimated at 38.4 days (Table 1). In the Rondônia´s savannas, for pastures of *M. maximus* cvs. Aruana and Vencedor, Costa et al. (2007) reported higher forage yields for rest periods varying between 28 and 35 days. For higher defoliation frequencies, the regrowth speed showed a high correlation with the preservation of apical meristems, whose preservation stimulates the formation of photosynthetic tissues through the expansion of new leaves, while the removal of apical meristems implies slower growth and originates the from the development of buds, notably of basal origin, for the production of new leaves (Cunha et al., 2012; Difante et al., 2011; Pena et al., 2009).

For Santos et al. (2004) the adequate interval between grazing of *M. maximus* cv. Tanzania-1 should not be established solely on the basis of the GDM accumulation rate, requiring knowledge about the interactions between stem production and grazing efficiency, consumption and forage quality. The authors recommend 38-day rest periods from October to April; 28 days in the grass reproductive phase (April and May) and about 48 days between May and September. Based on this premise, Barbosa et al. (2007) found an interaction between post-grazing residue height and defoliation frequency in pastures of *M. maximus* cv. Tanzania-1, with resting periods of 31 to 35 days and 24 to 27 days, respectively, for 25 and 50 cm of residue, which were correlated with 90% of light interception by the pasture canopy.

Rest periods affected N, P, Ca Mg and K levels negatively and linearly (Table 1), showing a dilution effect with a decrease in the frequency of defoliation of the grass. The concentrations estimated in this work were similar to or higher than those reported by Costa et al. (2007) for pastures of *M. maximus* cvs. Aruana, Atlas, Massai and Vencedor, submitted to different rest periods. For P, Ca, Mg and K, the levels obtained with rest periods of up to 21 days were higher than the internal critical level determined by Costa et al. (2006) for *M. maximus* cv. Centenário (1.71, 3.38, 2.44 and 19.27 g kg^{-1}, respectively for P, Ca, Mg and K). However, Oliveira et al. (2009) evaluated pastures of *M. maximus* cv. Mombaça and reported maximum concentrations of N, P, K, Ca and Mg, respectively at 104, 102, 105, 68 and 78 days of rest period.

Table 1. Green dry matter (GDM - kg ha^{-1}) yield and nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg) and potassium (K) concentrations of *Megathyrsus maximus* cv. Tamani, as affected by rest periods.

Variables	Rest Periods (days)					Regression Equation
	14	21	28	35	42	
GDM	1,285	2,329	2,981	3,717	3,397	$Y = 2{,}147 + 296.01\ X - 3.8542\ X^2\ (R^2 = 0{,}92)$
N (g/kg)	27.15	26.88	24.09	22.11	20.05	$Y = 31.64 - 0.2712\ x\ (r^2 = 0{,}94)$
P (g/kg)	2.19	2.01	1.93	1.87	1.75	$Y = 2.36 - 0.0146\ x\ (r^2 = 0{,}88)$
Ca (g/kg)	4.76	4.22	3.98	3.32	3.17	$Y = 5.52 - 0.0583\ x\ (r^2 = 0{,}90)$
Mg (g/kg)	2.81	2.56	2.28	2.08	1.97	$Y = 3.20 - 0.0309\ x\ (r^2 = 0{,}91)$
K (g/kg)	21.98	19.56	18.07	17.32	17.12	$Y = 23.59 - 0.1709\ x\ (r^2 = 0{,}86)$

The LAR was inversely proportional to the rest period, while LER, NLLT, ALL and LAI were adjusted to the quadratic regression model and the maximum values estimated at 15.2; 30.4; 33.8 and 36,2 days (Table 2). In the Rondônia´s savannas, in pastures of *M. maximus* cvs. Massai and Tobiatã, Costa et al. (2008) estimated higher NLLT, ALL and LAI for periods between 28 and 35 days of regrowth, which were recommended as most suitable for the management of grasses.

