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Forage productivity and chemical composition of *Megathyrsus maximus* cv. Tamani under defoliations regimes

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Abstract. The effects of defoliation frequency (21, 28, 35 and 42 days) and defoliation intensity (20, 30 and 40 cm above the ground) on green dry matter (GDM) yield, and chemical composition of *Megathyrsus maximus* cv. Tamani were evaluated under natural field conditions at the Roraima´s savannas. Defoliation regimes affect productivity and chemical composition of *M. maximus* cv. Tamani forage. The decrease in the pasture defoliation frequency and intensity improved the accumulation of forage, however it reduces the tissue concentrations of N, P, Ca, Mg and K. Irrespective of defoliation frequencies, the highest levels of N (25.31 g kg^{-1}), P (2.11 g kg^{-1}), Mg (2.78 g kg^{-1}) and K (21.13 g kg^{-1}) were recorded for the defoliation intensity at 40 cm above the ground, except for Ca (4.31 g kg^{-1}), where the greatest concentration was obtained with defoliations at 30 cm above the ground. The use of defoliation frequency around 32 days and defoliation intensity of 28 cm above the ground can be considered adequate for the management of pastures of *M. maximus* cv. Tamani, in order to provides higher forage productivity and quality, regrowth vigor, larger efficiency of forage utilization, greater tissue renewal and canopy structure more favorable to grazing.

Keywords: Calcium, green dry matter, magnesium, nitrogen, phosphorus, potassium

Produtividade e composição química da forragem de Megathyrsus maximus *cv. Tamani sob regimes de desfolhação*

Resumo. O efeito da frequência de desfolhação (21, 28, 35 e 42 dias) e intensidade de desfolhação (20, 30 e 40 cm acima do solo) sobre o rendimento e composição química da forragem de *Megathyrsus maximus* cv. Tamani foi avaliado em condições de campo nos cerrados de Roraima. Os regimes de desfolhação afetaram a produtividade e a composição química da forragem da gramínea. A redução na frequência e intensidade de desfolhação resultou em maiores rendimentos de matéria seca verde, contudo, implicou em decréscimos significativos dos teores de nitrogênio (N), fósforo (P), cálcio (Ca), magnésio (Mg) e potássio (K). Independentemente das frequências de desfolhação, as maiores concentrações de N (25,31 g kg^{-1}), P (2,11 g kg^{-1}), Mg (2,78 g kg^{-1}) e K (21,13 g kg^{-1}) na forragem foram registradas com cortes a 40 cm acima do solo, exceto para o Ca (4,31 g kg^{-1}) que apresentou maior teor com cortes a 30 cm acima do solo. Pastagens de *M. maximus* cv. Tamani manejadas sob frequência de desfolhação em torno de 32 dias e intensidade de desfolhação de 28 cm acima do solo proporcionam maior produtividade e qualidade da forragem, maior eficiência de sua utilização, maior renovação de tecidos e estrutura do dossel mais favorável ao pastejo.

Palavras-chave: Cálcio, matéria seca verde, magnésio, nitrogênio, fósforo, potássio

Productividad y composición química del forraje de Megathyrsus maximus *cv. Tamani bajo regímenes de defoliación*

Resumen. El efecto de la frecuencia de defoliación (21, 28, 35 y 42 días) y la intensidad de defoliación (20, 30 y 40 cm por encima del suelo) sobre el rendimiento de forraje y la composición química de *Megathyrsus maximus* cv. Tamani se evaluó en condiciones de campo en las sabanas de Roraima. Los regímenes de defoliación afectaron la productividad y la composición química del forraje de la gramínea. La reducción en la frecuencia e intensidad de la defoliación resultó en mayores rendimientos de materia seca verde, sin embargo, implicó disminuciones significativas en los niveles de nitrógeno (N), fósforo (P), calcio (Ca), magnesio (Mg) y potasio (K). Independientemente de las frecuencias de defoliación, las concentraciones más altas de N (25,31 g kg^{-1}), P (2,11 g kg^{-1}), Mg (2,78 g kg^{-1}) y K (21,13 g kg^{-1}) en el forraje se registraron con cortes a 40 cm por encima del suelo, excepto Ca (4,31 g kg^{-1}), que presentó el mayor contenido con cortes a 30 cm por encima del suelo. Pastizales de *M. maximus* cv. Tamani manejados bajo una frecuencia de defoliación alrededor de 32 días y una intensidad de defoliación de 28 cm sobre el suelo proporcionan mayor productividad y calidad del forraje, mayor eficiencia de su uso, mayor renovación de tejidos y estructura del dosel más favorable al pastoreo.