In pastures of *M. maximus* cv. Aruana, the prolongation of the rest period negatively affected the structure of its canopy, reducing the leaf/stem ratio and the tillers population, however, morphological and structural adaptations of the forage canopy allowed satisfactory regrowth under management in which the frequency between defoliation allows 4.0 new $tiller^{-1}$ leaves to appear during the rainy season. The adequate rest period in grass-Tanzania-1 pastures should not exceed 35 days and coincide with the appearance of at least 3.5 fully expanded leaves per tiller (Ferlin et al., 2006; Gomide et al., 2007; Pena et al., 2009).

Tabela 2. Number of live leaves $tiller^{-1}$ (NLLT), leaf appearance rate (LAR - leaf day^{-1} $tiller^{-1}$), leaf expansion rate (LER - cm day^{-1} $tiller^{-1}$), average leaf length (ALL - cm), tiller population density m^{-2} (TPD), leaf area index (LAI) and leaf senescence rate (LSF - cm day^{-1} $tiller^{-1}$) de *Megathyrsus maximus* cv. Tamani, as affected by rest periods.

Variables	Rest Periods (days)					Regression Equation
	14	21	28	35	42	
NLLT	3.97	4.35	4.88	5.11	4.31	$Y = 1.288 + 0.2377\ X - 0.0039\ X^2\ (R^2 = 0{,}89)$
LAR	0.284	0.207	0.174	0.146	0.103	$Y = 0.3519 - 0.00621\ x\ (r^2 = 0{,}94)$
LER	6.02	5.21	5.42	4.23	2.64	$Y = 4.847 + 0.1305\ X - 0.0043\ X^2\ (r^2 = 0{,}93)$
ALL	21.23	25.17	31.11	28.95	25.78	$Y = 1.024 + 2.0061\ X - 0.0325\ X^2\ (R^2 = 0{,}90)$
TPD	451	497	556	561	502	$Y = 183.7 + 23.922\ X - 0.3848\ X^2\ (R^2 = 0{,}93)$
LAI	1.78	2.49	3.15	3.67	3.42	$Y = 0.942 + 0{,}2319\ X - 0{,}0032\ X^2\ (R^2 = 0{,}94)$
LSR	0.231	0.268	0.299	0.321	0.344	$Y = 0.181 + 0.0041\ x\ (r^2 = 0{,}88)$

The LAI reflects the synthesis of the morphogenic and structural characteristics of the grass and expresses the balance of the processes that determine the supply (photosynthesis) and the demand (respiration, accumulation of reserves, synthesis and tissue senescence) of photoassimilates, establishing the growth rate of the pasture (Nabinger & Carvalho, 2009). When the intervals between defoliation are short, plants with a higher proportion of LAI in the lower part of the canopy have a higher residual LAI, ensuring rapid initial regrowth, due to greater light interception. However, if the regrowth period is long, plants of more upright and tall growth, with higher proportions of the LAI in the intermediate and upper canopy regions, have enough time to accumulate greater LAI and use better the incident radiation, being therefore more productive (Lemaire et al., 2011; Pereira, 2013). As the frequency of defoliation increases, the percentage of light intercepted by the canopy reaches its maximum point, LAI Ceiling, where for each new leaf that appears in the upper portion of the plant, the senescence of a leaf in its lower portion occurs, stabilizing or reducing the availability of green biomass as a result of the reduction of the light extinction coefficient. Immediately after grazing, despite the reduced shading, the remaining leaves may have a lower rate of photosynthesis, possibly due to their development partially occurring under intense shading (Cândido et al., 2005; Pereira, 2013).

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The main morphological strategy for escaping grasses from grazing would be adjustments in the ALL, considered as the most sensitive plastic characteristic and responsive to the intensity and frequency of defoliation (Lemaire et al., 2011; Pedreira et al., 2009). In this context, the grasses show abundant tillering, a more prostrate growth habit and a high rate of leaf expansion, allowing greater light interception and more vigorous regrowth when subjected to more frequent defoliation (Cavalli, 2016; Costa et al., 2014; Nabinger & Pontes, 2002).