Palabras clave: Calcio, materia seca verde, magnesio, nitrógeno, fósforo, potasio

Introduction

In Roraima, cattle ranching is a of the main economic activities and the cultivated pastures represent the main forage resource for the feeding of the herds. The use of continuous grazing or minimum rest periods, high intensities defoliation and non-replacement of nutrients removed via animal production are factors that contribute to low availability and quality of forage, with negative effects on the zootechnical performance of animals (Costa et al., 2007). Productivity and longevity of forage grasses derive from their capacity reconstitution and maintenance of the leaf area after defoliation, which affects the structure of the canopy, determining its speed of growth (Pereira, 2013). The accumulation of forage is closely related to the stadium of grass growth as a consequence of morphological and physiological changes that change the balance between production and senescence of tissues, with reflexes in the chemical composition, regrowth capacity andpasture persistence (Costa et al., 2014; Nabinger & Carvalho, 2009).

The central point of grazing management is to mediate the plant-animal encounter and determine the efficiency between the growth of the plant, its consumption and animal production to keep the production system (Hodgson, 1990). The balance between productivity and quality must be achieved, aiming to ensure the nutritional requirements of the animals and at the same time maximizing the efficiency of the production, use and conversion processes of the forage produced. The grassland management – defoliation frequency and intensity - promove conditions differences in the structure of the pasture that affect the process of defoliation by the animal and modify the growth dynamics of the pasture with influences on the biomass flows (Cavalli, 2016; Nascimento, 2014). Defoliation intensity represents the proportion of tissue plant removed by the animal in comparison to that made available for grazing, impacting the leaf area photosynthetically active remnant, the remobilization of organic reserves and the removal of apical meristems (Lemaire et al., 2011).

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 defoliation frequency 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 forage intake by animals (Lemaire et al., 2011).

In this work were evaluated the effects of defoliation frequency and itensity on forage accumulation and chemical composition 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 2016, which corresponded to an accumulated precipitation of 1,416 mm and an average monthly temperature of 24.79º 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 = 15.8 mg/kg; Ca + Mg = 1.19 $cmol_c.dm^{-3}$; K = 0.022 $cmol_c.dm^{-3}$ and Al = 0.13 $cmol_c.dm^{-3}$.

The experimental design was entirely randomized with three replications. The treatments consisted of four defoliation frequencies (21, 28, 35 and 42 days) and three defoliation intensities (20, 30 and 40 cm above the ground). 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 two times, being 1/3 when planting, and 2/3 at 21 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 6, 5, 4 and 3 cuts, respectively for defoliation frequencies of 21, 28, 35 and 42 days.

The evaluated parameters were green dry matter yield (GDM), nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg) and potassium (K) contents. 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 defoliation frequency and intensity, 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 GDM yields were affected ($P < 0.05$) by the interaction between frequencies and intensities of defoliation. The effect of the defoliation intensity was adjusted to the quadratic regression model ($Y = 1{,}481 + 204.85 X - 3.1752 X^2$ [$R^2 = 0.94$]) and the maximum value was estimated at 32.2 cm above the ground (Table 1). For *M. maximus* cv. Tamani pastures, Costa et al. (2020a) estimated that 28.2 cm above the ground was the best defoliation intensity, which was correlated to the higher tillering and higher rates of leaf appearance and expansion and lower leaf senescence. For pastures of *M. maximus* cvs. Tamani and Kenya, Tesk et al. (2020) suggest the use of grazing intensities of 25 and 35 cm above the ground, respectively, which were correlated to high forage yields and higher recovery speed after the grazing.

Table 1. Gren dry matter (kg ha^{-1}) yield of *Megathyrsus maximus* cv. Tamani, as affected by defoliation regimes

Defoliation Intensity (cm)	Defoliation Frequency (days)				Regression Equation
	21	28	35	42	
20	2,051	2,756	3,655	3,433	$Y = 3{,}680 + 368.94 X - 4.7143 X^2$ ($R^2 = 0{,}91$)
30	2,354	3,359	4,205	3,826	$Y = 5{,}505 + 520.03 X - 7.0621 X^2$ ($R^2 = 0{,}93$)
40	2,298	3,101	3,911	3,737	$Y = 3{,}686 + 387.28 X - 4.9897 X^2$ ($R^2 = 0{,}97$)

Defoliation implies a rapid decline in the amount of soluble carbohydrates available for the growth of grass roots, as a consequence of the reduction in its photosynthetic rate as a whole and preferential allocation of carbon to the plant parts in order to restore its leaf area (Costa et al., 2008; Lemaire et al., 2011; Pereira et al., 2011; Silva, 2019). Costa et al. (2020b) found that the best defoliation frequency for pastures of *M. maximus* cv. Tamani was estimated at 38.4 days, which showed a high correlation with tiller density and leaf area index and lower leaf senescence.

The GDM yields for all defoliation levels were higher than suggested by Minson (2012) as a minimum forage limit available in tropical grass pastures (2,000 kg ha^{-1}), so as not to restrict access and intake voluntary forage by animals. 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.