The LAR, LER and ALL obtained in this study, regardless of rest periods, were higher than those reported by Macedo et al. (2010) evaluating *M. maximus* cv. Mombaça that found average values of 0.011 and 0.010 leaves^{-1} tiller^{-1} day; 5.38 and 5.31 cm day^{-1} tiller^{-1} and 40.5 and 33.2 cm for ALL, respectively for rest periods of 36 and 48 days. When LSR equals LAR, NLLT becomes relatively constant and constitutes an objective and practical criterion for defining rest periods in rotating stocking and the grazing intensity in continuous stocking (Santos et al., 2004, Pereira, 2013). For *M. maximus* cv. Centenário, the beginning of grazing must be carried out when the tillers present, on average, three to four live leaves, in order to enhance the productivity and quality of the forage on offer (Costa et al., 2008). The LER has a high correlation with the production of GDM and has been used as a criterion for the selection of grasses in genetic improvement works (Nabinger and Carvalho; 2009, Pereira, 2013).

The LER is directly correlated with ALL, as smaller leaves are usually associated with higher LAR values. In this work, the correlation between LER and GDM yield was positive and significant ($r = 0.811$; $P<0.05$); while with the LAR the correlation was negative and not significant ($r = -0.531$; $P > 0.05$). The LER explained 65.8% of the increases in GDM yields, due to the rest period. The LAR can be considered as the most relevant morphogenic characteristic, as it directly influences the three structural characteristics of the pasture canopy: leaf size, tiller density and number of tiller^{-1} leaves (Pedreira et al., 2009; Santos et al. , 2012). According to Difante et al. (2011), the LAR and LER generally present a negative correlation, indicating that the higher the LAR, the shorter the time available for leaf elongation (Nabinger and Carvalho, 2009).

The TPD was affected quadratically by the rest periods and the maximum value estimated at 31.1 days (Table 2). Tillering represents the structural characteristic most strongly influenced by nutritional, environmental and management factors, which define the morphogenic characteristics that condition the physiological response of forage plants to management systems (Cecato et al., 2000; Garcez Neto et al., 2002; Martuscello et al., 2019).

The emission of new tillers is normally a continuous and accelerated process due to the defoliation of the plant, as a consequence of the improvement of the luminous environment at the base of the canopy (greater reason of red radiation: distant red), being mediated by two main factors: the supply of energy for photosynthesis and the number and activity of growth points (Gastal & Lemaire, 2002; Nabinger & Carvalho, 2009). In pastures of *M. maximus* cv. Vencedor, Costa et al. (2008) found a higher TPD for rest periods of 28 days (526 tillers m^{-2}), compared to 35 (456 tillers m^{-2}) or 42 days (317 tillers m^{-2}). Corsi (1984) observed an intense concentration in tiller emission in the first eight days after cutting in *M. maximus* ecotypes, while Barbosa et al. (2002) evaluating four cultivars of *M. maximus*, reported linear appearance of tillers, basilar and aerial, up to 21 days after cutting. The higher proportion of basilar tillers, notably in the first weeks, was a consequence of the greater light intensity on the basilar buds, which stimulated tillering (Pereira, 2013, Martuscello et al., 2019).

Rest periods affected negatively and linearly the LSR ($P < 0.05$), showing the adverse effects of lower defoliation frequency on forage quality (Table 2). Leaf senescence expresses the competition for metabolites and nutrients between old and growing young leaves, which reduces the availability of good quality forage (Santos et al., 2004; Lemaire et at., 2011). The estimated values were lower than those reported by Costa et al. (2007) for pastures of *M. maximus* cv. Vencedor (0.197; 0.225 and 0.247 cm day^{-1} $tiller^{-1}$, respectively for rest periods of 28, 35 and 42 days).