The effect of the defoliation frequency on GDM yields was adjusted to the quadratic regression model and the maximum values were estimated at 39.9; 36.1 and 38.2 days, respectively to defoliation intensities of 20, 30 and 40 cm above the ground (Table 1). The data indicate that the greater the defoliation intensity, greater should be the time available for adequate pasture recovery. In the Rondônia´s savannas, for pastures of *M. maximus* cvs. Centenário and Massai, Costa et al. (2007) reported higher forage yields for defoliation frequencies varying between 21 and 28 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 (Barbosa et al., 2002; Cunha et al., 2012; Difante et al., 2011; Pena et al., 2009).

The adequate interval between grazing of *M. maximus* cv. Tanzania-1 should not be established alone on the basis of the GDM accumulation rate, requiring knowledge about the interactions between stem production and grazing efficiency, consumption and forage quality (Santos et al., 2012; Santos et al., 2003). 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. In pastures of *M. maximus* cv. Aruana, the prolongation of the defoliation frequency 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 defoliation frequency 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).

Defoliation frequencies affected negatively and linearly the N, P, Ca Mg and K concentrations (Table 2), showing a dilution effect with a decrease in the frequency of defoliation of the grass. Irrespective of defoliation frequencies, the highest levels of N (25.31 g kg^{-1}), P (2.11 g kg^{-1}), Mg (2.78 g kg^{-1}) and K (21,13 g kg^{-1}) were recorded for the defoliation intensity at 40 cm above the ground, except for Ca (4.31 g kg^{-1}), where the greatest concentration was obtained with defoliations at 30 cm above the ground. 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 defoliation frequencies. 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 defoliation frequency.

Defoliation frequency affect grass chemical composition negatively and linearly, as a consequence of the potentiation of leaf senescence processes (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 (Lemaire et al., 2011; Santos et al., 2004). 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 & Pontes, 2002). The tiller when reaching a certain number of live leaves tillers^{-1} (NLLT) establishes the balance between the leaf appearance rate 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; Martuscello et al., 2019; Pereira, 2013).

Table 2. Nitrogen, phosphorus, calcium, magnesium and potassium concentrations of *Megathyrsus maximus* cv. Tamani, as affected by defoliation regimes

Defoliation Intensity (cm)	Defoliation Frequency (days) 21	28	35	42	Regression Equation
		Nitrogen (g kg^{-1})			
20	25.21	24.33	22.76	19.65	Y = 31.21 - 0.2607 x (r^2 = 0,96)
30	26.88	25.14	23.98	20.75	Y = 32.98 - 0.2793 x (r^2 = 0.89)
40	28.15	26.43	24.57	22.06	Y = 34.36 - 0.2876 x (r^2 = 0,92)
		Phosphorus (g kg^{-1})			
20	2.02	1.89	1.73	1.62	Y = 2.47 - 0.0194 x (r^2 = 0,97)
30	2.21	1.96	1.91	1.82	Y = 2.52 - 0.0176 x (r^2 = 0.93)
40	2.36	2.13	2.01	1.97	Y = 2.69 - 0.0184 x (r^2 = 0.95)
		Calcium (g kg^{-1})			
20	4.71	4.08	3.86	3.77	Y = 5.47 - 0.0434 x (r^2 = 0,91)
30	4.84	4.23	4.17	3.98	Y = 5.49 - 0.0377 x (r^2 = 0.95)
40	4.91	4.33	4.03	3.75	Y = 5.95 - 0.0543 x (r^2 = 0.90)
		Magnesium (g kg^{-1})			
20	2.57	2.13	2.02	1.89	Y = 3.12 - 0.0307 x (r^2 = 0,94)
30	2.93	2.51	2.43	2.22	Y = 3.51 - 0.0316 x (r^2 = 0.91)
40	3.12	2.90	2.66	2.45	Y = 3.81 - 0.0323 x (r^2 = 0.92)
		Potassium (g kg^{-1})			
20	20.45	18.98	17.71	17.32	Y = 23.39 - 0.1509 x (r^2 = 0,93)
30	22.51	20.08	18.97	18.11	Y = 26.35 - 0.2044 x (r^2 = 0.94)
40	23.19	21.75	20.36	19.22	Y = 27.11 - 0.2876 x (r^2 = 0.88)

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 forage yield and chemical composition of *M. maximus* cv. Tamani were affect by defoliation regimes. The decrease in the pasture defoliation frequency and intensity improved the accumulation of forage, however it reduces the tissue concentrations of N, P, Ca, Mg and K.

The use of defoliation frequency around 32 days and defoliation intensity of 28 cm above the ground can be considered adequate for the management of pastures of *M. maximus* cv. Tamani, in order to reconcile production, regrowth vigor and forage quality, greater tissue renewal and canopy structure more favorable to grazing.

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