Senescence reflects the natural physiological process that characterizes the last stage of leaf development, started after its complete expansion and progressively accentuated with the increase in leaf area, due to the shading of the leaves inserted in the lower portion and the low supply of photosynthetically active radiation, characterized by intense competition for light, nutrients and water between the different strata of the plant (Nabinger and Pontes, 2002). The tiller when reaching a certain NLLT establishes the balance between the LAR and the senescence of the leaves that have exceeded their life span, so for the appearance of a new leaf it implies the senescence of the previous leaf, keeping the NLLT relatively constant (Lemaire et al., 2011; Pereira, 2013, Martuscello et al., 2019).

The leaf senescence reduces the quality of the forage, however it represents an important physiological process in the dynamics of the grass tissue flow, since about 35; 68; 86 and 42% of N, P, K and Mg, respectively, can be recycled from senescent leaves and used for the production of new leaf tissues (Costa et al., 2013; Sarmiento et al., 2006).

Conclusions

The increase in the rest period of the pasture favors the accumulation of forage, however it reduces the tissue concentrations of N, P, Ca, Mg and K.

The rate of leaf appearance and the tiller populational density are inversely proportional to the rest periods, occurring the inverse as to the average leaf length, leaf area index and leaf senescence rate.

The use of rest periods of around 35 days can be considered adequate for the management of pastures of *M. maximus* cv. Tamani, in order to reconcile production, regrowth vigor and forage quality.

References

Almeida, O. G. (2015). Morfogênese e produção de acessos de *Panicum maximum*. In: *Monografia.(Bacharelado em Zootecnia). Universidade Federal de São João del Rei*. Universidade Federal de São João del Rei.

Barbosa, R. A., Nascimento Júnior, D., Euclides, V. P. B., Regazzi, A. J. & Fonseca, D. M. (2002). Características morfogênicas e acúmulo de forragem do capim-Tanzânia (*Panicum maximum* Jacq. cv. Tanzân ia) em dois resíduos forrageiros pós-pastejo. *Revista Brasileira de Zootecnia*, *31*(2), 583–593. http://dx.doi.org/10.1590/S1516-35982002000300007

Barbosa, R. A., Nascimento Júnior, D., Euclides, V. P. B., Silva, S. C., Zimmer, A. H. & Torres Júnior, R. A. (2007). Capim-tanzânia submetido a combinações entre intensidade e freqüência de pastejo. *Pesquisa Agropecuária Brasileira*, *42*(3), 329–340. http://dx.doi.org/10.1590/S0100-204X2007000300005

Cândido, M. J. D., Alexandrino, E. & Gomide, J. A. (2005). Duração do período de descanso e crescimento do dossel de *Panicum maximum* cv. Mombaça sob lotação intermitente. *Revista*

Brasileira de Zootecnia, *34*(2), 398–405. http://dx.doi.org/10.1590/S1516-35982005000200006

Cavalli, J. (2016). *Estratégias de manejo do pastejo para Panicum maximum cvs. Quênia e Tamani*. Universidade Federal de Mato Grosso.

Cecato, U., Machado, A. O., Martins, E. N., Pereira, L. A. F., Barbosa, M. A. A. & Santos, G. T. (2000). Avaliação da produção e de algumas características da rebrota de cultivares e acessos de *Panicum maximum* Jacq. sob duas alturas de corte. *Revista Brasileira de Zootecnia*, *29*(3), 660–668. https://doi.org/10.1590/S1516-35982000000300004

Corsi, M. (1984). *Effects of nitrogen rates and harvesting intervals on dry matter production, tillering and quality of the tropical grass, Panicum maximum, Jacq*. The Ohio State University.

Costa, C. A. A., Andrade, A. C., Magalhães, J. A., Mehl, H. U., Rodrigues, B. H. N., da Silva, E. M., Bitencourt, A. B., Santos, F. J. S. & Costa, N. L. (2014). Características agronômicas dos capins *Digitaria* sp. e *Cynodon dactylon* cv. Tifton-85 sob diferentes alturas de resíduo. *PUBVET*, *7*(1), 1509.

Costa, N. L, Magalhães, J. A., Pereira, R. G. A., Townsend, C. R. & Oliveira, J. R. C. (2007). Considerações sobre o manejo de pastagens na Amazônia Ocidental. *Revista do Conselho Federal de Medicina Veterinária*, *40*, 37–56.

Costa, N. L, Paulino, V. T., Magalhães, J. A., Townsend, C. R. & Pereira, R. G. A. (2008). Morfogênese de gramíneas forrageiras na Amazônia Ocidental. *PUBVET*, *2*, 1–24.

Costa, N. L., Moraes, A., Monteiro, A. L. G., Motta, A. C. V., Oliveira, R. A. & Rodrigues, A. N. A. (2013). Forage productivity and morphogenesis of *Axonopus aureus* under different nitrogen fertilization rates. *Revista Brasileira de Zootecnia*, *42*(8), 541–548. https://doi.org/10.1590/S1516-35982013000800002

Costa, N. L., Townsend, C. R. & Avelar, J. (2006). Formação e manejo de pastagens na Amazônia do Brasil. *Revista Electrónica de Veterinária*, *7*, 1–18.

Cunha, F. F., Mota Ramos, M., Brasileiro, A. C. A., Alves, R., Cóser, A. C., Martins, C. E., Cecon, P. R. & Silva, A. R. A. (2012). Produtividade da *Brachiaria brizantha* cv. Xaraés em diferentes manejos e doses de adubação, períodos de descanso e épocas do ano. *Idesia (Arica)*, *30*(1), 75–82. http://dx.doi.org/10.4067/S0718-34292012000100009

Difante, G. S., Nascimento Júnior, D., Silva, S. C., Euclides, V. P. B. & Montagner, D. B. (2011). Características morfogênicas e estruturais do capim-marandu submetido a combinações de alturas e intervalos de corte. *Revista Brasileira de Zootecnia*, *40*(5), 955–963. http://dx.doi.org/10.1590/S01516-35982011000500003

Ferlin, M. B., Euclides, V. P. B., Lempp, B., Gonçalves, M. C. & Cubas, A. C. (2006). Morfogênese e dinâmica do perfilhamento de *Panicum maximum* Jacq. cv. Tanzânia sob pastejo. *Ciência e Agrotecnologia*, *30*, 344–352. https://doi.org/10.1590/S1413-70542006000200022

Garcez Neto, A. F., Nascimento Júnior, D. & Regazzi, A. J. (2002). Respostas morfogênicas e estruturais de *Panicum maximum* cv. Mombaça sob diferentes níveis de adubação nitrogenada e alturas de corte. *Revista Brasileira de Zootecnia*, *31*(5), 1890–1900.

Gastal, F. & Lemaire, G. (2002). N uptake and distribution in crops: an agronomical and ecophysiological perspective. *Journal of Experimental Botany*, *53*(370), 789–799.

Gomide, C. A. M., Gomide, J. A. & Alexandrino, E. (2007). Características estruturais e produção de forragem em pastos de capim-mombaça submetidos a períodos de descanso. *Pesquisa Agropecuária Brasileira*, *42*(10), 1487–1494. http://dx.doi.org/10.1590/S0100-204X2007001000017

Lemaire, G., Hodgson, J. & Chabbi, A. (2011). *Grassland productivity and ecosystem services* (Vol. 1). Cabi. 287p.

Macedo, C. H. O., Alexandrino, E., Jakelaitis, A., Vaz, R. G. M. V., Reis, R. H. P. & Vendrusculo, J. (2010). Características agronômicas, morfogênicas e estruturais do capim" *Panicum maximum*" cv. Mombaça sob desfolhação intermitente. *Revista Brasileira de Saúde e Produção Animal*, *11*(4), 941–952. http://mc04.manuscriptcentral.com/rbspa-scielo2009

Martuscello, J. A., Rios, J. F., Ferreira, M. R., Assis, J. A., Braz, T. G. S. & Cunha, D. N. F. V. (2019). Produção e morfogênese de capim BRS Tamani sob diferentes doses de nitrogênio e intensidades de desfolhação. *Boletim de Indústria Animal*, *76*, 1–10. https://doi.org/10.17523/bia.2019.v76.e1441

Nabinger, C. & Carvalho, P. F. C. (2009). Ecofisiología de sistemas pastoriles: aplicaciones para su sustentabilidad. *Agrociencia*, *13*(3), 18–27.

Nabinger, C. & Pontes, L. S. (2002). Manejo da desfolha. *Simpósio Sobre Manejo da Pastagem*, 133–158.

Nascimento, H. L. B. (2014). Cultivares de *Panicum maximum* adubadas e manejadas com frequência de desfolhação correspondente a 95% de interceptação luminosa. 67 f. Dissertação. (Mestrado em Zootecnia). Universidade Federal de Viçosa.

Oliveira, P. S. R., Castagnara, D. D., Junior Gonçalves, A. C., Mesquita, E. E. & Neres, M. A. (2009). Teores de macromineerais em *Panicum maximum* cvs. Massai e Mombaça. *Synergismus Scyentifica*, *4*(1), 7–10.

Pedreira, B., Pedreira, C. G. S. & Silva, S. C. (2009). Acúmulo de forragem durante a rebrotação de capim-xaraés submetido a três estratégias de desfolhação. *Revista Brasileira de Zootecnia*, *38*(4), 618–625. http://dx.doi.org/10.1590/S1516-3598200900 0400005

Pena, K. S., Nascimento Júnior, D., Silva, S. C., Euclides, V. P. B. & Zanine, A. M. (2009). Características morfogênicas, estruturais e acúmulo de forragem do capim-tanzânia submetido a duas alturas e três intervalos de corte. *Revista Brasileira de Zootecnia*, *38*(11), 2127–2136. http://dx.doi.org/10.1590/S1516-35982009001100009

Pereira, V. V. (2013). A importância das características morfogênicas sobre o fluxo de tecidos no manejo de pastagens tropicais. *Revista em Agronegócio e Meio Ambiente*, *6*(2), 289–309.

Santos, M. R., Fonseca, D. M., Gomes, V. M., Silva, S. P., Silva, G. P. & Reis, M. (2012). Correlações entre características morfogênicas e estruturais em pastos de capim-braquiária. *Ciência Animal Brasileira*, *13*(1), 49–56. http://dx.doi.org/10.5216/cab.v13i1.13401

Santos, P. M., Balsalobre, M. A. A. & Corsi, M. (2004). Características morfogenéticas e taxa de acúmulo de forragem do capim-mombaça submetido a três intervalos de pastejo. *Revista Brasileira de Zootecnia*, *33*(4), 843–851. http://dx.doi.org/10.1590/S01516-35982004000400004

Sarmiento, G., Silva, M. P., Naranjo, M. E. & Pinillos, M. (2006). Nitrogen and phosphorus as limiting factors for growth and primary production in a flooded savanna in the Venezuelan Llanos. *Journal of Tropical Ecology*, *22*(2), 203–212. https://doi.org/10.1017/S0266467405003068

Silva, D. J. & Queiroz, A. C. (2002). *Análise de alimentos: métodos químicos e biológicos* (3rd ed.). Universdiade Federal de Viçosa.

Silva, F. C. (2009). Manual de análises químicas de solos, plantas e fertilizantes. In: *EMBRAPA* (Vol. 1). Embrapa Informação Tecnológica.

Souza, J. A. S. (2018). *Produção de gramíneas forrageiras dos gêneros Urochloa e Megathyrsus nas condições edafoclimáticas de Manaus, AM*. Universidade Federal do Amazonas.

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